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**Acknowledgements**

This document was created through collaboration amongst the members of the Illinois Energy Efficiency Stakeholder Advisory Group (SAG). The SAG is an open forum where interested parties may participate in the evolution of Illinois' energy efficiency programs. Parties wishing to participate in the SAG process may do so by visiting [http://www.ilsag.info/questions.html](http://www.ilsag.info/questions.html) and contacting the Independent Facilitator at Annette.Beitel@FutEE.biz. Parties wishing to participate in the Technical Advisory Committee (TAC), a subcommittee of the SAG, may do so by contacting the TRM Administrator at itrmadministrator@veic.org.

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<td>Citizen's Utility Board (CUB)</td>
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¹ Being an open forum, this list of SAG stakeholders and participants may change at any time.
Table 1.1: Document Revision History

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Summary of Measure Revisions

The following tables summarize the evolution of measures that are new, revised or errata. This version of the TRM contains 83 measure-level changes as described in the following table.

Table 1.2: Summary of Measure Level Changes

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The ‘Change Type’ column indicates what kind of change each measure has gone through. Specifically, when a measure error was identified and the TAC process resulted in a consensus, the measure is identified here as an ‘Errata’. In these instances the measure code indicates that a new version of the measure has been published, and that the effective date of the measure dates back to June 1st, 2014. Measures that are identified as ‘Revised’ were included in the third edition of the TRM, and have been updated for this edition of the TRM. Both ‘Revised’ and ‘New Measure(s)’ have an effective date of June 1st, 2015.

The following table provides an overview of the 83 measure-level changes that are included in this version of the TRM.

Table 1.3: Summary of Measure Revisions

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<td>4.4.29 Stack Economizer for Boilers Serving Process Loads</td>
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<td>CI-HVC-FTUN-V01-150601</td>
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<td>C&amp;I</td>
<td>4.5 Lighting</td>
<td>4.5.1 Commercial ENERGY STAR Compact Fluorescent</td>
<td>CI-LTG-CCFL-V04-140601</td>
<td>Errata</td>
<td>Update to RES v C&amp;I Split</td>
<td>Increase in kWh savings (more C&amp;I)</td>
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<td>4.5.1 Commercial ENERGY STAR Compact Fluorescent</td>
<td>CI-LTG-CCFL-V05-150601</td>
<td>Revision</td>
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<td>Increase in kWh savings (more C&amp;I)</td>
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<td>4.5.3 High Performance and Reduced Wattage T8 Fixtures</td>
<td>CI-LTG-T8FX-V03-140601</td>
<td>Errata</td>
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<td>Increase in kWh savings (more C&amp;I)</td>
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<td>Revision</td>
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<td>Increase in kWh savings (higher ISR)</td>
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<td>Measure Code</td>
<td>Change Type</td>
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<td>CI-LTG-LEDB-V03-140601</td>
<td>Errata</td>
<td>Update to RES v C&amp;I Split.</td>
<td>Increase in kWh savings (more C&amp;I)</td>
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<td>4.5.4 LED Bulbs and Fixtures</td>
<td>CI-LTG-LEDB-V04-150601</td>
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<td>4.5.12 T5 Fixtures and Lamps</td>
<td>CI-LTG-TSFX-V03-150601</td>
<td>Revision</td>
<td>Clarification of Direct Install assumptions. Measure life clarification Update to ISR Timing of sunsetting of T-12s as viable baseline pushed back a year.</td>
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<td>4.5.14 Commercial ENERGY STAR Specialty Compact Fluorescent Lamp</td>
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<td>ENERGY STAR and ENERGY STAR Most Efficient Clothes Washer</td>
<td>RS-APL-ESCL-V03-150601</td>
<td>Revision</td>
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<td>Refrigerator and Freezer Recycling</td>
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<td>Refrigerator and Freezer Recycling</td>
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<td>Air Source Heat Pump</td>
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<td>RS-HVC-CAC1-V04-150601</td>
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<td>Updated Federal Standard and costs</td>
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<td>5.3.4 Duct Insulation and Sealing</td>
<td>RS-HVC-DINS-V03-140601</td>
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<td>5.3.4 Duct Insulation and Sealing</td>
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<td>RS-HVC-GHEB-V03-150601</td>
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<td>• Providing separate calculation for TOS/NC and retrofit and when supported by electric or gas only utility or both.</td>
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<td>• Updated costs.</td>
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<td>RS-HVC-DHP-V02-150601</td>
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<td>5.3.13 Residential Furnace Tune up</td>
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<td>5.3.14 Boiler Reset Controls</td>
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<td>5.5.1 ENERGY STAR Compact Fluorescent Lamp</td>
<td>RS-LTG-ESCF-V04-150601</td>
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<td>5.5.2 ENERGY STAR Specialty Compact Fluorescent Lamp</td>
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<td>Revision</td>
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<td>5.5.3 ENERGY STAR Torchiere</td>
<td>RS-LTG-ESTO-V02-150601</td>
<td>Revision</td>
<td>Update to Coincidence Factors. Added leakage variable</td>
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<td>5.5.4 Exterior Hardwired Compact Fluorescent Lamp</td>
<td>RS-LTG-EFIX-V04-150601</td>
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<td>5.5.5 Interior Hardwired Compact Fluorescent Lamp</td>
<td>RS-LTG-IFIX-V04-150601</td>
<td>Revision</td>
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<td>5.5.6 LED Downlights</td>
<td>RS-LTG-LEDD-V03-140601</td>
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<td>Change Type</td>
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<td>5.5.6 LED Downlights</td>
<td>RS-LTG-LEDD-V04-150601</td>
<td>Revision</td>
<td>Update to Hours, Coincidence Factors. Added leakage variable. New Wattbase calculation for PAR, MR and MRX bulbs</td>
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<td>5.5.8 LED Screw Based Omnidirectional Bulbs</td>
<td>RS-LTG-LEDA-V03-150601</td>
<td>Revision</td>
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<td>5.6.1 Air Sealing</td>
<td>RS-SHL-AIRS-V03-150601</td>
<td>Revision</td>
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<td>5.6.2 Basement Sidewall Insulation</td>
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<td>Errata</td>
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<td>5.6.2 Basement Sidewall Insulation</td>
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<td>5.6.3 Floor Insulation Above Crawlspace</td>
<td>RS-SHL-FINS-V05-140601</td>
<td>Errata</td>
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<td>5.6.3 Floor Insulation Above Crawlspace</td>
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<td>5.6.4 Wall and Ceiling/Attic Insulation</td>
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1 Purpose of the TRM

The purpose of the Illinois Statewide Technical Reference Manual (TRM) is to provide a transparent and consistent basis for calculating energy (electric kilowatt-hours (kWh) and natural gas therms) and capacity (electric kilowatts (kW)) savings generated by the State of Illinois’ energy efficiency programs which are administered by the Department of Commerce and Economic Opportunity (DCEO) and the state’s largest electric and gas Utilities (collectively, Program Administrators).

The TRM is a technical document that is filed with the Illinois Commerce Commission (Commission or ICC) and is intended to fulfill a series of objectives, including:

- “Serve as a common reference document for all... stakeholders, [Program Administrators], 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[4] (“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.

- [Provide] 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.

- ...[S]upport coincident peak capacity (for electric) savings estimates and calculations for electric utilities in a manner consistent with the methodologies employed by the utility’s Regional Transmission Organization (“RTO”), as well as those necessary for statewide Illinois tracking of coincident peak capacity impacts.”

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2 220 ILCS 5/8-103, 220 ILCS 5/16-111.5B and 220 ILCS 5/8-104.
3 In addition to DCEO, the Program Administrators include: Ameren Illinois, ComEd, Peoples Gas, North Shore Gas, and Nicor Gas (collectively, the Utilities).
4 The Illinois TRC test is defined in 220 ILCS 5/8-104(b) and 20 ILCS 3855/1-10.
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’ Energy Efficiency Plan dockets. In the Final Orders, the ICC required the utilities to work with DCEO and the Illinois Energy Efficiency Stakeholder Advisory Group (SAG) to develop a statewide TRM. See, e.g., ComEd’s Final Order (Docket No. 10-0570, Final Order at 59-60, December 21, 2010); Ameren’s Final Order (Docket No. 10-0568, Order on Rehearing at 19, May 24, 2011); Peoples Gas/North Shore Gas’ Final Order (Docket No. 10-0564, Final Order at 76, May 24, 2011), and Nicor’s Final Order (Docket No. 10-0562, Final Order 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 include representatives from the following organizations:

- the Utilities (ComEd, Ameren IL, Nicor Gas, Peoples Gas/North Shore Gas),
- Illinois Department of Commerce and Economic Opportunity (DCEO),
- the independent evaluators (ADM Associates, The Cadmus Group, Itron, Navigant Consulting, Michael’s Engineering, Opinion Dynamics Corporation),
- ICC Staff,
- the Illinois Attorney General’s Office (AG),
- Natural Resources Defense Council (NRDC),
- the Environmental Law and Policy Center (ELPC),
- the Citizen’s Utility Board (CUB),
- The University of Illinois at Chicago,
- Future Energy Enterprises,
- Geothermal Alliance of Illinois,
- the Geothermal Exchange Organization.

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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.
1.2 Development Process

The first edition of the IL-TRM was approved by the Commission in ICC Docket No. 12-0528\(^\text{11}\). The second edition of the IL-TRM was approved by the Commission in ICC Docket No. 13-0437\(^\text{12}\). The policies surrounding the applicability and use of the IL-TRM in planning, implementation, and evaluation were established by the Commission in ICC Docket No. 13-0077\(^\text{13}\). The Commission extended these policies, including the applicability of the IL-TRM, to the Section 16-111.5B energy efficiency programs in ICC Docket No. 14-0588\(^\text{14}\) in order to increase certainty for all parties. The third edition of the IL-TRM was approved by the Commission in ICC Docket No. 14-0189\(^\text{15}\). This document represents the fourth edition of the IL-TRM. It contains a series of new measures, as well as a series of errata items\(^\text{16}\) and updates to existing measures that were already present in the first, second and third editions. Like the previous editions, it 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 meets with the SAG and/or the TRM TAC at least once each month to create a high level of transparency and vetting in the development of this TRM.

Measure requests that are submitted by interested parties are ranked based on the following criteria to determine the approximate priority level for order of inclusion in the TRM:

1. High Priority
   - For those existing measures that make up a significant portion of a utilities’ portfolio and/or where the impact of the requested change is high
   - For new measures where plans are in place to implement in the next program year

2. Medium Priority
   - For existing measures that are a less significant percent of a utilities’ portfolio and value change will not have a significant impact
   - For new measures where a savings value is estimated but implementation plans not yet developed

3. Low Priority
   - For existing measures that represent a very small percent of a utilities’ portfolio

\(^{16}\) Errata as well as links to the official IL-TRM documents, dockets, and policy documents are available on the following ICC webpage: [http://www.icc.illinois.gov/electricity/TRM.aspx](http://www.icc.illinois.gov/electricity/TRM.aspx)
For new measures that are just beginning to be explored and will not be implemented in the next program year

These rankings are used to align budget and schedule constraints with desired updates from the TRM.

As measure requests are finalized leading up to the next update of the TRM, weekly TAC meetings are often scheduled to maximize the level of collaboration and visibility into the measure characterization process. Where consensus does not emerge on specific measures or issues, those items are identified in a memo, and are not included in the TRM. As a result, this TRM represents a broad consensus amongst the SAG and TAC participants. In keeping with the goal of transparency, all of the comments and their status to-date are available through the TAC SharePoint web site, https://portal.veic.org.

For each measure characterization, this TRM includes engineering algorithm(s) and a value(s) for each parameter in the equation(s). 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 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 natural gas 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.

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17 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.
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.
2 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

   - This level of organization specifies the type of customer the measure applies to, either Commercial and Industrial or Residential.
   - Answers the question, “What category best describes the customer?”

2. End-use Category

   - 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.
   - Answers the question, “To what end-use category does the measure apply?”

   **Table 2.1: End-Use Categories in the TRM**

<table>
<thead>
<tr>
<th>Residential Market Sector</th>
<th>Commercial and Industrial Market Sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appliances</td>
<td>Agricultural Equipment</td>
</tr>
<tr>
<td>Consumer Electronics</td>
<td>Food Service Equipment</td>
</tr>
<tr>
<td>Hot Water</td>
<td>Hot Water</td>
</tr>
<tr>
<td>HVAC</td>
<td>HVAC</td>
</tr>
<tr>
<td>Lighting</td>
<td>Lighting</td>
</tr>
<tr>
<td>Shell</td>
<td>Miscellaneous</td>
</tr>
<tr>
<td></td>
<td>Refrigeration</td>
</tr>
</tbody>
</table>

3. Measure & Technology

   - 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.
   - 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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18 Note that the Public sector buildings and low income measures that DCEO administers are not listed as a separate Market Sector. The Public building type is one of a series of building types that are included in the appropriate measures in the Commercial and Industrial Sector.

19 Please note that this is not an exhaustive list of end-uses and that others may be included in future versions of the TRM.
2.1 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>
<thead>
<tr>
<th>Market (@@)</th>
<th>End-use (@@@@)</th>
<th>Measure (@@@@@)</th>
<th>Version (V##)</th>
<th>Effective Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>CI (C&amp;I)</td>
<td>AGE (Agricultural Equipment)</td>
<td>BLR_</td>
<td>V01</td>
<td>YYMMDD</td>
</tr>
<tr>
<td>RS (Residential)</td>
<td>APL (Appliances)</td>
<td>T5F_</td>
<td>V02</td>
<td>YYMMDD</td>
</tr>
<tr>
<td>CEL (Consumer Electronics)</td>
<td>T8F_</td>
<td>V03</td>
<td>YYMMDD</td>
<td></td>
</tr>
<tr>
<td>FSE (Food Service Equipment)</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td></td>
</tr>
<tr>
<td>HVC (HVAC)</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td></td>
</tr>
<tr>
<td>HW_ (Hot Water)</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td></td>
</tr>
<tr>
<td>LTG (Lighting)</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td></td>
</tr>
<tr>
<td>MSC (Miscellaneous)</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td></td>
</tr>
<tr>
<td>RFG (Refrigeration)</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td></td>
</tr>
<tr>
<td>SHL (Shell)</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td></td>
</tr>
</tbody>
</table>
2.2 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**

Brief description of measure stating how it saves energy, the markets it serves and any limitations to its applicability.

**DEFINITION OF EFFICIENT EQUIPMENT**

Clear definition of the criteria for the efficient equipment used to determine delta savings. Including any standards or ratings if appropriate.

**DEFINITION OF BASELINE EQUIPMENT**

Clear definition of the efficiency level of the baseline equipment used to determine delta savings including any standards or ratings if appropriate. If a Time of Sale measure the baseline will be new base level equipment (to replace existing equipment at the end of its useful life or for a new building). For Early Replacement or Early Retirement measures the baseline is the existing working piece of equipment that is being removed.

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The expected duration in years (or hours) of the savings. If an early replacement measure, the assumed life of the existing unit is also provided.

**DEEMED MEASURE COST**

For time of sale measures, incremental cost from baseline to efficient is provided. Installation costs should only be included if there is a difference between each efficiency level. For Early Replacement the full equipment and install cost of the efficient installation is provided in addition to the full deferred hypothetical baseline replacement cost.

**LOADSHAPE**

The appropriate loadshape to apply to electric savings is provided.

**COINCIDENCE FACTOR**

The summer coincidence factor is provided to estimate the impact of the measure on the utility's system peak – defined as 1PM to hour ending 5PM on non-holiday weekdays, June through August.

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**Algorithm**

**Calculation of Energy Savings**

Algorithms are provided followed by list of assumptions with their definition.

If there are no Input Variables, there will be a finite number of Output values. These will be identified and listed in a table. Where there are custom inputs, an example calculation is often provided to illustrate the algorithm and provide context.
ELECTRIC ENERGY SAVINGS

SUMMER COINCIDENT PEAK DEMAND SAVINGS

NATURAL GAS SAVINGS

WATER IMPACT DESCRIPTIONS AND CALCULATION

DEEMED O&M COST ADJUSTMENT CALCULATION

Only required if the operation and maintenance cost for the efficient case is different to the baseline.

MEASURE CODE
2.3 Variable 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 measure has a custom allowable input.

2.3.1 C&I Custom Value Use in Measure Implementation

This section defines the requirements for capturing Custom variables that can be used in place of defaults for select assumptions within the prescriptive measures defined in this statewide TRM. This approach 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 approach 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. A custom variable is when customer input is provided to define the number or the value is measured at the site. Custom values can also be supplied from product data of the measure installed. In certain cases the custom data can be provided from a documented study or report that is applicable to the measure. Custom variables and potential sources are clearly defined in the specific measures where “Actual” or “Custom” is noted.

In exceptional cases where the participant, program administrator, and independent evaluator all agree that the TRM algorithm for a particular energy efficiency measure does not accurately characterize the energy efficiency measure within a project due to the complexity in the design and configuration of the particular energy efficiency project, a more comprehensive custom engineering and financial analysis may be used that more accurately incorporates the attributes of the measure in the complex energy efficiency project. In such cases and consistent with Commission policy adopted in ICC Docket No. 13-0077, Program Administrators are subject to retrospective evaluation risk (retroactive adjustments to savings based on ex post evaluation findings) for such projects utilizing customized savings calculations.
2.4 Program Delivery & Baseline Definitions

The measure characterizations in this TRM are not grouped by program delivery type. 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

<table>
<thead>
<tr>
<th>Program</th>
<th>Attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time of Sale (TOS)</td>
<td>Definition: 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 or contractor based programs as examples. Baseline = New equipment. Efficient Case = New, premium efficiency equipment above federal and state codes and standard industry practice. Example: CFL rebate</td>
</tr>
<tr>
<td>New Construction (NC)</td>
<td>Definition: A program that intervenes during building design to support the use of more-efficient equipment and construction practices. Baseline = Building code or federal standards. Efficient Case = The program’s level of building specification Example: Building shell and mechanical measures</td>
</tr>
<tr>
<td>Retrofit (RF)</td>
<td>Definition: A program that upgrades existing equipment before the end of its useful life. Baseline = Existing equipment or the existing condition of the building or equipment. A single baseline applies over the measure’s life. Efficient Case = New, premium efficiency equipment above federal and state codes and standard industry practice. Example: Air sealing and insulation</td>
</tr>
<tr>
<td>Early Replacement (ERE)</td>
<td>Definition: A program that replaces existing equipment before the end of its expected life. Baseline = Dual; it begins as the existing equipment and shifts to new baseline equipment after the expected life of the existing equipment is over. Efficient Case = New, premium efficiency equipment above federal and state codes and standard industry practice. Example: Refrigerators, freezers</td>
</tr>
<tr>
<td>Early Retirement (ERE)</td>
<td>Definition: A program that retires duplicative equipment before its expected life is over. Baseline = The existing equipment, which is retired and not replaced. Efficient Case = Zero because the unit is retired. Example: Appliance recycling</td>
</tr>
<tr>
<td>Direct Install (DI)</td>
<td>Definition: A program where measures are installed during a site visit. Baseline = Existing equipment. Efficient Case = New, premium efficiency equipment above federal and state codes and standard industry practice.</td>
</tr>
</tbody>
</table>
Example: Lighting and low-flow hot water measures

**Efficiency Kits (KITS)**

**Definition:** A program where measures are provided free of charge to a customer in an Efficiency Kit.

**Baseline =** Existing equipment.

**Efficient Case =** New, premium efficiency equipment above federal and state codes and standard industry practice.

**Example:** 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 four 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.
3 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.

3.1 Footnotes & Documentation of Sources

Each new and updated measure characterization is supported by a work paper, which is posted to the SharePoint web site (https://portal.veic.org). Both the work paper and the measure characterizations themselves use 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 to the TRM’s Sharepoint website. These files can be found in the ‘Sources and Reference Documents’ folder in the main directory, and are also be posted to the SAG’s public web site (http://www.ilsag.info/technical-reference-manual.html).

3.2 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 or therms) 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.

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20 To gain access to the SharePoint web site, please contact the TRM Administrator, Nikki Clace at iltrmadministrator@veic.org.
3.3 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 T5/T8 Linear Fluorescents, Furnaces and Early Replacement Measures.

3.3.1 CFL and T5/T8 Linear Fluorescents Baseline Assumptions

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 40W 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.

In July 14, 2012, Federal Standards were enacted that were expected to eliminate T-12s as an option for linear fluorescent fixtures. Through v3.0 of the TRM, it was assumed that the T-12 would no longer be baseline for retrofits from 1/1/2016. However, due to significant loopholes in the legislation, T-12 compliant product is still freely available and in Illinois T-12s continue to hold a significant share of the existing and replacement lamp market. Therefore the timing of the sunsetting of T-12s as a viable baseline has been pushed back in v4.0 until 6/1/2016 and will be revisited in future update sessions.

3.3.2 Early Replacement Baseline Assumptions

A series of measures have an option to choose an Early Replacement Baseline. For these measures, the baseline assumption of the existing unit efficiency is based upon the average efficiency of units that were classified in Ameren’s PY3-PY4 as functioning and that meet efficiency and cost of replacement criteria in the following table.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Section</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Source Heat Pump</td>
<td>5.3.1</td>
<td>SEER &lt;=10 and cost of any repairs &lt;$249 per ton</td>
</tr>
<tr>
<td>Central Air Conditioner</td>
<td>5.3.3</td>
<td>SEER &lt;=10 and cost of any repairs &lt;$190 per ton</td>
</tr>
<tr>
<td>Boiler</td>
<td>5.3.6</td>
<td>AFUE &lt;= 75% and cost of any repairs &lt;$709</td>
</tr>
<tr>
<td>Furnace</td>
<td>4.4.11, 5.3.7</td>
<td>AFUE &lt;= 75% and cost of any repairs &lt;$528</td>
</tr>
<tr>
<td>Ground Source Heat Pump</td>
<td>5.3.8</td>
<td>SEER &lt;=10 and cost of any repairs &lt;$249 per ton</td>
</tr>
</tbody>
</table>

It is only appropriate to use these Early Replacement assumptions where these conditions are met. The TAC

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These criteria were documented in a memo entitled, “Early Replacement Measure Issue Summary_0409.docx.”
defined “functioning” as the unit is fully operational – providing sufficient space conditioning (i.e. heat exchanger, compressors, pumps work effectively) and/or the cost of repair is under 20% of the new baseline replacement cost. Therefore in order to apply early replacement assumptions the programs should apply the following eligibility criteria for the existing heating or cooling system in the home:

### 3.3.3 Furnace Baseline

“The prior national standard for residential oil and gas furnaces was 78% AFUE. DOE raised the standard in 2007 to 80% AFUE, effective 2015. However, virtually all furnaces on the market have an AFUE of 80% or better, which prompted states and environmental and consumer groups to sue DOE over its 2007 decision. In April 2009, DOE accepted a “voluntary remand” in that litigation. In October 2009, manufacturers and efficiency advocates negotiated an agreement that, for the first time, included different standard levels in three climate regions: the North, South, and Southwest. DOE issued a direct final rule (DFR) in June 2011 reflecting the standard levels in the consensus agreement. The DFR became effective on October 25, 2011 establishing new standards: In the North, most furnaces will be required to have an AFUE of 90%. The 80% AFUE standard for the South and Southwest will remain unchanged at 80%. Oil furnaces will be required to have an AFUE of 83% in all three regions. The amended standards will become effective in May 2013 for non-weatherized furnaces and in January 2015 for weatherized furnaces. DOE estimates that the standards will save about 3.3 quads (quadrillion Btu) of energy over 30 years and yield a net present value of about $14 billion at a 3 percent discount rate.

**Update:** On January 14th, 2013, the U.S. Department of Energy (DOE) proposed to settle a lawsuit brought by the American Public Gas Association (APGA) that seeks to roll back gas furnace efficiency standards. As a result, the new standards, completed in 2011 and slated to take effect in May 2013, would be eliminated in favor of yet another round of DOE hearings and studies. Even if DOE completes a new rulemaking in two years, it’s unlikely to take effect before 2020.22

As a result, each of the furnace measures contains the following language describing the baseline assumption:

“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%. The baseline will be adjusted when the Federal Standard is updated.”

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3.4 Glossary

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

Building Types:

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assisted Living MultiFamily</td>
<td>Applies to residential buildings of three or more units with staff to assist the occupants. Gross Floor Area should include all fully-enclosed space within the exterior walls of the building(s) including individual rooms or units, wellness centers, exam rooms, community rooms, small shops or service areas for residents and visitors (e.g. hair salons, convenience stores), staff offices, lobbies, atriums, cafeterias, kitchens, storage areas, hallways, basements, stairways, corridors between buildings, and elevator shafts.</td>
</tr>
<tr>
<td>Auditorium/Assembly</td>
<td>Applies to any performance space such as a theater, arena, or hall. Gross Floor Area should include all space within the building(s), including seating, stage and backstage areas, food service areas, retail areas, rehearsal studios, administrative/office space, mechanical rooms, storage areas, elevator shafts, and stairwells.</td>
</tr>
<tr>
<td>College/University</td>
<td>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, and stairwells.</td>
</tr>
<tr>
<td>Convenience Store</td>
<td>Applies to facility space used for the retail sale of a limited selection of food and beverage products. 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), and administrative areas.</td>
</tr>
<tr>
<td>Elementary School</td>
<td>Applies to a school serving children in any grades from Kindergarten through sixth grade. 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.</td>
</tr>
<tr>
<td>Exterior</td>
<td>Applies to unconditioned spaces that are outside of the building envelope.</td>
</tr>
<tr>
<td>Garage</td>
<td>Applies to unconditioned spaces either attached or detached from the primary building envelope that are not used for living space.</td>
</tr>
<tr>
<td>Grocery</td>
<td>Applies to facility space used for the retail sale of food and beverage products. It should not be used by restaurants. 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.</td>
</tr>
<tr>
<td>Healthcare Clinic</td>
<td>Applies to a facility space used to provide diagnosis and treatment for medical, dental, or psychiatric outpatient care. Gross Floor Area should include all space within the building(s) including offices, exam rooms, laboratories, lobbies, atriums, conference rooms and auditoriums, employee break rooms and kitchens, rest rooms, elevator shafts, stairways, mechanical rooms, and storage areas.</td>
</tr>
<tr>
<td>Heavy Industry</td>
<td>Heavy industry buildings are typically characterized by a plant that includes a main production area that has high ceilings and contains heavy equipment used for assembly</td>
</tr>
</tbody>
</table>

23 Source: US EPA, [www.energystar.gov](http://www.energystar.gov), Space Type Definitions
<table>
<thead>
<tr>
<th>Building Type</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>High School/Middle School</td>
<td>Applies to facility space used as a school building for 7th 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.</td>
</tr>
<tr>
<td>Hospital</td>
<td>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. Spaces more accurately characterized as a Healthcare Clinic should use that 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.</td>
</tr>
<tr>
<td>Hotel/Motel Combined (All Spaces)</td>
<td>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.</td>
</tr>
<tr>
<td>Hotel/Motel Common Areas</td>
<td>All the common areas open to guests of the hotel such as the lobby, corridors and stairways, and other spaces that may have continuous or large lighting and HVAC hours.</td>
</tr>
<tr>
<td>Hotel/Motel Guest Room</td>
<td>Applies to the guest rooms of the hotel or motel. These spaces are occupied intermittently.</td>
</tr>
<tr>
<td>Light Industry</td>
<td>Applies to buildings that are dedicated to manufacturing activities. Light industry buildings are characterized by consumer product and component manufacturing. These building types may be distinguished by categorizing NIACS (SIC) codes according to the needs of the Program Administrator.</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>Applies to spaces that do not fit clearly within any available categories should be designated as “miscellaneous”.</td>
</tr>
<tr>
<td>Multifamily-Mid Rise</td>
<td>Applies to residential buildings with up to four floors, including all public and multiuse spaces within the building envelope. Small Multifamily buildings best described as a house should use the residential measure characterizations.</td>
</tr>
<tr>
<td>Multifamily-High Rise Combined (All Spaces)</td>
<td>Applies to residential buildings with five or more floors, including all public and multiuse spaces within the building envelope. Gross Floor Area should include all fully-enclosed space within the exterior walls of the building(s) including living space in each unit (including occupied and unoccupied units), interior common areas (e.g. lobbies, offices, community rooms, common kitchens, fitness rooms, indoor pools), hallways, stairwells, elevator shafts, connecting corridors between buildings, storage areas, and mechanical space such as a boiler room. Open air stairwells, breezeways, and other similar areas that are not fully-enclosed should not be included in the Gross Floor Area.</td>
</tr>
<tr>
<td>Building Type</td>
<td>Definition</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Multifamily-High Rise</td>
<td><strong>Common Areas</strong> All the common areas open to occupants of the building such as the lobby, corridors and stairways, and other spaces that may have continuous or high lighting and HVAC hours.</td>
</tr>
<tr>
<td>Multifamily-High Rise</td>
<td><strong>Residential Units</strong> Applies to the residential units in the building only.</td>
</tr>
<tr>
<td>Movie Theater</td>
<td>Applies to buildings used for public or private film screenings. Gross Floor Area should include all space within the building(s), including seating areas, lobbies, concession stands, bathrooms, administrative/office space, mechanical rooms, storage areas, elevator shafts, and stairwells.</td>
</tr>
<tr>
<td>Office-Low Rise</td>
<td>Applies to facility spaces in buildings with four floors or fewer 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.</td>
</tr>
<tr>
<td>Office-Mid Rise</td>
<td>Applies to facility spaces in buildings with five to nine floors 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.</td>
</tr>
<tr>
<td>Office-High Rise</td>
<td>Applies to facility spaces in buildings with ten floors or more 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.</td>
</tr>
<tr>
<td>Religious Worship/Church</td>
<td>Applies to buildings that are used as places of worship. This includes churches, temples, mosques, synagogues, meetinghouses, or any other buildings that primarily function as a place of religious worship. Gross Floor Area should include all areas inside the building that includes the primary worship area, including food preparation, community rooms, classrooms, and supporting areas such as restrooms, storage areas, hallways, and elevator shafts.</td>
</tr>
<tr>
<td>Restaurant</td>
<td>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.</td>
</tr>
<tr>
<td>Retail/Service-Department store</td>
<td>Applies to facility space used to conduct the retail sale of consumer product goods. Stores must be at least 30,000 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: Grocery, Convenience Stores, Automobile Dealerships, and Restaurants.</td>
</tr>
<tr>
<td>Retail/Service-Strip Mall</td>
<td>Applies to facility space used to conduct the retail sale of consumer product goods. Stores must less than 30,000 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 excluded under this definition are: Grocery, Convenience Stores, Automobile Dealerships, and Restaurants.</td>
</tr>
<tr>
<td>Warehouse</td>
<td>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</td>
</tr>
</tbody>
</table>
Building Type | Definition
--- | ---
 | 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.

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.

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 2.1.1 for a list of the end-use categories that are incorporated in this TRM.

Energy Efficiency: "Energy efficiency" means measures that reduce the amount of electricity or natural gas required to achieve a given end use. "Energy efficiency" also includes measures that reduce the total Btus of electricity and natural gas needed to meet the end use or uses (20 ILCS 3855/1-10). For purposes of this Section, "energy efficiency" means measures that reduce the amount of energy required to achieve a given end use. "Energy efficiency" also includes measures that reduce the total Btus of electricity and natural gas needed to meet the end use or uses (220 ILCS 5/8-104(b)).

Equivalent Full Load Hours (EFLH): 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) or therms.

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).

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24 Measures that apply to the multifamily and public housing building types describe how to handle tenant versus master metered buildings.
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 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 measures) of implementing the High Efficiency equipment.

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

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

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.

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.”25 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 ICC to work with the SAG on the development of a statewide TRM.

### Table 3.2: Degree-Day Zones and Values by Market Sector

<table>
<thead>
<tr>
<th>Zone</th>
<th>Residential</th>
<th></th>
<th></th>
<th>Weather Station / City</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>HDD</td>
<td>CDD</td>
<td>HDD</td>
</tr>
<tr>
<td>1</td>
<td>5,352</td>
<td>820</td>
<td>4,272</td>
<td>2,173</td>
</tr>
<tr>
<td>2</td>
<td>5,113</td>
<td>842</td>
<td>4,029</td>
<td>2,181</td>
</tr>
<tr>
<td>3</td>
<td>4,379</td>
<td>1,108</td>
<td>3,406</td>
<td>2,666</td>
</tr>
<tr>
<td>4</td>
<td>3,378</td>
<td>1,570</td>
<td>2,515</td>
<td>3,358</td>
</tr>
<tr>
<td>5</td>
<td>3,438</td>
<td>1,370</td>
<td>2,546</td>
<td>3,090</td>
</tr>
<tr>
<td>Average</td>
<td>4,860</td>
<td>947</td>
<td>3,812</td>
<td>2,362</td>
</tr>
<tr>
<td>Base Temp</td>
<td>60F</td>
<td>65F</td>
<td>55F</td>
<td>55F</td>
</tr>
</tbody>
</table>
3.5 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>
<thead>
<tr>
<th>Period Category</th>
<th>Period Definition (Central Prevailing Time)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter On-Peak Energy</td>
<td>8AM - 11PM, weekdays, Oct – Apr, No NERC holidays</td>
</tr>
<tr>
<td>Winter Off-Peak Energy</td>
<td>All other hours</td>
</tr>
<tr>
<td>Summer On-Peak Energy</td>
<td>8AM - 11PM, weekdays, May – Sept, No NERC holidays</td>
</tr>
<tr>
<td>Summer Off-Peak Energy</td>
<td>All other hours</td>
</tr>
</tbody>
</table>

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 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 most 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.

ComEd uses 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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26 All loadshape information has been posted to the VEIC Sharepoint site, and is publically accessible through the Stakeholder Advisory Group’s web site. [http://www.ilsag.info/technical-reference-manual.html](http://www.ilsag.info/technical-reference-manual.html)
Table 3.4: Loadshapes by Season

<table>
<thead>
<tr>
<th>Loadshape Reference Number</th>
<th>Winter Peak Oct-Apr, M-F, non-holiday, 8AM - 11PM</th>
<th>Winter Off-peak Oct-Apr, All other time</th>
<th>Summer Peak May-Sept, M-F, non-holiday, 8AM - 11PM</th>
<th>Summer Off-peak May-Sept, All other time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential Clothes Washer</td>
<td>R01 47.0%</td>
<td>11.1%</td>
<td>34.0%</td>
<td>8.0%</td>
</tr>
<tr>
<td>Residential Dish Washer</td>
<td>R02 49.3%</td>
<td>8.7%</td>
<td>35.7%</td>
<td>6.3%</td>
</tr>
<tr>
<td>Residential Electric DHW</td>
<td>R03 43.2%</td>
<td>20.6%</td>
<td>24.5%</td>
<td>11.7%</td>
</tr>
<tr>
<td>Residential Freezer</td>
<td>R04 38.9%</td>
<td>16.4%</td>
<td>31.5%</td>
<td>13.2%</td>
</tr>
<tr>
<td>Residential Refrigerator</td>
<td>R05 37.0%</td>
<td>18.1%</td>
<td>30.1%</td>
<td>14.7%</td>
</tr>
<tr>
<td>Residential Indoor Lighting</td>
<td>R06 48.1%</td>
<td>15.5%</td>
<td>26.0%</td>
<td>10.5%</td>
</tr>
<tr>
<td>Residential Outdoor Lighting</td>
<td>R07 18.0%</td>
<td>44.1%</td>
<td>9.4%</td>
<td>28.4%</td>
</tr>
<tr>
<td>Residential Cooling</td>
<td>R08 4.1%</td>
<td>0.7%</td>
<td>71.3%</td>
<td>23.9%</td>
</tr>
<tr>
<td>Residential Electric Space Heat</td>
<td>R09 57.8%</td>
<td>38.8%</td>
<td>1.7%</td>
<td>1.7%</td>
</tr>
<tr>
<td>Residential Electric Heating and Cooling</td>
<td>R10 35.2%</td>
<td>22.8%</td>
<td>31.0%</td>
<td>11.0%</td>
</tr>
<tr>
<td>Residential Ventilation</td>
<td>R11 25.8%</td>
<td>32.3%</td>
<td>18.9%</td>
<td>23.0%</td>
</tr>
<tr>
<td>Residential - Dehumidifier</td>
<td>R12 12.9%</td>
<td>16.2%</td>
<td>31.7%</td>
<td>39.2%</td>
</tr>
<tr>
<td>Residential Standby Losses - Entertainment Center</td>
<td>R13 26.0%</td>
<td>32.5%</td>
<td>18.9%</td>
<td>22.6%</td>
</tr>
<tr>
<td>Residential Standby Losses - Home Office</td>
<td>R14 23.9%</td>
<td>34.6%</td>
<td>17.0%</td>
<td>24.5%</td>
</tr>
<tr>
<td>Commercial Electric Cooking</td>
<td>C01 40.6%</td>
<td>18.2%</td>
<td>28.7%</td>
<td>12.6%</td>
</tr>
<tr>
<td>Commercial Electric DHW</td>
<td>C02 40.5%</td>
<td>18.2%</td>
<td>28.5%</td>
<td>12.8%</td>
</tr>
<tr>
<td>Commercial Cooling</td>
<td>C03 4.9%</td>
<td>0.8%</td>
<td>66.4%</td>
<td>27.9%</td>
</tr>
<tr>
<td>Commercial Electric Heating</td>
<td>C04 53.5%</td>
<td>43.2%</td>
<td>1.9%</td>
<td>1.4%</td>
</tr>
<tr>
<td>Commercial Electric Heating and Cooling</td>
<td>C05 19.4%</td>
<td>13.5%</td>
<td>47.1%</td>
<td>19.9%</td>
</tr>
<tr>
<td>Loadshape Reference Number</td>
<td>Winter Peak Oct-Apr, M-F, non-holiday, 8AM - 11PM</td>
<td>Winter Off-peak Oct-Apr, All other time</td>
<td>Summer Peak May-Sept, M-F, non-holiday, 8AM - 11PM</td>
<td>Summer Off-peak May-Sept, All other time</td>
</tr>
<tr>
<td>----------------------------</td>
<td>--------------------------------------------------</td>
<td>----------------------------------------</td>
<td>-----------------------------------------------</td>
<td>-----------------------------------------</td>
</tr>
<tr>
<td>Commercial Indoor Lighting</td>
<td>C06 40.1%</td>
<td>18.6%</td>
<td>28.4%</td>
<td>12.9%</td>
</tr>
<tr>
<td>Grocery/Conv. Store Indoor Lighting</td>
<td>C07 31.4%</td>
<td>26.4%</td>
<td>22.8%</td>
<td>19.3%</td>
</tr>
<tr>
<td>Hospital Indoor Lighting</td>
<td>C08 29.1%</td>
<td>29.0%</td>
<td>21.0%</td>
<td>20.9%</td>
</tr>
<tr>
<td>Office Indoor Lighting</td>
<td>C09 42.1%</td>
<td>16.0%</td>
<td>30.4%</td>
<td>11.5%</td>
</tr>
<tr>
<td>Restaurant Indoor Lighting</td>
<td>C10 32.1%</td>
<td>25.7%</td>
<td>23.4%</td>
<td>18.8%</td>
</tr>
<tr>
<td>Retail Indoor Lighting</td>
<td>C11 35.5%</td>
<td>22.3%</td>
<td>25.8%</td>
<td>16.3%</td>
</tr>
<tr>
<td>Warehouse Indoor Lighting</td>
<td>C12 39.4%</td>
<td>18.5%</td>
<td>28.6%</td>
<td>13.5%</td>
</tr>
<tr>
<td>K-12 School Indoor Lighting</td>
<td>C13 45.8%</td>
<td>22.6%</td>
<td>20.2%</td>
<td>11.4%</td>
</tr>
<tr>
<td>Indust. 1-shift (8/5) (e.g., comp. air, lights)</td>
<td>C14 50.5%</td>
<td>7.2%</td>
<td>37.0%</td>
<td>5.3%</td>
</tr>
<tr>
<td>Indust. 2-shift (16/5) (e.g., comp. air, lights)</td>
<td>C15 47.5%</td>
<td>10.2%</td>
<td>34.8%</td>
<td>7.4%</td>
</tr>
<tr>
<td>Indust. 3-shift (24/5) (e.g., comp. air, lights)</td>
<td>C16 34.8%</td>
<td>23.2%</td>
<td>25.5%</td>
<td>16.6%</td>
</tr>
<tr>
<td>Indust. 4-shift (24/7) (e.g., comp. air, lights)</td>
<td>C17 25.8%</td>
<td>32.3%</td>
<td>18.9%</td>
<td>23.0%</td>
</tr>
<tr>
<td>Industrial Indoor Lighting</td>
<td>C18 44.3%</td>
<td>13.6%</td>
<td>32.4%</td>
<td>9.8%</td>
</tr>
<tr>
<td>Industrial Outdoor Lighting</td>
<td>C19 18.0%</td>
<td>44.1%</td>
<td>9.4%</td>
<td>28.4%</td>
</tr>
<tr>
<td>Commercial Outdoor Lighting</td>
<td>C20 23.4%</td>
<td>35.3%</td>
<td>13.0%</td>
<td>28.3%</td>
</tr>
<tr>
<td>Commercial Office Equipment</td>
<td>C21 37.7%</td>
<td>20.9%</td>
<td>26.7%</td>
<td>14.7%</td>
</tr>
<tr>
<td>Commercial Refrigeration</td>
<td>C22 38.5%</td>
<td>20.6%</td>
<td>26.7%</td>
<td>14.2%</td>
</tr>
<tr>
<td>Commercial Ventilation</td>
<td>C23 38.1%</td>
<td>20.6%</td>
<td>29.7%</td>
<td>11.6%</td>
</tr>
<tr>
<td>Traffic Signal - Red Balls, always changing or flashing</td>
<td>C24 25.8%</td>
<td>32.3%</td>
<td>18.9%</td>
<td>23.0%</td>
</tr>
<tr>
<td>Traffic Signal - Red Balls, changing day, off night</td>
<td>C25 37.0%</td>
<td>20.9%</td>
<td>27.1%</td>
<td>14.9%</td>
</tr>
<tr>
<td>Traffic Signal - Green Balls, always changing</td>
<td>C26 25.8%</td>
<td>32.3%</td>
<td>18.9%</td>
<td>23.0%</td>
</tr>
<tr>
<td>Loadshape Reference Number</td>
<td>Winter Peak Oct-Apr, M-F, non-holiday, 8AM - 11PM</td>
<td>Winter Off-peak Oct-Apr, All other time</td>
<td>Summer Peak May-Sept, M-F, non-holiday, 8AM - 11PM</td>
<td>Summer Off-peak May-Sept, All other time</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-----------------------------------------------</td>
<td>----------------------------------------</td>
<td>---------------------------------</td>
<td>----------------------------------------</td>
</tr>
<tr>
<td>Traffic Signal - Green Balls, changing day, off night</td>
<td>C27</td>
<td>37.0%</td>
<td>20.9%</td>
<td>27.1%</td>
</tr>
<tr>
<td>Traffic Signal - Red Arrows</td>
<td>C28</td>
<td>25.8%</td>
<td>32.3%</td>
<td>18.9%</td>
</tr>
<tr>
<td>Traffic Signal - Green Arrows</td>
<td>C29</td>
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<td>18.9%</td>
</tr>
<tr>
<td>Traffic Signal - Flashing Yellows</td>
<td>C30</td>
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<td>32.3%</td>
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</tr>
<tr>
<td>Traffic Signal - “Hand” Don’t Walk Signal</td>
<td>C31</td>
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<td>32.3%</td>
<td>18.9%</td>
</tr>
<tr>
<td>Traffic Signal - “Man” Walk Signal</td>
<td>C32</td>
<td>25.8%</td>
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<td>18.9%</td>
</tr>
<tr>
<td>Traffic Signal - Bi-Modal Walk/Don’t Walk</td>
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</tr>
<tr>
<td>Industrial Motor</td>
<td>C34</td>
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<tr>
<td>Industrial Process</td>
<td>C35</td>
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<tr>
<td>HVAC Pump Motor (heating)</td>
<td>C36</td>
<td>38.7%</td>
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<td>5.9%</td>
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<td>HVAC Pump Motor (cooling)</td>
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<td>HVAC Pump Motor (unknown use)</td>
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<td>23.2%</td>
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<tr>
<td>VFD - Supply fans &lt;10 HP</td>
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<td>38.8%</td>
<td>16.1%</td>
<td>28.4%</td>
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<tr>
<td>VFD - Return fans &lt;10 HP</td>
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<td>VFD - Boiler feedwater pumps &lt;10 HP</td>
<td>C42</td>
<td>42.9%</td>
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</tr>
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<td>VFD - Chilled water pumps &lt;10 HP</td>
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<td>Refrigeration Economizer</td>
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<td>Evaporator Fan Control</td>
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<td>Standby Losses - Commercial Office</td>
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<td>Loadshape Reference Number</td>
<td>Winter Peak Oct-Apr, M-F, non-holiday, 8AM - 11PM</td>
<td>Winter Off-peak Oct-Apr, All other time</td>
<td>Summer Peak May-Sept, M-F, non-holiday, 8AM - 11PM</td>
<td>Summer Off-peak May-Sept, All other time</td>
</tr>
<tr>
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<tr>
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<td>C48</td>
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<td>6.4%</td>
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<tr>
<td>VFD Cooling Tower Fans &lt;10 HP</td>
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<td>54.0%</td>
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<tr>
<td>Engine Block Heater Timer</td>
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<td>Door Heater Control</td>
<td>C51</td>
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<tr>
<td>Beverage and Snack Machine Controls</td>
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<td>Flat</td>
<td>C53</td>
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<tr>
<td>Religious Indoor Lighting</td>
<td>C54</td>
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# Table 3.5: Loadshapes by Month and Day of Week

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<th></th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
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<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
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<tbody>
<tr>
<td><strong>Residential Clothes Washer</strong></td>
<td>R01</td>
<td>7.0%</td>
<td>1.6%</td>
<td>6.3%</td>
<td>1.5%</td>
<td>6.6%</td>
<td>1.7%</td>
<td>6.7%</td>
<td>1.5%</td>
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<td>1.6%</td>
<td>6.5%</td>
</tr>
<tr>
<td><strong>Residential Dish Washer</strong></td>
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<td>1.2%</td>
<td>6.6%</td>
<td>1.2%</td>
<td>7.0%</td>
<td>1.4%</td>
<td>7.1%</td>
<td>1.2%</td>
<td>7.3%</td>
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<tr>
<td><strong>Residential Electric DHW</strong></td>
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<td>2.7%</td>
<td>6.1%</td>
<td>3.3%</td>
<td>6.2%</td>
<td>2.8%</td>
<td>5.0%</td>
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<tr>
<td><strong>Residential Freezer</strong></td>
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<td>2.2%</td>
<td>5.5%</td>
<td>2.6%</td>
<td>5.6%</td>
<td>2.2%</td>
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<tr>
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<td>4.9%</td>
<td>2.4%</td>
<td>5.2%</td>
<td>2.9%</td>
<td>5.3%</td>
<td>2.5%</td>
<td>6.2%</td>
<td>2.9%</td>
<td>5.8%</td>
</tr>
<tr>
<td><strong>Residential Indoor Lighting</strong></td>
<td>R06</td>
<td>7.1%</td>
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<td>2.1%</td>
<td>6.8%</td>
<td>2.4%</td>
<td>6.9%</td>
<td>2.1%</td>
<td>5.3%</td>
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<tr>
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<td>2.6%</td>
<td>7.0%</td>
<td>2.6%</td>
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<tr>
<td><strong>Residential Cooling</strong></td>
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<tr>
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<td>4.3%</td>
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<tr>
<td><strong>Residential - Dehumidifier</strong></td>
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</tr>
<tr>
<td><strong>Residential Standby Losses - Entertainment Center</strong></td>
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<td>3.8%</td>
<td>4.6%</td>
<td>3.5%</td>
<td>4.3%</td>
<td>3.7%</td>
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<tr>
<td><strong>Residential Standby</strong></td>
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<td>4.7%</td>
<td>3.5%</td>
<td>4.9%</td>
<td>3.3%</td>
</tr>
<tr>
<td>Losses - Home Office</td>
<td>Jan</td>
<td>Feb</td>
<td>Mar</td>
<td>Apr</td>
<td>May</td>
<td>Jun</td>
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<tr>
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<tr>
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<td>0.7%</td>
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<tr>
<td><strong>Grocery/Conv. Store Indoor Lighting</strong></td>
<td>C07</td>
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<td>3.7%</td>
<td>4.2%</td>
<td>3.5%</td>
<td>4.4%</td>
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<tr>
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<td>5.3%</td>
<td>3.2%</td>
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Page 45 of 801
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<th>Apr</th>
<th>May</th>
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<th>Oct</th>
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<td>(8/5) [e.g., comp. air, lights]</td>
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<td>5.2%</td>
<td>3.3%</td>
<td>4.9%</td>
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<td>(24/5) [e.g., comp. air, lights]</td>
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<td>C40</td>
<td>5.7%</td>
<td>2.3%</td>
<td>5.2%</td>
<td>2.1%</td>
<td>5.5%</td>
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<td>5.8%</td>
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</tr>
<tr>
<td>VFD - Exhaust fans &lt;10 HP</td>
<td>C41</td>
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<td>3.3%</td>
<td>4.6%</td>
<td>3.1%</td>
<td>4.9%</td>
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<tr>
<td>VFD - Boiler feedwater pumps &lt;10 HP</td>
<td>C42</td>
<td>6.4%</td>
<td>6.2%</td>
<td>5.7%</td>
<td>5.9%</td>
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<tr>
<td>VFD - Chilled water pumps &lt;10 HP</td>
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<td>0.8%</td>
<td>1.5%</td>
<td>0.7%</td>
<td>1.6%</td>
<td>0.9%</td>
<td>1.6%</td>
<td>0.8%</td>
<td>8.3%</td>
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</tr>
<tr>
<td>VFD Boiler circulation pumps &lt;10 HP</td>
<td>C44</td>
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<td>6.2%</td>
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<td>5.9%</td>
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<td>Refrigeration Economizer</td>
<td>C45</td>
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<td>8.0%</td>
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<td>Evaporator Fan Control</td>
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<tr>
<td>Standby Losses - Commercial Office</td>
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<td>1.2%</td>
<td>7.1%</td>
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<td>6.7%</td>
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<td>8.0%</td>
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<td>6.9%</td>
<td>1.1%</td>
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<td>VFD Boiler draft fans &lt;10 HP</td>
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<td>6.9%</td>
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<td>Religious Indoor Lighting C54</td>
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<td>3.9%</td>
<td>4.5%</td>
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3.6 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.

3.7 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 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. Residential cooling is based on 65F in agreement with a field study in Wisconsin. 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. Custom degree-days with building specific base temperatures are recommended for large C&I projects.

27 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.
29 Energy Center of Wisconsin, May 2008 metering study; “Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research”, p. 32 (amended in 2010).
30 This value is based upon experience, and it is preferable to use building-specific base temperatures when available.
Table 3.6: Degree-Day Zones and Values by Market Sector

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

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 3.2: Heating Degree-Day Zones by County
Table 3.7: Heating Degree-Day Zones by County

<table>
<thead>
<tr>
<th>Zone 1</th>
<th>Zone 2</th>
<th>Zone 3</th>
<th>Zone 4</th>
<th>Zone 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boone County</td>
<td>Bureau County</td>
<td>Adams County</td>
<td>Clinton County</td>
<td>Alexander County</td>
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<tr>
<td>Jo Daviess County</td>
<td>Carroll County</td>
<td>Bond County</td>
<td>Edwards County</td>
<td>Massac County</td>
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<td>Cook County</td>
<td>Brown County</td>
<td>Franklin County</td>
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<td>Winnebago County</td>
<td>DeKalb County</td>
<td>Calhoun County</td>
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<td>DuPage County</td>
<td>Cass County</td>
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<td>Grundy County</td>
<td>Champaign County</td>
<td>Hardin County</td>
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<td>Christian County</td>
<td>Jackson County</td>
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### Table 3.8: Cooling Degree-day Zones by County

<table>
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<th>Zone 1</th>
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<th>Zone 3</th>
<th>Zone 4</th>
<th>Zone 5</th>
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<tbody>
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<tr>
<td>Will County</td>
<td>Mason County</td>
<td>Wabash County</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Woodford County</td>
<td>McDonough County</td>
<td>Washington County</td>
<td></td>
<td></td>
</tr>
<tr>
<td>McLean County</td>
<td>Wayne County</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Menard County</td>
<td>White County</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Morgan County</td>
<td>Williamson County</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moultrie County</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Piatt County</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pike County</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sangamon County</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Schuyler County</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scott County</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shelby County</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tazewell County</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vermilion County</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3.8 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**

<table>
<thead>
<tr>
<th>Baseline Case:</th>
<th>O&amp;M costs equal $150 every two years.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficient Case:</td>
<td>O&amp;M costs equal $50 every five years.</td>
</tr>
</tbody>
</table>

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%.
3.9 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. 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.

31 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.
4 Commercial and Industrial Measures

4.1 Agricultural End Use

4.1.1 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\textsuperscript{32}

DEEMED MEASURE COST

The incremental cost per installed plug-in timer is $10.19\textsuperscript{33}.

COINCIDENCE FACTOR

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

\textsuperscript{32}Equipment life is expected to be longer, but measure life is more conservative to account for possible attrition in use over time.

\textsuperscript{33}Based on bulk pricing reported by EnSave, which administers the rebate in Vermont
Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

\[ \Delta \text{kWh} = \text{ISR} \times \text{Use Season} \times \%\text{Days} \times \text{HrSave/Day} \times kW_{\text{heater}} \times \text{ParaLd} \]

\[ = 78.39\% \times 87 \text{ days} \times 84.23\% \times 7.765 \text{ Hr/Day} \times 1.5 \text{ kW} \times 5.46 \text{ kWh} \]

\[ = 664 \text{ kWh} \]

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-V01-120601
4.1.2 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\(^{34}\).

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\(^{35}\).

DEEMED MEASURE COST

The incremental capital cost for the fans are as follows\(^{36}\):

<table>
<thead>
<tr>
<th>Fan Diameter Size (feet)</th>
<th>Incremental Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>$4150</td>
</tr>
<tr>
<td>22</td>
<td>$4180</td>
</tr>
<tr>
<td>24</td>
<td>$4225</td>
</tr>
</tbody>
</table>

LOADSHAPE

Loadshape C34 - Industrial Motor

COINCIDENTIAL FACTOR

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

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS\(^{37}\)

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

\(^{34}\) Act on Energy Commercial Technical Reference Manual No. 2010-4
\(^{35}\) Ibid.
\(^{36}\) Ibid.
\(^{37}\) Ibid.
High Volume Low Speed Fans

### Summer Coincident Peak Demand Savings

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

<table>
<thead>
<tr>
<th>Fan Diameter Size (feet)</th>
<th>kWh Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>6577</td>
</tr>
<tr>
<td>22</td>
<td>8543</td>
</tr>
<tr>
<td>24</td>
<td>10018</td>
</tr>
</tbody>
</table>

### 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-V01-120601

---

38 Ibid.
4.1.3 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:\(^{39}\).

<table>
<thead>
<tr>
<th>Diameter of Fan (inches)</th>
<th>Minimum Efficiency for Exhaust &amp; Ventilation Fans</th>
<th>Minimum Efficiency for Circulation Fans</th>
</tr>
</thead>
<tbody>
<tr>
<td>24 through 35</td>
<td>14.0 cfm/W at 0.10 static pressure</td>
<td>12.5 lbf/kW</td>
</tr>
<tr>
<td>36 through 47</td>
<td>17.1 cfm/W at 0.10 static pressure</td>
<td>18.2 lbf/kW</td>
</tr>
<tr>
<td>48 through 71</td>
<td>20.3 cfm/W at 0.10 static pressure</td>
<td>23.0 lbf/kW</td>
</tr>
</tbody>
</table>

**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\(^{40}\).

**DEEMED MEASURE COST**

The incremental capital cost for all fan sizes is $150\(^{41}\).

**LOADSHAPE**

Loadshape C34 - Industrial Motor

**COINCIDENCE FACTOR**

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

---


\(^{40}\) Ibid.

\(^{41}\) Ibid.
CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

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

<table>
<thead>
<tr>
<th>Diameter of Fan (inches)</th>
<th>kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>24 through 35</td>
<td>372</td>
</tr>
<tr>
<td>36 through 47</td>
<td>625</td>
</tr>
<tr>
<td>48 through 71</td>
<td>1122</td>
</tr>
</tbody>
</table>

SUMMER COINCIDENT PEAK DEMAND SAVINGS

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

<table>
<thead>
<tr>
<th>Diameter of Fan (inches)</th>
<th>kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>24 through 35</td>
<td>0.118</td>
</tr>
<tr>
<td>36 through 47</td>
<td>0.198</td>
</tr>
<tr>
<td>48 through 71</td>
<td>0.356</td>
</tr>
</tbody>
</table>

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_-_V01-120601

---

42 Ibid.
43 Ibid.
4.1.4 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.44

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 years45.

DEEMED MEASURE COST
The incremental capital cost for the waters are $787.50.46

LOADSHAPE
Loadshape C04 - Non-Residential Electric Heating

COINCIDENCE FACTOR
The measure has deemed kW savings therefore a coincidence factor is not applied

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS47
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. 48

45 Ibid.
46 Ibid.
47 Ibid.
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-V01-120601
4.2  Food Service Equipment End Use

4.2.1  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 $\geq 38\%$ and convection mode cooking efficiency $\geq 44\%$ utilizing ASTM standard F2861 and meet idle requirements below$^{49}$:

<table>
<thead>
<tr>
<th>Combi Oven Type</th>
<th>Steam Mode Idle Rate</th>
<th>Convection Mode Idle Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas Combi &lt; 15 pan capacity</td>
<td>15,000 Btu/hr</td>
<td>9,000 Btu/hr</td>
</tr>
<tr>
<td>Gas Combi 15-28 pan capacity</td>
<td>18,000 Btu/hr</td>
<td>11,000 Btu/hr</td>
</tr>
<tr>
<td>Gas Combi &gt; 28 pan capacity</td>
<td>28,000 Btu/hr</td>
<td>17,000 Btu/hr</td>
</tr>
</tbody>
</table>

**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$^{50}$.

**DEEMED MEASURE COST**

The incremental capital cost for this measure is $4300$\$^{51}$.

**LOADSHAPE**

N/A

---

$^{50}$ Deemed values from Nicor Gas were used. Nicor Gas Energy Efficiency Plan 2011-2014. Revised Plan Filed Pursuant to Order Docket 10-0562, May 27, 2011.
$^{51}$ Ibid.
**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.\(^\text{52}\)

**Water Impact Descriptions and Calculation**

N/A

**Deemed O&M Cost Adjustment Calculation**

N/A

**Measure Code: CI-FSE-CBOV-V01-120601**

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\(^{52}\) 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.
4.2.2 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.\(^53\)

DEEMED MEASURE COST

The incremental capital cost for this measure is provided below.\(^54\)

<table>
<thead>
<tr>
<th>Type</th>
<th>Refrigerator Incremental Cost, per unit</th>
<th>Freezer Incremental Cost, per unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid or Glass Door</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 &lt; V &lt; 15</td>
<td>$143</td>
<td>$142</td>
</tr>
<tr>
<td>15 ≤ V &lt; 30</td>
<td>$164</td>
<td>$166</td>
</tr>
<tr>
<td>30 ≤ V &lt; 50</td>
<td>$164</td>
<td>$166</td>
</tr>
<tr>
<td>V ≥ 50</td>
<td>$249</td>
<td>$407</td>
</tr>
</tbody>
</table>

LOADSHAPE

Loadshape C23 - Commercial Refrigeration

COINCIDENCE FACTOR

The summer peak coincidence factor for this measure is assumed to be 0.937.\(^{55}\)

---

### Algorithm

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

\[ \Delta \text{kWh} = (\text{kWh}_{\text{base}} - \text{kW}_{\text{hee}}) \times 365.25 \]

Where:

- **kWh\text{base}** = baseline maximum daily energy consumption in kWh
  
  = calculated using actual chilled or frozen compartment volume (V) of the efficient unit as shown in the table below.

<table>
<thead>
<tr>
<th>Type</th>
<th>kWhbase(^{56})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid Door Refrigerator</td>
<td>0.10 * V + 2.04</td>
</tr>
<tr>
<td>Glass Door Refrigerator</td>
<td>0.12 * V + 3.34</td>
</tr>
<tr>
<td>Solid Door Freezer</td>
<td>0.40 * V + 1.38</td>
</tr>
<tr>
<td>Glass Door Freezer</td>
<td>0.75 * V + 4.10</td>
</tr>
</tbody>
</table>

- **kW\text{hee}** = 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.

<table>
<thead>
<tr>
<th>Type</th>
<th>Refrigerator kWhe</th>
<th>Freezer kWhe</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 &lt; V &lt; 15</td>
<td>( \leq 0.089V + 1.411 )</td>
<td>( \leq 0.250V + 1.250 )</td>
</tr>
<tr>
<td>15 ( \leq V &lt; 30 )</td>
<td>( \leq 0.037V + 2.200 )</td>
<td>( \leq 0.400V - 1.000 )</td>
</tr>
<tr>
<td>30 ( \leq V &lt; 50 )</td>
<td>( \leq 0.056V + 1.635 )</td>
<td>( \leq 0.163V + 6.125 )</td>
</tr>
<tr>
<td>V ( \geq 50 )</td>
<td>( \leq 0.060V + 1.416 )</td>
<td>( \leq 0.158V + 6.333 )</td>
</tr>
</tbody>
</table>

\(^{55}\) The CF for Commercial Refrigeration was calculated based upon the Ameren provided eShapes


### Commercial Solid and Glass Door Refrigerators & Freezers

<table>
<thead>
<tr>
<th>Type</th>
<th>Refrigerator kWhe</th>
<th>Freezer kWhe</th>
</tr>
</thead>
<tbody>
<tr>
<td>$30 \leq V &lt; 50$</td>
<td>$\leq 0.088V + 2.625$</td>
<td>$\leq 0.250V + 13.500$</td>
</tr>
<tr>
<td>$V \geq 50$</td>
<td>$\leq 0.110V + 1.500$</td>
<td>$\leq 0.450V + 3.500$</td>
</tr>
</tbody>
</table>

$V$ = 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

$$\Delta kWh = (3.54 - 2.76) \times 365.25 = 285 \text{ kWh}$$

**Summer Coincident Peak Demand Savings**

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

Where:

$\text{HOURS}$ = equipment is assumed to operate continuously, 24 hours per day, 365.25 days per year.

$= 8766$

$\text{CF}$ = Summer Peak Coincidence Factor for measure

$= 0.937$

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

$$\Delta kW = \frac{285}{8766} \times 0.937 = 0.030 \text{ kW}$$

**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-V01-120601**
4.2.3 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:

<table>
<thead>
<tr>
<th>Gas</th>
<th>Electric</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENERGY STAR® qualified with 38% minimum cooking energy efficiency at heavy load (potato) cooking capacity for gas steam cookers.</td>
<td>ENERGY STAR® qualified with 50% minimum cooking energy efficiency at heavy load (potato) cooking capacity for electric steam cookers.</td>
</tr>
</tbody>
</table>

**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\(^{58}\)

**DEEMED MEASURE COST**

The incremental capital cost for this measure is $998\(^{59}\) for a natural gas steam cooker or $2490\(^{60}\) for an electric steam cooker.

**LOADSHAPE**

Loadshape C01 - Commercial Electric Cooking

**COINCIDENCE FACTOR**

Summer Peak Coincidence Factor for measure is provided below for different building type\(^{61}\):

<table>
<thead>
<tr>
<th>Location</th>
<th>CF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fast Food Limited Menu</td>
<td>0.32</td>
</tr>
<tr>
<td>Fast Food Expanded Menu</td>
<td>0.41</td>
</tr>
<tr>
<td>Pizza</td>
<td>0.46</td>
</tr>
</tbody>
</table>

---

\(^{58}\)California DEER 2008 which is also used by both the Food Service Technology Center and ENERGY STAR®.

\(^{59}\)Source for incremental cost for efficient natural gas steamer is RSG Commercial Gas Steamer Workpaper, January 2012.

\(^{60}\)Source for efficient electric steamer incremental cost is $2,490 per 2009 PG&E Workpaper - PGE CFLST104.1 - Commercial Steam Cooker - Electric and Gas as reference by KEMA in the ComEd C & I TRM.

**Algorithm**

**CALCULATION OF SAVINGS**

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

**ENERGY SAVINGS**

\[
\Delta \text{Savings} = (\Delta \text{Idle Energy} + \Delta \text{Preheat Energy} + \Delta \text{Cooking Energy}) \times Z
\]

For a gas cooker:

\[
\Delta \text{Savings} = \Delta \text{Btu} \times 1/100,000 \times Z
\]

For an electric steam cooker:

\[
\Delta \text{Savings} = \Delta \text{kWh} \times Z
\]

Where:

\[
Z = \text{days/yr steamer operating (use 365.25 days/yr if heavy use restaurant and exact number unknown)}
\]

\[
\Delta \text{Idle Energy} = ((1 - \text{CSM\%Baseline}) \times \text{IDLE\_BASE} + \text{CSM\%Baseline} \times \text{PC\_BASE} \times \text{E\_FOOD} / \text{EFF\_BASE}) \times (\text{HOURS\_day} - (\text{F} / \text{PC\_Base}) - (\text{PRE\_number} \times 0.25)) - (((1 - \text{CSM\%ENERGYSTAR}) \times \text{IDLE\_ENERGYSTAR} + \text{CSM\%ENERGYSTAR} \times \text{PC\_ENERGY} \times \text{E\_FOOD} / \text{EFF\_ENERGYSTAR}) \times (\text{HOURS\_day} - (\text{F} / \text{PC\_ENERGY}) - (\text{PRE\_number} \times 0.25))))
\]

Where:

\[
\text{CSM\%Baseline} = \text{Baseline Steamer Time in Manual Steam Mode (% of time)}
\]

\[
= 90\%^{62}
\]

\[
\text{IDLE\_Base} = \text{Idle Energy Rate of Base Steamer}^{63}
\]

<table>
<thead>
<tr>
<th>Number of Pans</th>
<th>IDLE_Base - Gas, Btu/hr</th>
<th>IDLE_Base - Electric, kw</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>11,000</td>
<td>1.0</td>
</tr>
<tr>
<td>4</td>
<td>14,667</td>
<td>1.33</td>
</tr>
<tr>
<td>5</td>
<td>18,333</td>
<td>1.67</td>
</tr>
<tr>
<td>6</td>
<td>22,000</td>
<td>2.0</td>
</tr>
</tbody>
</table>

---

\(^{62}\)Food Service Technology Center 2011 Savings Calculator

\(^{63}\)Food Service Technology Center 2011 Savings Calculator
**PC\textsubscript{Base}**

\[ \text{Production Capacity of Base Steamer} \]

<table>
<thead>
<tr>
<th>Number of Pans</th>
<th>PC\textsubscript{BASE} gas (lbs/hr)</th>
<th>PC\textsubscript{BASE} electric (lbs/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>65</td>
<td>70</td>
</tr>
<tr>
<td>4</td>
<td>87</td>
<td>93</td>
</tr>
<tr>
<td>5</td>
<td>108</td>
<td>117</td>
</tr>
<tr>
<td>6</td>
<td>130</td>
<td>140</td>
</tr>
</tbody>
</table>

\( \text{E}_{\text{FOOD}} \)

Amount of Energy Absorbed by the food during cooking known as ASTM Energy to Food (Btu/lb or kW/lb)

\[ = 105 \text{ Btu/lb} \] (gas steamers) or \( 0.0308 \) (electric steamers)

\( \text{EFF}_{\text{BASE}} \)

Heavy Load Cooking Efficiency for Base Steamer

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

\( \text{HOURS}_{\text{day}} \)

Average Daily Operation (hours)

<table>
<thead>
<tr>
<th>Type of Food Service</th>
<th>Hours\textsuperscript{day}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fast Food, limited menu</td>
<td>4</td>
</tr>
<tr>
<td>Fast Food, expanded menu</td>
<td>5</td>
</tr>
<tr>
<td>Pizza</td>
<td>8</td>
</tr>
<tr>
<td>Full Service, limited menu</td>
<td>8</td>
</tr>
<tr>
<td>Full Service, expanded menu</td>
<td>7</td>
</tr>
<tr>
<td>Cafeteria</td>
<td>6</td>
</tr>
<tr>
<td>Unknown</td>
<td>6\textsuperscript{ef}</td>
</tr>
<tr>
<td>Custom</td>
<td>Varies</td>
</tr>
</tbody>
</table>

\( F \)

Food cooked per day (lbs/day)

\[ = \text{custom or if unknown, use 100 lbs/day} \]

---

\textsuperscript{64}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\textsuperscript{®} savings calculator uses 23.3 lb/hr per pan for both electric and natural gas baseline steamers.

\textsuperscript{65}Reference ENERGY STAR\textsuperscript{®} savings calculator at http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COC.

\textsuperscript{66}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.


\textsuperscript{68}Unknown is average of other locations.
CSM\textsubscript{ENERGYSTAR} = ENERGY STAR Steamer’s Time in Manual Steam Mode (% of time)\textsuperscript{70}

= 0%

IDLE\textsubscript{ENERGYSTAR} = Idle Energy Rate of ENERGY STAR\textsuperscript{71}

<table>
<thead>
<tr>
<th>Number of Pans</th>
<th>IDLE\textsubscript{ENERGYSTAR} - gas, (Btu/hr)</th>
<th>IDLE\textsubscript{ENERGYSTAR} - electric, (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>6250</td>
<td>0.40</td>
</tr>
<tr>
<td>4</td>
<td>8333</td>
<td>0.53</td>
</tr>
<tr>
<td>5</td>
<td>10417</td>
<td>0.67</td>
</tr>
<tr>
<td>6</td>
<td>12500</td>
<td>0.80</td>
</tr>
</tbody>
</table>

PC\textsubscript{ENERGY} = Production Capacity of ENERGY STAR\textsuperscript{72} Steamer

<table>
<thead>
<tr>
<th>Number of Pans</th>
<th>PC\textsubscript{ENERGY} - gas(lbs/hr)</th>
<th>PC\textsubscript{ENERGY} - electric (lbs/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>55</td>
<td>50</td>
</tr>
<tr>
<td>4</td>
<td>73</td>
<td>67</td>
</tr>
<tr>
<td>5</td>
<td>92</td>
<td>83</td>
</tr>
<tr>
<td>6</td>
<td>110</td>
<td>100</td>
</tr>
</tbody>
</table>

EFF\textsubscript{ENERGYSTAR} = Heavy Load Cooking Efficiency for ENERGY STAR\textsuperscript{73} Steamer(%)

= 38\textsuperscript{73} (gas steamer) or 50\textsuperscript{15} (electric steamer)

PRE\textsubscript{number} = Number of preheats per day

= 1\textsuperscript{74} (if unknown, use 1)

\Delta Preheat Energy = ( \text{PRE\textsubscript{number}} \times \Delta Pre\textsuperscript{heat} )

\textsuperscript{69}Reference amount used by both Food Service Technology Center and ENERGY STAR\textsuperscript{8} savings calculator

\textsuperscript{70}Reference information from the Food Service Technology Center siting that ENERGY STAR\textsuperscript{8} steamers are not typically operated in constant steam mode, but rather are used in timed mode. Reference ENERGY STAR\textsuperscript{8} 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.

\textsuperscript{71}Food Service Technology Center 2011 Savings Calculator

\textsuperscript{72}Production capacity per Food Service Technology Center 2011 Savings Calculator of 18.3333 lb/hr per pan for gas ENERGY STAR\textsuperscript{6} steam cookers and 16.6667 lb/hr per pan for electric ENERGY STAR\textsuperscript{6} steam cookers. ENERGY STAR\textsuperscript{6} savings calculator uses 16.7 lb/hr per pan for electric and 20 lb/hr for natural gas ENERGY STAR\textsuperscript{6} steamers.

\textsuperscript{73}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

\textsuperscript{74}Reference ENERGY STAR\textsuperscript{6} savings calculator at http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COC and Food
Where:

\[ \text{PRE}_{\text{number}} = \text{Number of Preheats per Day} \]
\[ = 1^{75} \text{ (if unknown, use 1)} \]

\[ \text{PRE}_{\text{heat}} = \text{Preheat energy savings per preheat} \]
\[ = 11,000 \text{ Btu/preheat}^{76} \text{ (gas steamer) or 0.5 kWh/preheat}^{77} \text{ (electric steamer)} \]

\[ \Delta \text{Cooking Energy} = ((1/ \text{EFF}_{\text{BASE}}) - (1/ \text{EFF}_{\text{ENERGY STAR}}^\star)) \times F \times E_{\text{FOOD}} \]

Where:

\[ \text{EFF}_{\text{BASE}} = \text{Heavy Load Cooking Efficiency for Base Steamer} \]
\[ = 15\%^{78} \text{ (gas steamer) or 26\%}^{28} \text{ (electric steamer)} \]

\[ \text{EFF}_{\text{ENERGY STAR}} = \text{Heavy Load Cooking Efficiency for ENERGY STAR® Steamer} \]
\[ = 38\%^{79} \text{ (gas steamer) or 50\%}^{23} \text{ (electric steamer)} \]

\[ F = \text{Food cooked per day (lbs/day)} \]
\[ = \text{custom or if unknown, use 100 lbs/day}^{80} \]

\[ E_{\text{FOOD}} = \text{Amount of Energy Absorbed by the food during cooking known as ASTM Energy to Food}^{81} \]

<table>
<thead>
<tr>
<th>( E_{\text{FOOD}} ) (Btu/lb)</th>
<th>( E_{\text{FOOD}} ) (kWh/lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>105^{82}</td>
<td>0.0308^{83}</td>
</tr>
</tbody>
</table>

---

75 Reference ENERGY STAR® savings calculator at http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COC and Food
76 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
77 Reference Food Service Technology Center 2011 Savings Calculator values for Baseline Preheat Energy.
78 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.
79 Ibid.
80 Amount used by both Food Service Technology Center and ENERGY STAR® savings calculator
81 Reference ENERGY STAR® savings calculator at http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COC.
82 Ibid.
83 Ibid.
EXAMPLE

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

\[
\Delta S_{\text{savings}} = \Delta \text{Idle Energy} + \Delta \text{Preheat Energy} + \Delta \text{Cooking Energy} \times Z \times \frac{1}{100,000}
\]

\[
\Delta \text{Idle Energy} = (((1-0.9) \times 11000 + 0.9 \times 65 \times 105 / 0.15 \times (7 - (100 / 65) - (1 \times 0.25))) - (((1-0) \times 6250 + 0 \times 55 \times 105 / 0.38 \times (7 - (100 / 55) - (1 \times 0.25)))) +
\]

\[
\Delta \text{Preheat Energy} = (1 \times 11,000) +
\]

\[
\Delta \text{Cooking Energy} = ((1/0.15) - (1/0.38)) \times (100 \text{ lb/day} \times 105 \text{ btu/lb}))
\]

\[
\times 365.25 \text{ days}) \times 1/100,000 =
\]

\[
= 883 \text{ therms}
\]

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

\[
\Delta S_{\text{savings}} = \Delta \text{Idle Energy} + \Delta \text{Preheat Energy} + \Delta \text{Cooking Energy} \times Z
\]

\[
\Delta \text{Idle Energy} = (((1-0.9) \times 1.0 + 0.9 \times 70 \times 0.0308 / 0.26 \times (6 - (100 / 70) - (1 \times 0.25))) - (((1-0) \times 0.4 + 0 \times 50 \times 0.0308 / 0.50 \times (6 - (100 / 50) - (1 \times 0.25)))) +
\]

\[
\Delta \text{Preheat Energy} = (1 \times 0.5)) +
\]

\[
\Delta \text{Cooking Energy} = ((1/0.26) - (1/0.5)) \times (100 \times 0.0308))
\]

\[
\times 365.25 \text{ days} =
\]

\[
13,649 \text{ kWh}
\]
SUMMER COINCIDENT PEAK DEMAND SAVINGS

This is only applicable to the electric steam cooker.

\[ \Delta kW = \frac{\Delta kWh}{(\text{HOURS}_{\text{Day}} \times \text{Days}_{\text{Year}})} \times CF \]

Where:

- \( CF \) = Summer Peak Coincidence Factor for measure is provided below for different locations\(^{84}\):

<table>
<thead>
<tr>
<th>Location</th>
<th>CF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fast Food Limited Menu</td>
<td>0.32</td>
</tr>
<tr>
<td>Fast Food Expanded Menu</td>
<td>0.41</td>
</tr>
<tr>
<td>Pizza</td>
<td>0.46</td>
</tr>
<tr>
<td>Full Service Limited Menu</td>
<td>0.51</td>
</tr>
<tr>
<td>Full Service Expanded Menu</td>
<td>0.36</td>
</tr>
<tr>
<td>Cafeteria</td>
<td>0.36</td>
</tr>
</tbody>
</table>

- \( \text{Days}_{\text{Year}} \) = Annual Days of Operation
  - = custom or 365.25 days a year
  - Other values as defined above

EXAMPLE

For 3 pan electric steam cooker located in a cafeteria:

\[
\Delta kW = \frac{\Delta kWh}{(\text{HOURS}_{\text{Day}} \times \text{Days}_{\text{Year}})} \times CF \\
= \frac{13,649}{(6 \times 365.25)} \times 0.36 \\
= 2.24 \text{ kW}
\]

WATER IMPACT DESCRIPTIONS AND CALCULATION

This is applicable to both gas and electric steam cookers.

\[ \Delta \text{Water} = (W_{\text{BASE}} - W_{\text{ENERGYSTAR}}) \times \text{HOURS}_{\text{Day}} \times \text{Days}_{\text{Year}} \]

Where

- \( W_{\text{BASE}} \) = Water Consumption Rate of Base Steamer (gal/hr)
  - = 40\(^{85}\)
- \( W_{\text{ENERGYSTAR}} \) = Water Consumption Rate of ENERGY STAR® Steamer look up\(^{86}\)

---


\(^{86}\) Source Consortium for Energy Efficiency, Inc. September 2010 "Program Design Guidance for Steamers" for Tier 1A and Tier
<table>
<thead>
<tr>
<th>CEE Tier</th>
<th>gal/hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tier 1A</td>
<td>15</td>
</tr>
<tr>
<td>Tier 1B</td>
<td>4</td>
</tr>
<tr>
<td>Avg Efficient</td>
<td>10</td>
</tr>
<tr>
<td>Avg Most Efficient</td>
<td>3</td>
</tr>
</tbody>
</table>

\[
\text{Days}_{\text{year}} = \text{Annual Days of Operation} = \text{custom or 365.25 days a year}^{87}
\]

**EXAMPLE**

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

\[
\Delta \text{Water} = (40 - 10) \times 7 \times 365.25
\]

\[
= 76,703 \text{ gallons}
\]

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**Measure Code: CI-FSE-STMC-V03-150601**

1B water requirements. Ohio Technical Reference Manual 2010 for 10 gal/hr water consumption which can be used when Tier level is not known.

87Source for 365.25 days/yr is ENERGY STAR® savings calculator which references Food Service Technology research on average use, 2009.
4.2.4 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/hr 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. 88

DEEMED MEASURE COST

The incremental capital cost for this measure is $1800 89.

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

89 Ibid.
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\(^9\). The annual natural gas energy savings from this measure is a deemed value equaling 733 Therms\(^9\).

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-FSE-CVOV-V01-120601

\(^9\)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.
4.2.5 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 $\geq 44\%$ utilizing ASTM standard 1496 and an idle energy consumption rate $< 13,000$ Btu/hr.

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.$^{91}$

DEEMED MEASURE COST
The incremental capital cost for this measure is $50^{92}$

LOADSHAPE
N/A

COINCIDENCE FACTOR
N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS
N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS
N/A

$^{91}$ 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

$^{92}$ 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
**NATURAL GAS ENERGY SAVINGS**

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

\[ \Delta \text{Therms} = (\Delta \text{Daily idle Energy} + \Delta \text{Daily preheat Energy} + \Delta \text{Daily cooking Energy}) \times \text{Days} / 100000 \]

Where:

\[ \Delta \text{Daily idle Energy} = (\text{Idle base} \times \text{Idle base time}) - (\text{Idle \text{ENERGYSTAR}} \times \text{Idle \text{ENERGYSTAR time}}) \]

\[ \Delta \text{Daily preheat Energy} = (\text{Preheat number base} \times \text{Preheat time base} / 60 \times \text{Preheat rate base}) - (\text{Preheat number \text{ENERGYSTAR}} \times \text{Preheat time \text{ENERGYSTAR}} / 60 \times \text{Preheat rate \text{ENERGYSTAR}}) \]

\[ \Delta \text{Daily cooking Energy} = (\text{LB} \times \text{EFOOD/ Eff base}) - (\text{LB} \times \text{EFOOD/ Eff \text{ENERGYSTAR}}) \]

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

- **Eff\text{ENERGYSTAR}** = Cooking Efficiency \text{ENERGY STAR}  
  = custom or if unknown, use 44%

- **EffBase** = Cooking Efficiency Baseline  
  = custom or if unknown, use 30%

- **PC\text{ENERGYSTAR}** = Production Capacity \text{ENERGY STAR}  
  = custom or if unknown, use 80 pounds/hr

- **PC\text{Base}** = Production Capacity base  
  = custom or if unknown, use 70 pounds/hr

- **PreheatNumber\text{ENERGYSTAR}** = Number of preheats per day  
  = custom or if unknown, use 1

- **PreheatNumber\text{Base}** = Number of preheats per day  
  = custom or if unknown, use 1

- **PreheatTime\text{ENERGYSTAR}** = preheat length  
  = custom or if unknown, use 15 minutes

- **PreheatTime\text{Base}** = preheat length  
  = custom or if unknown, use 15 minutes

---

93 Algorithms and assumptions derived from \text{ENERGY STAR Oven Commercial Kitchen Equipment Savings Calculator}. http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COG
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.

\[ \Delta \text{Therms} = (\Delta \text{Idle Energy} + \Delta \text{Preheat Energy} + \Delta \text{Cooking Energy}) * \text{Days} /100000 \]

Where:

\[ \Delta \text{DailyIdleEnergy} = (18000*10.3) - (13000*10.5) \]
\[ = 49286 \text{ btu} \]

\[ \Delta \text{DailyPreheatEnergy} = (1 * 15 / 60 * 76000) - (1 * 15 / 60 * 44000) \]
\[ = 8000 \text{ btu} \]

\[ \Delta \text{DailyCookingEnergy} = (100 * 250 / .30) - (100 * 250 / .44) \]
\[ = 26515 \text{ btu} \]

\[ \Delta \text{Therms} = (49286+8000+26515)* 365.25 /100000 \]
\[ = 306 \text{ therms} \]

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A
DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-FSE-ESCV-V01-120
4.2.6 ENERGY STAR Dishwasher

DESCRIPTION

This measure applies to ENERGY STAR high and low temp under counter 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\(^{94}\)

<table>
<thead>
<tr>
<th>Dishwasher type</th>
<th>Equipment Life</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Low Temp</strong></td>
<td></td>
</tr>
<tr>
<td>Under Counter</td>
<td>10</td>
</tr>
<tr>
<td>Door Type</td>
<td>15</td>
</tr>
<tr>
<td>Single Tank Conventional</td>
<td>20</td>
</tr>
<tr>
<td>Multi Tank Conventional</td>
<td>20</td>
</tr>
<tr>
<td><strong>High Temp</strong></td>
<td></td>
</tr>
<tr>
<td>Under Counter</td>
<td>10</td>
</tr>
<tr>
<td>Door Type</td>
<td>15</td>
</tr>
<tr>
<td>Single Tank Conventional</td>
<td>20</td>
</tr>
<tr>
<td>Multi Tank Conventional</td>
<td>20</td>
</tr>
</tbody>
</table>

\(^{94}\) 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 $95

<table>
<thead>
<tr>
<th>Dishwasher type</th>
<th>Incremental Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Temp</td>
<td></td>
</tr>
<tr>
<td>Under Counter</td>
<td>$530</td>
</tr>
<tr>
<td>Door Type</td>
<td>$530</td>
</tr>
<tr>
<td>Single Tank Conventional</td>
<td>$170</td>
</tr>
<tr>
<td>Multi Tank Conventional</td>
<td>$0</td>
</tr>
<tr>
<td>High Temp</td>
<td></td>
</tr>
<tr>
<td>Under Counter</td>
<td>$1000</td>
</tr>
<tr>
<td>Door Type</td>
<td>$500</td>
</tr>
<tr>
<td>Single Tank Conventional</td>
<td>$270</td>
</tr>
<tr>
<td>Multi Tank Conventional</td>
<td>$0</td>
</tr>
</tbody>
</table>

LOADSHAPE

Loadshape C01 - Commercial Electric Cooking

SUMMER COINCIDENT PEAK DEMAND SAVINGS

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

<table>
<thead>
<tr>
<th>Location</th>
<th>CF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fast Food Limited Menu</td>
<td>0.32</td>
</tr>
<tr>
<td>Fast Food Expanded Menu</td>
<td>0.41</td>
</tr>
<tr>
<td>Pizza</td>
<td>0.46</td>
</tr>
<tr>
<td>Full Service Limited Menu</td>
<td>0.51</td>
</tr>
<tr>
<td>Full Service Expanded Menu</td>
<td>0.36</td>
</tr>
<tr>
<td>Cafeteria</td>
<td>0.36</td>
</tr>
</tbody>
</table>

Algorithm

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

- Electric building and booster water heating

---

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


### 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

**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

**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
Natural Gas building and booster water heating

<table>
<thead>
<tr>
<th>Dishwasher type</th>
<th>kWh</th>
<th>Therms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Temp Under Counter</td>
<td>0</td>
<td>56</td>
</tr>
<tr>
<td>Door Type</td>
<td>0</td>
<td>562</td>
</tr>
<tr>
<td>Single Tank Conventional</td>
<td>0</td>
<td>527</td>
</tr>
<tr>
<td>Multi Tank Conventional</td>
<td>0</td>
<td>809</td>
</tr>
<tr>
<td>High Temp Under Counter</td>
<td>0</td>
<td>330</td>
</tr>
<tr>
<td>Door Type</td>
<td>198</td>
<td>617</td>
</tr>
<tr>
<td>Single Tank Conventional</td>
<td>1752</td>
<td>773</td>
</tr>
<tr>
<td>Multi Tank Conventional</td>
<td>0</td>
<td>1510</td>
</tr>
</tbody>
</table>

**WATER SAVINGS**

Using standard assumptions water savings would be:

<table>
<thead>
<tr>
<th>Dishwasher type</th>
<th>Savings (gallons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Temp Under Counter</td>
<td>6,844</td>
</tr>
<tr>
<td>Door Type</td>
<td>6,8474</td>
</tr>
<tr>
<td>Single Tank Conventional</td>
<td>64,240</td>
</tr>
<tr>
<td>Multi Tank Conventional</td>
<td>98,550</td>
</tr>
<tr>
<td>High Temp Under Counter</td>
<td>26,828</td>
</tr>
<tr>
<td>Door Type</td>
<td>50,078</td>
</tr>
<tr>
<td>Single Tank Conventional</td>
<td>62,780</td>
</tr>
<tr>
<td>Multi Tank Conventional</td>
<td>122,640</td>
</tr>
</tbody>
</table>

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

\[
\Delta kW = \Delta kWh / \text{AnnualHours}
\]

Where:

\[
\text{AnnualHours} = \text{Hours} \times \text{Days}
\]
\[
= 365.25 \times 18
\]
\[
= 6575 \text{ annual hours}
\]
**Example:**
A low temperature undercounter dishwasher with electric building and booster water heaters would save:

\[
\Delta kW = \frac{\Delta kWh}{AnnualHours}
\]

\[
= \frac{1213}{6575}
\]

\[
= 0.184 \text{ kW}
\]

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**Measure Code: CI-FSE-ESDW-V01-120601**
4.2.7 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 $\geq 50\%$ 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.$^{98}$

DEEMED MEASURE COST
The incremental capital cost for this measure is $1200.^{99}$

LOADSHAPE
N/A

COINCIDENCE FACTOR
N/A

<table>
<thead>
<tr>
<th>Algorithm</th>
</tr>
</thead>
<tbody>
<tr>
<td>CALCULATION OF SAVINGS</td>
</tr>
</tbody>
</table>

ELECTRIC ENERGY SAVINGS
N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS
N/A

$^{98}$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
$^{99}$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
**NATURAL GAS ENERGY SAVINGS**

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

\[
\Delta \text{Therms} = (\Delta \text{DailyIdle Energy} + \Delta \text{DailyPreheat Energy} + \Delta \text{DailyCooking Energy}) \times \text{Days} / 100000
\]

Where:

\[
\Delta \text{DailyIdleEnergy} = (\text{IdleBase} \times \text{IdleBaseTime}) - (\text{IdleENERGYSTAR} \times \text{IdleENERGYSTAR Time})
\]

\[
\Delta \text{DailyPreheatEnergy} = (\text{PreHeatNumberBase} \times \text{PreheatTimeBase} / 60 \times \text{PreheatRateBase}) - (\text{PreheatNumberENERGYSTAR} \times \text{PreheatTimeENERGYSTAR} / 60 \times \text{PreheatRateENERGYSTAR})
\]

\[
\Delta \text{DailyCookingEnergy} = (\text{LB} \times \text{EFOOD} / \text{EffBase}) - (\text{LB} \times \text{EFOOD} / \text{EffENERGYSTAR})
\]

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
  - 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.

\[
\Delta \text{Therms} = (\Delta \text{Idle Energy} + \Delta \text{Preheat Energy} + \Delta \text{Cooking Energy}) \times \text{Days} / 100000
\]

Where:

\[
\Delta \text{DailyIdleEnergy} = (18550 \times 13.25) - (120981 \times 13.44)
= 64519 \text{ btu}
\]

\[
\Delta \text{DailyPreheatEnergy} = (1 \times 15 / 60 \times 64000) - (1 \times 15 / 60 \times 62000)
= 500 \text{ btu}
\]

\[
\Delta \text{DailyCookingEnergy} = (150 \times 570 / .35) - (150 \times 570 / .5)
= 73286 \text{ btu}
\]

\[
\Delta \text{Therms} = (64519 + 500 + 73286) \times 365.25 / 100000
= 508 \text{ therms}
\]
WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-FSE-ESFR-V01-120601
4.2.8 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/hr per square foot of cooking surface or less, utilizing ASTM F1275. The griddle must have an Idle
Energy Consumption Rate < 2,600 Btu/hr 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\textsuperscript{101}

DEEMED MEASURE COST
The incremental capital cost for this measure is $0 for an electric griddle and $60 for a gas griddle\textsuperscript{102}.

LOADSHAPE
Loadshape C01 - Commercial Electric Cooking

COINCIDENCE FACTOR
Summer Peak Coincidence Factor for measure is provided below for different building type\textsuperscript{103}:

<table>
<thead>
<tr>
<th>Location</th>
<th>CF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fast Food Limited Menu</td>
<td>0.32</td>
</tr>
<tr>
<td>Fast Food Expanded Menu</td>
<td>0.41</td>
</tr>
<tr>
<td>Pizza</td>
<td>0.46</td>
</tr>
<tr>
<td>Full Service Limited Menu</td>
<td>0.51</td>
</tr>
<tr>
<td>Full Service Expanded Menu</td>
<td>0.36</td>
</tr>
<tr>
<td>Cafeteria</td>
<td>0.36</td>
</tr>
</tbody>
</table>

\textsuperscript{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

\textsuperscript{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

\textsuperscript{103} Minnesota 2012 Technical Reference Manual, Electric Food Service_v03.2.xls,
http://mn.gov/commerce/energy/topics/conservation/Design-Resources/Deemed-Savings.jspech
Algorithm

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

\[ \Delta k\text{Wh} = (\Delta \text{Idle Energy} + \Delta \text{Preheat Energy} + \Delta \text{Cooking Energy}) \times \text{Days}/1000 \]

Where:

\[ \Delta \text{DailyIdleEnergy} = \left[ \text{Idle Base} \times \text{Width} \times \text{Length} (\text{LB/PCBase}) - \left( \text{Preheat Number Base} \times \text{Preheat Time Base}/60 \right) \right] - \left[ \text{Preheat Number ENERGY STAR} \times \text{Width} \times \text{Length} (\text{LB/PCENERGYSTAR}) - \left( \text{Preheat Time ENERGY STAR}/60 \right) \right] \]

\[ \Delta \text{DailyPreheatEnergy} = \left( \text{PreHeat Number Base} \times \text{Preheat Time Base} / 60 \times \text{Preheat Rate Base} \times \text{Width} \times \text{Depth} \right) - \left( \text{Preheat Number ENERGY STAR} \times \text{Preheat Time ENERGY STAR}/60 \times \text{Preheat Rate ENERGY STAR} \times \text{Width} \times \text{Depth} \right) \]

\[ \Delta \text{DailyCookingEnergy} = \left( \text{LB} \times \text{EFOOD/ Eff Base} \right) - \left( \text{LB} \times \text{EFOOD/ Eff ENERGY STAR} \right) \]

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

- **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.

\[
\Delta \text{DailyIdleEnergy} = \left[ 400 \times 3 \times 2 \times \left( \frac{100}{5.83} \right) - \left( 1 \times 15/60 \right) \right] \times \left[ 320 \times 3 \times 2 \times \left( \frac{100}{6.67} \right) - \left( 1 \times 15/60 \right) \right] = 3583 \text{ W}
\]

\[
\Delta \text{DailyPreheatEnergy} = \left( 1 \times \frac{15}{60} \times 2667 \times 3 \times 2 \right) - \left( 1 \times \frac{15}{60} \times 1333 \times 3 \times 2 \right) = 2000 \text{ W}
\]

\[
\Delta \text{DailyCookingEnergy} = \left( 100 \times 139/0.65 \right) - \left( 100 \times 139/0.70 \right) = 1527 \text{ W}
\]

\[
\Delta \text{kWh} = \left( 2000 + 1527 + 3583 \right) \times \frac{365.25}{1000} = 2597 \text{ kWh}
\]

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

\[
kW = \Delta \text{kWh/Hours} \times \text{CF}
\]
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

\[
\Delta \text{Therms} = 2595 \, \text{kWh} / 4308 \times .36 \\
= 0.22 \, \text{kW}
\]

**NATURAL GAS ENERGY SAVINGS**

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

\[
\Delta \text{Therms} = (\Delta \text{Idle Energy} + \Delta \text{Preheat Energy} + \Delta \text{Cooking Energy}) \times \text{Days} / 100000
\]

Where:

\[
\Delta \text{Daily Idle Energy} = (\text{Idle Base} \times \text{Width} \times \text{Length (LB/PCBase)} - (\text{Preheat Number Base} \times \text{Preheat Time Base}/60)) - (\text{_IDLEENERGYSTAR} \times \text{Width} \times \text{Length (LB/PCENERGYSTAR)} - (\text{Preheat Number ENERGYSTAR} \times \text{Preheat Time ENERGYSTAR}/60])
\]

\[
\Delta \text{Daily Preheat Energy} = (\text{Preheat Number Base} \times \text{Preheat Time Base} / 60 \times \text{Preheat Rate Base} \times \text{Width} \times \text{Depth}) - (\text{Preheat Number ENERGYSTAR} \times \text{Preheat Time ENERGYSTAR}/60 \times \text{Preheat Rate ENERGYSTAR} \times \text{Width} \times \text{Depth})
\]

\[
\Delta \text{Daily Cooking Energy} = (\text{LB} \times \text{EFOOD/ EFF Base}) - (\text{LB} \times \text{EFOOD/ EFF ENERGYSTAR})
\]

Where (new variables only):

- \text{EffENERGYSTAR} = Cooking Efficiency ENERGY STAR
- \text{EffBase} = Cooking Efficiency Baseline
- \text{PCENERGYSTAR} = Production Capacity ENERGY STAR
- \text{PCBase} = Production Capacity base
- \text{PreheatRateENERGYSTAR} = preheat energy rate high efficiency
- \text{PreheatRateBase} = preheat energy rate baseline
- \text{IdleENERGYSTAR} = Idle energy rate
- \text{IdleBase} = Idle energy rate

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

\[
\Delta \text{Therms} = 2595 \, \text{kWh} / 4308 \times .36 \\
= 0.22 \, \text{kW}
\]
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.

\[
\Delta\text{DailyIdleEnergy} = [\frac{3500 \times 3 \times 2}{{100/4.17}} - \frac{2650 \times 3 \times 2}{{100/7.5}} - \frac{1 \times 15}{60}] = 11258 \text{ Btu}
\]

\[
\Delta\text{DailyPreheatEnergy} = (\frac{1 \times 15}{60} \times 14,000 \times 3 \times 2) - (\frac{1 \times 15}{60} \times 10000 \times 3 \times 2) = 6000 \text{ btu}
\]

\[
\Delta\text{DailyCookingEnergy} = (100 \times \frac{475}{.32}) - (100 \times \frac{475}{.38}) = 23438 \text{ btu}
\]

\[
\Delta\text{Therms} = (11258 + 6000 + 23438) \times \frac{365.25}{100000} = 149 \text{ therms}
\]

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-FSE-ESGR-V01-120601**
4.2.9 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\(^{105}\).

DEEMED MEASURE COST
The incremental capital cost for this measure is\(^{106}\)

<table>
<thead>
<tr>
<th>HFHC Size</th>
<th>Incremental Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Size (20 cubic feet)</td>
<td>$1200</td>
</tr>
<tr>
<td>¾ Size (12 cubic feet)</td>
<td>$1800</td>
</tr>
<tr>
<td>½ Size (8 cubic feet)</td>
<td>$1500</td>
</tr>
</tbody>
</table>

LOADSHAPE
Loadshape C01 - Commercial Electric Cooking

\(^{105}\) 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

\(^{106}\) 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:

<table>
<thead>
<tr>
<th>Location</th>
<th>CF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fast Food Limited Menu</td>
<td>0.32</td>
</tr>
<tr>
<td>Fast Food Expanded Menu</td>
<td>0.41</td>
</tr>
<tr>
<td>Pizza</td>
<td>0.46</td>
</tr>
<tr>
<td>Full Service Limited Menu</td>
<td>0.51</td>
</tr>
<tr>
<td>Full Service Expanded Menu</td>
<td>0.36</td>
</tr>
<tr>
<td>Cafeteria</td>
<td>0.36</td>
</tr>
</tbody>
</table>

**Algorithm**

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

Custom calculation below, otherwise use deemed values depending on HFHC size:

<table>
<thead>
<tr>
<th>Cabinet Size</th>
<th>Savings (kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Size HFHC</td>
<td>9308</td>
</tr>
<tr>
<td>¾ Size HFHC</td>
<td>3942</td>
</tr>
<tr>
<td>½ Size HFHC</td>
<td>2628</td>
</tr>
</tbody>
</table>

\[
\Delta \text{kWh} = \text{HFHCBaseline kWh} - \text{HFHCENERGYSTAR kWh}
\]

Where:

\[
\text{HFHCBaseline kWh} = \text{PowerBaseline} \times \text{HOURSday} \times \text{Days/1000}
\]

\[
\text{PowerBaseline} = \text{Custom, otherwise}
\]

<table>
<thead>
<tr>
<th>Cabinet Size</th>
<th>Power (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Size HFHC</td>
<td>2500</td>
</tr>
<tr>
<td>¾ Size HFHC</td>
<td>1200</td>
</tr>
<tr>
<td>½ Size HFHC</td>
<td>800</td>
</tr>
</tbody>
</table>

\[
\text{HOURSday} = \text{Average Daily Operation}
\]

= custom or if unknown, use 15 hours

---


Days = Annual days of operation
= custom or if unknown, use 365.25 days a year

HFHC\text{ENERGYSTAR} \text{kWh} = \text{Power}_{\text{ENERGYSTAR}} \times \text{HOURS}_\text{day} \times \text{Days}/1000

\text{Power}_{\text{ENERGYSTAR}} = \text{Custom, otherwise}

<table>
<thead>
<tr>
<th>Cabinet Size</th>
<th>Power (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Size HFHC</td>
<td>800</td>
</tr>
<tr>
<td>(\frac{3}{4}) Size HFHC</td>
<td>480</td>
</tr>
<tr>
<td>(\frac{1}{2}) Size HFHC</td>
<td>320</td>
</tr>
</tbody>
</table>

\text{HOURS}_\text{day} = \text{Average Daily Operation}
= custom or if unknown, use 15 hours

\text{Days} = \text{Annual days of operation}
= custom or if unknown, use 365.25 days a year

\begin{array}{|c|c|}
\hline
\text{Cabinet Size} & \text{Power (W)} \\
\hline
\text{Full Size HFHC} & 800 \\
\text{\(\frac{3}{4}\) Size HFHC} & 480 \\
\text{\(\frac{1}{2}\) Size HFHC} & 320 \\
\hline
\end{array}

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

\[\Delta \text{kWh} = \frac{(\text{PowerBaseline} \times \text{HOURS}_\text{day} \times \text{Days})}{1000} - \frac{(\text{Power}_{\text{ENERGYSTAR}} \times \text{HOURS}_\text{day} \times \text{Days})}{1000}\]
\[= \frac{(2500 \times 15 \times 365.25)}{1000} - \frac{(800 \times 15 \times 365.25)}{1000}\]
\[= 9,314 \text{ kWh}\]

\text{SUMMER COINCIDENT PEAK DEMAND SAVINGS}

\[\Delta \text{kW} = \frac{\Delta \text{kWh}}{\text{Hours}} \times \text{CF}\]

Where:
\[\text{Hours} = \text{HOURS}_\text{day} \times \text{Days}\]

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

\[= \frac{9,314 \text{ kWh}}{(15 \times 365.25) \times .36}\]
\[= 0.61 \text{ kW}\]

\text{NATURAL GAS ENERGY SAVINGS}
N/A

\text{WATER IMPACT DESCRIPTIONS AND CALCULATION}
N/A

\text{DEEMED O&M COST ADJUSTMENT CALCULATION}
N/A

\text{MEASURE CODE: CI-FSE-ESH-V01-120601}
4.2.10 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.\(^{109}\)

**DEEMED MEASURE COST**

The incremental capital cost for this measure is provided below.\(^{110}\)

<table>
<thead>
<tr>
<th>Harvest Rate (H)</th>
<th>Incremental Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>100-200 lb ice machine</td>
<td>$296</td>
</tr>
<tr>
<td>201-300 lb ice machine</td>
<td>$312</td>
</tr>
<tr>
<td>301-400 lb ice machine</td>
<td>$559</td>
</tr>
<tr>
<td>401-500 lb ice machine</td>
<td>$981</td>
</tr>
<tr>
<td>501-1000 lb ice machine</td>
<td>$1,485</td>
</tr>
<tr>
<td>1001-1500 lb ice machine</td>
<td>$1,821</td>
</tr>
<tr>
<td>&gt;1500 lb ice machine</td>
<td>$2,194</td>
</tr>
</tbody>
</table>

**LOADSHAPE**

Loadshape C23 - Commercial Refrigeration

\(^{109}\)DEER 2008

COINCIDENCE FACTOR

The Summer Peak Coincidence Factor is assumed to equal 0.937

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

\[ \Delta k\text{WH} = \left( \frac{kWh_{\text{base}} - kWh_{\text{ee}}}{100} \right) \times (DC \times H) \times 365.25 \]

Where:

- \( kWh_{\text{base}} \) = 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.
- \( kWh_{\text{ee}} \) = 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.

<table>
<thead>
<tr>
<th>Ice Machine Type</th>
<th>kWhbase(^{111})</th>
<th>kWhee(^{112})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ice Making Head (H &lt; 450)</td>
<td>10.26 - 0.0086*H</td>
<td>9.23 - 0.0077*H</td>
</tr>
<tr>
<td>Ice Making Head (H ≥ 450)</td>
<td>6.89 - 0.0011*H</td>
<td>6.20 - 0.0010*H</td>
</tr>
<tr>
<td>Remote Condensing Unit, without remote compressor (H &lt; 1000)</td>
<td>8.85 - 0.0038*H</td>
<td>8.05 - 0.0035*H</td>
</tr>
<tr>
<td>Remote Condensing Unit, without remote compressor (H ≥ 1000)</td>
<td>5.1</td>
<td>4.64</td>
</tr>
<tr>
<td>Remote Condensing Unit, with remote compressor (H &lt; 934)</td>
<td>8.85 - 0.0038*H</td>
<td>8.05 - 0.0035*H</td>
</tr>
<tr>
<td>Remote Condensing Unit, with remote compressor (H ≥ 934)</td>
<td>5.3</td>
<td>4.82</td>
</tr>
<tr>
<td>Self Contained Unit (H &lt; 175)</td>
<td>18 - 0.0469*H</td>
<td>16.7 - 0.0436*H</td>
</tr>
<tr>
<td>Self Contained Unit (H ≥ 175)</td>
<td>9.8</td>
<td>9.11</td>
</tr>
</tbody>
</table>

\( 100 \) = conversion factor to convert kWhbase and kWhee into maximum kWh consumption per pound of ice.

\( DC \) = Duty Cycle of the ice machine

\(^{111}\)Baseline reflects federal standards which apply to units manufactured on or after January 1, 2010

\(^{112}\)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>
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

\[
\Delta \text{kWh} = \left(\frac{6.4 - 5.8}{100}\right) \times (0.57 \times 450) \times 365.25
\]
\[
= 562 \text{ kWh}
\]

SUMMER COINCIDENT PEAK DEMAND SAVINGS

\[
\Delta \text{kW} = \Delta \text{kWh} / (\text{HOURS} \times \text{DC}) \times \text{CF}
\]

Where:

HOURS = annual operating hours
= 8766

CF = 0.937

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

\[
\Delta \text{kW} = 562 / (8766 \times 0.57) \times 0.937
\]
\[
= 0.105 \text{ kW}
\]

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 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.

113 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 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.

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

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-FSE-ESIM-V01-120601
4.2.11 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:

<table>
<thead>
<tr>
<th>Time of Sale</th>
<th>Retrofit, Direct Install</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
<td>The baseline equipment is assumed to be an existing pre-rinse spray valve with a flow rate of 1.9 gallons per minute. 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</td>
</tr>
</tbody>
</table>

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 5 years.

DEEMED MEASURE COST

The cost of this measure is assumed to be $100.

LOADSHAPE

Loadshape C01 - Commercial Electric Cooking

---

116 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)  
118 Costs range from $60 Chicagoland (Integrys for North Shore & People's Gas) to $150 referenced by Nicor’s CLEAResultWorkpaper WPRSGCCODHW102 "Pre-Rinse Spray Valve." Act on Energy references $100.
C O I N C I D E N C E  F A C T O R

N/A

Algorithm

C A L C U L A T I O N  O F  E N E R G Y  S A V I N G S


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

Where:

\( \Delta \text{Gallons} \) = 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

Tout = Water Heater Outlet Water Temperature

= custom, otherwise assume Tin + 70°F temperature rise from Tin\(^{119}\)

Tin = Inlet Water Temperature

= custom, otherwise assume 54.1 °F\(^{120}\)

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

= custom, otherwise assume 97%\(^{121}\)

Flag = 1 if electric or 0 if gas

E X A M P L E

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:

\[ \Delta kWH = 30,326 \times 8.33 \times 1 \times ((70+54.1) - 54.1) \times (1/0.97) / 3,413 \times 1 \]

= 5,341 kWh

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:

\[ \Delta kWH = 47,175 \times 8.33 \times 1 \times ((70+54.1) - 54.1) \times (1/0.97) / 3,413 \times 1 \]

= 8,309 kWh

\(^{119}\)If unknown, assume a 70 degree temperature rise from Tin per Food Service Technology Center calculator assumptions to account for variations in mixing and water heater efficiencies

\(^{120}\)August 31, 2011 Memo of Savings for Hot Water Savings Measures to Nicor Gas 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.

\(^{121}\)This efficiency value is based on IECC 2012 performance requirement for electric resistant water heaters rounded without the slight adjustment allowing for reduction based on size of storage tank.
**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

N/A

**NATURAL GAS ENERGY SAVINGS**

\[ \Delta \text{Therms} = \Delta \text{Gallons} \times 8.33 \times 1 \times (T_{\text{out}} - T_{\text{in}}) \times (1/\text{EFF}) / 100,000 \text{ Btu} \]

Where (new variables only):

\[ \text{EFF} = \text{Efficiency of gas water heater supplying hot water to pre-rinse spray valve} \]

\[ = \text{custom, otherwise assume 75%}^{122} \]

**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:

\[ \Delta \text{Therms} = 30,326 \times 8.33 \times 1 \times ((70+54.1) - 54.1) \times (1/0.75)/100,000 \times 1.0 \]

\[ = 236 \text{ Therms} \]

**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:

\[ \Delta \text{Therms} = 47,175 \times 8.33 \times 1 \times ((70+54.1) - 54.1) \times (1/0.75)/100,000 \times (1-0) \]

\[ = 368 \text{ Therms} \]

**WATER IMPACT CALCULATION**^{123}

\[ \Delta \text{Gallons} = (\text{FLObase} - \text{FLOeff}) \text{gal/min} \times 60 \text{ min/hr} \times \text{HOURSday} \times \text{DAYSyear} \]

**Where:**

\[ \text{FLObase} = \text{Base case flow in gallons per minute, or custom} \]

<table>
<thead>
<tr>
<th>Time of Sale</th>
<th>Retrofit, Direct Install</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.6 gal/min^{124}</td>
<td>1.9 gal/min^{125}</td>
</tr>
</tbody>
</table>

\[ \text{FLOeff} = \text{Efficient case flow in gallons per minute or custom} \]

---

^{122} IECC 2012, Table C404.2, Minimum Performance of Water-Heating Equipment

^{123} In order to calculate energy savings, water savings must first be calculated

^{124} 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_prerinsesprayavles.pdf.

^{125} Verification measurements taken at 195 installations showed average pre and post flow rates 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)
### High Efficiency Pre-Rinse Spray Valve

<table>
<thead>
<tr>
<th>Time of Sale</th>
<th>Retrofit, Direct Install</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.06 gal/min</td>
<td>1.06 gal/min</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Application</th>
<th>Hours/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small, quick-service restaurants</td>
<td>1/2</td>
</tr>
<tr>
<td>Medium-sized casual dining restaurants</td>
<td>1.5</td>
</tr>
<tr>
<td>Large institutional establishments with cafeteria</td>
<td>3</td>
</tr>
</tbody>
</table>

**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

\[
= (1.6 - 1.06) \times 60 \times 3 \times 312
\]

\[
= 30,326 \text{ gal/yr}
\]

**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

\[
= (1.9 - 1.06) \times 60 \times 3 \times 312
\]

\[
= 47,175 \text{ gal/yr}
\]

#### DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

**MEASURE CODE: CI-FSE-SPRY-V02-120601**

---

126 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 website 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.

127 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 website 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.

4.2.12 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.

**DEEMED MEASURE COST**

The incremental capital cost for this measure is $2200.

**LOADSHAPE**

N/A

**COINCIDENCE FACTOR**

N/A

**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 661 Therms.

---

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

130 Ibid.

131 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.
WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-FSE-IRCB-V01-120601
4.2.13 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.$\textsuperscript{132}$

DEEMED MEASURE COST

The incremental capital cost for this measure is $2700$.$\textsuperscript{133}$

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 554 Therms.$\textsuperscript{134}$

$\textsuperscript{132}$Food Service Technology Center, ENERGY STAR and CEE do not currently provide calculators for this type of equipment therefore deemed values from Nicor Gas were used. Nicor Gas Energy Efficiency Plan 2011-2014. Revised Plan Filed Pursuant to Order Docket 10-0562, May 27, 2011

$\textsuperscript{133}$Ibid.
WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-FSE-IROV-V01-120601

---

13 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.
4.2.14 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^{135}

DEEMED MEASURE COST

The incremental capital cost for this measure is $1000^{136}

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 239 therms^{137}

---

^{135} Food Service Technology Center, ENERGY STAR and CEE do not currently provide calculators for this type of equipment therefore deemed values from Nicor Gas were used. Nicor Gas Energy Efficiency Plan 2011-2014. Revised Plan Filed Pursuant to Order Docket 10-0562, May 27, 2011

^{136} Ibid.
WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-FSE-IRBL-V01-120601

137 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.
4.2.15 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.

DEEMED MEASURE COST
The incremental capital cost for this measure is $5900.

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 1089 therms.

Footnotes:
138 Food Service Technology Center, ENERGY STAR and CEE do not currently provide calculators for this type of equipment therefore deemed values from Nicor Gas were used. Nicor Gas Energy Efficiency Plan 2011-2014. Revised Plan Filed Pursuant to Order Docket 10-0562, May 27, 2011
139 Ibid.
WATER IMPACT DESCRIPTIONS AND CALCULATION
N/A

DEEMED O&M COST ADJUSTMENT CALCULATION
N/A

MEASURE CODE: CI-FSE-IRUB-V01-120601

140 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
4.2.16 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.\(^{141}\)

**Deemed Measure Cost**

The incremental capital cost for this measure is\(^{142}\)

<table>
<thead>
<tr>
<th>Measure Category</th>
<th>Incremental Cost, $/fan</th>
</tr>
</thead>
<tbody>
<tr>
<td>DVC Control Retrofit</td>
<td>$1,988</td>
</tr>
<tr>
<td>DVC Control New</td>
<td>$1,000</td>
</tr>
</tbody>
</table>

**Loadshape**

Loadshape C23 - Commercial Ventilation

**Coincidence Factor**

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

---

\(^{141}\) PG&E Workpaper: Commercial Kitchen Demand Ventilation Controls-Electric, 2004 - 2005

\(^{142}\) Ibid.
Algorithm

**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 work paper.

**ELECTRIC ENERGY SAVINGS**

The following table provides the kWh savings

<table>
<thead>
<tr>
<th>Measure Name</th>
<th>Annual Energy Savings Per Unit (kWh/fan)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DVC Control Retrofit</td>
<td>4,486</td>
</tr>
<tr>
<td>DVC Control New</td>
<td>4,486</td>
</tr>
</tbody>
</table>

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

The following table provides the kW savings

<table>
<thead>
<tr>
<th>Measure Name</th>
<th>Coincident Peak Demand Reduction (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DVC Control Retrofit</td>
<td>0.76</td>
</tr>
<tr>
<td>DVC Control New</td>
<td>0.76</td>
</tr>
</tbody>
</table>

**NATURAL GAS ENERGY SAVINGS**

\[ \Delta \text{Therms} = \text{CFM} \times \text{HP} \times \frac{\text{Annual Heating Load}}{(\text{Eff(heat)} \times 100,000)} \]

Where:

- \( \text{CFM} \) = the average airflow reduction with ventilation controls per hood
- \( \text{HP} \) = 611 cfm/HP \(^{143}\)
- \( \text{HP} \) = actual if known, otherwise assume 7.75 HP
- Annual Heating Load = Annual heating energy required to heat fan exhaust make-up air, Btu/ftm

\(^{143}\) PG Workpaper, Commercial Kitchen Demand Ventilation Controls, PGECOFST116, June 1, 2009, 4,734 cfm reduction on average, with 7.75 fan horsepower on average.

\(^{144}\) Food Service Technology Center Outside Air Load Calculator, [http://www.fishnick.com/ventilation/oalc/oac.php](http://www.fishnick.com/ventilation/oalc/oac.php), with inputs of one cfm, and hours from Commercial Kitchen Demand Ventilation Controls (Average 17.8 hours a day 4.45 am to 10.30 pm). Savings for Rockford, Chicago, and Springfield were obtained from the calculator; values for Belleview and Marion were obtained by using the average savings per HDD from the other values.
### Example

For example, a kitchen hood in Rockford, IL with a 7.75 HP ventilation motor

\[
\Delta \text{Therms} = 611 \times 7.75 \times 154,000 / (0.80 \times 100,000)
\]

\[
= 9,115 \text{ Therms}
\]

### Water Impact Descriptions and Calculation

N/A

### Deemed O&M Cost Adjustment Calculation

N/A

**Measure Code:** CI-FSE-VENT-V02-140601

---

4.2.17 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 pasta 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\(^{146}\).

**DEEMED MEASURE COST**

The incremental capital cost for this measure is $2400\(^{147}\).

**LOADSHAPE**

N/A

**COINCIDENCE FACTOR**

N/A

<table>
<thead>
<tr>
<th>Algorithm</th>
</tr>
</thead>
</table>

**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\(^{148}\).

---

\(^{146}\)Food Service Technology Center, ENERGY STAR and CEE do not currently provide calculators for this type of equipment therefore deemed values from Nicor Gas were used. Nicor Gas Energy Efficiency Plan 2011-2014. Revised Plan Filed Pursuant to Order Docket 10-0562, May 27, 2011

\(^{147}\)Ibid.

WATER IMPACT DESCRIPTIONS AND CALCULATION
N/A

DEEMED O&M COST ADJUSTMENT CALCULATION
N/A

MEASURE CODE: CI-FSE-PCOK-V01-120601

deemed values should be compared to PY evaluation and revised as necessary.
4.2.18 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.\(^{149}\)

**DEEMED MEASURE COST**

The incremental capital cost for this measure is $8646.\(^{150}\)

**LOADSHAPE**

N/A

**COINCIDENCE FACTOR**

N/A

**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\(^{151}\).

---

\(^{149}\) Food Service Technology Center, ENERGY STAR and CEE do not currently provide calculators for this type of equipment therefore deemed values from Nicor Gas were used. Nicor Gas Energy Efficiency Plan 2011-2014. Revised Plan Filed Pursuant to Order Docket 10-0562, May 27, 2011.

\(^{150}\) Ibid.

\(^{151}\) Nicor Gas Energy Efficiency Plan 2011-2014. Revised Plan Filed Pursuant to Order Docket 10-0562, May 27, 2011. These
WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-FSE-RKOV-V01-120601

deeemed values should be compared to PY evaluation and revised as necessary
4.2.19 ENERGY STAR Electric Convection Oven

DESCRIPTION

Commercial convection ovens that are ENERGY STAR certified have higher heavy load cooking efficiencies, and lower idle energy rates, making them on average about 20 percent more efficient than standard models. Energy savings estimates are for ovens using full size (18” x 36”) sheet pans.

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 efficient equipment is assumed to be an ENERGY STAR qualified electric convection oven.

DEFINITION OF BASELINE EQUIPMENT

The baseline equipment is assumed to be a standard convection oven with a heavy load efficiency of 65%.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 12 years.\(^{152}\)

DEEMED MEASURE COST

The incremental cost for this measure is assumed to be $800 for half size units and $1000 for full size.\(^{153}\)

LOADSHAPE

Loadshape C01 - Commercial Electric Cooking

COINCIDENCE FACTOR

Summer Peak Coincidence Factor for measure is provided below for different building type:\(^{154}\):

<table>
<thead>
<tr>
<th>Location</th>
<th>CF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fast Food Limited Menu</td>
<td>0.32</td>
</tr>
<tr>
<td>Fast Food Expanded Menu</td>
<td>0.41</td>
</tr>
<tr>
<td>Pizza</td>
<td>0.46</td>
</tr>
<tr>
<td>Full Service Limited Menu</td>
<td>0.51</td>
</tr>
</tbody>
</table>


\(^{153}\) Based on data from the Regional Technical Forum for the Northwest Council (http://rtf.nwccouncil.org/measures/com/ComCookingConvectionOven_v2_0.xlsm) using actual list prices for 23 units from 2012, see “ComCookingConvectionOven_v2_0.xlsm”.

Algorithm

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

\[
\Delta \text{kWh} = \text{kWh}_{\text{base}} - \text{kWh}_{\text{eff}}
\]

\[
\text{kWh} = \left[ (\text{LB} \times \text{EFood/Eff}) + (\text{IDLE} \times (\text{HOURS}_{\text{DAY}} - \text{LB} / \text{PC} - \text{PRE} \text{TIME} / 60)) + \text{PRE} \text{ENERGY} \right] \times \text{DAYS}
\]

Where:

- \(\text{kWh}_{\text{base}}\) = the annual energy usage of the baseline equipment calculated using baseline values
- \(\text{kWh}_{\text{eff}}\) = the annual energy usage of the efficient equipment calculated using efficient values
- \(\text{HOURS}_{\text{DAY}}\) = daily operating hours
  - Actual, defaults:
  - Full Service, Limited Menu: 8
  - Full Service, Expanded Menu: 7
  - Cafeteria: 6
  - Unknown: 6
  - Custom: Varies

- \(\text{DAYS}\) = Days per year of operation
  - Actual, default = 365

---

156 Unknown is average of other locations
**PRE**<sub>TIME</sub> = Preheat time (min/day), the amount of time it takes a steamer to reach operating temperature when turned on

- 15 min/day<sup>158</sup>

**E<sub>FOOD</sub>** = ASTM Energy to Food (kWh/lb); the amount of energy absorbed by the food during cooking, per pound of food

- 0.0732<sup>159</sup>

**LB** = pounds of food cooked per day (lb/day)

- Actual, default = 100<sup>160</sup>

**EFF** = Heavy load cooking energy efficiency (%). See table below.

**IDLE** = Idle energy rate. See table below.

**PC** = Production capacity (lbs/hr). See table below.

**PRE<sub>ENERGY</sub>** = Preheat energy (kWh/day). See table below.

### Performance Metrics: Baseline and Efficient Values

<table>
<thead>
<tr>
<th>Metric</th>
<th>Baseline Model&lt;sup&gt;161&lt;/sup&gt;</th>
<th>Energy Efficient Model&lt;sup&gt;162&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRE&lt;sub&gt;ENERGY&lt;/sub&gt; (kWh)</td>
<td>1.5</td>
<td>1</td>
</tr>
<tr>
<td>IDLE (kW)</td>
<td>2</td>
<td>Actual, default = 1.0</td>
</tr>
<tr>
<td>EFF</td>
<td>65%</td>
<td>Actual, default = 74%</td>
</tr>
<tr>
<td>PC (lb/hr)</td>
<td>70</td>
<td>Actual, default = 79</td>
</tr>
</tbody>
</table>


<sup>158</sup> Food Service Technology Center (2002). *Commercial Cooking Appliance Technology Assessment*. Prepared by Don Fisher. Chapter 7: Ovens

<sup>159</sup> American Society for Testing and Materials. Industry standard for Commercial Ovens


<sup>162</sup> Average ratings of units on ENERGY STAR qualified list as of 10/2014. Preheat energy is not provided so default is provided based on FSTC life cycle cost calculator.
EXAMPLE
Using defaults provided above, the savings for a ENERGY STAR Electric Convection Oven in unknown location are:

\[
\begin{align*}
\text{kWh}_{\text{base}} & = [(100 \times 0.0732/0.65) + (2 \times (6 - 100/70 - 15/60)) + 1.5] \times 365 \\
& = 7,813 \text{ kWh} \\
\text{kWh}_{\text{eff}} & = [(100 \times 0.0732/0.74) + (1 \times (6 - 100/79 - 15/60)) + 1.0] \times 365 \\
& = 5,612 \text{ kWh} \\
\Delta \text{kWh} &= \text{kWh}_{\text{base}} - \text{kWh}_{\text{eff}} \\
& = 7,813 - 5,612 \\
& = 2200 \text{ kWh}
\end{align*}
\]

SUMMER COINCIDENT PEAK DEMAND SAVINGS

\[
\Delta \text{kW} = (\Delta \text{kWh} / (\text{HOURS}_{\text{DAY}} \times \text{DAYS})) \times \text{CF}
\]

Where:

\[
\begin{align*}
\Delta \text{kWh} &= \text{Annual energy savings (kWh)} \\
\text{CF} &= \text{Summer Peak Coincidence Factor for measure is provided below for different building type}^{163}:
\end{align*}
\]

<table>
<thead>
<tr>
<th>Location</th>
<th>CF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fast Food Limited Menu</td>
<td>0.32</td>
</tr>
<tr>
<td>Fast Food Expanded Menu</td>
<td>0.41</td>
</tr>
<tr>
<td>Pizza</td>
<td>0.46</td>
</tr>
<tr>
<td>Full Service Limited Menu</td>
<td>0.51</td>
</tr>
<tr>
<td>Full Service Expanded Menu</td>
<td>0.36</td>
</tr>
<tr>
<td>Cafeteria</td>
<td>0.36</td>
</tr>
<tr>
<td>Unknown</td>
<td>0.40</td>
</tr>
</tbody>
</table>

EXAMPLE

Using defaults provided above, the savings for a ENERGY STAR Electric Convection Oven in unknown location are:

\[ \Delta kW = \frac{2200}{(6 \times 365)} \times 0.40 \]
\[ = 0.40 \]

FOSSIL FUEL IMPACT DESCRIPTIONS AND CALCULATION

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-FSE-ECON-V01-150601
4.3 Hot Water

4.3.1 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**

<table>
<thead>
<tr>
<th>Gas, High Efficiency</th>
<th>Gas, Standard</th>
<th>Electric</th>
</tr>
</thead>
<tbody>
<tr>
<td>In order for this characterization to apply, the efficient equipment is assumed to have heating capacity over 75,000 Btu/hr and a Thermal Efficiency (TE) greater than or equal to 88%</td>
<td>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 Primary applications would include (but not limited to) hotels/motels, small commercial spaces, offices and restaurants</td>
<td>In order for this characterization to apply, the efficient equipment is assumed to have energy factor greater than or equal to 0.95 Minimum Thermal Efficiency of 0.98 Less than 3% standby loss (standby loss is calculated as percentage of annual (energy usage) Equivalent storage capacity to unit being replaced Qualified units must be GAMA/AHRI efficiency rating certified</td>
</tr>
</tbody>
</table>

**DEFINITION OF BASELINE EQUIPMENT**

<table>
<thead>
<tr>
<th>Gas, High Efficiency</th>
<th>Gas, Standard</th>
<th>Electric</th>
</tr>
</thead>
<tbody>
<tr>
<td>In order for this characterization to apply, the baseline condition is assumed to be a water heater with heating capacity over 75,000 Btu/hr and a Thermal Efficiency (TE) of 80%</td>
<td>In order for this characterization to apply, the baseline condition is assumed to be the minimum code compliant unit with 0.575 EF.</td>
<td>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.</td>
</tr>
</tbody>
</table>

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

<table>
<thead>
<tr>
<th>Gas, High Efficiency</th>
<th>Gas, Standard</th>
<th>Electric</th>
</tr>
</thead>
<tbody>
<tr>
<td>The expected measure life is assumed to be 15 Years</td>
<td>The expected measure life is assumed to be 15 years</td>
<td>The expected measure life is assumed to be 5 years</td>
</tr>
</tbody>
</table>

**DEEMED MEASURE COST**

<table>
<thead>
<tr>
<th>Gas, High Efficiency</th>
<th>Gas, Standard</th>
<th>Electric</th>
</tr>
</thead>
<tbody>
<tr>
<td>The incremental capital cost for this measure is $209</td>
<td>The deemed measure cost is assumed to be $400</td>
<td>The incremental capital cost for this measure is assumed to be</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tank Size</th>
<th>Incremental Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 gallons</td>
<td>$1050</td>
</tr>
<tr>
<td>80 gallons</td>
<td>$1050</td>
</tr>
<tr>
<td>100 gallons</td>
<td>$1950</td>
</tr>
</tbody>
</table>

**LOADSHAPE**

<table>
<thead>
<tr>
<th>Gas, High Efficiency</th>
<th>Gas, Standard</th>
<th>Electric</th>
</tr>
</thead>
<tbody>
<tr>
<td>N/A</td>
<td>N/A</td>
<td>Loadshape C02 - Non-Residential Electric DHW</td>
</tr>
</tbody>
</table>

**COINCIDENCE FACTOR**

<table>
<thead>
<tr>
<th>Gas, High Efficiency</th>
<th>Gas, Standard</th>
<th>Electric</th>
</tr>
</thead>
<tbody>
<tr>
<td>N/A</td>
<td>N/A</td>
<td>The measure has deemed kW savings therefor a coincidence factor is not applied</td>
</tr>
</tbody>
</table>

---

167 Ibid.  
168 Ibid.
Algorithm

Calculation of Savings

Electric Energy Savings

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

<table>
<thead>
<tr>
<th>Tank Size</th>
<th>Savings (kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 gallons</td>
<td>1,781</td>
</tr>
<tr>
<td>80 gallons</td>
<td>4,963</td>
</tr>
<tr>
<td>100 gallons</td>
<td>8,274</td>
</tr>
</tbody>
</table>

Summer Coincident Peak Demand Savings

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

<table>
<thead>
<tr>
<th>Tank Size</th>
<th>Savings (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 gallons</td>
<td>0.20</td>
</tr>
<tr>
<td>80 gallons</td>
<td>0.57</td>
</tr>
<tr>
<td>100 gallons</td>
<td>0.94</td>
</tr>
</tbody>
</table>

\(^{169}\) Ibid.  
\(^{170}\) Ibid.
NATURAL GAS ENERGY SAVINGS

<table>
<thead>
<tr>
<th>Gas, High Efficiency</th>
<th>Gas, Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>The annual natural gas energy savings from this measure is a deemed value equaling 251(^\text{171})</td>
<td>Gas savings depend on building type and are based on measure case energy factor of 0.67 and a heating capacity of 75 M\text{Btu/hr}. These values are averages of qualifying units. Savings values are derived from 2008 DEER Miser, which provides M\text{Btu/hr gas savings per M\text{Btu/hr capacity}}. Savings presented here are per water heater.(^\text{172})</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Energy Savings (therms/unit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assembly</td>
<td>185</td>
</tr>
<tr>
<td>Education – Primary/Secondary</td>
<td>124</td>
</tr>
<tr>
<td>Education – Post Secondary</td>
<td>178</td>
</tr>
<tr>
<td>Grocery</td>
<td>191</td>
</tr>
<tr>
<td>Health/Medical - Hospital</td>
<td>297</td>
</tr>
<tr>
<td>Lodging - Hotel</td>
<td>228</td>
</tr>
<tr>
<td>Manufacturing - Light Industrial</td>
<td>140</td>
</tr>
<tr>
<td>Office – &gt; 60,000 sq-ft</td>
<td>164</td>
</tr>
<tr>
<td>Office – &lt; 60,000 sq-ft</td>
<td>56</td>
</tr>
<tr>
<td>Restaurant - FastFood</td>
<td>109</td>
</tr>
<tr>
<td>Restaurant – Sit Down</td>
<td>166</td>
</tr>
<tr>
<td>Retail</td>
<td>105</td>
</tr>
<tr>
<td>Storage</td>
<td>150</td>
</tr>
<tr>
<td>Multi-Family</td>
<td>119</td>
</tr>
<tr>
<td>Other</td>
<td>148</td>
</tr>
</tbody>
</table>

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HW_-STWH-V01-120601

\(^{171}\) 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

4.3.2 Low Flow Faucet Aerators

**DESCRIPTION**
This measure relates to the direct installation of a low flow faucet aerator 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. Note if flow rates are measured, for example through a Direct Install program, then actual baseline flow rates should be used as opposed to the deemed values.

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**
The expected measure life is assumed to be 9 years.\(^{173}\)

**DEEMED MEASURE COST**
The incremental cost for this measure is $8\(^{174}\) or program actual.

**LOADSHAPE**
Loadshape C02 - Commercial Electric DHW

**COINCIDENCE FACTOR**
The coincidence factor for this measure is dependent on building type as presented below.


\(^{174}\) 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)
Algorithm

Calculation of Savings

Electric Energy Savings

Note these savings are per faucet retrofitted\(^\text{175}\).

\[ \Delta kWh = \%\text{ElectricDHW} \times \left( \frac{\text{GPM}_{\text{base}} - \text{GPM}_{\text{low}}}{\text{GPM}_{\text{base}}} \right) \times \text{Usage} \times EPG_{\text{electric}} \times \text{ISR} \]

Where:

\( \%\text{ElectricDHW} \) = proportion of water heating supplied by electric resistance heating

<table>
<thead>
<tr>
<th>DHW fuel</th>
<th>%Electric_DHW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric</td>
<td>100%</td>
</tr>
<tr>
<td>Fossil Fuel</td>
<td>0%</td>
</tr>
</tbody>
</table>

\( \text{GPM}_{\text{base}} \) = Average flow rate, in gallons per minute, of the baseline faucet “as-used”

= 1.39\(^\text{176}\) or custom based on metering studies\(^\text{177}\) or if measured during DI:

= Measured full throttle flow \(* 0.83 \) throttling factor\(^\text{178}\)

\( \text{GPM}_{\text{low}} \) = Average flow rate, in gallons per minute, of the low-flow faucet aerator “as-used”

= 0.94\(^\text{179}\) or custom based on metering studies\(^\text{180}\) or if measured during DI:

= Rated full throttle flow \(* 0.95 \) throttling factor\(^\text{181}\)

\(^{175}\) 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 building, several variables must be incorporated.

\(^{176}\) Email message from Maureen Hodgins, Research Manager for Water Research Foundation, to TAC/SAG, August 26, 2014

\(^{177}\) Measurement should be based on actual average flow consumed over a period of time rather than a one-time 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.


\(^{179}\) 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.

\(^{180}\) Measurement should be based on actual average flow consumed over a period of time rather than a one-time 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.
4.3.2 Low Flow Faucet Aerators

Usage = Estimated usage of mixed water (mixture of hot water from water heater line and cold water line) per faucet (gallons per year)

= If data is available to provide a reasonable custom estimate it should be used, if not use the following defaults (or substitute custom information in to the calculation):

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Gallons hot water per unit per day (A)</th>
<th>Unit</th>
<th>Estimated % hot water from Faucets (B)</th>
<th>Multiplier (C)</th>
<th>Unit per year</th>
<th>Days per year</th>
<th>Annual gallons mixed water per faucet (A<em>B</em>C*D)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small Office</td>
<td>1 person</td>
<td>100%</td>
<td>10 employees per faucet</td>
<td>250</td>
<td>2,500</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large Office</td>
<td>1 person</td>
<td>100%</td>
<td>45 employees per faucet</td>
<td>250</td>
<td>11,250</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fast Food Rest</td>
<td>0.7 meal/day</td>
<td>50%</td>
<td>75 meals per faucet</td>
<td>365</td>
<td>9,581</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sit-Down Rest</td>
<td>2.4 meal/day</td>
<td>50%</td>
<td>36 meals per faucet</td>
<td>365</td>
<td>15,768</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Retail</td>
<td>2 employee</td>
<td>100%</td>
<td>5 employees per faucet</td>
<td>365</td>
<td>3,650</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grocery</td>
<td>2 employee</td>
<td>100%</td>
<td>5 employees per faucet</td>
<td>365</td>
<td>3,650</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Warehouse</td>
<td>2 employee</td>
<td>100%</td>
<td>5 employees per faucet</td>
<td>250</td>
<td>2,500</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elementary School</td>
<td>0.6 person</td>
<td>50%</td>
<td>50 students per faucet</td>
<td>200</td>
<td>3,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jr High/High School</td>
<td>1.8 person</td>
<td>50%</td>
<td>50 students per faucet</td>
<td>200</td>
<td>9,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Health</td>
<td>90 patient</td>
<td>25%</td>
<td>2 Patients per faucet</td>
<td>365</td>
<td>16,425</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motel</td>
<td>20 room</td>
<td>25%</td>
<td>1 faucet per room</td>
<td>365</td>
<td>1,825</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hotel</td>
<td>14 room</td>
<td>25%</td>
<td>1 faucet per room</td>
<td>365</td>
<td>1,278</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>1 employee</td>
<td>100%</td>
<td>20 employees per faucet</td>
<td>250</td>
<td>5,000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

EPG_electric = Energy per gallon of mixed water used by faucet (electric water heater)

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

---

182 Table 2-45 Chapter 49, Service Water Heating, 2007 ASHRAE Handbook, HVAC Applications.
184 Based on review of the Illinois plumbing code (Employees and students per faucet). Retail, grocery, warehouse and health are estimates. Meals per faucet estimated as 4 bathroom and 3 kitchen faucets and average meals per day of 250 (based on California study above) – 250/7 = 36. Fast food assumption estimated.
\[ \text{Electricity Use} = \frac{(8.33 \times 1.0 \times (90 - 54.1))}{(0.98 \times 3412)} \]
\[ = 0.0894 \text{ kWh/gal} \]

- 8.33 = Specific weight of water (lbs/gallon)
- 1.0 = Heat Capacity of water (btu/lb°F)
- WaterTemp = Assumed temperature of mixed water
  - 86°F for Bath, 93°F for Kitchen, 91°F for Unknown
- SupplyTemp = Assumed temperature of water entering building
  - 54.1°F
- RE_electric = Recovery efficiency of electric water heater
  - 98%
- 3412 = Converts Btu to kWh (Btu/kWh)
- ISR = In service rate of faucet aerators dependent on install method as listed in table below.

<table>
<thead>
<tr>
<th>Selection</th>
<th>ISR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct Install - Deemed</td>
<td>0.95</td>
</tr>
</tbody>
</table>

---

185 Cadmus and Opinion Dynamics Showerhead and Faucet Aerator Meter Study Memorandum dated June 2013, directed to Michigan Evaluation Working Group. If the aerator location is unknown an average of 91% 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*93)+(0.3*86)=0.91.


187 Electric water heaters have recovery efficiency of 98%: http://www.ahridirectory.org/ahridirectory/pages/home.aspx

EXAMPLE

For example, a direct installed faucet in a large office with electric DHW:
\[ \Delta kWh = 1 \times \frac{((1.39 - 0.94)/1.39) \times 11,250 \times 0.0894 \times 0.95}{\text{Annual electric DHW recovery hours for faucet use}} \]
\[ = 309 \text{ kWh} \]

For example, a direct installed faucet in an Elementary School with electric DHW:
\[ \Delta kWh = 1 \times \frac{((1.39 - 0.94)/1.39) \times 3,000 \times 0.0894 \times 0.95}{\text{Annual electric DHW recovery hours for faucet use}} \]
\[ = 82.5 \text{ kWh} \]

SUMMER COINCIDENT PEAK DEMAND SAVINGS

\[ \Delta kW = (\Delta kWh / \text{Hours}) \times \text{CF} \]

Where:

\[ \Delta kWh \] = calculated value above on a per faucet basis

\[ \text{Hours} \] = Annual electric DHW recovery hours for faucet use

\[ = (\text{Usage} \times 0.545^{189})/\text{GPH} \]

\[ = \text{Calculate if usage is custom, if using default usage use:} \]

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Annual Recovery Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small Office</td>
<td>24</td>
</tr>
<tr>
<td>Large Office</td>
<td>109</td>
</tr>
<tr>
<td>Fast Food Rest</td>
<td>93</td>
</tr>
<tr>
<td>Sit-Down Rest</td>
<td>153</td>
</tr>
<tr>
<td>Retail</td>
<td>36</td>
</tr>
<tr>
<td>Grocery</td>
<td>36</td>
</tr>
<tr>
<td>Warehouse</td>
<td>24</td>
</tr>
<tr>
<td>Elementary School</td>
<td>29</td>
</tr>
<tr>
<td>Jr High/High School</td>
<td>88</td>
</tr>
<tr>
<td>Health</td>
<td>160</td>
</tr>
<tr>
<td>Motel</td>
<td>18</td>
</tr>
</tbody>
</table>

\(^{189}\) 54.5% is the proportion of hot 120°F water mixed with 54.1°F supply water to give 90°F mixed faucet water.
### Building Type Annual Recovery Hours

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Annual Recovery Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hotel</td>
<td>12</td>
</tr>
<tr>
<td>Other</td>
<td>49</td>
</tr>
</tbody>
</table>

Where:

- **GPH** = Gallons per hour recovery of electric water heater calculated for 85.9°F temp rise (140-54.1), 98% recovery efficiency, and typical 12kW electric resistance storage tank.
- **CF** = Coincidence Factor for electric load reduction

*Dependent on building type*\(^{190}\)

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Coincidence Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small Office</td>
<td>0.0064</td>
</tr>
<tr>
<td>Large Office</td>
<td>0.0288</td>
</tr>
<tr>
<td>Fast Food Rest</td>
<td>0.0084</td>
</tr>
<tr>
<td>Sit-Down Rest</td>
<td>0.0184</td>
</tr>
<tr>
<td>Retail</td>
<td>0.0043</td>
</tr>
<tr>
<td>Grocery</td>
<td>0.0043</td>
</tr>
<tr>
<td>Warehouse</td>
<td>0.0064</td>
</tr>
<tr>
<td>Elementary School</td>
<td>0.0096</td>
</tr>
<tr>
<td>Jr High/High School</td>
<td>0.0288</td>
</tr>
<tr>
<td>Health</td>
<td>0.0144</td>
</tr>
<tr>
<td>Motel</td>
<td>0.0006</td>
</tr>
<tr>
<td>Hotel</td>
<td>0.0004</td>
</tr>
<tr>
<td>Other</td>
<td>0.0128</td>
</tr>
</tbody>
</table>

\(^{190}\) Calculated as follows: Assumptions for percentage of usage during peak period (1-5pm) were made and then multiplied by 65/365 (65 being the number of days in peak period) and by the number of total annual recovery hours to give an estimate of the number of hours of recovery during peak periods. There are 260 hours in the peak period so the probability you will see savings during the peak period is calculated as the number of hours of recovery during peak divided by 260. See 'C&I Faucet Aerator.xls' for details.
**EXAMPLE**
For example, a direct installed faucet in a large office with electric DHW:

\[
\Delta kW = \frac{309}{109} \times 0.0288 = 0.0816 \text{ kW}
\]

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

\[
\Delta kW = \frac{82.5}{29} \times 0.0096 = 0.0273 \text{ kW}
\]

**FOSSIL FUEL IMPACT DESCRIPTIONS AND CALCULATION**

\[
\Delta \text{Therm} = \%\text{FossilDHW} \times \left(\frac{\text{GPM}_{\text{base}} - \text{GPM}_{\text{low}}}{\text{GPM}_{\text{base}}}\right) \times \text{Usage} \times \text{EPG}_{\text{gas}} \times \text{ISR}
\]

Where:

\[
\%\text{FossilDHW} = \text{proportion of water heating supplied by fossil fuel heating}
\]

<table>
<thead>
<tr>
<th>DHW fuel</th>
<th>%Fossil_DHW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric</td>
<td>0%</td>
</tr>
<tr>
<td>Fossil Fuel</td>
<td>100%</td>
</tr>
</tbody>
</table>

\[
\text{EPG}_{\text{gas}} = \text{Energy per gallon of mixed water used by faucet (gas water heater)}
\]

\[
= \frac{8.33 \times 1.0 \times (\text{WaterTemp} - \text{SupplyTemp})}{\text{RE}_{\text{gas}} \times 100,000}
\]

\[
= 0.00446 \text{ Therms/gal}
\]

Where:

\[
\text{RE}_{\text{gas}} = \text{Recovery efficiency of gas water heater}
\]

\[
= 67\%^{191}
\]

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

Other variables as defined above.

---

191 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 single family home. An average is used for this analysis by default.
EXAMPLE
For example, a direct installed faucet in a large office with gas DHW:

\[ \Delta \text{Therms} = 1 \times \frac{(1.39 - 0.94)}{1.39} \times 11,250 \times 0.00446 \times 0.95 \]
\[ = 15.4 \text{ Therms} \]

For example, a direct installed faucet in an Elementary School with gas DHW:

\[ \Delta \text{Therms} = 1 \times \frac{(1.39 - 0.94)}{1.39} \times 3,000 \times 0.00446 \times 0.95 \]
\[ = 4.12 \text{ Therms} \]

WATER IMPACT DESCRIPTIONS AND CALCULATION

\[ \Delta \text{gallons} = \left( \frac{\text{GPM}_\text{base} - \text{GPM}_\text{low}}{\text{GPM}_\text{base}} \right) \times \text{Usage} \times \text{ISR} \]

Variables as defined above

EXAMPLE
For example, a direct installed faucet in a large office:

\[ \Delta \text{gallons} = \frac{(1.39 - 0.94)}{1.39} \times 11,250 \times 0.95 \]
\[ = 3,640 \text{ gallons} \]

For example, a direct installed faucet in an Elementary School:

\[ \Delta \text{gallons} = \frac{(1.39 - 0.94)}{1.39} \times 3,000 \times 0.95 \]
\[ = 971 \text{ gallons} \]

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A
### Sources Used for GPM Assumptions

<table>
<thead>
<tr>
<th>Source ID</th>
<th>Reference</th>
</tr>
</thead>
</table>

**Measure Code: CI-HWE-LFFA-V05-140601**
4.3.3 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.\textsuperscript{192}

DEEMED MEASURE COST

The incremental cost for this measure is $12\textsuperscript{193} or program actual.

LOADSHAPE

Loadshape C02 - Commercial Electric DHW

COINCIDENCE FACTOR

The coincidence factor for this measure is assumed to be 2.78%\textsuperscript{194}.

\textsuperscript{192} 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/EMV20Forum/EMV%20Studies/measure_life_GDS%5B1%5D.pdf"

\textsuperscript{193} Direct-install price per showerhead assumes cost of showerhead (Market research average of $7 and assess and install time of $5 (20min @ $15/hr)

\textsuperscript{194} 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. 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
CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

Note these savings are per showerhead fixture

\[ \Delta \text{kWh} = \]

\[ \%\text{ElectricDHW} \times ((\text{GPM}_{\text{base}} \times \text{L}_{\text{base}} - \text{GPM}_{\text{low}} \times \text{L}_{\text{low}}) \times \text{NSPD} \times 365.25) \times \text{EPG}_{\text{electric}} \times \text{ISR} \]

Where:

- \%\text{ElectricDHW} = proportion of water heating supplied by electric resistance heating
  - = 1 if electric DHW, 0 if fuel DHW, if unknown assume 16% \[196\]
- \text{GPM}_{\text{base}} = Flow rate of the baseline showerhead
  - = 2.67 for Direct-install programs \[197\]
- \text{GPM}_{\text{low}} = As-used flow rate of the low-flow showerhead, which may, as a result of measurements of program evaluations deviate from rated flows, see table below:

<table>
<thead>
<tr>
<th>Rated Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0 GPM</td>
</tr>
<tr>
<td>1.75 GPM</td>
</tr>
<tr>
<td>1.5 GPM</td>
</tr>
<tr>
<td>Custom or Actual [198]</td>
</tr>
</tbody>
</table>

- \text{L}_{\text{base}} = Shower length in minutes with baseline showerhead
  - = 8.20 min \[199\]
- \text{L}_{\text{low}} = Shower length in minutes with low-flow showerhead
  - = 8.20 min \[200\]
- 365.25 = Days per year, on average.
- \text{NSPD} = Estimated number of showers taken per day for one showerhead
- \text{EPG}_{\text{electric}} = Energy per gallon of hot water supplied by electric

\[195\] Based on excel spreadsheet 120911.xls ...on SharePoint
\[196\] Table HC8.9. Water Heating in U.S. Homes in Midwest Region, Divisions, and States, 2009 (RECS)
\[197\] Based on measured data from Ameren IL EM&V of Direct-Install program. Program targets showers that are rated 2.5 GPM or above.
\[198\] 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.
\[199\] Representative value from sources 1, 2, 3, 4, 5, and 6 (See Source Table at end of measure section)
\[200\] Set equal to \text{L}_{\text{base}}.
Illinois Statewide Technical Reference Manual - 4.3.3 Low Flow Showerheads

\[
= \frac{8.33 \times 1.0 \times (\text{ShowerTemp} - \text{SupplyTemp})}{\text{RE}_{\text{electric}} \times 3412}
\]

\[
= \frac{8.33 \times 1.0 \times (105 - 54.1)}{0.98 \times 3412}
\]

\[
= 0.127 \text{ kWh/gal}
\]

8.33 = Specific weight of water (lbs/gallon)
1.0 = Heat Capacity of water (btu/lb °F)
ShowerTemp = Assumed temperature of water
= 105°F \(^{201}\)
SupplyTemp = Assumed temperature of water entering house
= 54.1°F \(^{202}\)
RE_{electric} = Recovery efficiency of electric water heater
= 98% \(^{203}\)
3412 = Converts Btu to kWh (btu/kWh)
ISR = In service rate of showerhead
= Dependant on program delivery method as listed in table below

<table>
<thead>
<tr>
<th>Selection</th>
<th>ISR (^{204})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct Install - Deemed</td>
<td>0.98</td>
</tr>
</tbody>
</table>

**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:

\[
\Delta \text{kWh} = 1 \times (((2.67\times8.20)\times1.5\times8.20)\times3\times365.25) \times 0.127 \times 0.98
\]

\[
= 1308.4 \text{ kWh}
\]

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

\[
\Delta \text{kW} = \Delta \text{kWh/Hours} \times \text{CF}
\]

Where:

\[
\Delta \text{kWh} = \text{calculated value above}
\]

\[
\text{Hours} = \text{Annual electric DHW recovery hours for showerhead use}
\]


= ((GPM_base * L_base) * NSPD * 365.25) * 0.773205 / 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

= 0.0278206

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:

\[ \Delta kW = \frac{1308.4}{674.1} \times 0.0278 \]

\[ \Delta kW = 0.054 \text{ kW} \]

FOSSIL FUEL IMPACT DESCRIPTIONS AND CALCULATION

\[ \Delta \text{Therms} = \% \text{FossilDHW} \times ((\text{GPM}_\text{base} \times \text{L}_\text{base} - \text{GPM}_\text{low} \times \text{L}_\text{low}) \times \text{NSPD} \times 365.25) \times \text{EPG}_\text{gas} \times \text{ISR} \]

Where:

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

<table>
<thead>
<tr>
<th>DHW fuel</th>
<th>%Fossil_DHW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric</td>
<td>0%</td>
</tr>
<tr>
<td>Fossil Fuel</td>
<td>100%</td>
</tr>
<tr>
<td>Unknown</td>
<td>84%207</td>
</tr>
</tbody>
</table>

EPG_gas = Energy per gallon of Hot water supplied by gas

\[ \text{EPG}_\text{gas} = \frac{(8.33 \times 1.0 \times (\text{ShowerTemp} - \text{SupplyTemp}))}{(\text{RE}_\text{gas} \times 100,000)} \]

\[ \text{EPG}_\text{gas} = 0.0063 \text{ Therm/gal} \]

205 77.3% is the proportion of hot 120F water mixed with 54.1°F supply water to give 105°F shower water

206 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](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*65/365.25 = 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

207 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:

\[ \text{RE}_{\text{gas}} = \text{Recovery efficiency of gas water heater} \]
\[ = 67\% \text{ }^{208} \]
\[ 100,000 = \text{Converts Btus to Therms (btu/Therm)} \]

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:

\[ \Delta \text{Therms} = 1.0 * ((2.67 * 8.2) - (1.5 * 8.2)) * 3 * 365.25 * 0.0063 * 0.98 \]
\[ = 64.9 \text{ therms} \]

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

\[ \Delta \text{gallons} = ((\text{GPM}_\text{base} * \text{L}_\text{base} - \text{GPM}_\text{low} * \text{L}_\text{low}) * \text{NSPD} * 365.25 * \text{ISR} \]

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:

\[ \Delta \text{gallons} = ((2.67 * 8.20) - (1.5 * 8.20)) * 3 * 365.25 * 0.98 \]
\[ = 10,302 \text{ gallons} \]

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

---

208 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 single family home. An average is used for this analysis by default.
Sources

<table>
<thead>
<tr>
<th>Source ID</th>
<th>Reference</th>
</tr>
</thead>
</table>

Measure Code: CI-HW_-LFSH-V03-150601
4.3.4 Commercial Pool Covers

**DESCRIPTION**

This measure refers to the installation of covers on commercial use pools that are heated with gas-fired equipment located either indoors or outdoors. By installing pool covers, the heating load on the pool boiler will be reduced by reducing the heat loss from the water to the environment and the amount of actual water lost due to evaporation (which then requires additional heated water to make up for it).

The main source of energy loss in pools is through evaporation. This is particularly true of outdoor pools where wind plays a larger role. The point of installing pool covers is threefold. First, it will reduce convective losses due to the wind by shielding the water surface. Second, it will insulate the water from the colder surrounding air. And third, it will reduce radiative losses to the night sky. In doing so, evaporative losses will also be minimized, and the boiler will not need to work as hard in replenishing the pool with hot water to keep the desired temperature.

This measure can be used for pools that (1) currently do not have pool covers, (2) have pool covers that are past the useful life of the existing cover, or (3) have pool covers that are past their warranty period and have failed.

**DEFINITION OF EFFICIENT EQUIPMENT**

For indoor pools, the efficient case is the installation of an indoor pool cover with a 5 year warranty on an indoor pool that operates all year.

For outdoor pools, the efficient case is the installation of an outdoor pool cover with a 5 year warranty on an outdoor pool that is open through the summer season.

**DEFINITION OF BASELINE EQUIPMENT**

For indoor pools, the base case is an uncovered indoor pool that operates all year.

For outdoor pools, the base case is an outdoor pool that is uncovered and is open through the summer season.

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The useful life of this measure is assumed to be 6 years.

**DEEMED MEASURE COST**

The table below shows the costs for the various options and cover sizes. Since this measure covers a mix of various sizes, the average cost of these options is taken to be the incremental measure cost.

---

209 The effective useful life of a pool cover is typically one year longer than its warranty period. SolaPool Covers. Pool Covers Website, FAQ: “How long will my SolaPool cover blanket last?”. Pool covers are typically offered with 3 and 5 year warranties with at least one company offering a 6 year warranty. Conversation with Trade Ally. Knorr Systems

### Commercial Pool Covers

<table>
<thead>
<tr>
<th>Cover Size</th>
<th>Edge Style</th>
<th>Hemmed (indoor)</th>
<th>Weighted (outdoor)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000-1,999 sq. ft.</td>
<td>$2.19</td>
<td>$2.24</td>
<td></td>
</tr>
<tr>
<td>2,000-2,999 sq. ft.</td>
<td>$2.01</td>
<td>$2.06</td>
<td></td>
</tr>
<tr>
<td>3,000+ sq. ft.</td>
<td>$1.80</td>
<td>$1.83</td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>$2.00</td>
<td>$2.04</td>
<td></td>
</tr>
</tbody>
</table>

### LOADSHAPE

N/A

### COINCIDENCE FACTOR

N/A

### NET TO GROSS RATIO

<table>
<thead>
<tr>
<th>Algorithm</th>
</tr>
</thead>
</table>

### CALCULATION OF ENERGY SAVINGS

#### ELECTRIC ENERGY SAVINGS

N/A

#### SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

#### NATURAL GAS SAVINGS

The calculations are based on modeling runs using RSPEC! Energy Smart Pools Software that was created by the U.S. Department of Energy. \(^{211}\)

\[ \Delta \text{Therms} = \text{SavingFactor} \times \text{Size of Pool} \]

Where

- **Savings factor** = dependant on pool location and listed in table below\(^{212}\)

<table>
<thead>
<tr>
<th>Location</th>
<th>Therm / sq-ft</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indoor</td>
<td>2.61</td>
</tr>
<tr>
<td>Outdoor</td>
<td>1.01</td>
</tr>
</tbody>
</table>

- **Size of Pool** = custom input

---

\(^{211}\) Full method and supporting information found in reference document: IL TRM - Business Pool Covers WorkPaper.docx. Note that the savings estimates are based upon Chicago weather data.

\(^{212}\) Business Pool Covers.xlsx
**WATER IMPACT DESCRIPTIONS AND CALCULATION**

\[ \Delta \text{Therms} = \text{WaterSavingFactor} \times \text{Size of Pool} \]

Where

\[ \text{WaterSavingFactor} = \text{Water savings for this measure dependant on pool location and listed in table below.}^{213} \]

<table>
<thead>
<tr>
<th>Location</th>
<th>Annual Savings Gal / sq-ft</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indoor</td>
<td>15.28</td>
</tr>
<tr>
<td>Outdoor</td>
<td>8.94</td>
</tr>
</tbody>
</table>

Size of Pool = Custom input

**DEEMED O&M COST ADJUSTMENT CALCULATION**

There are no O&M cost adjustments for this measure.

**MEASURE CODE: CI-HW_-_PLCV-V01-130601**

---

\(^{213}\) Ibid.
4.3.5 Tankless Water Heater

**DESCRIPTION**

This measure covers the installation of on-demand or instantaneous tankless water heaters. 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, the water is heated instantaneously as it passes through the heating element and then proceeds 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**

<table>
<thead>
<tr>
<th>Electric</th>
<th>Gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>To qualify for this measure, the tankless water heater shall be a new electric powered tankless hot water heater with an energy factor greater than or equal to 0.98 with an output greater than or equal to 5 GPM output at 70° F temperature rise.</td>
<td>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) 2012, Table C404.2.</td>
</tr>
</tbody>
</table>

**DEFINITION OF BASELINE EQUIPMENT**

<table>
<thead>
<tr>
<th>Electric</th>
<th>Gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>The baseline condition is assumed to be an electric commercial-grade tanked water heater 50 or more gallon storage capacity with an energy factor less than or equal to 0.9 or the water heater is five or more years old.</td>
<td>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) 2012, Table C404.2.</td>
</tr>
</tbody>
</table>

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

<table>
<thead>
<tr>
<th>Electric</th>
<th>Gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>The expected measure life is assumed to be 5 years.</td>
<td>The expected measure life is assumed to be 20 years.</td>
</tr>
</tbody>
</table>

**DEEMED MEASURE COST**

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

215 Ibid.
### Output (gpm) at delta T 70

<table>
<thead>
<tr>
<th>Output (gpm) at delta T 70</th>
<th>Incremental Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>$1050</td>
</tr>
<tr>
<td>10</td>
<td>$1050</td>
</tr>
<tr>
<td>15</td>
<td>$1950</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Program</th>
<th>Capital Cost, $ per unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retrofit</td>
<td>$3,255&lt;sup&gt;217&lt;/sup&gt;</td>
</tr>
<tr>
<td>Time of Sale or New Construction</td>
<td>$2,526&lt;sup&gt;218&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

**DEEMED O&M COST ADJUSTMENTS**

$100<sup>219</sup>

**LOADSHAPE**

Loadshape C02 - Commercial Electric DHW

**COINCIDENCE FACTOR**

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

---

<sup>217</sup> Based on AOE historical average installation data of 42 tankless gas hot water heaters

<sup>218</sup> <http://www.mncee.org/getattachment/7b8982e9-4d95-4bc9-8e64-f89033617f37/>. Low contractor estimate used to reflect less labor required in new construction of venting.

<sup>219</sup> Water heaters (WH) require annual maintenance. There are different levels of effort for annual maintenance depending if the unit is gas or electric, tanked or tankless. Electric and gas tank water heater manufacturers recommend an annual tank drain to clear sediments. Also recommended are “periodic” inspections by qualified service professionals of operating controls, heating element and wiring for electric WHs and thermostat, burner, relief valve internal flue-way and venting systems for gas WHs. Tankless WH require annual maintenance by licensed professionals to clean control compartments, burners, venting system and heat exchangers. This information is from WH manufacturer product brochures including GE, Rennai, Rheem, Takagi and Kenmore. References for incremental O&M costs were not found. Therefore the incremental cost of the additional annual maintenance for tankless WH is estimated at $100.
**Algorithm**

**CALCULATION OF ENERGY SAVINGS**

**ELECTRIC ENERGY SAVINGS**\(^{220}\)

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

<table>
<thead>
<tr>
<th>Output (gpm) at delta T 70</th>
<th>Savings (kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.0</td>
<td>2,992</td>
</tr>
<tr>
<td>10.0</td>
<td>7,905</td>
</tr>
<tr>
<td>15.0</td>
<td>12,879</td>
</tr>
</tbody>
</table>

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**\(^{221}\)

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

<table>
<thead>
<tr>
<th>Output (gpm) at delta T 70</th>
<th>Savings (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.0</td>
<td>0.34</td>
</tr>
<tr>
<td>10.0</td>
<td>0.90</td>
</tr>
<tr>
<td>15.0</td>
<td>1.47</td>
</tr>
</tbody>
</table>

**NATURAL GAS SAVINGS**

\[
\Delta \text{Therms} = \left[ \left( \frac{\text{Wgal} \times 8.33 \times (\text{Tout} - \text{Tin}) \times (1/\text{Eff base}) - (1/\text{Eff ee})}{100,000} \right) + \left( \frac{([SL \times 8,766]/\text{Eff base})}{100,000} \right) \right] \text{Btu/Therms}
\]

Where:

- Wgal = Annual water use for equipment in gallons
- custom, otherwise assume 21,915 gallons\(^{222}\)
- 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 °F\(^{223}\)

---

\(^{220}\) Act on Energy Technical Reference Manual, Table 9.6.2-3

\(^{221}\) Ibid.

\(^{222}\) 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.

Tin = Inlet Water Temperature
    = custom, otherwise assume 54.1 °F

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

<table>
<thead>
<tr>
<th>Input Btu/hr of existing, tanked water heater</th>
<th>Eff base</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size: ≤ 75,000 Btu/hr</td>
<td>0.67 - 0.0019*Tank Volume</td>
<td>Energy Factor</td>
</tr>
<tr>
<td>Size: &gt;75,000 Btu/hr and ≤ 155,000 Btu/hr</td>
<td>80%</td>
<td>Thermal Efficiency</td>
</tr>
<tr>
<td>Size: &gt;155,000 Btu/hr</td>
<td>80%</td>
<td>Thermal Efficiency</td>
</tr>
</tbody>
</table>

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

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 Thermal 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 (Et)
    = custom input, if unknown assume 0.84

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

<table>
<thead>
<tr>
<th>Input Btu/h of new, tankless water heater</th>
<th>Standby Loss (SL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size: ≤ 75,000 Btu/hr</td>
<td>0</td>
</tr>
<tr>
<td>Size: &gt;75,000 Btu/hr</td>
<td>(Input rating/800)+(110*√Tank Volume)</td>
</tr>
</tbody>
</table>

Where:
Tank Volume = custom input, if unknown assume, 60 gallons for <75,000 Btu/hr, 75 gallons for >75,000 Btu/hr and ≤ 155,000 Btu/hr and 150 for Size >155,000 Btu/hr

Input Rating = nameplate Btu/hr rating of water heater

August 31, 2011 Memo of Savings for Hot Water Savings Measures to Nicor Gas 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.

IECC 2012, Table C404.2, Minimum Performance of Water-Heating Equipment

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.

Stand-by loss is provided 2012 International Energy Conservation Code (IECC2012), Table C404.2, Minimum Performance of Water-Heating Equipment
EXAMPLE

For example, a 75,000 Btu/hr 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:

\[
\Delta \text{Therms} = \frac{[\text{21,915} \times 8.33 \times (130 - 54.1) \times \left(\frac{1}{0.8} - \frac{1}{0.84}\right) / 100,000] + \left[\frac{\text{1008.3} \times 8,766}{0.8}\right]}{100,000}
\]

= 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 $100

REFERENCE TABLES

Minimum Performance Water Heating Equipment

________________________

228 International Energy Conservation Code (IECC)2012
### TABLE 4.3.5.2

**MINIMUM PERFORMANCE OF WATER-HEATING EQUIPMENT**

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY (input)</th>
<th>SUBCATEGORY OR RATING CONDITION</th>
<th>PERFORMANCE REQUIRED</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water heaters, electric</td>
<td>≤ 12 kW</td>
<td>Resistance</td>
<td>0.97 - 0.00112 V·EF</td>
<td>DOE 10 CFR Part 410</td>
</tr>
<tr>
<td></td>
<td>&gt; 12 kW</td>
<td>Resistance</td>
<td>1.73 ± 0.15 SL Btu/h</td>
<td>ANSI Z21.110.3</td>
</tr>
<tr>
<td></td>
<td>≤ 24 amps and ≤ 260 volts</td>
<td>Heat pump</td>
<td>0.93 - 0.00112 V·EF</td>
<td>DOE 10 CFR Part 410</td>
</tr>
<tr>
<td>Storage water heaters, gas</td>
<td>≤ 75,000 Btu/h</td>
<td>≥ 20 gal</td>
<td>0.37 - 0.0019 V·EF</td>
<td>DOE 10 CFR Part 410</td>
</tr>
<tr>
<td></td>
<td>&gt; 75,000 Btu/h and ≤ 155,000 Btu/h</td>
<td>&lt; 4,000 Btu/h/gal</td>
<td>80% E&lt;sub&gt;e&lt;/sub&gt;</td>
<td>ANSI Z21.110.3</td>
</tr>
<tr>
<td></td>
<td>&gt; 155,000 Btu/h</td>
<td>&lt; 4,000 Btu/h/gal</td>
<td>80% E&lt;sub&gt;e&lt;/sub&gt;</td>
<td>ANSI Z21.110.3</td>
</tr>
<tr>
<td>Instantaneous water heaters, gas</td>
<td>&gt; 60,000 Btu/h and &lt; 200,000 Btu/h&lt;sup&gt;2&lt;/sup&gt;</td>
<td>≥ 4,000 Btu/h/gal and &lt; 2 gal</td>
<td>0.62 - 0.0019 V·EF</td>
<td>DOE 10 CFR Part 410</td>
</tr>
<tr>
<td></td>
<td>≥ 200,000 Btu/h</td>
<td>≥ 4,000 Btu/h/gal and &lt; 10 gal</td>
<td>80% E&lt;sub&gt;e&lt;/sub&gt;</td>
<td>ANSI Z21.110.3</td>
</tr>
<tr>
<td></td>
<td>≥ 200,000 Btu/h</td>
<td>≥ 4,000 Btu/h/gal and ≥ 10 gal</td>
<td>80% E&lt;sub&gt;e&lt;/sub&gt;</td>
<td>ANSI Z21.110.3</td>
</tr>
<tr>
<td>Storage water heaters, oil</td>
<td>≤ 106,000 Btu/h</td>
<td>≥ 20 gal</td>
<td>0.59 - 0.0019 V·EF</td>
<td>DOE 10 CFR Part 410</td>
</tr>
<tr>
<td></td>
<td>≥ 106,000 Btu/h</td>
<td>&lt; 4,000 Btu/h/gal</td>
<td>78% E&lt;sub&gt;e&lt;/sub&gt;</td>
<td>ANSI Z21.110.3</td>
</tr>
<tr>
<td>Instantaneous water heaters, oil</td>
<td>≤ 210,000 Btu/h</td>
<td>≥ 4,000 Btu/h/gal and &lt; 2 gal</td>
<td>0.39 - 0.0019 V·EF</td>
<td>DOE 10 CFR Part 410</td>
</tr>
<tr>
<td></td>
<td>&gt; 210,000 Btu/h</td>
<td>≥ 4,000 Btu/h/gal and &lt; 10 gal</td>
<td>80% E&lt;sub&gt;e&lt;/sub&gt;</td>
<td>ANSI Z21.110.3</td>
</tr>
<tr>
<td></td>
<td>&gt; 210,000 Btu/h</td>
<td>≥ 4,000 Btu/h/gal and ≥ 10 gal</td>
<td>78% E&lt;sub&gt;e&lt;/sub&gt;</td>
<td>ANSI Z21.110.3</td>
</tr>
<tr>
<td>Hot water supply boilers, gas and all</td>
<td>≥ 300,000 Btu/h and &lt; 12,500,000 Btu/h</td>
<td>≥ 4,000 Btu/h/gal and &lt; 10 gal</td>
<td>80% E&lt;sub&gt;e&lt;/sub&gt;</td>
<td>ANSI Z21.110.3</td>
</tr>
<tr>
<td>Hot water supply boilers, gas</td>
<td>≥ 300,000 Btu/h and &lt; 12,500,000 Btu/h</td>
<td>≥ 4,000 Btu/h/gal and ≥ 10 gal</td>
<td>80% E&lt;sub&gt;e&lt;/sub&gt;</td>
<td>ANSI Z21.110.3</td>
</tr>
<tr>
<td>Hot water supply boilers, oil</td>
<td>≥ 300,000 Btu/h and &lt; 12,500,000 Btu/h</td>
<td>≥ 4,000 Btu/h/gal and ≥ 10 gal</td>
<td>78% E&lt;sub&gt;e&lt;/sub&gt;</td>
<td>ANSI Z21.110.3</td>
</tr>
<tr>
<td>Pool heaters, gas and all</td>
<td>All</td>
<td>—</td>
<td>78% E&lt;sub&gt;e&lt;/sub&gt;</td>
<td>ASHRAE 145</td>
</tr>
<tr>
<td>Heat pump pool heaters</td>
<td>All</td>
<td>—</td>
<td>4.0 COP</td>
<td>ASHRAE 1180</td>
</tr>
<tr>
<td>Unified storage tanks</td>
<td>All</td>
<td>—</td>
<td>Minimum insulation requirement = 12.5 h·ft&lt;sup&gt;2&lt;/sup&gt;·F/ft&lt;sup&gt;3&lt;/sup&gt;·Btu</td>
<td>(none)</td>
</tr>
</tbody>
</table>

**MEASURE CODE:** CI-HW-TKWH-V02-120601
4.3.6 Ozone Laundry

**DESCRIPTION**

A new ozone laundry system(s) is added-on to new or existing commercial washing machine(s) using hot water heated with natural gas. The system generates ozone (O_3), a naturally occurring molecule, which helps clean fabrics by chemically reacting with soils in cold water. Adding an ozone laundry system(s) will reduce the amount of chemicals, detergents, and hot water needed to wash linens. Using ozone also reduces the total amount of water consumed, saving even more in energy.

Natural gas energy savings will be achieved at the hot water heater/boiler as they will be required to produce less hot water to wash each load of laundry. The decrease in hot water usage will increase cold water usage, but overall water usage at the facility will decrease.

Electric savings can be realized through reduced washer cycle length and reduced pumping load at the boiler feeding the commercial washers. The increased usage associated with operating the ozone system should also be accounted for when determining total kWh impact. Data reviewed for this measure characterization indicated that pumping savings should be accounted for, but washer savings and ozone generator consumption are comparatively so small that they can be ignored.

The reduced washer cycle length may decrease the dampness of the clothes when they move to the dryer. This can result in shorter runtimes which result in gas and electrical savings. However, at this time, there is inconclusive evidence that energy savings are achieved from reduced dryer runtimes so the resulting dryer effects are not included in this analysis. Additionally, there would be challenges verifying that dryer savings will be achieved throughout the life of the equipment.

This incentive only applies to the following facilities with on-premise laundry operations:

- Hotels/motels
- Fitness and recreational sports centers.
- Healthcare (excluding hospitals)
- Assisted living facilities

Ozone laundry system(s) could create significant energy savings opportunities at other larger facility types with on-premise laundry operations (such as correctional facilities, universities, and staff laundries), however, the results included in this analysis are based heavily on past project data for the applicable facility types listed above and may not apply to facilities outside of this list due to variances in number of loads and average pound (lbs.)-capacity per project site. Projects at these facilities should continue to be evaluated through custom programs and the applicable facility types and the resulting analysis should be updated based on new information.

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**

A new ozone laundry system(s) is added-on to new or existing commercial washing machine(s) using hot water heated with natural gas. The ozone laundry system(s) must transfer ozone into the water through:

- Venturi Injection
- Bubble Diffusion
- Additional applications may be considered upon program review and approval on a case by case basis
DEFINITION OF BASELINE EQUIPMENT

The base case equipment is a conventional washing machine system with no ozone generator installed. The washing machines are provided hot water from a gas-fired boiler.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure equipment effective useful life (EUL) is estimated at 10 years based on typical lifetime of the ozone generator’s corona discharge unit.\(^{229}\)

DEEMED MEASURE COST

The actual measure costs should be used if available. If not a deemed value of $79.84 / lbs capacity should be used\(^{230}\).

LOADSHAPE

Loadshape C53 – Flat

COINCIDENCE FACTOR

Past project documentation and data collection is not sufficient to determine a coincidence factor for this measure. Value should continue to be studied and monitored through additional studies due to limited data points used for this determination.

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS

Electric savings can be realized through reduced washer cycle length and reduced pumping load at the boiler feeding the commercial washers. There is also an increased usage associated with operating the ozone system. Data reviewed for this measure characterization indicated that while pumping savings is significant and should be accounted for, washer savings and ozone generator consumption are negligible, counter each other out and are well within the margin of error so these are not included to simplify the characterization\(^{231}\).

\[
\Delta kWh_{PUMP} = HP \times HP_{CONVERSION} \times \text{Hours} \times \%\text{water\_savings}
\]

\(^{229}\) Aligned with other national energy efficiency programs and confirmed with national vendors

\(^{230}\) Average costs per unit of capacity were generated using data collected from existing ozone laundry projects that received incentives under the Non-Residential Retrofit Demand Reduction program (NRR-DR), as well as from the Nicor Custom Incentive Program, and the Nicor Emerging Technology Program (ETP). See referenced document Table 2 and RSMeans Mechanical Cost Data, 31st Annual Edition (2008)

\(^{231}\) Washer savings were reviewed but were considered negligible and not included in the algorithm (0.00082 kWh / lbs-capacity, determined through site analysis through Nicor Emerging Technology Program (ETP) and confirmed with national vendors). Note that washer savings from Nicor’s site analysis are smaller than those reported in a WI Focus on Energy case study (0.23kWh/100lbs, Hampton Inn Brookfield, November 2010). Electric impact of operating ozone generator (0.0021 kWh / lbs-capacity same source as washer savings) was also considered negligible and not included in calculations. Values should continue to be studied and monitored through additional studies due to limited data points used for this determination.
Where:

\[ \Delta kWh_{PUMP} = \text{Electric savings from reduced pumping load} \]

\[ HP = \text{Brake horsepower of boiler feed water pump;} \]

\[ HP_{CONVERSION} = \text{Conversion from Horsepower to Kilowatt} \]

\[ = 0.746 \]

\[ \text{Hours} = \text{Actual associated boiler feed water pump hours} \]

\[ = 800 \text{ hours if unknown} \]

\[ \%_{\text{water_savings}} = \text{water reduction factor: how much more efficient an ozone injection washing machine is compared to a typical conventional washing machine as a rate of hot and cold water reduction.} \]

\[ = 25\% \]

Using defaults above:

\[ \Delta kWh_{PUMP} = 5 \times 0.746 \times 800 \times 0.25 \]

\[ = 746 kWh \]

Default per lb capacity:

\[ = \frac{\Delta kWh_{PUMP}}{\text{lb capacity}} \]

Where:

\[ \text{Lbs-Capacity} = \text{Average Capacity in lbs of washer} \]

\[ = 254.38 \]

\[ \frac{\Delta kWh_{PUMP}}{\text{lb capacity}} = \frac{746}{254.38} \]

\[ = 2.93 kWh/lb-capacity \]

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

Past project documentation and data collection is not sufficient to determine summer coincident peak demand savings for this measure. Value should continue to be studied and monitored through additional studies due to limited data points used for this determination. In absence of site-specific data, the summer coincident peak demand savings should be assumed to be zero.

---

232 Assumed average horsepower for boilers connected to applicable washer  
233 Engineered estimate provided by CLEAResult review of Nicor custom projects. Machines spent approximately 7 minutes per hour filling with water and were in operation approximately 20 hours per day. Total pump time therefore estimated as 7/60 * 20 * 365 = 852 hours, and rounded down conservatively to 800 hours.  
234 Average water reduction factors were generated using data collected from existing ozone laundry projects that received incentives under the Non-Residential Retrofit Demand Reduction program (NRR-DR). Table 6 summarizes data gathered from several NRR-DR projects, Nicor Custom projects, and Nicor ETP projects. Nicor Savings Numbers are associated with ACEE_AWE_Ozone Laundry / From Gas Savings Calculations  
235 Average lbs-capacity per project site was generated using data collected from existing ozone laundry projects that received incentives under the Non-Residential Retrofit Demand Reduction program (NRR-DR), as well as from the Nicor Custom Incentive Program, and the Nicor Emerging Technology Program (ETP). See referenced document Table 2
\[ \Delta kW = 0 \]

**Natural Gas Savings**

\[ \Delta \text{T} = \text{T}_{\text{baseline}} \times \% \text{hot_water_savings} \]

Where:

- \( \Delta \text{T} \) = Gas savings resulting from a reduction in hot water use, in therm.
- \( \text{T}_{\text{baseline}} \) = Annual Baseline Gas Consumption
  
  \[ \text{T}_{\text{baseline}} = \text{WHE} \times \text{WUtiliz} \times \text{WUsage_hot} \]

Where:

- \( \text{WHE} \) = water heating energy: energy required to heat the hot water used
  
  \[ \text{WHE} = 0.00885 \text{ therm/gallon}^{236} \]

- \( \text{WUtiliz} \) = washer utilization factor: the annual pounds of clothes washed per year
  
  \[ \text{WUtiliz} = \text{actual, if unknown use 916,150 lbs laundry}^{237}, \text{approximately equivalent to 13 cycles/day} \]

- \( \text{WUsage_hot} \) = hot water usage factor: how much hot water a typical conventional washing machine utilizes, normalized per pounds of clothes washed
  
  \[ \text{WUsage_hot} = 1.19 \text{ gallons/lbs laundry}^{238} \]

Using defaults above:

\[ \text{T}_{\text{baseline}} = 0.00885 \times 916,150 \times 1.19 = 9,648 \text{ therms} \]

Default per lb capacity:

\[ \frac{\text{T}_{\text{baseline}}}{\text{lb capacity}} = \frac{9,648}{254.38} = 37.9 \text{ therms/lb-capacity} \]

\[ \% \text{hot_water_savings} \] = hot water reduction factor: how much more efficient an ozone injection washing machine is, compared to a typical conventional washing machine, as a rate of hot water reduction

\[ \% \text{hot_water_savings} = 81\%^{239} \]

---

236 Assuming boiler efficiency is the regulated minimum efficiency (80%), per Title 20 Appliance Standard of the California Energy Regulations (October 2007). The incoming municipal water temperature is assumed to be 55 °F with an average hot water supply temperature of 140°F, based on default test procedures on clothes washers set by the Department of Energy’s Office of Energy Efficiency and Renewable Energy (Federal Register, Vol. 52, No. 166). Enthalpies for these temperatures (107 btu/lbs at 140F, 23.07 btu/lbs at 55F) were obtained from ASHRAE Fundamentals

237 Average utilization factors were generated using data collected from existing ozone laundry projects that received incentives under the NRR-DR program. Table 3 summarizes data gathered from several NRR-DR projects, Nicor Custom projects, and Nicor ETP projects

238 Average hot water usage factors were generated using data collected from existing ozone laundry projects that received incentives under the NRR-DR program. summarises data gathered from several NRR-DR projects:

239 Average hot water reduction factors were generated using data collected from existing ozone laundry projects that received incentives under the Non-Residential Retrofit Demand Reduction program (NRR-DR). Table 5 summarises data gathered from
Savings using defaults above:
\[
\Delta \text{Therm} = \text{Therm}_{\text{baseline}} \times \%\text{hot\_water\_savings}
\]
\[
= 9648 \times 0.81
\]
\[
= 7,815 \text{ therms}
\]

Default per lb capacity:
\[
\Delta \text{Therm} / \text{lb-capacity} = \frac{7815}{254.38}
\]
\[
= 30.7 \text{ therms} / \text{lb-capacity}
\]

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

The water savings calculations listed here account for the combination of hot and cold water used. Savings calculations for this measure were based on the reduction in total water use from implementing an ozone washing system to the base case. There are three main components in obtaining this value:

\[
\Delta \text{gallons} = \text{WUsage} \times \text{WUtiliz} \times \%\text{water\_savings}
\]

Where:
- \(\Delta \text{gallons}\) = reduction in total water use from implementing an ozone washing system to the base case
- \(\text{WUsage}\) = water usage factor: how efficiently a typical conventional washing machine utilized hot and cold water normalized per unit of clothes washed
  \[
  = 2.03 \text{ gallons/lbs laundry}^{240}
  \]
- \(\text{WUtiliz}\) = washer utilization factor: the annual pounds of clothes washed per year
  \[
  = \text{actual, if unknown use 916,150 lbs laundry}^{241}, \text{approximately equivalent to 13 cycles/day}
  \]
- \(\%\text{water\_savings}\) = water reduction factor: how much more efficient an ozone injection washing machine is compared to a typical conventional washing machine as a rate of hot and cold water reduction.
  \[
  = 25\%^{242}
  \]

Savings using defaults above:
\[
\Delta \text{Gallons} = \text{WUsage} \times \text{WUtiliz} \times \%\text{water\_savings}
\]
\[
= 2.03 \times 916,150 \times 0.25
\]
\[
= 464,946 \text{ gallons}
\]

Default per lb capacity:

---

240 Average water usage factors were generated using data collected from existing ozone laundry projects that received incentives under the NRR-DR program. summarizies data gathered from several NRR-DR projects
241 Average utilization factors were generated using data collected from existing ozone laundry projects that received incentives under the NRR-DR program. Table 3 summarizes data gathered from several NRR-DR projects, Nicor Custom projects, and Nicor ETP projects.
242 Average water reduction factors were generated using data collected from existing ozone laundry projects that received incentives under the Non-Residential Retrofit Demand Reduction program (NRR-DR). Table 6 summarizes data gathered from several NRR-DR projects, Nicor Custom projects, and Nicor ETP projects. Nicor Savings Numbers are associated with ACEE_AWE_Ozone Laundry / From Gas Savings Calculations
\( \Delta \text{Gallons / lb-capacity} = \frac{464,946}{254.38} \)
\( = 1,828 \text{ gallons / lb-capacity} \)

**DEEMED O&M COST ADJUSTMENT CALCULATION**

Maintenance is required for the following components annually:

- Ozone Generator: filter replacement, check valve replacement, fuse replacement, reaction chamber inspection/cleaning, reaction chamber o-ring replacement
- Air Preparation – Heat Regenerative: replacement of two medias
- Air Preparation – Oxygen Concentrators: filter replacement, pressure relief valve replacement, compressor rebuild
- Venturi Injector: check valve replacement

Maintenance is expected to cost $0.79 / lbs capacity.

**REFERENCES**

2. "Health, United States, 2008" Table 120, U.S. Department of Health & Human Services, Centers for Disease Control & Prevention, National Center for Health Statistics, [http://www.cdc.gov/nchs/data/hus/hus08.pdf#120](http://www.cdc.gov/nchs/data/hus/hus08.pdf#120)
7. Federal Register, Vol. 52, No. 166
8. 2009 ASHRAE Handbook – Fundamentals, Thermodynamic Properties of Water at Saturation, Section 1.1 (Table 3), 2009
9. Table 2 through 6: Excel file summarizing data collected from existing ozone laundry projects that received incentives under the NRR-DR program

**MEASURE code CI-HW-OZLD-V01-140601**

---

4.3.7 Multifamily Central Domestic Hot Water Plants

DESCRIPTION
This measure covers multifamily central domestic hot water (DHW) plants with thermal efficiencies greater than or equal to 88%. This measure is applicable to any combination of boilers and storage tanks provided the thermal efficiency of the boilers is greater than 88%. Plants providing other than solely DHW are not applicable to this measure.

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

DEFINITION OF EFFICIENT EQUIPMENT
To qualify the boiler(s) must have a Thermal Efficiency of 88% or greater and supply domestic hot water to multifamily buildings.

DEFINITION OF BASELINE EQUIPMENT
For TOS the baseline boiler is assumed to have a Thermal Efficiency of 80%. For Early Replacement the savings are calculated between existing unit and efficient unit consumption during the remaining life of the existing unit, and between new baseline unit as above and efficient unit consumption for the remainder of the measure life.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT
The measure life for the domestic hot water boilers is 15 years.

DEEMED MEASURE COST
TOS: The actual install cost should be used for the efficient case, minus the baseline cost assumption provided below:

<table>
<thead>
<tr>
<th>Capacity Range</th>
<th>Baseline Installed Cost per kBtuh</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;300 kBtuh</td>
<td>$65 per kBTU/h</td>
</tr>
<tr>
<td>300 – 2500 kBtuh</td>
<td>$38 per kBTU/h</td>
</tr>
<tr>
<td>&gt;2500 kBtuh</td>
<td>$32 per kBTU/h</td>
</tr>
</tbody>
</table>

LOADSHAPE
N/A

COINCIDENCE FACTOR

244 IECC 2012, Table C404.2, Minimum Performance of Water-Heating Equipment
246 Baseline install costs are based on data from the W017 Itron California Measure Cost Study, accessed via http://www.energydataweb.com/cpuc/search.aspx. The data is provided in a file named “MCS Results Matrix – Volume I”.

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Algorithm

**CALCULATION OF ENERGY SAVINGS**

**ELECTRIC ENERGY SAVINGS**

There are no anticipated electrical savings from this measure.

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

N/A

**NATURAL GAS SAVINGS**

Time of Sale:

\[ \Delta \text{Therms} = \text{Hot Water Savings} + \text{Standby Loss Savings} \]

\[ = \left( \frac{\text{MFHH} \times \# \text{Units} \times \text{GPD} \times \text{Days/yr} \times \text{Water} \times (\text{Tout} - \text{Tin}) \times (1/\text{Eff}_{\text{base}} - 1/\text{Eff}_{\text{ee}})}{100,000} \right) + \left( \frac{\text{SL} \times \text{Hours/yr} \times (1/\text{Eff}_{\text{base}} - 1/\text{Eff}_{\text{ee}})}{100,000} \right) \]

Early Replacement\textsuperscript{247}:

\[ \Delta \text{Therms for remaining life of existing unit (1st 5 years):} \]

\[ = \left( \frac{\text{MFHH} \times \# \text{Units} \times \text{GPD} \times \text{Days/yr} \times \text{Water} \times (\text{Tout} - \text{Tin}) \times (1/\text{Eff}_{\text{exist}} - 1/\text{Eff}_{\text{ee}})}{100,000} \right) + \left( \frac{\text{SL} \times \text{Hours/yr} \times (1/\text{Eff}_{\text{exist}} - 1/\text{Eff}_{\text{ee}})}{100,000} \right) \]

\[ \Delta \text{Therms for remaining measure life (next 10 years):} \]

\[ = \left( \frac{\text{MFHH} \times \# \text{Units} \times \text{GPD} \times \text{Days/yr} \times \text{Water} \times (\text{Tout} - \text{Tin}) \times (1/\text{Eff}_{\text{base}} - 1/\text{Eff}_{\text{ee}})}{100,000} \right) + \left( \frac{\text{SL} \times \text{Hours/yr} \times (1/\text{Eff}_{\text{base}} - 1/\text{Eff}_{\text{ee}})}{100,000} \right) \]

Where:

- \text{MFHH} = \text{number of people in Multi-Family House Hold}
- \text{MFHH} = \text{Actual. If unknown assume 2.1 persons/unit}\textsuperscript{248}
- \# \text{Units} = \text{Number of units served by hot water boiler}

\textsuperscript{247} 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).

= Actual
GPD = Gallons of hot water used per person per day
= Actual. If unknown assume 17.6 gallons per person per day\textsuperscript{249}
Days/yr = 365.25
\textit{\nu} \text{Water} = Specific Weight of Water
= 8.33 gal/lb
Tout = tank temperature of hot water
= 125\textdegree F or custom
Tin = Incoming water temperature from well or municipal system
= 54\textdegree F\textsuperscript{250}
Eff\_base = thermal efficiency of base unit
= 80\%\textsuperscript{251}
Eff\_ee = thermal efficiency of efficient unit complying with this measure
= Actual. If unknown assume 88\%
Eff\_exist = thermal efficiency of existing unit
= Actual. If unknown assume 73\%\textsuperscript{252}
SL = Standby Loss\textsuperscript{253}
= \left(\frac{\text{Input rating}}{800}\right) + (110 \times \sqrt{\text{Tank Volume}})

\begin{align*}
\text{Input rating} & = \text{Name plate input capacity in Btuh} \\
\text{Tank Volume} & = \text{Rated volume of the tank in gallons}
\end{align*}

\text{Hours / yr} = 8766 \text{ hours}

\textsuperscript{249} Email message from Maureen Hodgins, Research Manager for Water Research Foundation, to TAC/SAG, August 26, 2014
\textsuperscript{250} US DOE Building America Program. Building America Analysis Spreadsheet. For Chicago, IL http://www1.eere.energy.gov/buildings/building_america/analysis_spreadsheets.html
\textsuperscript{251} IECC 2012, Table C404.2, Minimum Performance of Water Heating Equipment
\textsuperscript{252} Based upon DCEO data provided 10/2014; average age adjusted efficiency of existing units replaced through the program. Efficiency age adjustment of 0.5\% per year based upon NREL “Building America Performance Analysis Procedures for Existing Homes”.
\textsuperscript{253} Stand-by loss is provided in 2012 International Energy Conservation Code (IECC2012), Table C404.2, Minimum Performance of Water Heating Equipment
EXAMPLES

Time of Sale:
For example, an 88% 1000 gallon boiler with 150,000 Btuh input rating installed serving 50 units.

\[
\Delta \text{Therms} = \text{Hot Water Savings} + \text{Standby Loss Savings}
\]

\[
\Delta \text{Therms} = \frac{[(\text{MFHH} \times \#\text{Units} \times \text{GPD} \times \text{Days/yr} \times \mu\text{Water} \times (\text{Tout} - \text{Tin}) \times (1/\text{Eff}_{\text{base}} - 1/\text{Eff}_{\text{ee}}))}{100,000} + \frac{[(\text{SL} \times \text{Hours/yr} \times (1/\text{Eff}_{\text{base}} - 1/\text{Eff}_{\text{ee}}))}{100,000}
\]

\[
= \frac{[(2.1 \times 50 \times 17.6 \times 8.33 \times 365.25 \times 1.0 \times (125 - 54) \times (1/0.8 - 1/0.88))}{100000} + \frac{[(150000/800 + (110 \times \sqrt{1000})) \times 8766 \times (1/0.8 - 1/0.88))}{100000}
\]

\[
= 454 + 37
\]

= 490 therms

Early Replacement:
For example, an 88% 1000 gallon boiler with 150,000 Btuh input rating installed serving 50 units replaces a working unit with unknown efficiency.

\[
\Delta \text{Therms} = \frac{[(2.1 \times 50 \times 17.6 \times 8.33 \times 365.25 \times 1.0 \times (125 - 54) \times (1/0.73 - 1/0.88))}{100000} + \frac{[(150000/800 + (110 \times \sqrt{1000})) \times 8766 \times (1/0.73 - 1/0.88))}{100000}
\]

\[
= 932 + 75
\]

= 1007 therms

\[
\Delta \text{Therms} \text{ for remaining measure life (next 10 years)}:
\]

\[
= 454 + 37 \text{ (as above)}
\]

= 490 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION
N/A

DEEMED O&M COST ADJUSTMENT CALCULATION
N/A

MEASURE CODE: CI-HW_-MDHW-V01-150601
4.3.8 Controls for Central Domestic Hot Water

DESCRIPTION

Demand control recirculation pumps seek to reduce inefficiency by combining control via temperature and demand inputs, whereby the controller will not activate the recirculation pump unless both (a) the recirculation loop return water has dropped below a prescribed temperature (e.g. 100°F) and (b) a CDHW demand is sensed as water flow through the CDHW system.

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

DEFINITION OF EFFICIENT EQUIPMENT

Re-circulating pump shall cycle on based on (a) the recirculation loop return water dropping below a prescribed temperature (e.g. 100°F) and (b) a CDHW demand is sensed as water flow through the CDHW system.

DEFINITION OF BASELINE EQUIPMENT

The base case for this measure category are existing, un-controlled Recirculation Pumps on gas-fired Central Domestic Hot Water Systems.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The effective useful life is 15 years\textsuperscript{254}.

DEEMED MEASURE COST

Incremental Cost: $1,200\textsuperscript{255}

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A


Algorithm

**Calculation of Energy Savings**

**Electric Energy Savings**

Deemed at 651 kWh\(^{257}\).

**Summer Coincident Peak Demand Savings**

N/A

**Natural Gas Savings**

\[ \Delta \text{Therms} = 55.9^{258} \times \text{number of dwelling units} \]

**Example**

For example, an apartment building with 53 units:

\[ \Delta \text{Therms} = 55.9 \times 53 \]

\[ = 2,962.7 \text{ therms} \]

**Water Impact Descriptions and Calculation**

N/A

**Deemed O&M Cost Adjustment Calculation**

N/A

**Measure Code: CI-HW_-CDHW-V01-150601**

---

\(^{256}\) See Illinois_Statewide_TRM_Workpaper_Demand Control Central DHW for more details

\(^{257}\) Based on results from the Nicor Gas Emerging Technology Program study, this value is the average kWh saved per pump. Note this value does not reflect savings from electric units but electrical savings from gas-fired units.

\(^{258}\) Based on results from the Nicor Gas Emerging Technology Program study, this value is the average therms saved per dwelling unit.
4.4 HVAC End Use

Many of the commercial HVAC measures use equivalent full load hours (EFLH) to calculate heating and cooling savings. The tables with these values are included in this section and referenced in each measure.

To calculate the updated EFLHs by building type and climate zone provided below, a TAC Subcommittee utilized building energy models originally developed for ComEd\textsuperscript{259}, applying some adjustments and additions for new building type models and mechanical systems. Based on comparisons with available field data from Navigant, the EFLH calculation was finalized by the Subcommittee to be the annual total (heating or cooling) output (in Btu) divided by the 95th percentile hourly peak output (heating or cooling) demand (in Btu/hr). This calculation keeps EFLH independent of modeled systems efficiency (which is utilized in the TRM savings calculation) and buffers EFLH value from hourly variances in the modeling that are not representative of actual buildings. See “EFLH Description 2015-02-11.doc” for further explanation.

The building characteristics can be found in the reference table named “EFLH Building Descriptions Updated 2014-11-21.xlsx”.

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Zone 1 (Rockford)</th>
<th>Zone 2 (Chicago)</th>
<th>Zone 3 (Springfield)</th>
<th>Zone 4 (Belleville)</th>
<th>Zone 5 (Marion)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assembly</td>
<td>1,787</td>
<td>1,831</td>
<td>1,635</td>
<td>1,089</td>
<td>1,669</td>
</tr>
<tr>
<td>Assisted Living</td>
<td>1,683</td>
<td>1,646</td>
<td>1,446</td>
<td>1,063</td>
<td>1,277</td>
</tr>
<tr>
<td>College</td>
<td>1,530</td>
<td>1,430</td>
<td>1,276</td>
<td>709</td>
<td>849</td>
</tr>
<tr>
<td>Convenience Store</td>
<td>1,481</td>
<td>1,368</td>
<td>1,214</td>
<td>871</td>
<td>973</td>
</tr>
<tr>
<td>Elementary School</td>
<td>1,781</td>
<td>1,736</td>
<td>1,531</td>
<td>1,057</td>
<td>1,283</td>
</tr>
<tr>
<td>Garage</td>
<td>985</td>
<td>969</td>
<td>852</td>
<td>680</td>
<td>752</td>
</tr>
<tr>
<td>Grocery</td>
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<td>1,602</td>
<td>1,404</td>
<td>876</td>
<td>1,047</td>
</tr>
<tr>
<td>Healthcare Clinic</td>
<td>1,579</td>
<td>1,620</td>
<td>1,414</td>
<td>963</td>
<td>1,019</td>
</tr>
<tr>
<td>High School</td>
<td>1,845</td>
<td>1,857</td>
<td>1,666</td>
<td>1,187</td>
<td>1,388</td>
</tr>
<tr>
<td>Hospital - CAV no econ\textsuperscript{260}</td>
<td>1,764</td>
<td>1,818</td>
<td>1,549</td>
<td>1,332</td>
<td>1,512</td>
</tr>
<tr>
<td>Hospital - CAV econ\textsuperscript{261}</td>
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<td>1,853</td>
<td>1,580</td>
<td>1,369</td>
<td>1,555</td>
</tr>
<tr>
<td>Hospital - VAV econ\textsuperscript{262}</td>
<td>731</td>
<td>695</td>
<td>522</td>
<td>314</td>
<td>340</td>
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<tr>
<td>Hospital - FCU</td>
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<td>1,512</td>
<td>1,232</td>
<td>1,448</td>
<td>1,946</td>
</tr>
<tr>
<td>Hotel/Motel</td>
<td>1,761</td>
<td>1,712</td>
<td>1,544</td>
<td>1,056</td>
<td>1,290</td>
</tr>
</tbody>
</table>

\textsuperscript{259} A full description of the ComEd model development is found in “ComEd Portfolio Modeling Report. Energy Center of Wisconsin July 30, 2010”

\textsuperscript{260} Based on model with single duct reheat system with a fixed outdoor air volume.

\textsuperscript{261} Based on model with single duct reheat system with airside economizer controls, with constant volume zone reheat boxes and single speed fan motors.

\textsuperscript{262} Based on model with single duct reheat system with airside economizer controls, zone VAV reheat boxes and VFD fan motors.
<table>
<thead>
<tr>
<th>Building Type</th>
<th>Heating EFLH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Zone 1</td>
</tr>
<tr>
<td></td>
<td>(Rockford)</td>
</tr>
<tr>
<td>Hotel/Motel - Common</td>
<td>1,601</td>
</tr>
<tr>
<td>Hotel/Motel - Guest</td>
<td>1,758</td>
</tr>
<tr>
<td>Manufacturing Facility</td>
<td>1,048</td>
</tr>
<tr>
<td>MF - High Rise</td>
<td>1,526</td>
</tr>
<tr>
<td>MF - High Rise - Common</td>
<td>1,815</td>
</tr>
<tr>
<td>MF - High Rise - Residential</td>
<td>1,475</td>
</tr>
<tr>
<td>MF - Mid Rise</td>
<td>1,666</td>
</tr>
<tr>
<td>Movie Theater</td>
<td>1,916</td>
</tr>
<tr>
<td>Office - High Rise - CAV no econ</td>
<td>2,020</td>
</tr>
<tr>
<td>Office - High Rise - CAV econ</td>
<td>2,089</td>
</tr>
<tr>
<td>Office - High Rise - VAV econ</td>
<td>1,528</td>
</tr>
<tr>
<td>Office - High Rise - FCU</td>
<td>1,118</td>
</tr>
<tr>
<td>Office - Low Rise</td>
<td>1,428</td>
</tr>
<tr>
<td>Office - Mid Rise</td>
<td>1,585</td>
</tr>
<tr>
<td>Religious Building</td>
<td>1,603</td>
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<tr>
<td>Restaurant</td>
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<td>1,392</td>
</tr>
<tr>
<td>Retail - Strip Mall</td>
<td>1,332</td>
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<tr>
<td>Warehouse</td>
<td>1,456</td>
</tr>
<tr>
<td>Unknown</td>
<td>1,553</td>
</tr>
</tbody>
</table>
Equivalent Full Load Hours for Cooling (EFLH<sub>cooling</sub>):

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Zone 1 (Rockford)</th>
<th>Zone 2 (Chicago)</th>
<th>Zone 3 (Springfield)</th>
<th>Zone 4 (Belleville)</th>
<th>Zone 5 (Marion)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assembly</td>
<td>725</td>
<td>796</td>
<td>937</td>
<td>1,183</td>
<td>932</td>
</tr>
<tr>
<td>Assisted Living</td>
<td>1,475</td>
<td>1,457</td>
<td>1,773</td>
<td>2,110</td>
<td>1,811</td>
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<tr>
<td>College</td>
<td>475</td>
<td>481</td>
<td>662</td>
<td>746</td>
<td>806</td>
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<tr>
<td>Convenience Store</td>
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<td>1,067</td>
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<td>1,541</td>
<td>1,371</td>
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<td>Elementary School</td>
<td>725</td>
<td>764</td>
<td>905</td>
<td>1,142</td>
<td>956</td>
</tr>
<tr>
<td>Garage</td>
<td>934</td>
<td>974</td>
<td>1,226</td>
<td>1,582</td>
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<td>Grocery</td>
<td>1,033</td>
<td>1,000</td>
<td>1,236</td>
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<td>1,286</td>
</tr>
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<td>1,282</td>
<td>1,305</td>
<td>1,519</td>
<td>1,767</td>
<td>1,571</td>
</tr>
<tr>
<td>High School</td>
<td>675</td>
<td>721</td>
<td>840</td>
<td>1,060</td>
<td>920</td>
</tr>
<tr>
<td>Hospital - CAV no econ</td>
<td>4,166</td>
<td>4,275</td>
<td>4,319</td>
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<td>Hospital - CAV econ</td>
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<td>2,112</td>
</tr>
<tr>
<td>Hospital - VAV econ</td>
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<td>1,592</td>
<td>1,853</td>
<td>2,163</td>
<td>1,876</td>
</tr>
<tr>
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<td>1,233</td>
<td>1,186</td>
<td>1,436</td>
<td>1,274</td>
<td>1,616</td>
</tr>
<tr>
<td>Hotel/Motel - Common</td>
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<td>2,103</td>
<td>2,344</td>
<td>1,391</td>
<td>2,651</td>
</tr>
<tr>
<td>Hotel/Motel - Guest</td>
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<td>1,019</td>
<td>1,269</td>
<td>1,216</td>
<td>1,418</td>
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<tr>
<td>Manufacturing Facility</td>
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<td>1,055</td>
<td>1,209</td>
<td>1,453</td>
<td>1,273</td>
</tr>
<tr>
<td>MF - High Rise</td>
<td>921</td>
<td>845</td>
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<td>1,779</td>
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<td>839</td>
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<td>831</td>
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<td>1,055</td>
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<td>809</td>
<td>767</td>
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<td>1,119</td>
<td>993</td>
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<td>1,178</td>
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<td>1,865</td>
<td>1,725</td>
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<td>1,452</td>
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<td>1,279</td>
<td>1,627</td>
<td>1,325</td>
</tr>
<tr>
<td>Building Type</td>
<td>Zone 1 (Rockford)</td>
<td>Zone 2 (Chicago)</td>
<td>Zone 3 (Springfield)</td>
<td>Zone 4 (Belleville)</td>
<td>Zone 5 (Marion)</td>
</tr>
<tr>
<td>------------------------</td>
<td>-------------------</td>
<td>------------------</td>
<td>----------------------</td>
<td>---------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Retail - Department Store</td>
<td>949</td>
<td>889</td>
<td>1,124</td>
<td>1,367</td>
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<td>919</td>
<td>1,149</td>
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<tr>
<td>Warehouse</td>
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<td>422</td>
<td>647</td>
<td>533</td>
</tr>
<tr>
<td>Unknown</td>
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<td>1,221</td>
<td>1,408</td>
<td>1,670</td>
<td>1,480</td>
</tr>
</tbody>
</table>
4.4.1 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 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

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 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.\(^\text{263}\)

DEEMED MEASURE COST

The incremental capital cost for this measure is $35\(^\text{264}\) per ton.

LOADSHAPE

Loadshape C03 - Commercial Cooling

COINCIDENCE FACTOR

\[
\text{CF}_{\text{SSP}} = \text{Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)}
\]

\[
= 91.3\% \quad \text{265}
\]

\(^{263}\)ibid.

\(^{264}\)ibid.
CF\textsubscript{PJM} = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)
= 47.8%\textsuperscript{266}

Algorithm

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

For units with cooling capacities less than 65 kBtu/hr:
\[
\Delta kWH = (kBtu/hr) * \left[ \frac{1}{SEER_{before}} - \frac{1}{SEER_{after}} \right] * EFLH
\]
For units with cooling capacities equal to or greater than 65 kBtu/hr:
\[
\Delta kWH = (kBtu/hr) * \left[ \frac{1}{EER_{before}} - \frac{1}{EER_{after}} \right] * EFLH
\]

Where:
- \( kBtu/hr \) = capacity of the cooling equipment actually installed in kBtu per hour (1 ton of cooling capacity equals 12 kBtu/hr).
- \( SEER_{before} \) = Seasonal Energy Efficiency Ratio of the equipment prior to tune-up
- \( SEER_{after} \) = Seasonal Energy Efficiency Ratio of the equipment after to tune-up
- \( EER_{before} \) = Energy Efficiency Ratio of the baseline equipment prior to tune-up
- \( EER_{after} \) = Energy Efficiency Ratio of the baseline equipment after to tune-up
- \( EFLH \) = Equivalent Full Load Hours for cooling are provided in section 4.4 HVAC End Use

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

\[
\Delta kW_{SSP} = (kBtu/hr * (1/EER_{before} - 1/EER_{after})) * CF_{SSP}
\]
\[
\Delta kW_{PJM} = (kBtu/hr * (1/EER_{before} - 1/EER_{after})) * CF_{PJM}
\]

Where:
- \( CF_{SSP} \) = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)
  = 91.3%\textsuperscript{267}

\textsuperscript{265} 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.
\textsuperscript{266} 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-Spm, M-F, June through August) is divided by the maximum AC load during the year.
\textsuperscript{267} 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.
\[ \text{CF}_{\text{PJM}} = \text{PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)} = 47.8\% \]

**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-ACTU-V02-150601**

---

268 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.
4.4.2 Space Heating Boiler Tune-up

**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[269] 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 a boiler that has not had a tune-up within the past 36 months.

---

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The life of this measure is 3 years\textsuperscript{270}

DEEMED MEASURE COST

The cost of this measure is $0.83/MBtu/hr\textsuperscript{271} per tune-up

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

\[ \Delta \text{therms} = \frac{(\text{Capacity} \times \text{EFLH} \times (((\text{Effbefore} + \text{Ei}) / \text{Effbefore}) - 1))}{100,000} \]

Where:

- Capacity = Boiler gas input size (Btu/hr)
- EFLH = Equivalent Full Load Hours for heating are provided in section 4.4 HVAC End Use
- Effbefore = Efficiency of the boiler before the tune-up
- Ei = Efficiency Improvement of the boiler tune-up measure

\textsuperscript{270} Act on Energy Commercial Technical Reference Manual No. 2010-4, 9.2.2 Gas Boiler Tune-up

\textsuperscript{271} Work Paper – Tune up for Boilers serving Space Heating and Process Load by Resource Solutions Group, January 2012
100,000 = Converts Btu to therms

**EXAMPLE**
For example, a 1050 kBtu boiler in a Chicago high rise office records an efficiency prior to tune up of 82% AFUE and a 1.8% improvement in efficiency are tune up:

\[
\Delta\text{therms} = \frac{(1,050,000 \times 2050 \times ((0.82 + 0.018)/0.82 - 1))}{100,000} \\
= 473 \text{ Therms}
\]

**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-V05-150601**
4.4.3 Process Boiler Tune-up

**DESCRIPTION**

This measure is for a non-residential boiler for process loads. For space heating, see measure 4.4.2. 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 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 a boiler that has not had a tune-up within the past 36 months.

---

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The life of this measure is 3 years\textsuperscript{273}

DEEMED MEASURE COST

The cost of this measure is $0.83/MBtu/hr\textsuperscript{274} 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

\[
\Delta \text{therms} = \left( \frac{Ngi \times 8766 \times UF}{100} \right) \times (1 - \frac{\text{Eff}_{\text{pre}}}{\text{Eff}_{\text{measured}}})
\]

Where:

- \text{Ngi} = \text{Boiler gas input size (kBtu/hr)}
  = \text{custom}
- \text{UF} = \text{Utilization Factor}
  = 41.9\%\textsuperscript{275} or \text{custom}

\textsuperscript{273} Act on Energy Commercial Technical Reference Manual No. 2010-4, 9.2.2 Gas Boiler Tune-up
\textsuperscript{274} Work Paper – Tune up for Boilers serving Space Heating and Process Load by Resource Solutions Group, January 2012
Eff\textsubscript{pre} = Boiler Combustion Efficiency Before Tune-Up

= Actual

Eff\textsubscript{measured} = Boiler Combustion Efficiency After Tune-Up

= Actual

100 = conversion from kBtu to therms

8766 = hours a year

**EXAMPLE**

For example, a 80% 1050 kBtu boiler is tuned-up resulting in final efficiency of 81.3%:

\[ \Delta \text{therms} = \left( \frac{1050 \times 8766 \times 0.419}{100} \right) \times (1 - \frac{0.80}{0.813}) \]

= 617 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-V04-150601**
4.4.4 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\(^ {276}\)

DEEMED MEASURE COST
The cost of this measure is $612\(^ {277}\)

LOADSHAPE
N/A

COINCIDENCE FACTOR
N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS
N/A

---

\(^ {276}\) CLEAreferencess the Brooklyn Union Gas Company, High Efficiency Heating and Water and Controls, Gas Energy Efficiency Program Implementation Plan.

SUMMER COINCIDENT PEAK DEMAND SAVINGS
N/A

NATURAL GAS ENERGY SAVINGS
Therm Savings = Binput * SF * EFLH / (100)
Where:
- Binput = Boiler Input Capacity (kBtu/hr)
  - custom
- SF = Savings factor
  - 8%278 or custom
- EFLH = Equivalent Full Load Hours for heating are provided in section 4.4 HVAC End Use
  - 100 = conversion from kBtu to therms

EXAMPLE
For example, a 800 kBtu/hr boiler at a restaurant in Rockford, IL
\[ \Delta \text{Therms} = 800 \times 0.08 \times 1,350 / (100) \]
\[ = 864 \text{ Therms} \]

WATER IMPACT DESCRIPTIONS AND CALCULATION
N/A

DEEMED O&M COST ADJUSTMENT CALCULATION
N/A

MEASURE CODE: CI-HVC-BLRC-V03-150601

278 Savings factor is the estimate of annual gas consumption that is saved due to adding boiler reset controls. The CLEAResults 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.
4.4.5 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.\(^{279}\)

**DEEMED MEASURE COST**

The incremental capital cost for a unit heater is $676.\(^{280}\)

**LOADSHAPE**

N/A

**COINCIDENCE FACTOR**

N/A

---

<table>
<thead>
<tr>
<th>Algorithm</th>
</tr>
</thead>
</table>

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

N/A

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

N/A

\(^{279}\)DEER 2008

\(^{280}\)ENERGY STAR and CEE do not currently provide calculators for this type of equipment therefore deemed values from Nicor Gas were used. Nicor Gas Energy Efficiency Plan 2011-2014. Revised Plan Filed Pursuant to Order Docket 10-0562, May 27, 2011
**NATURAL GAS ENERGY SAVINGS**

The annual natural gas energy savings from this measure is a deemed value equaling 266 Therms.

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-HVC-CUHT-V01-120601**
4.4.6 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 the 2009 International Energy Conservation Code, Table 503.2.3(7).

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The expected measure life is assumed to be 20 years \(^{281}\).

**DEEMED MEASURE COST**

The incremental capital cost for this measure is provided below.

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>Size Category</th>
<th>Incremental Cost ($/ton) (^{282})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air cooled, electrically operated</td>
<td>All capacities</td>
<td>$127/ton (^{283})</td>
</tr>
<tr>
<td>Water cooled, electrically operated, positive</td>
<td>All capacities</td>
<td>$22/ton</td>
</tr>
<tr>
<td>displacement (reciprocating)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water cooled, electrically operated, positive</td>
<td>&lt; 150 tons</td>
<td>$128/ton</td>
</tr>
<tr>
<td>displacement (rotary screw and scroll)</td>
<td>&gt;= 150 tons and &lt; 300 tons</td>
<td>$70/ton</td>
</tr>
<tr>
<td></td>
<td>&gt;= 300 tons</td>
<td>$48/ton</td>
</tr>
</tbody>
</table>


\(^{283}\) Calculated as the simple average of screw and reciprocating air-cooled chiller incremental costs from DEER2008. This assumes that baseline shift from IECC 2009 to IECC 2012 carries the same incremental costs. Values should be verified during evaluation.
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.

\[ CF_{SSP} = \text{Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)} \]
\[ = 91.3\% \]

\[ CF_{PJM} = \text{PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)} \]
\[ = 47.8\% \]

Algorithm

CALCULATION OF SAVINGS

Electric Energy Savings

\[ \Delta k\text{WH} = \text{TONS} \times ((\text{IPLV}_{\text{base}}) - (\text{IPLV}_{\text{ee}})) \times \text{EFLH} \]

Where:

\[ \text{TONS} = \text{chiller nominal cooling capacity in tons (note: 1 ton = 12,000 Btu/hr)} \]
\[ = \text{Actual installed} \]

\[ \text{IPLV}_{\text{base}} = \text{efficiency of baseline equipment expressed as Integrated Part Load Value (kW/ton). Chiller units are dependent on chiller type. See Chiller Units, Conversion Values and Baseline Efficiency Values by Chiller Type and Capacity in the Reference Tables section.} \]

\[ \text{IPLV}_{\text{ee}} = \text{efficiency of high efficiency equipment expressed as Integrated Part Load Value (kW/ton)} \]
\[ = \text{Actual installed} \]

\[ \text{EFLH} = \text{Equivalent Full Load Hours for cooling are provided in section 4.4 HVAC End Use.} \]

---

284 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.

285 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.

286 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 2012, it is expressed in terms of IPLV here.

287 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/
For example, a 100 ton air-cooled electrically operated chiller in a high-rise office building with IPLV of 14 EER (0.86 kW/ton) and baseline EER of 12.5 (0.96 kW/ton) in Rockford would save:

\[
\Delta k\text{WH} = 100 \times (0.96 - 0.86) \times 923
\]
\[
= 9,230 \text{ kWh}
\]

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

\[
\Delta k\text{W}_{\text{SSP}} = \text{TONS} \times ((\text{PE}_{\text{base}}) - (\text{PE}_{\text{ee}})) \times \text{CF}_{\text{SSP}}
\]

\[
\Delta k\text{W}_{\text{PJM}} = \text{TONS} \times ((\text{PE}_{\text{base}}) - (\text{PE}_{\text{ee}})) \times \text{CF}_{\text{PJM}}
\]

Where:

- \(\text{PE}_{\text{base}}\) = Peak efficiency of baseline equipment expressed as Full Load (kW/ton)
- \(\text{PE}_{\text{ee}}\) = Peak efficiency of high efficiency equipment expressed as Full Load (kW/ton)
- \(\text{CF}_{\text{SSP}}\) = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)
  - 91.3%
- \(\text{CF}_{\text{PJM}}\) = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)
  - 47.8%

For example, a 100 ton air-cooled electrically operated chiller in a high-rise office building with a full load IPLV of 12 EER (0.86 kW/ton) with baseline full load IPLV 9.56 EER (1.3 kW/ton) in Rockford would save:

\[
\Delta k\text{W}_{\text{SSP}} = 100 \times ((1.3) - (1.0)) \times 0.913
\]
\[
= 23 \text{ kW}
\]

**NATURAL GAS ENERGY SAVINGS**

N/A

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**REFERENCE TABLES**

Chillers are rated with different units depending on equipment type as shown below:

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air cooled, electrically operated</td>
<td>EER</td>
</tr>
<tr>
<td>Water cooled, electrically operated, positive</td>
<td>kW/ton</td>
</tr>
<tr>
<td>displacement (reciprocating)</td>
<td></td>
</tr>
</tbody>
</table>
### Electric Chiller

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water cooled, electrically operated, positive displacement (rotary screw and scroll)</td>
<td>kW/ton</td>
</tr>
</tbody>
</table>

In order to convert chiller equipment ratings to IPLV the following relationships are provided:

\[
\begin{align*}
\text{kW/ton} & = \frac{12}{\text{EER}} \\
\text{kW/ton} & = \frac{12}{(\text{COP} \times 3.412)} \\
\text{COP} & = \frac{\text{EER}}{3.412} \\
\text{COP} & = \frac{12}{\text{kW/ton}} \times 3.412 \\
\text{EER} & = \frac{12}{\text{kW/ton}} \\
\text{EER} & = \text{COP} \times 3.412
\end{align*}
\]
### Baseline Efficiency Values by Chiller Type and Capacity

#### Table C403.2.3(r)

**Minimum Efficiency Requirements: Water-Chilling Packages**

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY</th>
<th>UNITS</th>
<th>BEFORE 1/1/2010</th>
<th>PATH A</th>
<th>PATH B</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air-cooled chillers</td>
<td>&lt; 150 tons</td>
<td>EER</td>
<td>≥ 9.562</td>
<td>≥ 10.4</td>
<td>≥ 9.562</td>
<td>NA/NA</td>
</tr>
<tr>
<td></td>
<td>≥ 150 tons</td>
<td>EER</td>
<td>≥ 10.4</td>
<td>≥ 9.562</td>
<td>≥ 12.500</td>
<td>NA/NA</td>
</tr>
<tr>
<td>Air-cooled without condenser, electrical operated</td>
<td>All capacities</td>
<td>EER</td>
<td>≥ 10.586</td>
<td>≥ 11.782</td>
<td>NA/NA</td>
<td>NA/NA</td>
</tr>
<tr>
<td>Water-cooled, electrically operated, reciprocating</td>
<td>All capacities</td>
<td>kW/ton &lt; 0.837</td>
<td>&lt; 0.696</td>
<td>≤ 0.780</td>
<td>≤ 0.630</td>
<td>≤ 0.800</td>
</tr>
<tr>
<td>Water-cooled, electrically operated, positive displacement</td>
<td>&lt; 75 tons and &lt; 150 tons</td>
<td>kW/ton 0.790</td>
<td>0.676</td>
<td>≤ 0.775</td>
<td>≤ 0.615</td>
<td>≤ 0.790</td>
</tr>
<tr>
<td></td>
<td>≥ 150 tons and &lt; 300 tons</td>
<td>kW/ton 0.717</td>
<td>0.627</td>
<td>≤ 0.680</td>
<td>≤ 0.580</td>
<td>≤ 0.718</td>
</tr>
<tr>
<td></td>
<td>≥ 300 tons</td>
<td>kW/ton 0.639</td>
<td>0.571</td>
<td>≤ 0.620</td>
<td>≤ 0.540</td>
<td>≤ 0.639</td>
</tr>
<tr>
<td>Water-cooled, electrically operated, centrifugal</td>
<td>&lt; 150 tons</td>
<td>kW/ton 0.703</td>
<td>≤ 0.669</td>
<td>≤ 0.776</td>
<td>≤ 0.615</td>
<td>≤ 0.790</td>
</tr>
<tr>
<td></td>
<td>≥ 150 tons and &lt; 300 tons</td>
<td>kW/ton 0.634</td>
<td>0.596</td>
<td>≤ 0.634</td>
<td>≤ 0.596</td>
<td>≤ 0.639</td>
</tr>
<tr>
<td></td>
<td>≥ 300 tons and &lt; 600 tons</td>
<td>kW/ton 0.576</td>
<td>0.549</td>
<td>≤ 0.576</td>
<td>≤ 0.549</td>
<td>≤ 0.600</td>
</tr>
<tr>
<td></td>
<td>≥ 600 tons</td>
<td>kW/ton 0.576</td>
<td>0.549</td>
<td>≤ 0.570</td>
<td>≤ 0.539</td>
<td>≤ 0.590</td>
</tr>
<tr>
<td>Air-cooled, absorption single effect</td>
<td>All capacities</td>
<td>CCP</td>
<td>&gt; 0.600</td>
<td>NR</td>
<td>&gt; 0.600</td>
<td>NR/NA</td>
</tr>
<tr>
<td>Water-cooled, absorption single effect</td>
<td>All capacities</td>
<td>CCP</td>
<td>≥ 0.700</td>
<td>NR</td>
<td>≥ 0.700</td>
<td>NR/NA</td>
</tr>
<tr>
<td>Absorption double effect, indirect fired</td>
<td>All capacities</td>
<td>CCP</td>
<td>≥ 1.000</td>
<td>≥ 1.050</td>
<td>≥ 1.000</td>
<td>≥ 1.050</td>
</tr>
<tr>
<td>Absorption double effect, direct fired</td>
<td>All capacities</td>
<td>CCP</td>
<td>≥ 1.000</td>
<td>≥ 1.050</td>
<td>≥ 1.000</td>
<td>≥ 1.050</td>
</tr>
</tbody>
</table>

**TEST PROCEDURE**

- **PATH A**
  - Path A: Path A is not applicable.
  - Path B: Path B is not applicable.

**FOR SI:** 1 ton = 3517 W, 1 British thermal unit per hour = 0.2931 W, °C = (°F) - 32/1.8.

**NA:** Not applicable, not to be used for compliance. **NR:** No requirement.

**a.** The centrifugal chiller equipment requirements, after adjustment in accordance with Section C403.2.3.1 or Section C403.2.3.2, do not apply to chillers used in low-temperature applications where the design leaving fluid temperature is less than 36°F. The requirements do not apply to positive displacement chillers with leaving fluid temperatures less than or equal to 32°F. The requirements do not apply to absorption chillers with design leaving fluid temperatures less than 40°F.

**b.** Compliance with this standard can be obtained by meeting the minimum requirements of Path A or B. However, both the full load and IPLV shall be met to fulfill the requirements of Path A or B.

**c.** Chapter 6 of the referenced standard contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

**MEASURE CODE:** CI-HVC-CHIL-V03-150601

---

4.4.7 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:

<table>
<thead>
<tr>
<th>Product Class (Btu/H)</th>
<th>Federal Standard EER, with louvered sides</th>
<th>Federal Standard EER, without louvered sides</th>
<th>ENERGY STAR EER, with louvered sides</th>
<th>ENERGY STAR EER, without louvered sides</th>
<th>CEE TIER 1 EER</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 8,000</td>
<td>9.7</td>
<td>9</td>
<td>10.7</td>
<td>9.9</td>
<td>11.2</td>
</tr>
<tr>
<td>8,000 to 13,999</td>
<td>9.8</td>
<td>8.5</td>
<td>10.8</td>
<td>9.4</td>
<td>11.3</td>
</tr>
<tr>
<td>14,000 to 19,999</td>
<td>9.7</td>
<td>8.5</td>
<td>10.7</td>
<td>9.4</td>
<td>11.2</td>
</tr>
<tr>
<td>&gt;= 20,000</td>
<td>8.5</td>
<td>8.5</td>
<td>9.4</td>
<td>9.4</td>
<td>9.8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Casement</th>
<th>Federal Standard (EER)</th>
<th>ENERGY STAR (EER)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Casement-only</td>
<td>8.7</td>
<td>9.6</td>
</tr>
<tr>
<td>Casement-slider</td>
<td>9.5</td>
<td>10.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Reverse Cycle - Product Class (Btu/H)</th>
<th>Federal Standard EER, with louvered sides</th>
<th>Federal Standard EER, without louvered sides</th>
<th>ENERGY STAR EER, with louvered sides</th>
<th>ENERGY STAR EER, without louvered sides</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 14,000</td>
<td>N/A</td>
<td>8.5</td>
<td>N/A</td>
<td>9.4</td>
</tr>
<tr>
<td>&gt;= 14,000</td>
<td>N/A</td>
<td>8</td>
<td>N/A</td>
<td>8.8</td>
</tr>
<tr>
<td>&lt; 20,000</td>
<td>9</td>
<td>N/A</td>
<td>9.9</td>
<td>N/A</td>
</tr>
<tr>
<td>&gt;= 20,000</td>
<td>8.5</td>
<td>N/A</td>
<td>9.4</td>
<td>N/A</td>
</tr>
</tbody>
</table>

---


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
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 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.\(^{290}\)

**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.\(^{291}\)

**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.

\[
CF_{SSP} = \text{Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)}
\]
\[
= 91.3\% \quad ^{292}
\]

\[
CF_{PJM} = \text{PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)}
\]
\[
= 47.8\% \quad ^{293}
\]

---


\(^{291}\) Based on field study conducted by Efficiency Vermont

\(^{292}\) 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.

\(^{293}\) 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.
Algorithm

**CALCULATION OF SAVINGS**

**ENERGY SAVINGS**

\[ \Delta k\text{Wh} = \left( \text{FLH}_{\text{Room AC}} \times \text{Btu/H} \times (1/\text{EER}_{\text{base}} - 1/\text{EER}_{\text{ee}}) \right)/1000 \]

Where:

- \( \text{FLH}_{\text{Room AC}} \) = Full Load Hours of room air conditioning unit
  - dependent on location:
    - Zone 1 (Rockford) = 294
    - Zone 2 (Chicago) = 253
    - Zone 3 (Springfield) = 310
    - Zone 4 (Belleville) = 391
    - Zone 5 (Marion) = 254

- \( \text{Btu/H} \) = Size of unit
  - Actual. If unknown assume 8500 Btu/hr

- \( \text{EER}_{\text{base}} \) = Efficiency of baseline unit
  - As provided in tables above

- \( \text{EER}_{\text{ee}} \) = 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 ENERGY STAR unit, with louvered sides, in Rockford:

\[
\Delta k\text{Wh}_{\text{ENERGY STAR}} = \frac{(253 \times 8500 \times (1/9.8 - 1/10.8))}{1000}
\]

\[= 20.3 \text{ kWh} \]

---

294 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](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](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.

295 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

\[ \Delta kW = \text{Btu/H} \times \frac{(1/EER_{base} - 1/EER_{ee})}{1000} \times CF \]

Where:

- \( CF_{SSP} \) = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour) = 91.3% \(^{296}\)
- \( CF_{PJM} \) = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period) = 47.8% \(^{297}\)

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

\[ \Delta kW_{\text{ENERGY STAR}} = \frac{(8500 \times (1/9.8 - 1/10.8))}{1000} \times 0.913 \]

\[ = 0.073 \text{ kW} \]

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-V01-120601

\(^{296}\) 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.

\(^{297}\) 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.
4.4.8  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

Guest room energy management thermostats replace manual heating/cooling temperature set-point and fan On/Off/Auto thermostat controls. Two possible baselines exist based on whether housekeeping staff are directed to set-back (or turn off) thermostats when rooms are not rented.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure life for GREM is 15 years.298

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.299

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape C03 - Commercial Cooling

COINCIDENCE FACTOR

A coincidence factor is not used in the determination of coincident peak kW savings.

298 DEER 2008 value for energy management systems
299 This value was extracted from Smart Ideas projects in PY1 and PY2.
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. Note that care should be taken in selecting a value consistent with actual baseline conditions (e.g. whether housekeeping staff are directed to set-back/turn-off the thermostats when rooms are unrented). Different values are provided for Motels and Hotels since significant differences in shell performance, number of external walls per room and typical heating and cooling efficiencies result in significantly different savings estimates. Energy savings estimates are derived using a prototypical EnergyPlus simulation of a motel and a hotel\(^3\). Model outputs are normalized to the installed capacity and reported here as kWh/Ton, coincident peak kW/Ton and Therms/Ton.

ELECTRIC ENERGY SAVINGS

<table>
<thead>
<tr>
<th>Climate Zone (City based upon)</th>
<th>Heating Source</th>
<th>Baseline</th>
<th>Electric Savings (kWh/Ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Rockford)</td>
<td>PTAC w/ Electric Resistance Heating</td>
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</table>

\(^3\) For motels, see S. Keates, ADM Associates Workpaper: “Suggested Revisions to Guest Room Energy Management (PTAC & PTHP)”, 11/14/2013 and spreadsheet summarizing the results: ‘GREM Savings Summary_IL TRM_1_22_14.xlsx’. In 2014 the hotel models were also run to compile results, rather than by applying adjustment factors to the motel results as had been done in V3.0 of the TRM. The updated values can be found in ‘GREM Savings Summary (Hotel)_IL TRM_10_16_14.xls’.
### Motel Electric Energy Savings

<table>
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<tr>
<th>Climate Zone (City based upon)</th>
<th>Heating Source</th>
<th>Baseline</th>
<th>Electric Savings (kWh/Ton)</th>
</tr>
</thead>
<tbody>
<tr>
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### Hotel Electric Energy Savings

<table>
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<th>Electric Savings (kWh/Ton)</th>
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<td>PTHP</td>
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<td>No Housekeeping Setback</td>
<td>253</td>
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<tr>
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<td>Central Hot Water Fan Coil w/ Electric Resistance Heating</td>
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<tr>
<td>2 (Chicago)</td>
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<td>188</td>
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### Hotel Electric Energy Savings

<table>
<thead>
<tr>
<th>Climate Zone (City based upon)</th>
<th>Heating Source</th>
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<th>Electric Savings (kWh/Ton)</th>
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<tbody>
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<tr>
<td>3 (Springfield)</td>
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<td>291</td>
</tr>
<tr>
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<td>PTAC w/ Gas Heating</td>
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<tr>
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<td>No Housekeeping Setback</td>
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<tr>
<td></td>
<td>PTHP</td>
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<td>No Housekeeping Setback</td>
<td>233</td>
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<tr>
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<tr>
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</tr>
<tr>
<td></td>
<td></td>
<td>No Housekeeping Setback</td>
<td>146</td>
</tr>
<tr>
<td>4 (Belleville)</td>
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<td>PTHP</td>
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<td>146</td>
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<tr>
<td></td>
<td>Central Hot Water Fan Coil w/ Electric Resistance</td>
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## Hotel Electric Energy Savings

<table>
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<tr>
<th>Climate Zone (City based upon)</th>
<th>Heating Source</th>
<th>Baseline</th>
<th>Electric Savings (kWh/Ton)</th>
</tr>
</thead>
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<td></td>
<td>No Housekeeping Setback</td>
<td>146</td>
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</table>
## SUMMER COINCIDENT PEAK DEMAND SAVINGS

<table>
<thead>
<tr>
<th>Climate Zone (City based upon)</th>
<th>Heating Source</th>
<th>Baseline</th>
<th>Coincident Peak Demand Savings (kW/Ton)</th>
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<td>0.17</td>
</tr>
<tr>
<td></td>
<td>PTAC w/ Gas Heating</td>
<td>Housekeeping Setback</td>
<td>0.08</td>
</tr>
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<td>No Housekeeping Setback</td>
<td>0.17</td>
</tr>
<tr>
<td></td>
<td>PTHP</td>
<td>Housekeeping Setback</td>
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<td>0.28</td>
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<td>Motor Coincident Peak Demand Savings</td>
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<td><strong>Climate Zone (City based upon)</strong></td>
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</tr>
<tr>
<td><strong>Heating Source</strong></td>
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<tr>
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<table>
<thead>
<tr>
<th>Hotel Coincident Peak Demand Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Climate Zone (City based upon)</strong></td>
</tr>
<tr>
<td><strong>Heating Source</strong></td>
</tr>
<tr>
<td><strong>Baseline</strong></td>
</tr>
<tr>
<td><strong>Coincident Peak Demand Savings</strong></td>
</tr>
<tr>
<td>kW/Ton</td>
</tr>
<tr>
<td>No Housekeeping Setback</td>
</tr>
<tr>
<td>1 (Rockford)</td>
</tr>
<tr>
<td>PTAC w/ Electric Resistance Heating</td>
</tr>
<tr>
<td>Housekeeping Setback</td>
</tr>
<tr>
<td>0.08</td>
</tr>
<tr>
<td>No Housekeeping Setback</td>
</tr>
<tr>
<td>0.11</td>
</tr>
<tr>
<td>PTAC w/ Gas Heating</td>
</tr>
<tr>
<td>Housekeeping Setback</td>
</tr>
<tr>
<td>0.08</td>
</tr>
<tr>
<td>No Housekeeping Setback</td>
</tr>
<tr>
<td>0.11</td>
</tr>
<tr>
<td>PTHP</td>
</tr>
<tr>
<td>Housekeeping Setback</td>
</tr>
<tr>
<td>0.08</td>
</tr>
<tr>
<td>No Housekeeping Setback</td>
</tr>
<tr>
<td>0.11</td>
</tr>
<tr>
<td>Central Hot Water Fan Coil w/ Electric Resistance Heating</td>
</tr>
<tr>
<td>Housekeeping Setback</td>
</tr>
<tr>
<td>0.05</td>
</tr>
<tr>
<td>No Housekeeping Setback</td>
</tr>
<tr>
<td>0.08</td>
</tr>
<tr>
<td>Central Hot Water Fan Coil w/ Gas Heating</td>
</tr>
<tr>
<td>Housekeeping Setback</td>
</tr>
<tr>
<td>0.05</td>
</tr>
<tr>
<td>No Housekeeping Setback</td>
</tr>
<tr>
<td>0.08</td>
</tr>
<tr>
<td>2 (Chicago)</td>
</tr>
<tr>
<td>PTAC w/ Electric Resistance Heating</td>
</tr>
<tr>
<td>Housekeeping Setback</td>
</tr>
<tr>
<td>0.07</td>
</tr>
<tr>
<td>No Housekeeping Setback</td>
</tr>
<tr>
<td>0.11</td>
</tr>
<tr>
<td>PTAC w/ Gas Heating</td>
</tr>
<tr>
<td>Housekeeping Setback</td>
</tr>
<tr>
<td>0.07</td>
</tr>
<tr>
<td>No Housekeeping Setback</td>
</tr>
<tr>
<td>0.11</td>
</tr>
<tr>
<td>PTHP</td>
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<tr>
<td>Housekeeping Setback</td>
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<tr>
<td>0.07</td>
</tr>
<tr>
<td>No Housekeeping Setback</td>
</tr>
<tr>
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</tr>
<tr>
<td>Housekeeping Setback</td>
</tr>
<tr>
<td>0.05</td>
</tr>
<tr>
<td>No Housekeeping Setback</td>
</tr>
<tr>
<td>0.07</td>
</tr>
<tr>
<td>Central Hot Water Fan Coil w/ Gas Heating</td>
</tr>
<tr>
<td>Housekeeping Setback</td>
</tr>
<tr>
<td>0.05</td>
</tr>
<tr>
<td>No Housekeeping Setback</td>
</tr>
<tr>
<td>0.07</td>
</tr>
<tr>
<td>3 (Springfield)</td>
</tr>
<tr>
<td>PTAC w/ Electric Resistance Heating</td>
</tr>
<tr>
<td>Housekeeping Setback</td>
</tr>
<tr>
<td>0.08</td>
</tr>
<tr>
<td>No Housekeeping Setback</td>
</tr>
<tr>
<td>0.11</td>
</tr>
<tr>
<td>PTAC w/ Gas Heating</td>
</tr>
<tr>
<td>Housekeeping Setback</td>
</tr>
<tr>
<td>0.08</td>
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</tbody>
</table>
### Hotel Coincident Peak Demand Savings

<table>
<thead>
<tr>
<th>Climate Zone (City based upon)</th>
<th>Heating Source</th>
<th>Baseline</th>
<th>Coincident Peak Demand Savings (kW/Ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>No Housekeeping Setback</td>
<td>0.11</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Housekeeping Setback</td>
<td>0.08</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No Housekeeping Setback</td>
<td>0.11</td>
</tr>
<tr>
<td></td>
<td>Central Hot Water Fan Coil w/ Electric Resistance Heating</td>
<td>Housekeeping Setback</td>
<td>0.05</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No Housekeeping Setback</td>
<td>0.07</td>
</tr>
<tr>
<td></td>
<td>Central Hot Water Fan Coil w/ Gas Heating</td>
<td>Housekeeping Setback</td>
<td>0.05</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No Housekeeping Setback</td>
<td>0.07</td>
</tr>
<tr>
<td></td>
<td>PTAC w/ Electric Resistance Heating</td>
<td>Housekeeping Setback</td>
<td>0.08</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No Housekeeping Setback</td>
<td>0.11</td>
</tr>
<tr>
<td></td>
<td>PTAC w/ Gas Heating</td>
<td>Housekeeping Setback</td>
<td>0.08</td>
</tr>
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<td></td>
<td></td>
<td>No Housekeeping Setback</td>
<td>0.11</td>
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<tr>
<td></td>
<td>PTHP</td>
<td>Housekeeping Setback</td>
<td>0.08</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No Housekeeping Setback</td>
<td>0.11</td>
</tr>
<tr>
<td></td>
<td>Central Hot Water Fan Coil w/ Electric Resistance Heating</td>
<td>Housekeeping Setback</td>
<td>0.05</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No Housekeeping Setback</td>
<td>0.08</td>
</tr>
<tr>
<td></td>
<td>Central Hot Water Fan Coil w/ Gas Heating</td>
<td>Housekeeping Setback</td>
<td>0.05</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No Housekeeping Setback</td>
<td>0.08</td>
</tr>
<tr>
<td></td>
<td>PTAC w/ Electric Resistance Heating</td>
<td>Housekeeping Setback</td>
<td>0.08</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No Housekeeping Setback</td>
<td>0.11</td>
</tr>
<tr>
<td></td>
<td>PTAC w/ Gas Heating</td>
<td>Housekeeping Setback</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>No Housekeeping Setback</td>
<td>0.11</td>
</tr>
<tr>
<td></td>
<td>PTHP</td>
<td>Housekeeping Setback</td>
<td>0.08</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No Housekeeping Setback</td>
<td>0.11</td>
</tr>
<tr>
<td></td>
<td>Central Hot Water Fan Coil w/ Electric Resistance Heating</td>
<td>Housekeeping Setback</td>
<td>0.05</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No Housekeeping Setback</td>
<td>0.08</td>
</tr>
<tr>
<td></td>
<td>Central Hot Water Fan Coil w/ Gas Heating</td>
<td>Housekeeping Setback</td>
<td>0.05</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No Housekeeping Setback</td>
<td>0.08</td>
</tr>
</tbody>
</table>
### NATURAL GAS ENERGY SAVINGS

For PTACs with gas heating:

#### Motel Natural Gas Energy Savings

<table>
<thead>
<tr>
<th>Climate Zone (City based upon)</th>
<th>Baseline</th>
<th>Gas Savings (Therms/Ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Rockford)</td>
<td>Housekeeping Setback</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>No Housekeeping Setback</td>
<td>71</td>
</tr>
<tr>
<td>2 (Chicago)</td>
<td>Housekeeping Setback</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>No Housekeeping Setback</td>
<td>62</td>
</tr>
<tr>
<td>3 (Springfield)</td>
<td>Housekeeping Setback</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>No Housekeeping Setback</td>
<td>52</td>
</tr>
<tr>
<td>4 (Belleville)</td>
<td>Housekeeping Setback</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>No Housekeeping Setback</td>
<td>70</td>
</tr>
<tr>
<td>5 (Marion-Williamson)</td>
<td>Housekeeping Setback</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>No Housekeeping Setback</td>
<td>47</td>
</tr>
</tbody>
</table>

#### Hotel Natural Gas Energy Savings

<table>
<thead>
<tr>
<th>Climate Zone (City based upon)</th>
<th>Heating Source</th>
<th>Baseline</th>
<th>Gas Savings (Therms/Ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Rockford)</td>
<td>PTAC w/ Gas Heating</td>
<td>Housekeeping Setback</td>
<td>3.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No Housekeeping Setback</td>
<td>6.4</td>
</tr>
<tr>
<td></td>
<td>Central Hot Water Fan Coil w/ Gas Heating</td>
<td>Housekeeping Setback</td>
<td>3.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No Housekeeping Setback</td>
<td>6.4</td>
</tr>
<tr>
<td>2 (Chicago)</td>
<td>PTAC w/ Gas Heating</td>
<td>Housekeeping Setback</td>
<td>3.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No Housekeeping Setback</td>
<td>6.5</td>
</tr>
<tr>
<td></td>
<td>Central Hot Water Fan Coil w/ Gas Heating</td>
<td>Housekeeping Setback</td>
<td>3.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No Housekeeping Setback</td>
<td>6.5</td>
</tr>
<tr>
<td>3 (Springfield)</td>
<td>PTAC w/ Gas Heating</td>
<td>Housekeeping Setback</td>
<td>2.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No Housekeeping Setback</td>
<td>4.1</td>
</tr>
<tr>
<td></td>
<td>Central Hot Water Fan Coil w/ Gas Heating</td>
<td>Housekeeping Setback</td>
<td>2.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No Housekeeping Setback</td>
<td>4.1</td>
</tr>
<tr>
<td>4 (Belleville)</td>
<td>PTAC w/ Gas Heating</td>
<td>Housekeeping Setback</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No Housekeeping Setback</td>
<td>4.8</td>
</tr>
</tbody>
</table>
### Hotel Natural Gas Energy Savings

<table>
<thead>
<tr>
<th>Climate Zone (City based upon)</th>
<th>Heating Source</th>
<th>Baseline</th>
<th>Gas Savings (Therms/Ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central Hot Water Fan Coil w/ Gas Heating</td>
<td>Housekeeping Setback</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No Housekeeping Setback</td>
<td>4.8</td>
<td></td>
</tr>
<tr>
<td>5 (Marion-Williamson) PTAC w/ Gas Heating</td>
<td>Housekeeping Setback</td>
<td>2.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No Housekeeping Setback</td>
<td>4.2</td>
<td></td>
</tr>
<tr>
<td>Central Hot Water Fan Coil w/ Gas Heating</td>
<td>Housekeeping Setback</td>
<td>2.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No Housekeeping Setback</td>
<td>4.2</td>
<td></td>
</tr>
</tbody>
</table>

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-HVC-GREM-V05-150601**
4.4.9 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) 2012.\(^{301}\)

**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) 2012.\(^{301}\). 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.\(^{301}\)

**DEEMED MEASURE COST**

For analysis purposes, the incremental capital cost for this measure is assumed as $100 per ton for air-cooled units.\(^{302}\) The incremental cost for all other equipment types should be determined on a site-specific basis.

**LOADSHAPE**

Loadshape C05 - Commercial 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.

\[
\begin{align*}
CF_{SSP} &= \text{Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)} \\
&= 91.3\% \quad ^{303} \\
CF_{PJM} &= \text{PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)}
\end{align*}
\]


\(^{302}\) Based on a review of TRM incremental cost assumptions from Vermont, Wisconsin, and California.

\(^{303}\) 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.
Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

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

\[ \Delta \text{kWh} = \text{Annual kWh Savings}_{\text{cool}} + \text{Annual kWh Savings}_{\text{heat}} \]

\[ \text{Annual kWh Savings}_{\text{cool}} = (\text{kBtu/hr}_{\text{cool}}) \times [(1/\text{SEERbase}) - (1/\text{SEER}_{\text{ee}})] \times \text{EFLH}_{\text{cool}} \]

\[ \text{Annual kWh Savings}_{\text{heat}} = (\text{kBtu/hr}_{\text{cool}}) \times [(1/\text{HSPF}_{\text{base}}) - (1/\text{HSPF}_{\text{ee}})] \times \text{EFLH}_{\text{heat}} \]

For units with cooling capacities equal to or greater than 65 kBtu/hr:

\[ \Delta \text{kWh} = \text{Annual kWh Savings}_{\text{cool}} + \text{Annual kWh Savings}_{\text{heat}} \]

\[ \text{Annual kWh Savings}_{\text{cool}} = (\text{kBtu/hr}_{\text{cool}}) \times [(1/\text{EERbase}) - (1/\text{EER}_{\text{ee}})] \times \text{EFLH}_{\text{cool}} \]

\[ \text{Annual kWh Savings}_{\text{heat}} = \frac{(\text{kBtu/hr}_{\text{heat}})}{3.412} \times [(1/\text{COPbase}) - (1/\text{COP}_{\text{ee}})] \times \text{EFLH}_{\text{heat}} \]

Where:

- \text{kBtu/hr}_{\text{cool}} = capacity of the cooling equipment in kBTU per hour (1 ton of cooling capacity equals 12 kBTU/hr).
- = Actual installed
- \text{SEER}_{\text{base}} = Seasonal Energy Efficiency Ratio of the baseline equipment; see table below for values.

304 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

305 International Energy Conservation Code (IECC) 2012
### TABLE C403.2.3:10
**ELECTRICALLY OPERATED UNITARY AND APPLIED HEAT PUMPS**

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY</th>
<th>HEATING SECTION TYPE</th>
<th>SUBCATEGORY OR RATING CONDITION</th>
<th>MINIMUM EFFICIENCY</th>
<th>TEST PROCEDURE*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air cooled (cooling mode)</td>
<td>&lt; 65,000 Btu/h^*</td>
<td>All</td>
<td>Single Package</td>
<td>13.0 SEER</td>
<td>AHRI 210/240</td>
</tr>
<tr>
<td>Through-the-wall, air cooled</td>
<td>≤ 30,000 Btu/h</td>
<td>All</td>
<td>Single Package</td>
<td>13.0 SEER</td>
<td>AHRI 340/300</td>
</tr>
<tr>
<td>Single-duct high-velocity air cooled</td>
<td>&lt; 65,000 Btu/h^*</td>
<td>All</td>
<td>Split System</td>
<td>10.0 SEER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 65,000 Btu/h and &lt; 135,000 Btu/h</td>
<td>Electric Resistance (or None)</td>
<td>Single Package</td>
<td>11.0 EER 11.2 EER</td>
<td>AHRI 340/300</td>
</tr>
<tr>
<td></td>
<td>All other</td>
<td>Split System</td>
<td>Single Package</td>
<td>10.8 EER 11.0 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 135,000 Btu/h and &lt; 240,000 Btu/h</td>
<td>Electric Resistance (or None)</td>
<td>Single Package</td>
<td>10.6 EER 10.7 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>All other</td>
<td>Split System</td>
<td>Single Package</td>
<td>10.4 EER 10.5 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 240,000 Btu/h</td>
<td>Electric Resistance (or None)</td>
<td>Single Package</td>
<td>9.5 EER 9.6 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>All other</td>
<td>Split System</td>
<td>Single Package</td>
<td>9.3 EER 9.4 EER</td>
<td></td>
</tr>
<tr>
<td>Water source (cooling mode)</td>
<td>&lt; 17,000 Btu/h</td>
<td>All</td>
<td>86°F entering water</td>
<td>11.2 EER</td>
<td>ISO 13256-1</td>
</tr>
<tr>
<td></td>
<td>≥ 17,000 Btu/h and &lt; 65,000 Btu/h</td>
<td>All</td>
<td>86°F entering water</td>
<td>12.0 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 65,000 Btu/h and &lt; 135,000 Btu/h</td>
<td>All</td>
<td>86°F entering water</td>
<td>12.0 EER</td>
<td></td>
</tr>
<tr>
<td>Ground water source (cooling mode)</td>
<td>&lt; 135,000 Btu/h</td>
<td>All</td>
<td>59°F entering water</td>
<td>16.2 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>All</td>
<td>77°F entering water</td>
<td>13.4 EER</td>
<td></td>
</tr>
<tr>
<td>Water-source water to water</td>
<td>&lt; 135,000 Btu/h</td>
<td>All</td>
<td>86°F entering water</td>
<td>10.6 EER</td>
<td>ISO 13256-2</td>
</tr>
<tr>
<td>(cooling mode)</td>
<td></td>
<td>All</td>
<td>59°F entering water</td>
<td>16.3 EER</td>
<td></td>
</tr>
<tr>
<td>Ground water source (cooling mode)</td>
<td>&lt; 135,000 Btu/h</td>
<td>All</td>
<td>77°F entering fluid</td>
<td>12.1 EER</td>
<td></td>
</tr>
<tr>
<td>Air cooled (heating mode)</td>
<td>&lt; 65,000 Btu/h^*</td>
<td>—</td>
<td>Split System</td>
<td>7.7 HSPF</td>
<td>AHRI 210/240</td>
</tr>
<tr>
<td>Through-the-wall, (air cooled, heating mode)</td>
<td>≤ 30,000 Btu/h^*</td>
<td>—</td>
<td>Single Package</td>
<td>7.7 HSPF</td>
<td></td>
</tr>
<tr>
<td>Small-duct high velocity (air cooled, heating mode)</td>
<td>&lt; 65,000 Btu/h^*</td>
<td>—</td>
<td>Split System</td>
<td>6.8 HSPF</td>
<td></td>
</tr>
</tbody>
</table>

(continued)
SEERee = Seasonal Energy Efficiency Ratio of the energy efficient equipment.
= Actual installed

EFLH_{cool} = Equivalent Full Load Hours for cooling are provided in section 4.4 HVAC End Use.

HSPF_{base} = Heating Seasonal Performance Factor of the baseline equipment; see table above for values.

HSPF_{eff} = Heating Seasonal Performance Factor of the energy efficient equipment.
= Actual installed

EFLH_{heat} = heating mode equivalent full load hours are provided in section 4.4 HVAC End Use.

EER_{base} = Energy Efficiency Ratio of the baseline equipment; see the table above for values. Since IECC 2012 does not provide EER requirements for air-cooled heat pumps < 65 kBtu/hr, assume the following conversion from SEER to EER: EER=SEER/1.1.

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

kBtu/hr_{heat} = capacity of the heating equipment in kBtu per hour.
= Actual installed

3.412 = Btu per Wh.

COP_{base} = coefficient of performance of the baseline equipment; see table above for values.

COP_{eff} = coefficient of performance of the energy efficient equipment.
= Actual installed

Annual kWh Savings_{cool} = (kBtu/hr_{cool}) \times [(1/SEER_{base}) - (1/SEER_{ee})] \times EFLH_{cool}

Annual kWh Savings_{heat} = (kBtu/hr_{heat}) \times [(1/HSPF_{base}) - (1/HSPF_{ee})] \times EFLH_{heat}

For example a 5 ton cooling unit at a restaurant in Chicago with 60 kbtu heating with an efficient EER of 14 and an efficient HSPF of 9 saves

\[ \Delta kW = (60) \times [(1/13) - (1/14)] \times 1134 + [(60) \times [(1/7.7) - (1/9)] \times 1354 \]

\[ = 1650 \text{ kWh} \]

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

\[ \Delta kW = (kBtu/hr_{cool}) \times [(1/EER_{base}) - (1/EER_{ee})] \times CF \]

Where CF value is chosen between:

- CF_{SSP} = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)
- CF_{SSP} = 91.3\% \text{ \textsuperscript{306}}
- CF_{PJM} = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)
- CF_{PJM} = 47.8\% \text{ \textsuperscript{307}}

For example a 5 ton cooling unit with 60 kbtu heating with an efficient EER of 14 and an efficient HSPF of 9 saves

\[ \Delta kW = [(60) \times [(1/13) - (1/14)]] \times .913 \]

\[ = 0.3 \]

**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-V03-150601**

\textsuperscript{306} 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.

\textsuperscript{307} 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.
4.4.10 High Efficiency Boiler

**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 or multifamily 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 gases. Because multiple heat exchangers are used to remove waste heat from the escaping flue gases, some of the flue gases 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% for hot water boilers and 81% for steam boilers.

**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/hr and is Final Rule, Federal Register, volume 74, Number 139, Wednesday, July 22, 2009 for boiler ≥300,000 Btu/hr.

Hot water boiler baseline:

<table>
<thead>
<tr>
<th>Year</th>
<th>Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot Water &lt;300,000 Btu/hr &lt; June 1, 2013</td>
<td>80% AFUE</td>
</tr>
<tr>
<td>Hot Water &lt;300,000 Btu/hr ≥ June 1, 2013</td>
<td>82% AFUE</td>
</tr>
<tr>
<td>Hot Water ≥300,000 &amp; ≤2,500,000 Btu/hr</td>
<td>80% TE</td>
</tr>
<tr>
<td>Hot Water &gt;2,500,000 Btu/hr</td>
<td>82% Ec</td>
</tr>
</tbody>
</table>

308 The Federal baseline for boilers <300,000 btu/hr changes from 80% to 82% in September 2012. To prevent a change in baseline mid-program, the increase in efficiency is delayed until June 2013 when a new program year starts.
Steam boiler baseline:

<table>
<thead>
<tr>
<th>Year</th>
<th>Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam &lt;300,000 Btu/hr &lt; June 1, 2013</td>
<td>75% AFUE</td>
</tr>
<tr>
<td>Steam &lt;300,000 Btu/hr ≥ June 1, 2013</td>
<td>80% AFUE</td>
</tr>
<tr>
<td>Steam - all except natural draft ≥300,000 &amp; ≤2,500,000 Btu/hr</td>
<td>79% TE</td>
</tr>
<tr>
<td>Steam - natural draft ≥300,000 &amp; ≤2,500,000 Btu/hr</td>
<td>77% TE</td>
</tr>
<tr>
<td>Steam - all except natural draft &gt;2,500,000 Btu/hr</td>
<td>79% TE</td>
</tr>
<tr>
<td>Steam - natural draft &gt;2,500,000 Btu/hr</td>
<td>77% TE</td>
</tr>
</tbody>
</table>

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The expected measure life is assumed to be 20 years.\(^{310}\)

**DEEMED MEASURE COST**

The incremental capital cost for this measure depends on efficiency as listed below.\(^{311}\)

<table>
<thead>
<tr>
<th>Measure Tier</th>
<th>Incr. Cost, per unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENERGY STAR® Minimum</td>
<td>$1,470</td>
</tr>
<tr>
<td>AFUE 90%</td>
<td>$2,400</td>
</tr>
<tr>
<td>AFUE 95%</td>
<td>$3,370</td>
</tr>
<tr>
<td>AFUE ≥ 96%</td>
<td>$4,340</td>
</tr>
<tr>
<td>Boilers &gt; 300,000 Btu/hr with TE (thermal efficiency) rating</td>
<td>Custom</td>
</tr>
</tbody>
</table>

**LOADSHAPE**

N/A

**COINCIDENCE FACTOR**

N/A

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\(^{309}\) Ibid.

\(^{310}\) 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.

\(^{311}\) Average of low and high incremental cost based on Nicor Gas 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.
Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

\[ \Delta \text{Therms} = \text{EFLH} \times \text{Capacity} \times \left( \frac{\text{EfficiencyRating(actual)} - \text{EfficiencyRating(base)}}{\text{EfficiencyRating(base)}} \right) / 100,000 \]

Where:

- EFLH = Equivalent Full Load Hours for heating are provided in section 4.4 HVAC End Use
- Capacity = Nominal Heating Input Capacity Boiler Size (Btu/hr) for efficient unit not existing unit
  = custom Boiler input capacity in Btu/hr
- EfficiencyRating(base) = Baseline Boiler Efficiency Rating, dependant on year and boiler type. Baseline efficiency values by boiler type and capacity are found in the Definition of Baseline Equipment Section
- EfficiencyRating(actual) = Efficient Boiler Efficiency Rating use actual value

<table>
<thead>
<tr>
<th>Measure Type</th>
<th>Actual AFUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENERGY STAR® Minimum</td>
<td>85%</td>
</tr>
<tr>
<td>AFUE 90%</td>
<td>90%</td>
</tr>
<tr>
<td>AFUE 95%</td>
<td>95%</td>
</tr>
<tr>
<td>AFUE ≥ 96%</td>
<td>≥ 96%</td>
</tr>
<tr>
<td>Custom</td>
<td>Value to one significant digit i.e. 95.7%</td>
</tr>
</tbody>
</table>

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

\[ \Delta \text{Therms} = 2,089 \times 150,000 \times \left( \frac{0.90 - 0.80}{0.80} \right) / 100,000 \text{ Btu/Therm} \]

\[ \Delta \text{Therms} = 392 \text{ Therms} \]

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A
DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-BOIL-V05-150601
4.4.11 High Efficiency Furnace

**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 and EREP. If applied to other program types, the measure savings should be verified.

**Time of Sale:**

a. The installation of a new high efficiency, gas-fired condensing furnace in a commercial location. This could relate to the replacement of an existing unit at the end of its useful life, or the installation of a new system.

**Early Replacement:**

a. The early removal of an existing functioning AFUE 75% or less furnace from service, prior to its natural end of life, and replacement with a new high efficiency 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. At time of writing, the DOE had rescinded the next Federal Standard change for furnaces; however it is likely that a new standard will be in effect after the assumed remaining useful life of the existing unit. For the purposes of this measure- the new baseline is assumed to be 90%.

b. The assumption of the existing unit efficiency in the Early Replacement section of this TRM is based upon the average efficiency of units that were classified in Ameren’s PY3-PY4 as functioning and AFUE <=75%. Therefore it is only appropriate to use these Early Replacement assumptions where those conditions are met. The TAC defined “functioning” as the unit is fully operational – providing sufficient space conditioning (i.e. heat exchanger, compressors, pumps work effectively) and/or the cost of repair is under 20% of the new baseline replacement cost. Therefore in order to apply early replacement assumptions the programs should apply the following eligibility criteria: AFUE <=75% and cost of any repairs <$528.

**DEFINITION OF EFFICIENT EQUIPMENT**

To qualify for this measure the installed equipment must be a furnace with input energy less than 225,000 Btu/hr rated natural gas fired furnace with an Annual Fuel Utilization Efficiency (AFUE) rating and fan electrical efficiency exceeding the program requirements:

**DEFINITION OF BASELINE EQUIPMENT**

Time of Sale: 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%. The baseline will be adjusted when the Federal Standard is updated.

Early replacement: The baseline for this measure is the efficiency of the existing equipment for the assumed remaining useful life of the unit and a new baseline unit for the remainder of the measure life. As discussed above we estimate that the new baseline unit that could be purchased in the year the existing unit would have needed replacing is 90%.
DEFINITION OF MEASURE LIFE

The expected measure life is assumed to be 16.5 years\(^{312}\).
Remaining life of existing equipment is assumed to be 5.5 years\(^{313}\).

DEEMED MEASURE COST

Time of Sale: The incremental capital cost for this measure depends on efficiency as listed below\(^{314}\):

<table>
<thead>
<tr>
<th>AFUE</th>
<th>Installation Cost</th>
<th>Incremental Install Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>80%</td>
<td>$2011</td>
<td>n/a</td>
</tr>
<tr>
<td>90%</td>
<td>$2641</td>
<td>$630</td>
</tr>
<tr>
<td>91%</td>
<td>$2727</td>
<td>$716</td>
</tr>
<tr>
<td>92%</td>
<td>$2813</td>
<td>$802</td>
</tr>
<tr>
<td>93%</td>
<td>$3049</td>
<td>$1,038</td>
</tr>
<tr>
<td>94%</td>
<td>$3286</td>
<td>$1,275</td>
</tr>
<tr>
<td>95%</td>
<td>$3522</td>
<td>$1,511</td>
</tr>
<tr>
<td>96%</td>
<td>$3758</td>
<td>$1,747</td>
</tr>
</tbody>
</table>

Early Replacement: The full installation cost is provided in the table above. The assumed deferred cost (after 5.5 years) of replacing existing equipment with a new baseline unit is assumed to be $2641. This cost should be discounted to present value using the utilities’ discount rate.

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

\[ \Delta kWh = \text{Heating Savings} + \text{Cooling Savings} + \text{Shoulder Season Savings} \]

Where:

\(^{312}\) Average of 15-18 year lifetime estimate made by the Consortium for Energy Efficiency in 2010.

\(^{313}\) Assumed to be one third of effective useful life

\(^{314}\) Based on data from Appendix E of the Appliance Standards Technical Support Documents including equipment cost and installation labor (http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/fb_fr_tsd/appendix_e.pdf). Where efficiency ratings are not provided, the values are interpolated from those that are.
Heating Savings = Brushless DC motor or Electronically commutated motor (ECM)  
= 418 kWh

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

Shoulder Season Savings = Brushless DC motor or electronically commutated motor (ECM) savings during shoulder seasons
= 51 kWh

**EXAMPLE**
For example, a blower motor in an office building where air conditioning presence is unknown:

\[ \Delta \text{kWh} = \text{Heating Savings} + \text{Cooling Savings} + \text{Shoulder Season Savings} \]

\[ \Delta \text{kWh} = 418 + 263 + 51 \]

\[ \Delta \text{kWh} = 732 \text{kWh} \]

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**
For units that have evaporator coils and condensing units and are cooling in the summer in addition to heating in the winter the summer coincident peak demand savings should be calculated. If the unit is not equipment with coils or condensing units, the summer peak demand savings will not apply.

\[ \Delta \text{kW} = (\Delta \text{kWh}/\text{HOURSyear}) \times \text{CF} \]

Where:

\[ \text{HOURSyear} = \text{Actual hours per year if known, otherwise use hours from Table below for building type} \]

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Pumps and fans (h/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>College/University</td>
<td>4216</td>
</tr>
<tr>
<td>Grocery</td>
<td>5840</td>
</tr>
<tr>
<td>Heavy Industry</td>
<td>3585</td>
</tr>
<tr>
<td>Hotel/Motel</td>
<td>6872</td>
</tr>
</tbody>
</table>

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.

The weighted average value is based on assumption that 75% of buildings installing BPM furnace blower motors have Central AC.

ComEd Trm June 1, 2010 page 139. The Office hours is based upon occupancy from the eQuest model developed for EFLH, since it was agreed the ComEd value was too low.
### Building Type Pumps and fans (h/yr)

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Pumps and fans (h/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light Industry</td>
<td>2465</td>
</tr>
<tr>
<td>Medical</td>
<td>6871</td>
</tr>
<tr>
<td>Office</td>
<td>2301</td>
</tr>
<tr>
<td>Restaurant</td>
<td>4654</td>
</tr>
<tr>
<td>Retail/Service</td>
<td>3438</td>
</tr>
<tr>
<td>School (K-12)</td>
<td>2203</td>
</tr>
<tr>
<td>Warehouse</td>
<td>3222</td>
</tr>
<tr>
<td>Average = Miscellaneous</td>
<td>4103</td>
</tr>
</tbody>
</table>

CF = Summer Peak Coincidence Factor for measure is provided below for different building types:

<table>
<thead>
<tr>
<th>Location</th>
<th>CF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Restaurant</td>
<td>0.80</td>
</tr>
<tr>
<td>Office</td>
<td>0.66</td>
</tr>
<tr>
<td>School (K-12)</td>
<td>0.22</td>
</tr>
<tr>
<td>College/University</td>
<td>0.56</td>
</tr>
<tr>
<td>Medical</td>
<td>0.75</td>
</tr>
</tbody>
</table>

**EXAMPLE**

For example, a blower motor in an office building where air conditioning presence is unknown:

\[
\Delta kW = (732 / 2301) * 0.66
\]

\[
= 0.21 kW
\]

**NATURAL GAS ENERGY SAVINGS**

Time of Sale:

\[
\Delta \text{Therms} = \text{EFLH} * \text{Capacity} * \left( \frac{(AFUE(\text{eff}) - AFUE(\text{base})/AFUE(\text{base}))}{100,000 \text{ Btu/Therm}} \right)
\]

Early replacement:

\[
\Delta \text{Therms for remaining life of existing unit (1st 5.5 years)}:
\]

---

318 Based on DEER 2008 values
319 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).
\[ \Delta \text{Therms} = EFLH \times \text{Capacity} \times (\text{AFUE(eff)} - \text{AFUE(exist)}) / 100,000 \text{ Btu/Therm} \]

\[ \Delta \text{Therms for remaining measure life (next 11 years):} \]
\[ \Delta \text{Therms} = EFLH \times \text{Capacity} \times (\text{AFUE(eff)} - \text{AFUE(base)}) / 100,000 \text{ Btu/Therm} \]

Where:

- **EFLH** = Equivalent Full Load Hours for heating are provided in section 4.4 HVAC End Use.
- **Capacity** = Nominal Heating Input Capacity Furnace Size (Btu/hr) for efficient unit not existing unit.
  - = custom Furnace input capacity in Btu/hr
- **AFUE(exist)** = Existing Furnace Annual Fuel Utilization Efficiency Rating
  - = Use actual AFUE rating where it is possible to measure or reasonably estimate.
  - If unknown, assume 64.4 AFUE% \(^{320}\).
- **AFUE(base)** = Baseline Furnace Annual Fuel Utilization Efficiency Rating, dependant on year as listed below:
  - Dependent on program type as listed below \(^{321}\):
    | Program Year       | AFUE(base) |
    |--------------------|------------|
    | Time of Sale       | 80%        |
    | Early Replacement  | 90%        |

- **AFUE(ef)** = Efficient Furnace Annual Fuel Utilization Efficiency Rating.
  - = Actual. If Unknown, assume 95% \(^{322}\).

**EXAMPLE**

For example, a 150,000 btu/hr 92% efficient furnace at a low rise office building in Rockford, in the year 2012

\[ \Delta \text{Therms} = 1428 \times 150,000 \times ((0.92-0.80)/0.80)/ 100,000 = 321 \text{ Therms} \]

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

\(^{320}\) Average nameplate efficiencies of all Early Replacement qualifying equipment in Ameren PY3-PY4.

\(^{321}\) 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.

\(^{322}\) Minimum ENERGY STAR efficiency after 2.1.2012.
MEASURE CODE: CI-HVC-FRNC-V04-150601
4.4.12 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\(^{323}\)

DEEMED MEASURE COST

The incremental capital cost for this measure is $1716\(^{324}\)

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

\(^{323}\)ENERGY STAR and CEE do not currently provide calculators for this type of equipment therefore deemed values from Nicor Gas were used. Nicor Gas Energy Efficiency Plan 2011-2014. Revised Plan Filed Pursuant to Order Docket 10-0562, May 27, 2011

\(^{324}\)Ibid.
**NATURAL GAS ENERGY SAVINGS**

The annual natural gas energy savings from this measure is a deemed value equaling 451 Therms.\(^{325}\)

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-HVC-IRHT-V01-120601**

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\(^{325}\) 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.
4.4.13 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 characterizes:

   a) Time of Sale: the purchase and installation of a new efficient PTAC or PTHP.
   b) Early Replacement: the early removal of an existing PTAC or PTHP from service, prior to its natural end of life, and replacement with a new efficient PTAC or PTHP 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. The measure is only valid for non-fuel switching installations — for example replacing a cooling only PTAC with a PTHP can currently not use the TRM.

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 PTACs or PTHPs that exceed baseline efficiencies.

DEFINITION OF BASELINE EQUIPMENT

Time of Sale: the baseline conditions is provided in the Federal Baseline reference table provided below.

Early Replacement: the baseline is the existing PTAC or PTHP for the assumed remaining useful life of the unit and the new baseline as defined above for the remainder of the measure life.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 15 years.  

Remaining life of existing equipment is assumed to be 5 years

DEEMED MEASURE COST

Time of Sale: The incremental capital cost for this equipment is estimated to be $84/ton.

Early Replacement: The measure cost is the full cost of removing the existing unit and installing a new one. The actual program cost should be used. If unknown assume $1,047 per ton.

The assumed deferred cost (after 5 years) of replacing existing equipment with new baseline unit is assumed to be

---

327 Standard assumption of one third of effective useful life.
328 DEER 2008. This assumes that baseline shift from IECC 2006 to IECC 2012 carries the same incremental costs. Values should be verified during evaluation
329 Based on DCEO – IL PHA Efficient Living Program data.
$963 per ton\textsuperscript{330}. This cost should be discounted to present value using the utilities’ discount rate.

**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.

\[
\begin{align*}
CF_{SSP} &= \text{Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)} \\
&= 91.3\% \text{\textsuperscript{331}} \\
CF_{PJM} &= \text{PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)} \\
&= 47.8\% \text{\textsuperscript{332}}
\end{align*}
\]

Algorithm

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

Electric savings for PTACs and PTHPs should be calculated using the following algorithms

**ENERGY SAVINGS**

Time of Sale:

\[
\begin{align*}
\text{PTAC } \Delta \text{kWh} &= \text{Annual kWh Savings}_{\text{cool}} \\
\text{PTHP } \Delta \text{kWh} &= \text{Annual kWh Savings}_{\text{cool}} + \text{Annual kWh Savings}_{\text{heat}}
\end{align*}
\]

\[
\begin{align*}
\text{Annual kWh Savings}_{\text{cool}} &= (\text{kBtu/hr}_{\text{cool}}) \times [(1/\text{EER}_{\text{base}}) - (1/\text{EER}_{\text{ee}})] \times \text{EFLH}_{\text{cool}} \\
\text{Annual kWh Savings}_{\text{heat}} &= (\text{kBtu/hr}_{\text{heat}})/3.412 \times [(1/\text{COP}_{\text{base}}) - (1/\text{COP}_{\text{ee}})] \times \text{EFLH}_{\text{heat}}
\end{align*}
\]

Early Replacement:

\[
\Delta \text{kWh for remaining life of existing unit (1st 5 years)} = \text{Annual kWh Savings}_{\text{cool}} + \text{Annual kWh Savings}_{\text{heat}}
\]

\textsuperscript{330} Based on subtracting TOS incremental cost from the DCEO data.  
\textsuperscript{331} 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.  
\textsuperscript{332} 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.  
\textsuperscript{333} There are no heating efficiency improvements for PTACs since although some do provide heating, it is always through electric resistance and therefore the COPbase and COPee would be 1.0.
Annual kWh Savings<sub>cool</sub> = (kBtu/hr<sub>cool</sub>) * [(1/EER<sub>exist</sub>) – (1/EER<sub>ee</sub>)] * EFLH<sub>cool</sub>

Annual kWh Savings<sub>heat</sub> = (kBtu/hr<sub>heat</sub>) / 3.412 * [(1/COP<sub>exist</sub>) – (1/COP<sub>ee</sub>)] * EFLH<sub>heat</sub>

ΔkWh for remaining measure life (next 10 years) = Annual kWh Savings<sub>cool</sub> + Annual kWh Savings<sub>heat</sub>

Annual kWh Savings<sub>cool</sub> = (kBtu/hr<sub>cool</sub>) * [(1/EER<sub>base</sub>) – (1/EER<sub>ee</sub>)] * EFLH<sub>cool</sub>

Annual kWh Savings<sub>heat</sub> = (kBtu/hr<sub>heat</sub>) / 3.412 * [(1/COP<sub>base</sub>) – (1/COP<sub>ee</sub>)] * EFLH<sub>heat</sub>

Where:

kBtu/hr<sub>cool</sub> = capacity of the cooling equipment in kBtu per hour (1 ton of cooling capacity equals 12 kBtu/hr).

EFLH<sub>cool</sub> = Equivalent Full Load Hours for cooling are provided in section 4.4 HVAC End Use:

EFLH<sub>heat</sub> = Equivalent Full Load Hours for heating are provided in section 4.4 HVAC End Use

EER<sub>exist</sub> = Energy Efficiency Ratio of the existing equipment

EER<sub>base</sub> = Energy Efficiency Ratio of the baseline equipment; see the table below for values.

Copy of Table C403.2.3(3), IECC 2012: Minimum Efficiency Requirements: Electrically operated packaged terminal air conditioners, packaged terminal heat pumps

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>Minimum Efficiency as of 10/08/2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTAC (Cooling mode)</td>
<td></td>
</tr>
<tr>
<td>New Construction</td>
<td>13.8 – (0.300 x Cap/1000) EER</td>
</tr>
<tr>
<td>Replacements</td>
<td>10.9 – (0.213 x Cap/1000) EER</td>
</tr>
<tr>
<td>PTHP (Cooling mode)</td>
<td></td>
</tr>
<tr>
<td>New Construction</td>
<td>14.0 – (0.300 x Cap/1000) EER</td>
</tr>
<tr>
<td>Replacements</td>
<td>10.8 – (0.213 x Cap/1000) EER</td>
</tr>
<tr>
<td>PTHP (Heating mode)</td>
<td></td>
</tr>
<tr>
<td>New Construction</td>
<td>3.2 – (0.026 x Cap/1000) COP</td>
</tr>
<tr>
<td>Replacements</td>
<td>2.9 – (0.026 x Cap/1000) COP</td>
</tr>
</tbody>
</table>

“Cap” = The rated cooling capacity of the project in Btu/hr. If the units capacity is less than 7000 Btu/hr, use 7,000 Btu/hr in the calculation. If the unit’s capacity is greater

334 Estimated using the IECC building energy code up until year 2003 (p107; https://law.resource.org/pub/us/code/ibr/icc.iecc.2000.pdf) and assuming a 1 ton unit; EER = 10 – (0.16 * 12,000/1,000) = 8.1.
than 15,000 Btu/hr, use 15,000 Btu/hr in the calculations.

Replacement unit shall 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 (406mm) in height and less than 42 inches (1067 mm) in width.

\[ \text{EER}_{ee} = \text{Energy Efficiency Ratio of the energy efficient equipment. For air-cooled air conditioners < 65 kBtu/hr, if the actual EER}_{ee} \text{ is unknown, assume the following conversion from SEER to EER: EER = SEER/1.1.} \]

\[ k\text{Btu/hr}_{heating} = \text{capacity of the heating equipment in kBtu per hour.} \]

\[ 3.412 = \text{Btu per Wh.} \]

\[ \text{COP}_{exist} = \text{coefficient of performance of the existing equipment} \]

\[ = \text{Actual. If unknown assume 1.0 COP for PTAC units and 2.6 COP}^{335} \text{ for PTHPs.} \]

\[ \text{COP}_{base} = \text{coefficient of performance of the baseline equipment; see table above for values.} \]

\[ \text{COP}_{ee} = \text{coefficient of performance of the energy efficient equipment.} \]

\[ = \text{Actual installed} \]

### Time of Sale (assuming new construction baseline):

For example a 1 ton PTAC with an efficient EER of 12 at a hotel in Rockford saves:

\[ = [(12) * [(1/10.2) – (1/12)] * 1,042 \]

\[ = 184 \text{ kWh} \]

### Early Replacement (assuming replacement baseline for deferred replacement in 5 years):

For example a 1 ton PTHP with an efficient EER of 12, COP of 3.0 in Rockford replaces a PTAC unit (with electric resistance heat) with unknown efficiency.

\[ \Delta k\text{Wh for remaining life of existing unit (1st 5 years)} \]

\[ = (12 * (1/8.1 – 1/12) * 1,042) + (12/3.412 * (1/1.0 – 1/3.0) * 1,758) \]

\[ = 502 + 4,122 \]

\[ = 4,624 \text{ kWh} \]

\[ \Delta k\text{Wh for remaining measure life (next 10 years)} \]

\[ = (12 * (1/8.3 – 1/12) * 1,042) + (12/3.412 * (1/1.0 – 1/3.0) * 1,758) \]

\[ = 465 + 4,122 \]

\[ = 34,587 \text{ kWh} \]

---

335 Estimated using the IECC building energy code up until year 2003 (p107; https://law.resource.org/pub/us/code/ibr/icc.iecc.2000.pdf) and assuming a 1 ton unit; COP = 2.9 – (0.026 * 12,000/1,000) = 2.6
**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

**Time of Sale:**

$$\Delta kW = \text{kBtu/hr}_{cool} \times [(1/EER_{base}) - (1/EER_{ee})] \times CF$$

**Early Replacement:**

- \(\Delta kW\) for remaining life of existing unit (1st 5 years):
  $$\Delta kW = \text{kBtu/hr}_{cool} \times [(1/EER_{exist}) - (1/EER_{ee})] \times CF$$
- \(\Delta k\text{Wh}\) for remaining measure life (next 10 years):
  $$\Delta k\text{Wh} = \text{kBtu/hr}_{cool} \times [(1/EER_{base}) - (1/EER_{ee})] \times CF$$

**Where:**

- \(CF_{SSP}\) = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour) = 91.3% \(^{336}\)
- \(CF_{PJM}\) = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period) = 47.8% \(^{337}\)

**Time of Sale:**

For example a 1 ton replacement cooling unit with no heating with an efficient EER of 12 at a hotel in Rockford saves

$$\Delta kW_{SSP} = 12 \times (1/10.2 - 1/12) \times 0.913$$

$$\Delta kW_{SSP} = 0.16 \text{kW}$$

For example a 1 ton PTHP with an efficient EER of 12, COP of 3.0 in Rockford replaces a PTAC unit with unknown efficiency.

$$\Delta kW = 12 \times (1/8.1 - 1/12) \times 0.913$$

$$\Delta kW = 0.44 \text{kW}$$

$$\Delta kW = 12 \times (1/8.3 - 1/12) \times 0.913$$

$$\Delta kW = 0.41 \text{kW}$$

**NATURAL GAS ENERGY SAVINGS**

N/A

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

\(^{336}\) 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.

\(^{337}\) 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: CI-HVC-PTAC-V05-150601
4.4.14 Pipe Insulation

**DESCRIPTION**

This measure provides rebates for installation of ≥1” or ≥2” fiberglass, foam, calcium silicate or other types of insulation with similar insulating properties to existing bare pipe on straight piping as well as other pipe components such as elbows, tees, valves, and flanges for all non-residential installations.

Default per linear foot savings estimates are provided for the both exposed indoor or above ground outdoor piping distributing fluid in the following system types (natural gas fired systems only):

- Hydronic heating systems (with or without outdoor reset controls), including:
  - boiler systems that do not circulate water around a central loop and operate upon demand from a thermostat (“non-recirculation”)
  - systems that recirculate during heating season only (“Recirculation – heating season only”)
  - systems recirculating year round (“Recirculation – year round”)
- Domestic hot water
- Low and high-pressure steam systems
  - non-recirculation
  - recirculation - heating season only
  - recirculation - year round

Process piping can also use the algorithms provided but requires custom entry of hours.

Minimum qualifying nominal pipe diameter is 1.” Indoor piping must have at least 1” of insulation and outdoor piping must have at least 2” of insulation and include an all-weather protective jacket. New advanced insulating materials may be thinner and savings can be calculated with 3E Plus.

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 efficient case is installing pipe wrap insulation to a length of pipe. Indoor piping must have at least 1” of insulation (or equivalent R-value) and outdoor piping must have at least 2” of insulation (or equivalent R-value) and include an all-weather protective jacket. Minimum qualifying pipe diameter is 1.” Insulation must be continuous and contiguous over fittings that directly connect to straight pipe, including elbows and tees. 338

**DEFINITION OF BASELINE EQUIPMENT**

The base case for savings estimates is a bare pipe. Pipes are required by new construction code to be insulated but are still commonly found uninsulated in older commercial buildings.

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The measure life is assumed to be 15 years. 339

---

DEEMED MEASURE COST

Actual costs should be used if known. Otherwise the deemed measure costs below based on RS Means\(^{340}\) pricing reference materials may be used.\(^{341}\) The following table summarizes the estimated costs for this measure per foot of insulation added and include installation costs:

<table>
<thead>
<tr>
<th>Insulation Thickness</th>
<th>1 Inch (Indoor)</th>
<th>2 Inches (Outdoor)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipe- RS Means #</td>
<td>220719.10.5170</td>
<td>220719.10.5530</td>
</tr>
<tr>
<td>Jacket- RS Means #</td>
<td>220719.10.0156</td>
<td>220719.10.0320</td>
</tr>
<tr>
<td>Jacket Type</td>
<td>PVC</td>
<td>Aluminum</td>
</tr>
<tr>
<td>Insulation Cost per foot</td>
<td>$9.40</td>
<td>$13.90</td>
</tr>
<tr>
<td>Jacket Cost per foot</td>
<td>$4.57</td>
<td>$7.30</td>
</tr>
<tr>
<td><strong>Total Cost per foot</strong></td>
<td><strong>$13.97</strong></td>
<td><strong>$21.20</strong></td>
</tr>
</tbody>
</table>

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**

\[
\Delta \text{therms per foot}^{342} = \frac{((Q_{\text{base}} - Q_{\text{eff}}) \times \text{EFLH})}{(100,000 \times \eta_{\text{Boiler}})} \times \text{TRF} \\
= \text{[Provided by tables below]} \times \text{TRF}
\]

\(^{340}\) RS Means 2008. Mechanical Cost Data, pages 106 to 119
\(^{341}\) RS Means 2010: “for fittings, add 3 linear feet for each fitting plus 4 linear feet for each flange of the fitting”
\(^{342}\) This value comes from the reference table “Savings Summary by Building Type and System Type.” The formula and the input tables in this section document assumptions used in calculation spreadsheet “Pipe Insulation Savings 2013-11-12.xlsx”
Δtherms = (L_{sp} + L_{oc,i}) \times \text{Δtherms per foot}

Where:

- EFLH = Equivalent Full Load Hours for Heating
  = Actual or defaults by building type provided in Section 4.4, HVAC end use
  For year round recirculation or domestic hot water:
  = 8,766
  For heating season recirculation, hours with the outside air temperature below 55°F:

<table>
<thead>
<tr>
<th>Zone</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone 1 (Rockford)</td>
<td>5,039</td>
</tr>
<tr>
<td>Zone 2 (Chicago)</td>
<td>4,963</td>
</tr>
<tr>
<td>Zone 3 (Springfield)</td>
<td>4,495</td>
</tr>
<tr>
<td>Zone 4 (Belleville)</td>
<td>4,021</td>
</tr>
<tr>
<td>Zone 5 (Marion)</td>
<td>4,150</td>
</tr>
<tr>
<td>Zone 1 (Rockford)</td>
<td>5,039</td>
</tr>
</tbody>
</table>

Q_{base} = Heat Loss from Bare Pipe (Btu/hr/ft)
= See table below

Q_{eff} = Heat Loss from Insulated Pipe (Btu/hr/ft)
= See table below

100,000 = conversion factor (1 therm = 100,000 Btu)

\eta_{Boiler} = Efficiency of the boiler being used to generate the hot water or steam in the pipe
= 81.9% for water boilers
= 80.7% for steam boilers, except multifamily low-pressure
= 64.8% for multifamily low-pressure steam boilers

TRF = Thermal Regain Factor for space type, applied only to space heating energy and is applied to values resulting from Δtherms/ft tables below
= See table below for base TRF values by pipe location

---

343 Average efficiencies of units from the California Energy Commission (CEC).
344 Ibid.
346 Thermal regain for residential pipe insulation measures is discussed in Home Energy Services Impact Evaluation, prepared for the Massachusetts Residential Retrofit and Low Income Program Area Evaluation, Cadmus Group, Inc., August 2012 and Andrews, John, Better Duct Systems for Home Heating and Cooling, U.S. Department of Energy, 2001. Recognizing the differences between residential and commercial heating systems, the factors have been adjusted based on professional judgment. This factor would benefit from additional study and evaluation.
May vary seasonally such as: TRF[summer] * summer hours + TRF[winter] * winter hours where TRF values reflecting summer and winter conditions are apportioned by the hours for those conditions. TRF may also be adjusted by building specific balance temperature and operating hours above and below that balance temperature.\textsuperscript{347}

<table>
<thead>
<tr>
<th>Pipe Location</th>
<th>Assumed Regain</th>
<th>TRF, Thermal Regain Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outdoor</td>
<td>0%</td>
<td>1.0</td>
</tr>
<tr>
<td>Indoor, heated space</td>
<td>85%</td>
<td>0.15</td>
</tr>
<tr>
<td>Indoor, semi-heated, (unconditioned space, with heat transfer to conditioned space. E.g.: boiler room, ceiling plenum, basement, crawlspace, wall)</td>
<td>30%</td>
<td>0.70</td>
</tr>
<tr>
<td>Indoor, unheated, (no heat transfer to conditioned space)</td>
<td>0%</td>
<td>1.0</td>
</tr>
<tr>
<td>Location not specified</td>
<td>85%</td>
<td>0.15</td>
</tr>
<tr>
<td>Custom</td>
<td>Custom</td>
<td>1 – assumed regain</td>
</tr>
</tbody>
</table>

$L_{sp} = \text{Length of straight pipe to be insulated (linear foot)}$

$L_{oc,I} = \text{actual installed (linear foot)}$

$L_{oc,I} = \text{Total equivalent length of the other components (valves and tees) of pipe to be insulated}$

$L_{sp} = \text{Actual installed (linear foot). See table "Equivalent Length of Other Components – Elbows and Tees" for equivalent lengths.}$

The heat loss estimates ($Q_{\text{base}}$ and $Q_{\text{eff}}$) were developed using the 3E Plus v4.0 software program.\textsuperscript{348} The energy savings analysis is based on adding 1-inch (indoor) or 2-inch (outdoor) thick insulation around bare pipe. The thermal conductivity of pipe insulation varies by material and temperature rating; to obtain a typical value, a range of materials allowed for this measure were averaged. For insulation materials not in the table below, use 3E Plusv4.0 software to calculate $Q_{\text{base}}$ and $Q_{\text{eff}}$.

\textsuperscript{347} Thermal Regain Factor_4-30-14.docx

\textsuperscript{348} 3E Plus is a heat loss calculation software provided by the NAIMA (North American Insulation Manufacturer Association).
### Insulation Type, Conductivity, and Max Temp

<table>
<thead>
<tr>
<th>Insulation Type</th>
<th>Conductivity (Btu.in / hr.ft².ºF @ 75ºF)</th>
<th>Max temp (ºF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polyethylene foam</td>
<td>0.25</td>
<td>200</td>
</tr>
<tr>
<td>Flexible polyurethane-based foam</td>
<td>0.27</td>
<td>200</td>
</tr>
<tr>
<td>Fiberglass</td>
<td>0.31</td>
<td>250</td>
</tr>
<tr>
<td>Melamine foam</td>
<td>0.26</td>
<td>350</td>
</tr>
<tr>
<td>Flexible silicon foam</td>
<td>0.40</td>
<td>392</td>
</tr>
<tr>
<td>Calcium silicate</td>
<td>0.40</td>
<td>1200</td>
</tr>
<tr>
<td>Cellular glass</td>
<td>0.31</td>
<td>400</td>
</tr>
<tr>
<td>Average conductivity of all these materials (Btu.in / hr.ft².ºF @ 75ºF)</td>
<td>0.31</td>
<td></td>
</tr>
</tbody>
</table>

The pipe fluid temperature assumption used depends upon both the system type and whether there is outdoor reset controls:

<table>
<thead>
<tr>
<th>System Type</th>
<th>Fluid temperature assumption (ºF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot Water space heating with outdoor reset - Non recirculation</td>
<td>145</td>
</tr>
<tr>
<td>Hot Water space heating without outdoor reset - Non recirculation</td>
<td>170</td>
</tr>
<tr>
<td>Hot Water space heating with outdoor reset – Recirculation heating season only</td>
<td>145</td>
</tr>
<tr>
<td>Hot Water space heating without outdoor reset – Recirculation heating season only</td>
<td>170</td>
</tr>
<tr>
<td>Hot Water space heating with outdoor reset – Recirculation year round</td>
<td>130</td>
</tr>
<tr>
<td>Hot Water space heating without outdoor reset – Recirculation year round</td>
<td>170</td>
</tr>
<tr>
<td>Domestic Hot Water</td>
<td>125</td>
</tr>
<tr>
<td>Low Pressure Steam</td>
<td>225</td>
</tr>
<tr>
<td>High Pressure Steam</td>
<td>312</td>
</tr>
</tbody>
</table>
### Pipe Insulation

<table>
<thead>
<tr>
<th></th>
<th>Indoor Insulation, Hot Water</th>
<th>Indoor Insulation, Low Pressure Steam</th>
<th>Indoor Insulation, High Pressure Steam</th>
<th>Domestic Hot Water</th>
<th>Outdoor Insulation, Hot Water</th>
<th>Outdoor Insulation, Low Pressure Steam</th>
<th>Outdoor Insulation, High Pressure Steam</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insulation thickness (inch)</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Temperature, Fluid in Pipe (°F)</td>
<td>170 (w/o reset)</td>
<td>225</td>
<td>312</td>
<td>125</td>
<td>170 (w/o reset)</td>
<td>225</td>
<td>312</td>
</tr>
<tr>
<td></td>
<td>145 (w/ reset heat)</td>
<td>145 (w/ reset heat)</td>
<td>130 (w/ reset year)</td>
<td>145 (w/ reset heat)</td>
<td>130 (w/ reset year)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Av. steam pressure (psig)</td>
<td>n/a</td>
<td>10.9</td>
<td>82.8</td>
<td>n/a</td>
<td>10.9</td>
<td>82.8</td>
<td></td>
</tr>
<tr>
<td>Operating Time (hrs/yr)</td>
<td>2,746 (non-recirc)</td>
<td>5,039 (recirc heating season)</td>
<td>8,760 (recirc year round)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ambient Temperature (°F)</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>48.6</td>
<td>48.6</td>
<td>48.6</td>
</tr>
<tr>
<td>Wind speed (mph)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>9.4</td>
<td>9.4</td>
<td>9.4</td>
</tr>
<tr>
<td><strong>Pipe parameters</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pipe material</td>
<td>Copper</td>
<td>Steel</td>
<td>Steel</td>
<td>Copper</td>
<td>Copper</td>
<td>Steel</td>
<td>Steel</td>
</tr>
<tr>
<td>Pipe size for Heat Loss Calc</td>
<td>2&quot;</td>
<td>2&quot;</td>
<td>2&quot;</td>
<td>2&quot;</td>
<td>2&quot;</td>
<td>2&quot;</td>
<td>2&quot;</td>
</tr>
<tr>
<td>Outer Diameter, Pipe, actual</td>
<td>2.38&quot;</td>
<td>2.38&quot;</td>
<td>2.38&quot;</td>
<td>2.38&quot;</td>
<td>2.38&quot;</td>
<td>2.38&quot;</td>
<td>2.38&quot;</td>
</tr>
<tr>
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<td>460 (w/o reset)</td>
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349 DOE Weather Data.


350 Ibid.
### Annual Energy Savings

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<th>Boiler / Water Heater efficiency</th>
<th>Indoor Insulation, Hot Water</th>
<th>Indoor Insulation, Low Pressure Steam</th>
<th>Indoor Insulation, High Pressure Steam</th>
<th>Domestic Hot Water</th>
<th>Outdoor Insulation, Hot Water</th>
<th>Outdoor Insulation, Low Pressure Steam</th>
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<td>Heat = heating season only, year = year round</td>
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<th>Annual Gas Use, Measure case (therms/yr/ft)</th>
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### Notes
- **Heat** = heating season only, **year** = year round
Values below must be multiplied by the appropriate Thermal Regain Factor (TRF). All variables were the same except for hours of operation in the calculation of the default savings per foot for the various building types and applications as presented in the table below:

**Savings Summary for Indoor pipe insulation by System Type and Building Type (Δtherms per foot)**

(continues for 3.5 pages)

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<tr>
<th>Location</th>
<th>System Type</th>
<th>Building Type</th>
<th>Zone 1 (Rockford)</th>
<th>Zone 2 (Chicago)</th>
<th>Zone 3 (Springfield)</th>
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| LP Steam – non-recirculation | Assembly | 4.25 | 4.36 | 3.89 | 2.59 | 3.97 |
|                             | Assisted Living | 4.01 | 3.92 | 3.44 | 2.53 | 3.04 |
|                             | College | 3.64 | 3.40 | 3.04 | 1.69 | 2.02 |
|                             | Convenience Store | 3.52 | 3.26 | 2.89 | 2.07 | 2.32 |
|                             | Elementary School | 4.24 | 4.13 | 3.64 | 2.52 | 3.05 |
|                             | Garage | 2.34 | 2.31 | 2.03 | 1.62 | 1.79 |
|                             | Grocery | 3.83 | 3.81 | 3.34 | 2.08 | 2.49 |
|                             | Healthcare Clinic | 3.76 | 3.85 | 3.36 | 2.29 | 2.42 |
### Annual therm Savings per linear foot (therm/ft)

**Location** | **System Type** | **Building Type** | **Zone 1 (Rockford)** | **Zone 2 (Chicago)** | **Zone 3 (Springfield)** | **Zone 4 (Belleville)** | **Zone 5 (Marion)**
--- | --- | --- | --- | --- | --- | --- | ---
High School |  |  | 4.39 | 4.42 | 3.96 | 2.82 | 3.30
Hospital - CAV no econ |  |  | 4.20 | 4.33 | 3.69 | 3.17 | 3.60
Hospital - CAV econ |  |  | 4.25 | 4.41 | 3.76 | 3.26 | 3.70
Hospital - VAV econ |  |  | 1.74 | 1.65 | 1.24 | 0.75 | 0.81
Hospital - FCU |  |  | 3.15 | 3.60 | 2.93 | 3.44 | 4.63
Hotel/Motel |  |  | 4.19 | 4.07 | 3.67 | 2.51 | 3.07
Hotel/Motel - Common |  |  | 3.81 | 3.87 | 3.68 | 3.00 | 3.15
Hotel/Motel - Guest |  |  | 4.18 | 4.05 | 3.62 | 2.42 | 2.98
Manufacturing Facility |  |  | 2.49 | 2.41 | 2.23 | 1.35 | 1.51
MF - High Rise |  |  | 4.52 | 4.46 | 4.07 | 3.46 | 3.47
MF - High Rise - Common |  |  | 5.38 | 5.22 | 4.68 | 3.23 | 4.17
MF - High Rise - Residential |  |  | 4.37 | 4.34 | 3.94 | 3.41 | 3.33
MF - Mid Rise |  |  | 4.94 | 4.99 | 4.30 | 3.16 | 3.60
Movie Theater |  |  | 4.33 | 4.26 | 3.98 | 3.03 | 3.61
Office - High Rise - CAV no econ |  |  | 4.81 | 4.88 | 4.45 | 2.98 | 3.24
Office - High Rise - CAV econ |  |  | 4.97 | 5.07 | 4.66 | 3.21 | 3.54
Office - High Rise - VAV econ |  |  | 3.64 | 3.71 | 3.06 | 1.81 | 2.01
Office - High Rise - FCU |  |  | 2.66 | 2.62 | 2.27 | 1.20 | 1.26
Office - Low Rise |  |  | 3.40 | 3.39 | 2.69 | 1.65 | 1.89
Office - Mid Rise |  |  | 3.77 | 3.78 | 3.19 | 2.03 | 2.26
Religious Building |  |  | 3.82 | 3.58 | 3.43 | 2.51 | 2.87
Restaurant |  |  | 3.21 | 3.22 | 2.89 | 2.19 | 2.60
Retail - Department Store |  |  | 3.31 | 3.04 | 2.86 | 1.86 | 2.12
Retail - Strip Mall |  |  | 3.17 | 2.94 | 2.59 | 1.79 | 1.93
Warehouse |  |  | 3.46 | 3.23 | 3.33 | 2.08 | 2.56
Unknown |  |  | 3.70 | 3.66 | 3.26 | 2.34 | 2.71
LP Steam | All buildings, Recirculation heating season only (Hours below 55F) |  | 11.99 | 11.81 | 10.70 | 9.57 | 9.88
LP Steam | All buildings, Recirculation year round (All hours) |  | 20.84 | 20.84 | 20.84 | 20.84 | 20.84
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### Savings Summary for Outdoor pipe insulation by System Type and Building Type (Δtherms per foot) (continues for 3.5 pages)

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### Annual therm Savings per linear foot (therm /ft)

(2" pipe / 1" insulation for hot water, 2" insulation for steam)

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**Hot Water Space**

Heating without outdoor reset – non-recirculation
## Annual therm Savings per linear foot (therm /ft)

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### Annual therm Savings per linear foot (therm /ft)

(2" pipe / 1" insulation for hot water, 2" insulation for steam)

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<td>Retail -</td>
<td></td>
<td>Department Store</td>
<td></td>
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<tr>
<td>Retail -</td>
<td></td>
<td>Strip Mall</td>
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<tr>
<td>Assisted Living</td>
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</tr>
<tr>
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<td>Convenience Store</td>
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<td>Elementary School</td>
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<tr>
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<tr>
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<tr>
<td>Healthcare Clinic</td>
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<td>High School</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Hospital -</td>
<td></td>
<td>CAV no econ</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Hospital -</td>
<td></td>
<td>CAV econ</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Hospital -</td>
<td></td>
<td>VAV econ</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Hospital -</td>
<td></td>
<td>FCU</td>
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</tr>
<tr>
<td>Hotel/Motel</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Hotel/Motel -</td>
<td></td>
<td>Common</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Hotel/Motel -</td>
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<td>Guest</td>
<td></td>
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</tr>
<tr>
<td>Manufacturing Facility</td>
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<td></td>
</tr>
<tr>
<td>MF - High Rise</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MF - High Rise</td>
<td></td>
<td>Common</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MF - High Rise</td>
<td></td>
<td>Residential</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>MF - Mid Rise</td>
<td></td>
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<tr>
<td>Movie Theater</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Office -</td>
<td></td>
<td>High Rise - CAV no econ</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Annual therm Savings per linear foot (therm/ft) (2” pipe / 1” insulation for hot water, 2” insulation for steam)
For insulation covering elbows and tees that connect straight pipe, a calculated surface area will be assumed based on the dimensions for fittings given by ANSI/ASME B36.19. The surface area is then converted to an equivalent length of pipe that must be added to the total length of straight pipe in order to calculate total savings. Equivalent pipe lengths are given in 1” increments in pipe diameter for simplicity. In the case of pipe diameters in between full inch diameters, the closest equivalent length should be used. The larger pipe sizes mostly apply to steam header piping, which has the most heat loss per foot.

**Calculated Surface Areas of Elbows and Tees**

<table>
<thead>
<tr>
<th>Nominal Pipe Diameter</th>
<th>Calculated Surface Area (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>90 Degree Elbow$^{351}$</td>
</tr>
<tr>
<td>1”</td>
<td>0.10</td>
</tr>
<tr>
<td>2”</td>
<td>0.41</td>
</tr>
<tr>
<td>3”</td>
<td>0.93</td>
</tr>
<tr>
<td>4”</td>
<td>1.64</td>
</tr>
</tbody>
</table>

$^{351}$ Based on the dimensions for diameter, long radius, and short radius given by ANSI/ASME 36.19
$^{352}$ Based on the center to face and diameter dimensions given by ANSI/ASME B36.19
### Nominal Pipe Diameter

<table>
<thead>
<tr>
<th>Nominal Pipe Diameter</th>
<th>Calculated Surface Area (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>90 Degree Elbow</td>
</tr>
<tr>
<td>5”</td>
<td>2.57</td>
</tr>
<tr>
<td>6”</td>
<td>3.70</td>
</tr>
<tr>
<td>8”</td>
<td>6.58</td>
</tr>
<tr>
<td>10”</td>
<td>10.28</td>
</tr>
<tr>
<td>12”</td>
<td>14.80</td>
</tr>
</tbody>
</table>

### Equivalent Length of Other Components – Elbows and Tees (\(L_{eq}\))

<table>
<thead>
<tr>
<th>Nominal Pipe Diameter</th>
<th>Equivalent Length of Other Components (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>90 Degree Elbow</td>
</tr>
<tr>
<td>1”</td>
<td>0.30</td>
</tr>
<tr>
<td>2”</td>
<td>0.66</td>
</tr>
<tr>
<td>3”</td>
<td>1.01</td>
</tr>
<tr>
<td>4”</td>
<td>1.40</td>
</tr>
<tr>
<td>5”</td>
<td>1.76</td>
</tr>
<tr>
<td>6”</td>
<td>2.13</td>
</tr>
<tr>
<td>8”</td>
<td>2.91</td>
</tr>
<tr>
<td>10”</td>
<td>3.65</td>
</tr>
<tr>
<td>12”</td>
<td>4.44</td>
</tr>
</tbody>
</table>

For insulation around valves or flanges, a surface area from ASTM standard C1129-12 will be assumed for 2” pipes. For 1” pipes, which weren’t included in the standard, a linear-trended value will be used. The surface area is then converted to an equivalent length of either 1” or 2” straight pipe that must be added to the total length of straight pipe in order to calculate total savings.

### Calculated Surface Areas of Flanges and Valves

#### Valves

<table>
<thead>
<tr>
<th>Class (psi)</th>
<th>150</th>
<th>300</th>
<th>600</th>
<th>900</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPS (in)</td>
<td>ft²</td>
<td>ft²</td>
<td>ft²</td>
<td>ft²</td>
</tr>
<tr>
<td>1</td>
<td>0.69</td>
<td>1.8</td>
<td>1.8</td>
<td>2.4</td>
</tr>
<tr>
<td>2</td>
<td>2.21</td>
<td>2.94</td>
<td>2.94</td>
<td>5.2</td>
</tr>
<tr>
<td>2.5</td>
<td>2.97</td>
<td>3.51</td>
<td>3.91</td>
<td>6.6</td>
</tr>
<tr>
<td>3</td>
<td>3.37</td>
<td>4.39</td>
<td>4.69</td>
<td>6.5</td>
</tr>
<tr>
<td>4</td>
<td>4.68</td>
<td>6.06</td>
<td>7.64</td>
<td>9.37</td>
</tr>
<tr>
<td>6</td>
<td>7.03</td>
<td>9.71</td>
<td>13.03</td>
<td>15.8</td>
</tr>
</tbody>
</table>

#### Flanges

<table>
<thead>
<tr>
<th>Class (psi)</th>
<th>150</th>
<th>300</th>
<th>600</th>
<th>900</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPS (in)</td>
<td>ft²</td>
<td>ft²</td>
<td>ft²</td>
<td>ft²</td>
</tr>
<tr>
<td>1</td>
<td>0.36</td>
<td>0.36</td>
<td>0.4</td>
<td>1.23</td>
</tr>
<tr>
<td>2</td>
<td>0.71</td>
<td>0.84</td>
<td>0.88</td>
<td>1.54</td>
</tr>
<tr>
<td>3</td>
<td>1.06</td>
<td>1.32</td>
<td>1.36</td>
<td>1.85</td>
</tr>
<tr>
<td>4</td>
<td>1.44</td>
<td>1.83</td>
<td>2.23</td>
<td>2.64</td>
</tr>
<tr>
<td>6</td>
<td>2.04</td>
<td>2.72</td>
<td>3.6</td>
<td>4.37</td>
</tr>
</tbody>
</table>
### Equivalent Length of Other Components - Flanges and Valves (L_{oc})

<table>
<thead>
<tr>
<th>ANSI Class (psi)</th>
<th>Equivalent Length of Other Components (ft)</th>
<th>1&quot; Valve</th>
<th>1&quot; Flange</th>
<th>2&quot; Valve</th>
<th>2&quot; Flange</th>
</tr>
</thead>
<tbody>
<tr>
<td>150</td>
<td></td>
<td>3.56</td>
<td>1.05</td>
<td>3.56</td>
<td>1.14</td>
</tr>
<tr>
<td>300</td>
<td></td>
<td>4.73</td>
<td>1.05</td>
<td>4.73</td>
<td>1.35</td>
</tr>
<tr>
<td>600</td>
<td></td>
<td>4.73</td>
<td>1.16</td>
<td>4.73</td>
<td>1.42</td>
</tr>
<tr>
<td>900</td>
<td></td>
<td>8.37</td>
<td>3.57</td>
<td>8.37</td>
<td>2.48</td>
</tr>
</tbody>
</table>

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-HVC-PINS-V03-150601**
4.4.15 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) 2012.

**DEFINITION OF BASELINE EQUIPMENT**

In order for this characterization to apply, the baseline 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) 2012. 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.\(^\text{353}\)

**DEEMED MEASURE COST**

The incremental capital cost for this measure is assumed to be $100 per ton.\(^\text{354}\)

**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.

\[
CF_{SSP} = \text{Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)}
\]

\[
= 91.3\% \quad ^{355}
\]

---


\(^{354}\) Based on a review of TRM incremental cost assumptions from Vermont, Wisconsin, and California. This assumes that baseline shift from IECC 2009 to IECC 2012 carries the same incremental costs. Values should be verified during evaluation.

\[
\text{CF}_{\text{PJM}} = \text{PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)} = 47.8\% \quad \text{356}
\]

Algorithm

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

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

\[
\Delta kWH = (\text{kBtu/hr}) \times \left[ \frac{1}{\text{SEERbase}} - \frac{1}{\text{SEERee}} \right] \times \text{EFLH}
\]

For units with cooling capacities equal to or greater than 65 kBtu/hr:

\[
\Delta kWH = (\text{kBtu/hr}) \times \left[ \frac{1}{\text{EERbase}} - \frac{1}{\text{EERee}} \right] \times \text{EFLH}
\]

Where:

- kBtu/hr = capacity of the cooling equipment actually installed in kBtu per hour (1 ton of cooling capacity equals 12 kBtu/hr).
- SEERbase = Seasonal Energy Efficiency Ratio of the baseline equipment; see table below for default values\(^\text{357}\):

---

\(^\text{355}\) 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.

\(^\text{356}\) 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.

\(^\text{357}\) International Energy Conservation Code (IECC) 2012
### TABLE C401.2.3(1)

**MINIMUM ELECTRICITY REQUIREMENTS: ELECTRICALLY OPERATED UNITARY AIR CONDITIONERS AND CONDENSING UNITS**

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY</th>
<th>HEATING SECTION TYPE</th>
<th>SUBCATEGORY OR RATING CONDITION</th>
<th>MINIMUM EFFICIENCY Before 6/1/2011</th>
<th>MINIMUM EFFICIENCY As of 6/1/2011</th>
<th>TEST PROCEDURE*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air conditioners, air cooled</td>
<td>&lt; 65,000 Btu/h</td>
<td>All</td>
<td>Split System</td>
<td>13.0 SEER</td>
<td>13.0 SEER</td>
<td>AHRI 210/240</td>
</tr>
<tr>
<td></td>
<td>≥ 65,000 Btu/h</td>
<td>Electric Resistance</td>
<td>Split System</td>
<td>11.2 EER</td>
<td>11.2 EER</td>
<td>AHRI 340/360</td>
</tr>
<tr>
<td></td>
<td>and ≤ 135,000 Btu/h</td>
<td>(or None)</td>
<td>Single Package</td>
<td>11.4 EER</td>
<td>11.4 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 135,000 Btu/h</td>
<td>All other</td>
<td>Split System</td>
<td>11.0 EER</td>
<td>11.0 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>and &lt; 240,000 Btu/h</td>
<td>Electric Resistance</td>
<td>Single Package</td>
<td>11.2 EER</td>
<td>11.2 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 240,000 Btu/h</td>
<td>(or None)</td>
<td>Split System</td>
<td>10.8 EER</td>
<td>10.8 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>and &lt; 760,000 Btu/h</td>
<td>All other</td>
<td>Single Package</td>
<td>10.0 EER</td>
<td>10.0 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 760,000 Btu/h</td>
<td>Electric Resistance</td>
<td>Split System</td>
<td>9.7 EER</td>
<td>9.7 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(or None)</td>
<td>(or None)</td>
<td>Single Package</td>
<td>9.5 EER</td>
<td>9.5 EER</td>
<td></td>
</tr>
<tr>
<td>Air conditioners, water cooled</td>
<td>&lt; 65,000 Btu/h</td>
<td>All</td>
<td>Split System</td>
<td>12.1 EER</td>
<td>12.1 EER</td>
<td>AHRI 210/240</td>
</tr>
<tr>
<td></td>
<td>≥ 65,000 Btu/h</td>
<td>Electric Resistance</td>
<td>Split System</td>
<td>11.5 EER</td>
<td>11.5 EER</td>
<td>AHRI 340/360</td>
</tr>
<tr>
<td></td>
<td>(or None)</td>
<td>(or None)</td>
<td>Single Package</td>
<td>11.7 EER</td>
<td>11.7 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>and ≤ 135,000 Btu/h</td>
<td>All other</td>
<td>Split System</td>
<td>11.3 EER</td>
<td>11.3 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 135,000 Btu/h</td>
<td>Electric Resistance</td>
<td>Single Package</td>
<td>11.0 EER</td>
<td>11.0 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(or None)</td>
<td>(or None)</td>
<td>Split System</td>
<td>11.2 EER</td>
<td>11.2 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>and &lt; 240,000 Btu/h</td>
<td>All other</td>
<td>Single Package</td>
<td>10.8 EER</td>
<td>10.8 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 240,000 Btu/h</td>
<td>Electric Resistance</td>
<td>Split System</td>
<td>11.0 EER</td>
<td>11.0 EER</td>
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<tr>
<td></td>
<td>(or None)</td>
<td>(or None)</td>
<td>Single Package</td>
<td>11.1 EER</td>
<td>11.1 EER</td>
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</tr>
<tr>
<td></td>
<td>and &lt; 760,000 Btu/h</td>
<td>All other</td>
<td>Split System</td>
<td>10.8 EER</td>
<td>10.8 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 760,000 Btu/h</td>
<td>Electric Resistance</td>
<td>Single Package</td>
<td>11.0 EER</td>
<td>11.0 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(or None)</td>
<td>(or None)</td>
<td>Split System</td>
<td>11.1 EER</td>
<td>11.1 EER</td>
<td></td>
</tr>
</tbody>
</table>

*continued*
SEER_{ee} = Seasonal Energy Efficiency Ratio of the energy efficient equipment (actually installed).

EER_{base} = Energy Efficiency Ratio of the baseline equipment; see table above for default values. Since IECC 2012 does not provide EER requirements for air-cooled air conditioners < 65 kBtu/hr, assume the following conversion from SEER to EER: EER ≈ SEER/1.1.

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

EFLH = Actual installed Equivalent Full Load Hours for cooling are provided in section 4.4 HVAC End Use:

For example a 5 ton air cooled split system with a SEER of 15 at a retail strip mall in Rockford would save

\[ \Delta \text{kWh} = (60) \times \left( \frac{1}{13} - \frac{1}{15} \right) \times 950 \]
\[ = 585 \text{ kWh} \]

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

\[ \Delta W_{SSP} = (\text{kBtu/hr}) \times (1/\text{EER}_{base} - 1/\text{EER}_{Ree}) \times \text{CF}_{SSP} \]
\[ \Delta W_{PJM} = (\text{kBtu/hr}) \times (1/\text{EER}_{base} - 1/\text{EER}_{Ree}) \times \text{CF}_{PJM} \]

Where:

\[
\begin{align*}
CF_{SSP} & = \text{Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)} \\
& = 91.3\% \tag{358} \\
CF_{PJM} & = \text{PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)} \\
& = 47.8\% \tag{359}
\end{align*}
\]

For example a 5 ton air cooled split system with a SEER of 15 in Rockford would save

\[
\Delta kW_{SSP} = (60) \times \left[\frac{1}{13} - \frac{1}{15}\right] \times 0.913 \\
= 0.562
\]

\textbf{NATURAL GAS ENERGY SAVINGS}

N/A

\textbf{WATER IMPACT DESCRIPTIONS AND CALCULATION}

N/A

\textbf{MEASURE CODE: CI-HVC-SPUA-V03-150601}

---

\textsuperscript{358} 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.

\textsuperscript{359} 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.
4.4.16 Steam Trap Replacement or Repair

**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) including multifamily buildings, 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 are reduced 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.

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The life of this measure is 6 years.

**DEEMED MEASURE COST**

<table>
<thead>
<tr>
<th>Steam System</th>
<th>Cost per trap 360 ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial Dry Cleaners</td>
<td>77</td>
</tr>
<tr>
<td>Commercial Heating (including Multifamily), low pressure steam</td>
<td>77</td>
</tr>
<tr>
<td>Industrial Medium Pressure &gt;15 psig psig &lt; 30 psig</td>
<td>180</td>
</tr>
<tr>
<td>Steam Trap, Industrial Medium Pressure ≥30 &lt;75 psig</td>
<td>223</td>
</tr>
<tr>
<td>Steam Trap, Industrial High Pressure ≥75 &lt;125 psig</td>
<td>276</td>
</tr>
<tr>
<td>Steam Trap, Industrial High Pressure ≥125 &lt;175 psig</td>
<td>322</td>
</tr>
<tr>
<td>Steam Trap, Industrial High Pressure ≥175 &lt;250 psig</td>
<td>370</td>
</tr>
</tbody>
</table>

360 Source paper is the CLEAResult "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.

361 Ibid.
### Steam System Cost per trap (£)$

<table>
<thead>
<tr>
<th>Steam System</th>
<th>Cost per trap (£)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam Trap, Industrial High Pressure ≥250 psig</td>
<td>418</td>
</tr>
<tr>
<td>Steam Trap, Industrial Medium Pressure ≥30 &lt;75 psig</td>
<td>223</td>
</tr>
<tr>
<td>Steam Trap, Industrial High Pressure ≥75 &lt;125 psig</td>
<td>276</td>
</tr>
<tr>
<td>Steam Trap, Industrial High Pressure ≥125 &lt;175 psig</td>
<td>322</td>
</tr>
<tr>
<td>Steam Trap, Industrial High Pressure ≥175 &lt;250 psig</td>
<td>370</td>
</tr>
<tr>
<td>Steam Trap, Industrial High Pressure ≥250 psig</td>
<td>418</td>
</tr>
</tbody>
</table>

### LOADSHAPE

N/A

### COINCIDENCE FACTOR

N/A

---

**Algorithm**

**CALCULATION OF SAVINGS**

**ENERGY SAVINGS**

\[ \Delta \text{therm} = S * (Hv/B) * \text{Hours} * A * L / 100,000 \]

Where:

- \( S \) = Maximum theoretical steam loss per trap

### Avg Steam Loss (lb/hr/trap)

<table>
<thead>
<tr>
<th>Steam System</th>
<th>Avg Steam Loss (lb/hr/trap)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial Dry Cleaners</td>
<td>38.1</td>
</tr>
<tr>
<td>Commercial Heating (including Multifamily) LPS</td>
<td>13.8</td>
</tr>
<tr>
<td>Industrial Low Pressure, &lt;15 psig</td>
<td>13.8</td>
</tr>
<tr>
<td>Industrial Medium Pressure &gt;15 psig &lt; 30 psig</td>
<td>12.7</td>
</tr>
<tr>
<td>Steam Trap, Industrial Medium Pressure ≥30 &lt;75 psig</td>
<td>19.0</td>
</tr>
<tr>
<td>Steam Trap, Industrial High Pressure ≥75 &lt;125 psig</td>
<td>67.9</td>
</tr>
<tr>
<td>Steam Trap, Industrial High Pressure ≥125 &lt;175 psig</td>
<td>105.8</td>
</tr>
<tr>
<td>Steam Trap, Industrial High Pressure ≥175 &lt;250 psig</td>
<td>143.7</td>
</tr>
<tr>
<td>Steam Trap, Industrial High Pressure ≥250 psig</td>
<td>200.5</td>
</tr>
</tbody>
</table>

---

362 CLEAResult "Steam Traps Revision #1" dated August 2011.
Hv = Heat of vaporization of steam

<table>
<thead>
<tr>
<th>Steam System</th>
<th>Heat of Vaporization (Btu/lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial Dry Cleaners</td>
<td>890</td>
</tr>
<tr>
<td>Commercial Heating (including Multifamily) LPS</td>
<td>951</td>
</tr>
<tr>
<td>Industrial Low Pressure ≤15 psig</td>
<td>951</td>
</tr>
<tr>
<td>Industrial Medium Pressure &gt;15 psig &lt; 30 psig</td>
<td>945</td>
</tr>
<tr>
<td>Steam Trap, Industrial Medium Pressure ≥30 &lt;75 psig</td>
<td>928</td>
</tr>
<tr>
<td>Steam Trap, Industrial High Pressure ≥75 &lt;125 psig</td>
<td>894</td>
</tr>
<tr>
<td>Steam Trap, Industrial High Pressure ≥125 &lt;175 psig</td>
<td>868</td>
</tr>
<tr>
<td>Steam Trap, Industrial High Pressure ≥175 &lt;250 psig</td>
<td>846</td>
</tr>
<tr>
<td>Steam Trap, Industrial High Pressure ≥250 psig</td>
<td>820</td>
</tr>
</tbody>
</table>

B = Boiler efficiency

= custom, if unknown:

= 80.7% for steam boilers, except multifamily low-pressure

= 64.8% for multifamily low-pressure steam boilers

Hours = Annual operating hours of steam plant

<table>
<thead>
<tr>
<th>Steam System</th>
<th>Zone (where applicable)</th>
<th>Hours/Yr (n/a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial Dry Cleaners</td>
<td></td>
<td>2,425</td>
</tr>
<tr>
<td>Industrial Low Pressure ≤15 psig</td>
<td></td>
<td>7,752</td>
</tr>
<tr>
<td>Industrial Medium Pressure &gt;15 psig &lt; 30 psig</td>
<td></td>
<td>7,752</td>
</tr>
<tr>
<td>Steam Trap, Industrial Medium Pressure ≥30 &lt;75 psig</td>
<td>n/a</td>
<td>7,752</td>
</tr>
<tr>
<td>Steam Trap, Industrial High Pressure ≥75 &lt;125 psig</td>
<td></td>
<td>7,752</td>
</tr>
<tr>
<td>Steam Trap, Industrial High Pressure ≥125 &lt;175 psig</td>
<td></td>
<td>7,752</td>
</tr>
<tr>
<td>Steam Trap, Industrial High Pressure ≥175 &lt;250 psig</td>
<td></td>
<td>7,752</td>
</tr>
</tbody>
</table>

363 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 CLEAResult"Steam Traps Revision #1" dated August 2011.

364 Ibid.


366 CLEAResult"Steam Traps Revision #1" dated August 2011, which references Enbridge service territory data and kW Engineering study.
### Steam System Zone (where applicable) Hours/Yr

<table>
<thead>
<tr>
<th>Steam System</th>
<th>Zone (where applicable)</th>
<th>Hours/Yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam Trap, Industrial High Pressure ≥250 psig</td>
<td></td>
<td>7,752</td>
</tr>
<tr>
<td>Industrial Medium Pressure &gt;15 psig &lt; 30 psig</td>
<td></td>
<td>7,752</td>
</tr>
<tr>
<td>Steam Trap, Industrial Medium Pressure ≥30 &lt;75 psig</td>
<td></td>
<td>7,752</td>
</tr>
<tr>
<td>Commercial Heating (including Multifamily) LPS</td>
<td>1 (Rockford)</td>
<td>4,272</td>
</tr>
<tr>
<td></td>
<td>2 (Chicago O'Hare)</td>
<td>4,029</td>
</tr>
<tr>
<td></td>
<td>3 (Springfield)</td>
<td>3,406</td>
</tr>
<tr>
<td></td>
<td>4 (Belleville)</td>
<td>2,515</td>
</tr>
<tr>
<td></td>
<td>5 (Marion)</td>
<td>2,546</td>
</tr>
</tbody>
</table>

A = Adjustment factor  
= 50%\(^{368}\)

This factor is to account for reducing the maximum theoretical steam flow (S) to the average steam flow (the Enbridge factor).

L = Leaking & blow-thru  
L is 1.0 when applied to the replacement 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 leaking and need to be replaced. A custom value can be utilized if a supported by an evaluation.

### Steam System %

<table>
<thead>
<tr>
<th>Steam System</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Custom</td>
<td>Custom</td>
</tr>
<tr>
<td>Commercial Dry Cleaners</td>
<td>27%</td>
</tr>
<tr>
<td>Industrial Low Pressure ≤15 psig</td>
<td>16%</td>
</tr>
<tr>
<td>Industrial Medium and High Pressure &gt;15 psig</td>
<td>16%</td>
</tr>
<tr>
<td>Commercial Heating (including Multifamily) LPS</td>
<td>27%</td>
</tr>
</tbody>
</table>

\(^{367}\) Since commercial LPS reflect heating systems, Hours/yr are equivalent to HDD55 zone table  
\(^{368}\) Enbridge adjustment factor used as referenced in CLEAResult “Steam Traps Revision #1” dated August 2011 and DOE Federal Energy Management Program Steam Trap Performance Assessment.  
\(^{369}\) Dry cleaners survey data as referenced in CLEAResult “Steam Traps Revision #1” dated August 2011.
EXAMPLE

For example, a commercial dry cleaning facility with the default hours of operation and boiler efficiency;

\[ \Delta \text{Therms} = S \times \left( \frac{Hv}{B} \right) \times \text{Hours} \times A \times L \]

\[ = 38.1 \text{ lbs/hr/trap} \times \left( \frac{890 \text{ Btu/lb}}{80\%} \right)/100,000 \times 2,425 \times 50\% \times 27\% = \]

138.8 therms per trap

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-STRE-V03-140601
4.4.17 Variable Speed Drives for HVAC Pumps and Cooling Tower Fans

**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. There is a separate measure for HVAC supply and return fans. All other VSD applications require custom analysis by the program administrator. 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 2012 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; measure life for process is 10 years.

**DEEMED MEASURE COST**

Customer provided costs will be used when available. Default measure costs are noted below for up to 20 hp motors. Custom costs must be gathered from the customer for motor sizes not listed below.

<table>
<thead>
<tr>
<th>HP</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-5 HP</td>
<td>$1,330</td>
</tr>
<tr>
<td>7.5 HP</td>
<td>$1,622</td>
</tr>
<tr>
<td>10 HP</td>
<td>$1,898</td>
</tr>
<tr>
<td>15 HP</td>
<td>$2,518</td>
</tr>
<tr>
<td>20 HP</td>
<td>$3,059</td>
</tr>
</tbody>
</table>

---

370 Efficiency Vermont TRM 10/26/11 for HVAC VSD motors
371 DEER 2008
LOADSHAPE

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.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

\[ \Delta \text{kWh} = \frac{\text{BHP}}{\text{EFFi}} \times \text{Hours} \times \text{ESF} \]

Where:

\( \text{BHP} \) = System Brake Horsepower

(Nominal motor HP * Motor load factor)

Motors are assumed to have a load factor of 65% for calculating kW if actual values cannot be determined\(^{373}\). Custom load factor may be applied if known.

\( \text{EFFi} \) = Motor efficiency, installed. Actual motor efficiency shall be used to calculate kW. If not known a default value of 93% shall be used.\(^{374}\)

\( \text{Hours} \) = Default hours are provided for HVAC applications which vary by HVAC application and building type\(^{375}\). When available, actual hours should be used.

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Pumps and fans</th>
</tr>
</thead>
<tbody>
<tr>
<td>College/University</td>
<td>4216</td>
</tr>
<tr>
<td>Grocery</td>
<td>5840</td>
</tr>
<tr>
<td>Heavy Industry</td>
<td>3585</td>
</tr>
<tr>
<td>Hotel/Motel</td>
<td>6872</td>
</tr>
</tbody>
</table>


\(^{375}\) ComEd Trm June 1, 2010 page 139. The Office hours is based upon occupancy from the eQuest model developed for EFLH, since it was agreed the ComEd value was too low.
### Building Type

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Pumps and fans</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light Industry</td>
<td>2465</td>
</tr>
<tr>
<td>Medical</td>
<td>6871</td>
</tr>
<tr>
<td>Office</td>
<td>2301</td>
</tr>
<tr>
<td>Restaurant</td>
<td>4654</td>
</tr>
<tr>
<td>Retail/Service</td>
<td>3438</td>
</tr>
<tr>
<td>School(K-12)</td>
<td>2203</td>
</tr>
<tr>
<td>Warehouse</td>
<td>3222</td>
</tr>
<tr>
<td>Average = Miscellaneous</td>
<td>4103</td>
</tr>
</tbody>
</table>

### ESF

ESF = Energy savings factor varies by VFD application. Units are kW/HP.

<table>
<thead>
<tr>
<th>Application</th>
<th>ESF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot Water Pump</td>
<td>0.424</td>
</tr>
<tr>
<td>Chilled Water Pump</td>
<td>0.411</td>
</tr>
<tr>
<td>Air Foil/backward incline</td>
<td>0.354</td>
</tr>
<tr>
<td>Air Foil/ backward incline inlet Guide Vanes</td>
<td>0.227</td>
</tr>
<tr>
<td>Forward Curved Fan, with discharge dampers</td>
<td>0.179</td>
</tr>
<tr>
<td>Forward Curved Inlet Guide Vanes</td>
<td>0.092</td>
</tr>
</tbody>
</table>

### SUMMER COINCIDENT PEAK DEMAND SAVINGS

\[
\Delta kW = \text{BHP/EFFi} \times \text{DSF}
\]

Where:

DSF = Demand Savings Factor varies by VFD application. Units are kW/HP. Values listed below are based on typical peak load for the listed application.

<table>
<thead>
<tr>
<th>Application</th>
<th>DSF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot Water Pump</td>
<td>0</td>
</tr>
<tr>
<td>Chilled Water Pump</td>
<td>0.299</td>
</tr>
<tr>
<td>Air foil / backward incline</td>
<td>0.260</td>
</tr>
<tr>
<td>Air Foil / backward incline inlet Guide Vanes</td>
<td>0.130</td>
</tr>
<tr>
<td>Forward Curved Fan, with discharge dampers</td>
<td>0.136</td>
</tr>
</tbody>
</table>

---

376 Ibid.
377 Ibid.
FOSSIL FUEL IMPACT DESCRIPTIONS AND CALCULATION

There are no expected fossil fuel impacts for this measure.

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-VSDHP-V02-150601
4.4.18 Small Commercial Programmable Thermostats

DESCRIPTION
This measure characterizes the energy savings from the installation of a new Programmable Thermostat for reduced heating energy consumption through temperature set-back during unoccupied or reduced demand times. This measure is limited to small businesses, as they have smaller HVAC systems that are similar to residential HVAC systems and may be controlled by a simple manual adjustment thermostat. Mid to large sized businesses will typically have a building automation system or some other form of automated HVAC controls. Therefore, it is limited to select building types, including small office, retail – strip mall, restaurants (characterized as 1, 2 or 3 meal), small manufacturing, religious facilities, and convenience stores. This measure is only appropriate for single zone heating systems. Custom calculations are required for savings for programmable thermostats installed in multi-zone systems.

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 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.

DEFINITION OF BASELINE EQUIPMENT
For new thermostats the baseline is a non-programmable thermostat requiring manual intervention to change temperature setpoint.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT
The expected measure life of a programmable thermostat is assumed to be 8 years based upon equipment life only. For the purposes of claiming savings for a new programmable thermostat, this is reduced by a 50% persistence factor to give a final measure life of 4 years.

DEEMED MEASURE COST
Actual material and labor costs should be used if the implementation method allows. If unknown the capital and labor cost for this measure is assumed to be $181 per thermostat. For the purposes of screening and planning it should be assumed that one thermostat will serve 5 tons of Cooling Capacity at a cost of $36.20 / ton or 115kBtu of Heating Capacity at a cost of $1.57 / kBtu.

LOADSHAPE
N/A

---

378 Table 1, HVAC Controls, Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007
379 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.
380 Nicor Rider 30 Business EER Program Database, Paid Rebates with Programmable Thermostat Installation Costs, Program to Date as of January 11, 2013.
COINCIDENCE FACTOR
N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

\[ \Delta kWh = [\text{Baseline Energy Use (kWh/Ton)} - \text{Proposed Energy Use (kWh/Ton)}] \times \text{Cooling Capacity (Tons)} \]

The following equations are used to calculate baseline and proposed electric energy use. The savings is the difference between the proposed and baseline calculated usage. This approach allows the savings estimate to account for the operational attributes of the baseline as well as the proposed case, yielding a better estimate than an approach that assumes a particular baseline or proposed energy use to determine savings.

### Electric Energy Use Equations (kWh / ton)

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Fan Mode During Occupied Period (Fo)</th>
<th>Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assembly</td>
<td>Continuous</td>
<td>CZ+Fu*(0.83<em>Tc+0.83</em>Th+1.67<em>Ws-293.018)-0.0922</em>Tc<em>Th+1.291</em>Ws</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>CZ+Fu*(1.911-0.12<em>Tc)+Tc</em>(0.00311<em>Ws-0.229)+0.11</em>Ws</td>
</tr>
<tr>
<td>Convenience Store</td>
<td>Continuous</td>
<td>CZ+Fu*(-28.629<em>Tc-11.69</em>Th+19.118<em>Ws-2935.12)+0.909</em>Ws</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>CZ+Fu*(7.082<em>Ws-12.688)+Th</em>(0.043<em>Ws-6.38)+1.669</em>Ws</td>
</tr>
<tr>
<td>Office – Low Rise</td>
<td>Continuous</td>
<td>CZ+Fu*(-8.41<em>Th+11.766</em>Ws-1910.81)+Tc*(0.282*Ws-43.851)</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>CZ+Fu*(-1.475<em>Th+0.755</em>Ws-114.373)+Th*(0.151<em>Ws-24.016)+1.612</em>Ws</td>
</tr>
<tr>
<td>Religious</td>
<td>Continuous</td>
<td>CZ+Fu*(-1.579<em>Tc-18.14</em>Th+15.01<em>Ws-2417.74)+Tc</em>(0.177*Ws-26.412)</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>CZ+Fu*(0.266<em>Ws-2.067)+Th</em>(0.00936<em>Ws-1.655)+0.918</em>Ws</td>
</tr>
<tr>
<td>Restaurant – Fast Food</td>
<td>Continuous</td>
<td>CZ+Fu*(-8.41<em>Th+11.766</em>Ws-1910.81)+Tc*(0.282*Ws-43.851)</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>CZ+Fu*(-1.475<em>Th+0.755</em>Ws-114.373)+Th*(0.151<em>Ws-24.016)+1.612</em>Ws</td>
</tr>
<tr>
<td>Restaurant – Full Service</td>
<td>Continuous</td>
<td>CZ+Fu*(0.377<em>Tc+0.124</em>Th+0.13<em>Ws-24.893)+Tc</em>(-0.0143<em>Th+0.0166</em>Ws-2.691)+0.898*Ws</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>CZ+Fu*(1.073<em>Ws-1.912)+Th</em>(0.0249<em>Ws-3.29)+0.511</em>Ws</td>
</tr>
<tr>
<td>Retail – Department Store</td>
<td>Continuous</td>
<td>CZ+Fu*(1.077<em>Tc-10.697</em>Th+6.91<em>Ws-1117.18)+Tc</em>(0.0583<em>Ws-7.54)+1.231</em>Ws</td>
</tr>
</tbody>
</table>

### Building Type | Fan Mode During Occupied Period (Fo) | Equation |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mall</td>
<td>Intermittent</td>
<td>( CZ+0.0894<em>Fu^<em>Tc+Th^</em>(-0.0142</em>Tc+0.04<em>Ws-5.278)+0.884</em>Ws )</td>
</tr>
</tbody>
</table>

Where:

- **CZ** = Climate Zone Coefficient  
  = Depends on Building Type and Fan Mode During Occupied Period (see table below)
- **Tc** = Degrees of Cooling Setback °F  
  = Must be between 0-15°F
- **Th** = Degrees of Heating Setback °F  
  = Must be between 0-15°F
- **Fo** = Fan Mode During Occupied Period (Note: Commercial mechanical code requires continuous fan operation during occupied periods to meet ventilation requirements.)  
  = Continuous for occupied fan that runs continuously (e.g. Fan Mode Set to ‘On’)  
  = Intermittent for occupied fan that runs intermittently (e.g. Fan Mode Set to ‘Auto’)
- **Fu** = Fan Mode During Unoccupied Period  
  = 0 for unoccupied fan that runs continuously (e.g. Fan Mode Set to ‘On’)  
  = 1 for unoccupied fan that runs intermittently (e.g. Fan Mode Set to ‘Auto’)
- **Ws** = Weekly Hours thermostat is in Occupied mode  
  = Minimum values depends on Building Type (see table below), maximum value of 168 (24/7)  
  (e.g.: Weekly occupancy schedule of Mon-Sat 8AM-5PM, Sun 9AM-2PM, Ws = 59)

#### Electric Energy Use Climate Zone Coefficients and Minimum Weekly Hours Occupied

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Fan Mode During Occupied Period (Fo)</th>
<th>Climate Zone Coefficient (CZ)382</th>
<th>Minimum Ws</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Assembly</td>
<td>Continuous</td>
<td>911.366</td>
<td>928.924</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>735.752</td>
<td>762.831</td>
</tr>
<tr>
<td>Convenience Store</td>
<td>Continuous</td>
<td>4817.094</td>
<td>4832.784</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>1478.133</td>
<td>1514.568</td>
</tr>
<tr>
<td>Office - Low Rise</td>
<td>Continuous</td>
<td>5047.662</td>
<td>5039.592</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>825.072</td>
<td>808.965</td>
</tr>
</tbody>
</table>

382 Climate Zones Referenced in Section 3.7, Table 3.6

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Fan Mode During Occupied Period (Fo)</th>
<th>Climate Zone Coefficient (CZ)382</th>
<th>Minimum Ws</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Religious Facility</td>
<td>Continuous</td>
<td>4197.117</td>
<td>4172.858</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>632.404</td>
<td>603.395</td>
</tr>
<tr>
<td>Restaurant – Fast Food</td>
<td>Continuous</td>
<td>1342.988</td>
<td>1378.661</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>993.764</td>
<td>1039.643</td>
</tr>
<tr>
<td>Restaurant – Full Service</td>
<td>Continuous</td>
<td>4070.35</td>
<td>4094.742</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>1472.014</td>
<td>1516.05</td>
</tr>
<tr>
<td>Retail – Department Store</td>
<td>Continuous</td>
<td>1510.201</td>
<td>1496.47</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>701.27</td>
<td>702.129</td>
</tr>
<tr>
<td>Retail – Strip Mall</td>
<td>Continuous</td>
<td>1926.294</td>
<td>1930.137</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>656.479</td>
<td>673.257</td>
</tr>
</tbody>
</table>

**EXAMPLE**

A low rise office in Rockford (Climate Zone 1) is occupied Mon-Fri 7AM-6PM and has a 10 ton DX RTU controlled by a manual thermostat. The fan runs continuously during the occupied hours and building staff do not manually change the fan mode, cooling or heating setpoints during unoccupied periods.

A programmable thermostat is installed by a contractor who sets the occupied schedule to Mon-Fri 7AM-6PM with a 10°F cooling and heating unoccupied temperature setback. The contractor also programs the fan to operate continuously during the occupied periods and to intermittent “auto” during the unoccupied periods.

\[
\Delta kWh = \left[\text{Baseline Energy Use (kWh/Ton)} - \text{Proposed Energy Use (kWh/Ton)}\right] \times \text{Cooling Capacity (Tons)}
\]

Baseline Energy Use (kWh/Ton) = Equation for Office Low Rise, Fo=Continuous

\[
= CZ + Fu \times 7.082 \times Tc - 41.199 \times Th + 18.734 \times Ws - 3288.55 + Tc \times 0.205 \times Ws - 34.929
\]

\[
= 5047.662 + 0 \times 7.082 - 41.199 \times 0 + 18.734 \times 168 - 3288.55 + 0 \times 0.205 \times 168 - 34.929
\]

\[
= 5047.662 \text{ kWh/Ton}
\]

Proposed Energy Use (kWh/Ton) = Equation for Office Low Rise, Fo=Continuous

\[
= CZ + Fu \times 7.082 \times Tc - 41.199 \times Th + 18.734 \times Ws - 3288.55 + Tc \times 0.205 \times Ws - 34.929
\]

\[
= 5047.662 + 1 \times 7.082 - 41.199 \times 10 + 18.734 \times 55 - 3288.55 + 10 \times 0.205 \times 55 - 34.929
\]

\[
= 2,211.722 \text{ kWh/Ton}
\]

\[
\Delta kWh = \left[5,047.622 \text{ (kWh/Ton)} - 2,211.722 \text{ (kWh/Ton)}\right] \times 10 \text{ Tons}
\]

\[
= 2,835.89 \text{ kWh/Ton} \times 10 \text{ Tons}
\]

\[
= 28,358.9 \text{ kWh}
\]

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

N/A
NATURAL GAS ENERGY SAVINGS

\[ \Delta \text{Therms} = (\text{Baseline Energy Use (Therms/kBtuh)} - \text{Proposed Energy Use(Therms/kBtuh)}) \times \text{Output Heating Capacity (kBtuh)} \]

The following equations are used to calculate baseline and proposed natural gas energy use. The savings is the difference between the proposed and baseline calculated usage. This approach allows the savings estimate to account for the operational attributes of the baseline as well as the proposed case, yielding a better estimate than an approach that assumes a particular baseline or proposed energy use to determine savings.

### Natural Gas Energy Use Equations (therms / kbtu output)

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Fan Mode During Occupied Period (Fo)</th>
<th>Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assembly</td>
<td>Continuous</td>
<td>( CZ + Fu \times (0.232 \times Th + 0.0984 \times Ws - 18.79) + Th \times (0.00271 \times Ws - 0.535) + 0.0142 \times Ws )</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>( CZ + Fu \times (0.00405 \times Th + 0.000519 \times Ws - 0.11) + Th \times (0.0000689 \times Ws - 0.0118) + 0.0022 \times Ws )</td>
</tr>
<tr>
<td>Convenience Store</td>
<td>Continuous</td>
<td>( CZ + Fu \times (0.00545 \times Th - 0.00251 \times Ws + 0.416) + Th \times (0.000123 \times Ws - 0.0204) + 0.00183 \times Ws )</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>( CZ + Fu \times (0.00405 \times Th - 0.000519 \times Ws - 0.11) + Th \times (0.0000689 \times Ws - 0.0118) + 0.0022 \times Ws )</td>
</tr>
<tr>
<td>Office – Low Rise</td>
<td>Continuous</td>
<td>( CZ + Fu \times (0.0205 \times Th - 0.364) + Th \times (0.00046 \times Ws - 0.0554) + 0.00169 \times Ws )</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>( CZ + Fu \times (0.00745 \times Th - 0.416) + Th \times (0.000123 \times Ws - 0.0204) + 0.00183 \times Ws )</td>
</tr>
<tr>
<td>Religious</td>
<td>Continuous</td>
<td>( CZ + Fu \times 0.00791 \times Th + Th \times (0.00096 \times Ws - 0.167) + 0.00184 \times Ws )</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>( CZ + Fu \times 0.00143 \times Th - 0.0309) + Th \times (0.0008 \times Ws - 0.134) + 0.00219 \times Ws )</td>
</tr>
<tr>
<td>Restaurant – Fast Food</td>
<td>Continuous</td>
<td>( CZ + Fu \times (0.0431 \times Th + 0.0424 \times Ws - 7.517) + Th \times (0.00113 \times Ws - 0.213) + 0.00119 \times Ws )</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>( CZ + Fu \times (0.0125 \times Th + 0.0036 \times Ws - 0.71) + Th \times (0.000329 \times Ws - 0.0615) + 0.00738 \times Ws )</td>
</tr>
<tr>
<td>Restaurant – Full Service</td>
<td>Continuous</td>
<td>( CZ + Fu \times (0.00445 \times Ws - 0.535) + Th \times (0.000679 \times Ws - 0.1) + 0.00218 \times Ws )</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>( CZ + Fu \times (0.00144 \times Th + 0.00262 \times Ws - 0.0553) + Th \times (0.00018 \times Ws - 0.0299) + 0.00166 \times Ws )</td>
</tr>
<tr>
<td>Retail – Department Store</td>
<td>Continuous</td>
<td>( CZ + th \times (0.00203 \times Th + Th \times (0.000591 \times Ws - 0.0812) + 0.00194 \times Ws )</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>( CZ + Th \times (0.000406 \times Ws - 0.0611) + 0.00228 \times Ws )</td>
</tr>
<tr>
<td>Retail – Strip Mall</td>
<td>Continuous</td>
<td>( CZ + Fu \times (0.00998 \times Th + 0.00207 \times Ws - 0.206) + Th \times (0.000665 \times Ws - 0.101) + 0.00292 \times Ws )</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>( CZ + Fu \times (0.00383 \times Th - 0.0656) + Th \times (0.000575 \times Ws - 0.0912) + 0.00249 \times Ws )</td>
</tr>
</tbody>
</table>

Where:

- **CZ** = Climate Zone Coefficient
- **Fo** = Depends on Building Type and Fan Mode During Occupied Period (see table below)
- **Th** = Degrees of Heating Setback °F
- **Ws** = Must be between 0-15°F
**4.4.18 Small Commercial Programmable Thermostats**

- **Fo** = Fan Mode During Occupied Period (Note: Commercial mechanical code requires continuous fan operation during occupied periods to meet ventilation requirements.)
  - Continuous for occupied fan that runs continuously (e.g. Fan Mode Set to ‘On’)
  - Intermittent for occupied fan that runs intermittently (e.g. Fan Mode Set to ‘Auto’)

- **Fu** = Fan Mode During Unoccupied Period
  - 0 for unoccupied fan that runs continuously (e.g. Fan Mode Set to ‘On’)
  - 1 for unoccupied fan that runs intermittently (e.g. Fan Mode Set to ‘Auto’)

- **Ws** = Weekly Hours thermostat is in Occupied mode
  - Minimum values depends on Building Type (see table below), maximum value of 168 (24/7)
  - (e.g.: Weekly occupancy schedule of Mon-Sat 8AM-5PM, Sun 9AM-2PM, Ws = 59)

### Natural Gas Energy Use Climate Zone Coefficients and Minimum Weekly Hours Occupied

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Fan Mode During Occupied Period (Fo)</th>
<th>Climate Zone Coefficient (CZ)</th>
<th>Minimum Ws</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Assembly</td>
<td>Continuous</td>
<td>19.872</td>
<td>17.83</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>0.237</td>
<td>0.0989</td>
</tr>
<tr>
<td>Convenience Store</td>
<td>Continuous</td>
<td>1.493</td>
<td>1.081</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>1.128</td>
<td>0.854</td>
</tr>
<tr>
<td>Office - Low Rise</td>
<td>Continuous</td>
<td>1.718</td>
<td>1.317</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>3.447</td>
<td>3.022</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>5.914</td>
<td>5.368</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>1.227</td>
<td>0.636</td>
</tr>
<tr>
<td>Restaurant – Full Service</td>
<td>Continuous</td>
<td>5.247</td>
<td>4.484</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>0.951</td>
<td>0.704</td>
</tr>
<tr>
<td>Retail – Department Store</td>
<td>Continuous</td>
<td>4.385</td>
<td>3.854</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>3.061</td>
<td>2.672</td>
</tr>
<tr>
<td>Retail – Strip Mall</td>
<td>Continuous</td>
<td>3.917</td>
<td>3.394</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>2.659</td>
<td>2.292</td>
</tr>
</tbody>
</table>

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-HVC-PROG-V02-150601**
4.4.19 Demand Controlled Ventilation

DESCRIPTION

Demand control ventilation (DCV) adjusts outside ventilation air based on the number of occupants and the ventilation demands that those occupants create. DCV is part of a building’s ventilation system control strategy. It may include hardware, software, and controls as an integral part of a building’s ventilation design. Active control of the ventilation system provides the opportunity to reduce heating and cooling energy use.

The primary component is a control sensor to communicate either directly with the economizer or with a central computer. The component is most typically a carbon dioxide (CO\textsubscript{2}) sensor, occupancy sensor, or turnstile counter. This measure is applicable to multiple building types, and savings are classified by the specific building types defined in the Illinois TRM. This measure is modeled to assume night time set backs are in operation and minimum outside air is being used when the building is unoccupied. Systems that have static louvers or that are open at night will likely have greater savings by using the custom program.

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 condition is defined by new CO\textsubscript{2} sensors installed on return air systems where no other sensors were previously installed. For heating savings, this measure does not apply to any system with terminal reheat (constant volume or variable air volume). For terminal reheat system a custom savings calculation should be used.

DEFINITION OF BASELINE EQUIPMENT

The base case for this measure is a space with no demand control capability. The current code minimum for outside air (OA) is 17 CFM per occupant (ASHRAE 62.1) which is the value assumed in this measure.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The deemed measure life is 10 years and based on CO\textsubscript{2} sensor estimated life.\textsuperscript{383}

DEEMED MEASURE COST

The deemed measure cost is assumed to be the full cost of installation of a DCV retrofit including sensor cost ($500) and installation ($1000 labor) for a total of $1500\textsuperscript{384}.

LOADSHAPE

Commercial ventilation C23

COINCIDENCE FACTOR

N/A

\textsuperscript{383} During the course of conversations with vendors and Building Automation System (BAS) contractors, it was determined that sensors have to be functional for up to 10 years. It is recommended that they are part of a normal preventive maintenance program in which calibration is an important part of extending useful life. Although they are not subject to mechanical failure, they do fall out of tolerance over time.

\textsuperscript{384} Discussion with vendors
Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS

\[ \Delta \text{kWh} = \text{Condition Space}/1000 \times \text{Savings\_Factor} \]

Where:

- Conditioned Space = actual square footage of conditioned space controlled by sensor
- Elec\_Savings\_Factor = value in table below based on building type and weather zone

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Elect_Savings_Factor (kWh/1000 sq ft)</th>
<th>Zone 1 (Rockford)</th>
<th>Zone 2 (Chicago)</th>
<th>Zone 3 (Springfield)</th>
<th>Zone 4 (Belleville)</th>
<th>Zone 5 (Marion)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office - Low-rise</td>
<td></td>
<td>454</td>
<td>456</td>
<td>460</td>
<td>456</td>
<td>462</td>
</tr>
<tr>
<td>Office - Mid-rise</td>
<td></td>
<td>430</td>
<td>431</td>
<td>432</td>
<td>428</td>
<td>433</td>
</tr>
<tr>
<td>Office - High-rise</td>
<td></td>
<td>448</td>
<td>450</td>
<td>452</td>
<td>449</td>
<td>454</td>
</tr>
<tr>
<td>Religious Building</td>
<td></td>
<td>493</td>
<td>509</td>
<td>573</td>
<td>584</td>
<td>605</td>
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<tr>
<td>Restaurant</td>
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<td>505</td>
<td>515</td>
<td>553</td>
<td>569</td>
<td>581</td>
</tr>
<tr>
<td>Retail - Department Store</td>
<td></td>
<td>620</td>
<td>625</td>
<td>630</td>
<td>638</td>
<td>642</td>
</tr>
<tr>
<td>Retail - Strip Mall</td>
<td></td>
<td>380</td>
<td>376</td>
<td>356</td>
<td>406</td>
<td>407</td>
</tr>
<tr>
<td>Convenience Store</td>
<td></td>
<td>602</td>
<td>603</td>
<td>610</td>
<td>612</td>
<td>614</td>
</tr>
<tr>
<td>Elementary School</td>
<td></td>
<td>317</td>
<td>327</td>
<td>352</td>
<td>352</td>
<td>363</td>
</tr>
<tr>
<td>High School</td>
<td></td>
<td>305</td>
<td>316</td>
<td>340</td>
<td>340</td>
<td>352</td>
</tr>
<tr>
<td>College/ University</td>
<td></td>
<td>392</td>
<td>410</td>
<td>434</td>
<td>449</td>
<td>462</td>
</tr>
<tr>
<td>Healthcare Clinic</td>
<td></td>
<td>353</td>
<td>358</td>
<td>379</td>
<td>383</td>
<td>389</td>
</tr>
<tr>
<td>Lodging</td>
<td></td>
<td>576</td>
<td>578</td>
<td>586</td>
<td>588</td>
<td>591</td>
</tr>
<tr>
<td>Manufacturing</td>
<td></td>
<td>481</td>
<td>482</td>
<td>482</td>
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<td>482</td>
</tr>
<tr>
<td>Special Assembly Auditorium</td>
<td></td>
<td>410</td>
<td>427</td>
<td>479</td>
<td>494</td>
<td>514</td>
</tr>
<tr>
<td>Default</td>
<td></td>
<td>451</td>
<td>458</td>
<td>475</td>
<td>482</td>
<td>490</td>
</tr>
</tbody>
</table>

385 The electric energy savings was calculated using TMY3 weather data and methodology consistent with ASHRAE standards. Savings are calculated on an annual basis for each given temperature zone in Illinois. Energy savings for DCV were developed utilizing standards, inputs and approaches as set forth by ASHRAE 62.1and 90.1, respectively. Building input parameters like square footage, equipment efficiencies and occupancy match those used in the EFLH calculations. Reference calculation found in Demand Control Ventilation 12-30-13.xls.
For example: 7,500 SqFt of low-rise office space in Chicago.

\[ \Delta \text{kWh} = \frac{7,500 \text{ SqFt}}{1000} \times 456 \text{ kWh} = 3,420 \text{ kWh} \]

**Summer Coincident Peak Demand Savings**

NA

**Natural Gas Savings**

\[ \Delta \text{therms} = \frac{\text{Conditioned Space}}{1000} \times \text{Therm} \_\text{Savings} \_\text{Factor} \]

Where:

- Conditioned Space = actual square footage of conditioned space controlled by sensor
- Therm \_\text{Savings} \_\text{Factor} = value in table below based on building type and weather zone\(^{386}\)

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Therm _\text{Savings} _\text{Factor} (Therm/1000 sq ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Zone 1 (Rockford)</td>
</tr>
<tr>
<td></td>
<td>Zone 2 (Chicago)</td>
</tr>
<tr>
<td></td>
<td>Zone 3 (Springfield)</td>
</tr>
<tr>
<td></td>
<td>Zone 4 (Belleville)</td>
</tr>
<tr>
<td></td>
<td>Zone 5 (Marion)</td>
</tr>
<tr>
<td>Office - Low-rise</td>
<td>30</td>
</tr>
<tr>
<td>Office - Mid-rise</td>
<td>20</td>
</tr>
<tr>
<td>Office - High-rise</td>
<td>27</td>
</tr>
<tr>
<td>Religious Building</td>
<td>191</td>
</tr>
<tr>
<td>Restaurant</td>
<td>135</td>
</tr>
<tr>
<td>Retail - Department Store</td>
<td>47</td>
</tr>
<tr>
<td>Retail - Strip Mall</td>
<td>31</td>
</tr>
<tr>
<td>Convenience Store</td>
<td>23</td>
</tr>
<tr>
<td>Elementary School</td>
<td>83</td>
</tr>
<tr>
<td>High School</td>
<td>81</td>
</tr>
<tr>
<td>College/ University</td>
<td>161</td>
</tr>
<tr>
<td>Healthcare Clinic</td>
<td>57</td>
</tr>
<tr>
<td>Lodging</td>
<td>26</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>21</td>
</tr>
</tbody>
</table>

\(^{386}\) The natural gas energy savings was calculated using TMY3 weather data and methodology consistent with ASHRAE standards. Savings are calculated on an annual basis for each given temperature zone in Illinois. Energy savings for DCV were developed utilizing standards, inputs and approaches as set forth by ASHRAE 62.1 and 90.1, respectively. Building input parameters like square footage, equipment efficiencies and occupancy match those used in the EFLH calculations. Reference calculation found in Demand Control Ventilation 12-30-13.xls.
### Building Type Therm Savings Factor (Therm/1000 sq ft)

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Zone 1 (Rockford)</th>
<th>Zone 2 (Chicago)</th>
<th>Zone 3 (Springfield)</th>
<th>Zone 4 (Belleville)</th>
<th>Zone 5 (Marion)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Special Assembly Auditorium</td>
<td>225</td>
<td>198</td>
<td>179</td>
<td>175</td>
<td>154</td>
</tr>
<tr>
<td>De-fault</td>
<td>77</td>
<td>68</td>
<td>60</td>
<td>58</td>
<td>51</td>
</tr>
</tbody>
</table>

For example: 7500 SqFt of low-rise office space in Chicago.

\[
\Delta \text{Therms} = 7,500 \text{ SqFt} \times 26 \text{ Therm/1000 SqFt} = 195 \text{ Therms}
\]

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-HVC-DCV-V02-140601**
4.4.20 High Turndown Burner for Space Heating Boilers

**DESCRIPTION**

This measure is for a non-residential boilers equipped with linkageless controls providing space heating with burners having a turndown less than 6:1.\(^{387}\) Turndown is the ratio of the high firing rate to the low firing rate. When boilers are subjected to loads below the low firing rate, the boiler must cycle on/off to meet the load requirements. A higher turndown ratio reduces burner startups, provides better load control, saves wear-and-tear on the burner, and reduces purge-air requirements, all of these benefits result in better overall efficiency.

This measure was developed to be applicable to the following program types: NC, TOS, RF.

If applied to other program types, the measure savings should be verified.

**DEFINITION OF EFFICIENT EQUIPMENT**

To qualify the boiler linkageless burner must operate with a turndown greater than or equal to 10:1 and be subjected to loads less than or equal to 30%\(^{388}\) of the full fire input MBH for greater than 60%\(^{389}\) of the operating hours.

**DEFINITION OF BASELINE EQUIPMENT**

The baseline boiler utilizes a linkageless burner with a turndown ratio of 6:1 or less and is used primarily for space heating. Redundant boilers do not qualify.

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The expected measure life is assumed to be 21 years.\(^{390}\)

**DEEMED MEASURE COST**

The deemed installed measure cost including labor is approximately $2.53/MBtu/hr.\(^{391}\)

**DEEMED O&M COST ADJUSTMENTS**

N/A

**LOADSHAPE**

N/A

**COINCIDENCE FACTOR**

N/A


\(^{388}\) Focus on Energy Evaluation, Business Programs: Deemed Savings Manual V1.0, March 22, 2010. This factor implies that boilers are 30% oversized on average.

\(^{389}\) FES Analysis of bin hours based upon a 30% oversizing factor.


\(^{391}\) FES review of PY2/PY3 costs for custom People’s and North Shore high turndown burner projects. See High Turndown Costs.xlsx for details.
Algorithm

Calculation of Savings

Electric Energy Savings

N/A

Summer Coincident Peak Demand Savings

N/A

Natural Gas Savings

\[ \Delta \text{therms} = N_{gi} \times SF \times EFLH / 100 \]

Where:

- \( N_{gi} \) = Boiler gas input size (kBtu/hr) = custom
- \( SF \) = Savings Factor = Percentage of energy loss per hour
  
  \[ = \left( \sum ((EL_{base} - EL_{eff}) \times H_{cycling}) \right) / H \times 100 \]

Where:

- \( EL_{base} \) = Base Boiler Percentage of energy loss due to cycling at % of Base Boiler Load where \( BL_{base} \leq TDR_{base} \)
  
  \[ = 0.003 \times (\text{Cycles}_{base})^2 - 0.001 \times \text{Cycles}_{base} \]

Where:

- \( \text{Cycles}_{base} \) = Number of Cycles/hour of base boiler
  
  \[ = \frac{TDR_{base}}{BL} \]

Where:

- \( BL \) = % of full boiler load at bin hours being evaluated. This is assumed to be a straight line based on 0% load at the building balance point (assumed to be 55F), and full load corrected for the oversizing (OSF) at the lowest temperature bin of -10 to -5F.
- \( OSF \) = Oversizing Factor = 1.3 or custom
  
  \[ TDR_{base} = \text{Turndown ratio} = 0.33 \]

Where:

- \( EL_{eff} \) = Efficient Boiler Percentage of energy loss due to cycling at % of Efficient Boiler Load
  
  \[ = 0.003 \times (\text{Cycles}_{eff})^2 - 0.001 \times \text{Cycles}_{eff} \]

394 Ibid.
Where:

\[ \text{Cycles\_eff} = \frac{\text{TDR\_eff}}{\text{BL}} \]

Where:

\[ \text{TDR\_eff} = \text{Turndown ratio} = 0.10^{395} \text{ or custom} \]

\[ \text{H\_cycling} = \text{Hours base boiler is cycling at \% of base boiler load} \]

\[ = \text{see table below or custom} \]

\[ \text{H} = \text{Total Number of Hours in Heating Season} \]

\[ = 4,946 \text{ or custom} \]

\[ 100 = \text{convert to a percentage} \]

\[ \text{SF} = \frac{69.1}{4946} \times 100 = 1.4\% \text{ or custom (see table below for summary of values)} \]

<table>
<thead>
<tr>
<th>Temperature</th>
<th>H_cycling</th>
<th>BL</th>
<th>EL_base</th>
<th>EL_eff</th>
<th>(EL_base-EL_eff)\times Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 to 55</td>
<td>601</td>
<td>6.0%</td>
<td>8.5%</td>
<td>0.7%</td>
<td>47.2</td>
</tr>
<tr>
<td>45 to 50</td>
<td>603</td>
<td>12.0%</td>
<td>2.0%</td>
<td>0.0%</td>
<td>12.0</td>
</tr>
<tr>
<td>40 to 45</td>
<td>455</td>
<td>18.0%</td>
<td>0.8%</td>
<td>0.0%</td>
<td>3.8</td>
</tr>
<tr>
<td>35 to 40</td>
<td>925</td>
<td>24.0%</td>
<td>0.4%</td>
<td>0.0%</td>
<td>4.0</td>
</tr>
<tr>
<td>30 to 35</td>
<td>814</td>
<td>30.0%</td>
<td>0.3%</td>
<td>0.0%</td>
<td>2.1</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>69.1</td>
</tr>
</tbody>
</table>

\[ \text{EFLH} = \text{Equivalent Full Load Hours for heating are provided in section 4.4 HVAC End Use.} \]

\[ 100 = \text{convert kBtu to therms} \]

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-HVAC-HTBC-V04-140601**

\[ ^{395} \text{10:1 ratio used to qualify for efficient equipment.} \]
4.4.21 Linkageless Boiler Controls for Space Heating

DESCRIPTION

This measure is for a non-residential boiler providing space heating and currently having single point positioning combustion control. In single-point positioning control, the fuel valve is linked to the combustion air damper via a jackshaft mechanism to maintain correspondence between fuel and combustion air input. Most boilers with single point positioning control do not maintain low excess air levels over their entire firing range. Generally these boilers are calibrated at high fire, but due to the non-linearity required for efficient combustion, excess air levels tend to dramatically increase as the firing rate decreases. Boiler efficiency drops as the excess air levels are increased.

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 the boiler burner must have a linkageless control system allowing the combustion air damper position to be adjusted and set for optimal efficiency at several firing rates throughout the burner’s firing range. This requires the fuel valve and combustion air damper to each be powered by a separate actuator. An alternative to the combustion air damper is a Variable Speed Drive on the combustion air fan.

DEFINITION OF BASELINE EQUIPMENT

The baseline boiler utilizes single point positioning for the burner combustion control.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 16 years.\(^{396}\)

DEEMED MEASURE COST

The deemed measure cost is estimated at $2.50/MBtu/hr burner input.\(^{397}\)

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

\(^{396}\) Total number of hours for heating with a base temperature of 55°F for Chicago, IL as noted by National Climate Data Center
Algorithm

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

When a Variable Speed Drive is incorporated, electrical savings are calculated according to the Variable Speed Drive measure.

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

N/A

**NATURAL GAS SAVINGS**

\[ \text{Δtherms} = \text{Ngi} \times \text{SF} \times \text{EFLH} / 100 \]

Where:

- \( \text{Ngi} \) = Boiler gas input size (kBtu/hr) = custom
- \( \text{SF} \) = Savings factor

Note: Savings factor is the percentage increase in efficiency as a result of the addition of linkageless burner controls. At an average boiler load of 35%, single point controls are assumed to have excess air of 91%, while linkageless controls are assumed to have 34% excess air. The difference between controls types is 57% at this average operating condition. A 15% reduction in excess air is approximately a 1% increase in efficiency. Therefore the nominal combustion efficiency increase is \( 57 / 15 \times 1\% = 3.8\% \).

- \( \text{EFLH} \) = Equivalent Full Load Hours for heating are provided in section 4.4 HVAC End Use
- \( 100 \) = convert kBtu to therms

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE:** CI-HVC-LBC-V04-140601

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398 Available and Emerging Technologies for Reducing Greenhouse Gas Emissions from Industrial, Commercial, and Institutional Boilers, Prepared by the Sector Policies and Programs Division Office of Air Quality Planning and Standards U.S. Environmental Protection Agency Research Triangle Park, North Carolina 27711, October 2010, Table 1. ICI Boilers – Summary of Greenhouse Gas Emission Reduction Measures, pg. 8

399 Department of Energy (DOE). January 2012, Steam Tip Sheet #4, Improve Your Boiler’s Combustion Efficiency. Advanced Manufacturing Office. Washington, DC: U.S. Department of Energy. This value was determined as an appropriate average over the stack temperatures and excess air levels indicated.
4.4.22 Oxygen Trim Controls for Space Heating Boilers

**DESCRIPTION**

This measure is for a non-residential boiler providing space heating without oxygen trim combustion controls. Oxygen trim controls limit the amount of excess oxygen provided to the burner for combustion. This oxygen level is dependent upon the amount of air provided. Oxygen trim control converts parallel positioning, linkageless controls, into a closed-loop control configuration with the addition of an exhaust gas analyzer and PID controller. Boilers with oxygen trim controls can maintain a predetermined excess air rate (generally 15% to 30% excess air) over the entire burner firing rate. Boilers without these controls typically have excess air rates around 30% over the entire firing rate. Boiler efficiency drops as the excess air levels are increased.

This measure was developed to be applicable to the following program types: NC, TOS, RF.

If applied to other program types, the measure savings should be verified.

**DEFINITION OF EFFICIENT EQUIPMENT**

To qualify the boiler burner must have an oxygen control system allowing the combustion air to be adjusted to maintain a predetermined excess oxygen level in the flue exhaust at all firing rates throughout the burner’s firing range. This requires an oxygen sensor in the flue exhaust and linkageless fuel valve and combustion air controls.

**DEFINITION OF BASELINE EQUIPMENT**

The baseline boiler utilizes single point positioning for the burner combustion control.

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The measure life for the O2 Trim controls is 18 years.\(^{400}\)

**DEEMED MEASURE COST**

The deemed measure cost is approximately $23,250.\(^{401}\)

**LOADSHAPE**

N/A

**COINCIDENCE FACTOR**

N/A

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\(^{401}\) CODES AND STANDARDS ENHANCEMENT INITIATIVE (CASE) PROCESS BOILERS, 2013 California Building Energy Efficiency Standards, California Utilities Statewide Codes and Standards Team, October 2011, pg. 22
Algorithm

Calculation of Savings

Electric Energy Savings

N/A

Summer Coincident Peak Demand Savings

N/A

Natural Gas Energy Savings

$$\Delta \text{therms} = \text{Ng}_i \times \text{SF} \times \text{EFLH} / 100$$

Where:

- $\text{Ng}_i$ = Boiler gas input size (kBtu/hr)
- $\text{SF}$ = Custom
- $\text{EFLH}$ = Default Equivalent Full Load Hours for heating are provided in section 4.4 HVAC End Use. When available, actual hours should be used.
- $100$ = convert kBtu to therms

Note: Savings factor is the percentage reduction in gas consumption as a result of the addition of O2 trim controls. Linkageless controls have an excess air rate of 28% over the entire firing range. O2 trim controls have an excess air rate of 15%. The average difference is 13%. A 15% reduction in excess air is approximately a 1% increase in efficiency. Therefore the nominal combustion efficiency increase is $13 / 15 * 1% = 0.87\%$.

Water Impact Descriptions and Calculation

N/A

Deemed O&M Cost Adjustment Calculation

The deemed annual Operations and Maintenance cost is $800.$

Measure Code: CI-HVC-O2TC-V01-140601

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$^{403}$ Ibid

$^{405}$ Department of Energy (DOE). January 2012, Steam Tip Sheet #4, Improving Your Boiler’s Combustion Efficiency. Advanced Manufacturing Office. Washington, DC: U.S. Department of Energy. This value was determined as an appropriate average over the stack temperatures and excess air levels indicated.
4.4.23 Shut Off Damper for Space Heating Boilers or Furnaces

DESCRIPTION

This measure is for non-residential atmospheric boilers or furnaces providing space heating without a shut off damper. When appliances are on standby mode warm room air is drawn through the stack via the draft hood or dilution air inlet at a rate proportional to the stack height, diameter and outdoor temperature. More air is drawn through the vent immediately after the appliance shuts off and the flue is still hot. Installation of a new shut off damper can prevent heat from being drawn up the warm vent and reducing the amount of air that passes through the furnace or boiler heat exchanger. This reduction in air can slightly increase overall operating efficiency by reducing the time needed to achieve steady-state operating conditions.

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

To qualify the space heating boiler or furnace must have a new electrically or thermally activated shut off damper installed on either the exhaust flue or combustion air intake. Barometric dampers do not qualify. The damper actuation shall be interlocked with the firing controls.

DEFINITION OF BASELINE EQUIPMENT

The baseline boiler or furnace incorporates no shut off damper on the combustion air intake or flue exhaust.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure life for the shut off damper is 15 years.\textsuperscript{406}

DEEMED MEASURE COST

The deemed measure cost for this approximately $1,500.\textsuperscript{407}

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A


\textsuperscript{407} CODES AND STANDARDS ENHANCEMENT INITIATIVE (CASE) PROCESS BOILERS, 2013 California Building Energy Efficiency Standards, California Utilities Statewide Codes and Standards Team, October 2011, pg. 22
4.4.23 Shut Off Damper for Space Heating Boilers or Furnaces

**Algorithm**

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

N/A

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

N/A

**NATURAL GAS ENERGY SAVINGS**

\[ \Delta \text{therms} = \frac{N_{gi} \times SF \times EFLH}{100} \]

Where:

- \( N_{gi} \) = Boiler gas input size (kBtu/hr)
- \( SF \) = Savings factor
- \( EFLH \) = Default Equivalent Full Load Hours for heating are provided in section 4.4 HVAC End Use. When available, actual hours should be used.
- 100 = convert kBtu to therms

**Note:** The savings factor assumes the boiler or furnace is located in an unconditioned space. The savings factor can be higher for those units located within conditioned space.

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

The deemed annual Operations and Maintenance cost is $112.

**MEASURE CODE: CI-HVC-SODP-V01-140601**

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408 Based on internet review of savings potential;
“Up to 1%”: Page 9, The Carbon Trust, “Steam and high temperature hot water boilers”
http://www.carbontrust.com/media/13332/ctv052_steam_and_high_temperature_hot_water_boilers.pdf
“1 - 2%”: Page 2, Sustainable Energy Authority of Ireland “Steam Systems Technical Guide”,

409 CODES AND STANDARDS ENHANCEMENT INITIATIVE (CASE) PROCESS BOILERS, 2013 California Building Energy Efficiency Standards, California Utilities Statewide Codes and Standards Team, October 2011, pg. 22
4.4.24 Small Pipe Insulation

**DESCRIPTION**

This measure provides rebates for adding insulation to bare pipes with inner diameters of ½” and ¾”. Insulation must be at least one inch thick. Since new construction projects are required by code to have pipe insulation, this measure is only for retrofits of existing facilities. This covers bare straight pipe as well as all fittings.

Default savings are provided on a per linear foot basis. It is assumed that the majority of pipes less than one inch in commercial facilities are used for domestic hot water. However, this measure can cover hydronic heating systems as well as low and high pressure steam systems.

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 case is a ½” or ¾” diameter pipe with at least one inch of insulation. Insulation must be protected from damage which includes moisture, sunlight, equipment maintenance and wind. Outdoor pipes should have a weather protective jacket. Insulation must be continuous over straight pipe, elbows and tees.

**DEFINITION OF BASELINE EQUIPMENT**

The base case for savings estimates is a bare hot water or steam pipe with a fluid temperature of 105 degrees Fahrenheit or greater. Current new construction code requires insulation amounts similar to this measure though this base case is commonly found in older existing buildings.

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The measure life is assumed to be 15 years. ⁴¹⁰

**DEEMED MEASURE COST**

The incremental measure cost for insulation is the full cost of adding insulation to the pipe. Actual installation costs should be used for the measure cost. For planning purposes, the following costs can be used to estimate the full cost of materials and labor. ⁴¹¹

<table>
<thead>
<tr>
<th>Insulation Thickness</th>
<th>¾” pipe</th>
<th>½” pipe</th>
</tr>
</thead>
<tbody>
<tr>
<td>1”</td>
<td>$4.45</td>
<td>$4.15</td>
</tr>
</tbody>
</table>

**LOADSHAPE**

N/A

---


⁴¹¹ A market survey was performed to determine these costs.
C O I N C I D E N C E  F A C T O R

N/A

Algorithm

C A L C U L A T I O N  O F  E N E R G Y  S A V I N G S

E L E C T R I C  E N E R G Y  S A V I N G S

N/A

S U M M E R  C O I N C I D E N T  P E A K  D E M A N D  S A V I N G S

N/A

N A T U R A L  G A S  S A V I N G S

\[ \Delta \text{therms per foot} = \frac{[(Q_{\text{base}} - Q_{\text{eff}}) \times \text{EFLH}]}{(100,000 \times \eta_{\text{Boiler}})} \times \text{TRF} \]

\[ = \frac{[\text{Provided by tables below}]}{\text{TRF}} \times \text{TRF} \]

\[ \Delta \text{therms} = (L_{sp} + L_{oc,i}) \times \Delta \text{therms per foot} \]

Where:

EFLH = Equivalent Full Load Hours for Heating

= Actual or defaults by building type provided in Section 4.4, HVAC end use

For year round recirculation or domestic hot water:

\[ = 8,766 \]

For heating season recirculation, hours with the outside air temperature below 55°F:

<table>
<thead>
<tr>
<th>Zone</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone 1 (Rockford)</td>
<td>5,039</td>
</tr>
<tr>
<td>Zone 2 (Chicago)</td>
<td>4,963</td>
</tr>
<tr>
<td>Zone 3 (Springfield)</td>
<td>4,495</td>
</tr>
<tr>
<td>Zone 4 (Belleville/)</td>
<td>4,021</td>
</tr>
<tr>
<td>Zone 5 (Marion)</td>
<td>4,150</td>
</tr>
</tbody>
</table>

\[ Q_{\text{base}} = \text{Heat Loss from Bare Pipe (Btu/hr/ft)} \]

\[ 412 \text{This value comes from the reference table “Savings Summary by Building Type and System Type.” The formula and the input tables in this section document assumptions used in calculation spreadsheet “Pipe Insulation Savings 2013-11-12.xlsx”} \]
= See table below

\[
Q_{\text{eff}} = \text{Heat Loss from Insulated Pipe (Btu/hr/ft)}
\]

= See table below

100,000 = conversion factor (1 therm = 100,000 Btu)

\( \eta_{\text{Boiler}} \) = Efficiency of the boiler being used to generate the hot water or steam in the pipe

= 81.9% for water boilers \(^{413}\)

= 80.7% for steam boilers, except multifamily low-pressure \(^{414}\)

= 64.8% for multifamily low-pressure steam boilers \(^{415}\)

\( \text{TRF} \) = Thermal Regain Factor for space type, applied only to space heating energy and is applied to values resulting from \( \Delta \)therms/ft tables below \(^{416}\)

= See table below for base TRF values by pipe location

May vary seasonally such as: TRF[summer] * summer hours + TRF[winter] * winter hours where TRF values reflecting summer and winter conditions are apportioned by the hours for those conditions. TRF may also be adjusted by building specific balance temperature and operating hours above and below that balance temperature.\(^{417}\)

<table>
<thead>
<tr>
<th>Pipe Location</th>
<th>Assumed Regain</th>
<th>TRF, Thermal Regain Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outdoor</td>
<td>0%</td>
<td>1.0</td>
</tr>
<tr>
<td>Indoor, heated space</td>
<td>85%</td>
<td>0.15</td>
</tr>
<tr>
<td>Indoor, semi-heated, (unconditioned space, with heat transfer to conditioned space. E.g.: boiler room, ceiling plenum, basement, crawlspace, wall)</td>
<td>30%</td>
<td>0.70</td>
</tr>
<tr>
<td>Indoor, unheated, (no heat transfer to conditioned space)</td>
<td>0%</td>
<td>1.0</td>
</tr>
<tr>
<td>Location not specified</td>
<td>85%</td>
<td>0.15</td>
</tr>
<tr>
<td>Custom</td>
<td>Custom</td>
<td>1 – assumed regain</td>
</tr>
</tbody>
</table>

\( L_{\text{sp}} \) = Length of straight pipe to be insulated (linear foot)

\( L_{\text{loc},\text{i}} \) = Total equivalent length of (elbows and tees) of pipe to be insulated. Use table below to

---

\(^{413}\) Average efficiencies of units from the California Energy Commission (CEC).

\(^{414}\) Ibid.


\(^{416}\) Thermal regain for residential pipe insulation measures is discussed in Home Energy Services Impact Evaluation, prepared for the Massachusetts Residential Retrofit and Low Income Program Area Evaluation, Cadmus Group, Inc., August 2012 and Andrews, John, Better Duct Systems for Home Heating and Cooling, U.S. Department of Energy, 2001. Recognizing the differences between residential and commercial heating systems, the factors have been adjusted based on professional judgment. This factor would benefit from additional study and evaluation.

\(^{417}\) Thermal Regain Factor_4-30-14.docx
determine equivalent lengths.

<table>
<thead>
<tr>
<th>Nominal Pipe Diameter</th>
<th>Equivalent Length (ft)</th>
<th>90 Degree Elbow</th>
<th>Straight Tee</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2&quot;</td>
<td></td>
<td>0.04</td>
<td>0.03</td>
</tr>
<tr>
<td>3/4&quot;</td>
<td></td>
<td>0.06</td>
<td>0.05</td>
</tr>
</tbody>
</table>

\( Q_{\text{base}} \) = Heat Loss from Bare Pipe (Btu/hr/ft). Calculated with the 3E Plus software.

\( Q_{\text{eff}} \) = Heat Loss from Insulated Pipe (Btu/hr/ft). Calculated with the 3E Plus software.

The table below shows the deemed therm savings by building type and region on a per linear foot basis for both ½" and ¾” copper pipe.

The following table provides deemed values for 1/2” copper pipe, temperatures are assumed by category below, and insulation is assumed to be one inch fiberglass.

<table>
<thead>
<tr>
<th>Piping Use</th>
<th>Building Type</th>
<th>Zone 1 (Rockford)</th>
<th>Zone 2 (Chicago)</th>
<th>Zone 3 (Springfield)</th>
<th>Zone 4 (Belleville)</th>
<th>Zone 5 (Marion)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space Heating Non-recirclating</td>
<td>Assembly</td>
<td>0.117</td>
<td>0.120</td>
<td>0.107</td>
<td>0.071</td>
<td>0.109</td>
</tr>
<tr>
<td></td>
<td>Assisted Living</td>
<td>0.110</td>
<td>0.107</td>
<td>0.094</td>
<td>0.069</td>
<td>0.083</td>
</tr>
<tr>
<td></td>
<td>College</td>
<td>0.100</td>
<td>0.093</td>
<td>0.083</td>
<td>0.046</td>
<td>0.055</td>
</tr>
<tr>
<td></td>
<td>Convenience Store</td>
<td>0.097</td>
<td>0.089</td>
<td>0.079</td>
<td>0.057</td>
<td>0.064</td>
</tr>
<tr>
<td></td>
<td>Elementary School</td>
<td>0.116</td>
<td>0.113</td>
<td>0.100</td>
<td>0.069</td>
<td>0.084</td>
</tr>
<tr>
<td></td>
<td>Garage</td>
<td>0.064</td>
<td>0.063</td>
<td>0.056</td>
<td>0.044</td>
<td>0.049</td>
</tr>
<tr>
<td></td>
<td>Grocery</td>
<td>0.105</td>
<td>0.105</td>
<td>0.092</td>
<td>0.057</td>
<td>0.068</td>
</tr>
<tr>
<td></td>
<td>Healthcare Clinic</td>
<td>0.103</td>
<td>0.106</td>
<td>0.092</td>
<td>0.063</td>
<td>0.066</td>
</tr>
<tr>
<td></td>
<td>High School</td>
<td>0.120</td>
<td>0.121</td>
<td>0.109</td>
<td>0.077</td>
<td>0.091</td>
</tr>
<tr>
<td></td>
<td>Hospital - CAV no econ</td>
<td>0.115</td>
<td>0.119</td>
<td>0.101</td>
<td>0.087</td>
<td>0.099</td>
</tr>
<tr>
<td></td>
<td>Hospital - CAV econ</td>
<td>0.117</td>
<td>0.121</td>
<td>0.103</td>
<td>0.089</td>
<td>0.101</td>
</tr>
<tr>
<td></td>
<td>Hospital - VAV econ</td>
<td>0.048</td>
<td>0.045</td>
<td>0.034</td>
<td>0.020</td>
<td>0.022</td>
</tr>
<tr>
<td></td>
<td>Hospital - FCU</td>
<td>0.087</td>
<td>0.099</td>
<td>0.080</td>
<td>0.094</td>
<td>0.127</td>
</tr>
<tr>
<td></td>
<td>Hotel/Motel</td>
<td>0.115</td>
<td>0.112</td>
<td>0.101</td>
<td>0.069</td>
<td>0.084</td>
</tr>
<tr>
<td></td>
<td>Hotel/Motel - Common</td>
<td>0.104</td>
<td>0.106</td>
<td>0.101</td>
<td>0.082</td>
<td>0.086</td>
</tr>
<tr>
<td></td>
<td>Hotel/Motel - Guest</td>
<td>0.115</td>
<td>0.111</td>
<td>0.099</td>
<td>0.066</td>
<td>0.082</td>
</tr>
<tr>
<td></td>
<td>Manufacturing Facility</td>
<td>0.068</td>
<td>0.066</td>
<td>0.061</td>
<td>0.037</td>
<td>0.041</td>
</tr>
<tr>
<td></td>
<td>MF - High Rise</td>
<td>0.100</td>
<td>0.098</td>
<td>0.090</td>
<td>0.076</td>
<td>0.076</td>
</tr>
<tr>
<td>Piping Use</td>
<td>Building Type</td>
<td>Annual Therms Saved / Linear Foot</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------------</td>
<td>--------------------------</td>
<td>-----------------------------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Zone 1 (Rockford)</td>
<td>Zone 2 (Chicago)</td>
<td>Zone 3 (Springfield)</td>
<td>Zone 4 (Belleville)</td>
<td>Zone 5 (Marion)</td>
</tr>
<tr>
<td>MF - High Rise - Common</td>
<td></td>
<td>0.118</td>
<td>0.115</td>
<td>0.103</td>
<td>0.071</td>
<td>0.092</td>
</tr>
<tr>
<td>MF - High Rise - Residential</td>
<td></td>
<td>0.096</td>
<td>0.096</td>
<td>0.087</td>
<td>0.075</td>
<td>0.073</td>
</tr>
<tr>
<td>MF - Mid Rise</td>
<td></td>
<td>0.109</td>
<td>0.110</td>
<td>0.095</td>
<td>0.070</td>
<td>0.079</td>
</tr>
<tr>
<td>Movie Theater</td>
<td></td>
<td>0.119</td>
<td>0.117</td>
<td>0.109</td>
<td>0.083</td>
<td>0.099</td>
</tr>
<tr>
<td>Office - High Rise - CAV no econ</td>
<td></td>
<td>0.132</td>
<td>0.134</td>
<td>0.122</td>
<td>0.082</td>
<td>0.089</td>
</tr>
<tr>
<td>Office - High Rise - CAV econ</td>
<td></td>
<td>0.136</td>
<td>0.139</td>
<td>0.128</td>
<td>0.088</td>
<td>0.097</td>
</tr>
<tr>
<td>Office - High Rise - VAV econ</td>
<td></td>
<td>0.100</td>
<td>0.102</td>
<td>0.084</td>
<td>0.050</td>
<td>0.055</td>
</tr>
<tr>
<td>Office - High Rise - FCU</td>
<td></td>
<td>0.073</td>
<td>0.072</td>
<td>0.062</td>
<td>0.033</td>
<td>0.035</td>
</tr>
<tr>
<td>Office - Low Rise</td>
<td></td>
<td>0.093</td>
<td>0.093</td>
<td>0.074</td>
<td>0.045</td>
<td>0.052</td>
</tr>
<tr>
<td>Office - Mid Rise</td>
<td></td>
<td>0.103</td>
<td>0.104</td>
<td>0.088</td>
<td>0.056</td>
<td>0.062</td>
</tr>
<tr>
<td>Religious Building</td>
<td></td>
<td>0.105</td>
<td>0.098</td>
<td>0.094</td>
<td>0.069</td>
<td>0.079</td>
</tr>
<tr>
<td>Restaurant</td>
<td></td>
<td>0.088</td>
<td>0.088</td>
<td>0.079</td>
<td>0.060</td>
<td>0.071</td>
</tr>
<tr>
<td>Retail - Department Store</td>
<td></td>
<td>0.091</td>
<td>0.083</td>
<td>0.078</td>
<td>0.051</td>
<td>0.058</td>
</tr>
<tr>
<td>Retail - Strip Mall</td>
<td></td>
<td>0.087</td>
<td>0.081</td>
<td>0.071</td>
<td>0.049</td>
<td>0.053</td>
</tr>
<tr>
<td>Warehouse</td>
<td></td>
<td>0.095</td>
<td>0.089</td>
<td>0.091</td>
<td>0.057</td>
<td>0.070</td>
</tr>
<tr>
<td>Unknown</td>
<td></td>
<td>0.101</td>
<td>0.100</td>
<td>0.089</td>
<td>0.064</td>
<td>0.074</td>
</tr>
<tr>
<td><strong>Space Heating - recirculation heating, season only</strong></td>
<td><strong>All buildings (Hours below 55°F)</strong></td>
<td>0.329</td>
<td>0.324</td>
<td>0.293</td>
<td>0.262</td>
<td>0.271</td>
</tr>
<tr>
<td><strong>Space Heating - recirculation year round</strong></td>
<td><strong>All buildings (All hours)</strong></td>
<td>0.572</td>
<td>0.572</td>
<td>0.572</td>
<td>0.572</td>
<td>0.572</td>
</tr>
<tr>
<td>DHW</td>
<td>Recirculation loop</td>
<td>0.572</td>
<td>0.572</td>
<td>0.572</td>
<td>0.572</td>
<td>0.572</td>
</tr>
<tr>
<td>Process</td>
<td>Custom</td>
<td>Custom</td>
<td>Custom</td>
<td>Custom</td>
<td>Custom</td>
<td>Custom</td>
</tr>
</tbody>
</table>
The following table provides deemed savings values for 3/4" copper pipe with temperatures assumed by category below, insulation is assumed to be one inch fiberglass.

<table>
<thead>
<tr>
<th>Piping Use</th>
<th>Building Type</th>
<th>Annual Therms Saved / Linear Foot</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Zone 1 (Rockford)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Zone 1 (Rockford)</td>
</tr>
<tr>
<td>Assembly</td>
<td></td>
<td>0.142</td>
</tr>
<tr>
<td>Assisted Living</td>
<td></td>
<td>0.133</td>
</tr>
<tr>
<td>College</td>
<td></td>
<td>0.121</td>
</tr>
<tr>
<td>Convenience Store</td>
<td></td>
<td>0.117</td>
</tr>
<tr>
<td>Elementary School</td>
<td></td>
<td>0.141</td>
</tr>
<tr>
<td>Garage</td>
<td></td>
<td>0.078</td>
</tr>
<tr>
<td>Grocery</td>
<td></td>
<td>0.127</td>
</tr>
<tr>
<td>Healthcare Clinic</td>
<td></td>
<td>0.125</td>
</tr>
<tr>
<td>High School</td>
<td></td>
<td>0.146</td>
</tr>
<tr>
<td>Hospital - CAV no econ</td>
<td></td>
<td>0.140</td>
</tr>
<tr>
<td>Hospital - CAV econ</td>
<td></td>
<td>0.142</td>
</tr>
<tr>
<td>Hospital - VAV econ</td>
<td></td>
<td>0.058</td>
</tr>
<tr>
<td>Hospital - FCU</td>
<td></td>
<td>0.105</td>
</tr>
<tr>
<td>Hotel/Motel</td>
<td></td>
<td>0.140</td>
</tr>
<tr>
<td>Hotel/Motel - Common</td>
<td></td>
<td>0.127</td>
</tr>
<tr>
<td>Hotel/Motel - Guest</td>
<td></td>
<td>0.139</td>
</tr>
<tr>
<td>Manufacturing Facility</td>
<td></td>
<td>0.083</td>
</tr>
<tr>
<td>MF - High Rise</td>
<td></td>
<td>0.121</td>
</tr>
<tr>
<td>MF - High Rise - Common</td>
<td></td>
<td>0.144</td>
</tr>
<tr>
<td>MF - High Rise - Residential</td>
<td></td>
<td>0.117</td>
</tr>
<tr>
<td>MF - Mid Rise</td>
<td></td>
<td>0.132</td>
</tr>
<tr>
<td>Movie Theater</td>
<td></td>
<td>0.144</td>
</tr>
<tr>
<td>Office - High Rise - CAV no econ</td>
<td></td>
<td>0.160</td>
</tr>
<tr>
<td>Office - High Rise - CAV econ</td>
<td></td>
<td>0.165</td>
</tr>
<tr>
<td>Office - High Rise - VAV econ</td>
<td></td>
<td>0.121</td>
</tr>
<tr>
<td>Office - High Rise - FCU</td>
<td></td>
<td>0.089</td>
</tr>
<tr>
<td>Office - Low Rise</td>
<td></td>
<td>0.113</td>
</tr>
<tr>
<td>Office - Mid Rise</td>
<td></td>
<td>0.126</td>
</tr>
<tr>
<td>Religious Building</td>
<td></td>
<td>0.127</td>
</tr>
<tr>
<td>Piping Use</td>
<td>Building Type</td>
<td>Annual Therms Saved / Linear Foot</td>
</tr>
<tr>
<td>---------------------</td>
<td>------------------------</td>
<td>-----------------------------------</td>
</tr>
<tr>
<td></td>
<td>Zone 1 (Rockford)</td>
<td>Zone 2 (Chicago)</td>
</tr>
<tr>
<td>Restaurant</td>
<td>0.107</td>
<td>0.107</td>
</tr>
<tr>
<td>Retail - Department Store</td>
<td>0.110</td>
<td>0.101</td>
</tr>
<tr>
<td>Retail - Strip Mall</td>
<td>0.106</td>
<td>0.098</td>
</tr>
<tr>
<td>Warehouse</td>
<td>0.115</td>
<td>0.108</td>
</tr>
<tr>
<td>Unknown</td>
<td>0.123</td>
<td>0.122</td>
</tr>
<tr>
<td>Space Heating - recirculation heating season only</td>
<td>All buildings (Hours below 55°F)</td>
<td>0.399</td>
</tr>
<tr>
<td>Space Heating - recirculation year round</td>
<td>All buildings (All hours)</td>
<td>0.694</td>
</tr>
<tr>
<td>DHW</td>
<td>Recirculation loop</td>
<td>0.694</td>
</tr>
<tr>
<td>Process</td>
<td>Custom</td>
<td>Custom</td>
</tr>
</tbody>
</table>

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE Code:** CI-HVC-SPIN-V01-150601
4.4.25 Small Commercial Programmable Thermostat Adjustments

**DESCRIPTION**

This measure involves reprogramming existing commercial programmable thermostats or building automation systems for reduced energy consumption through adjustments of unoccupied heating/cooling setpoints and/or fan control. This measure is limited to packaged HVAC units that are controlled by a commercial thermostat or building automation system. The measure is limited to select building types presented below.

<table>
<thead>
<tr>
<th>Eligible Small Commercial Building Types</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building Type</td>
</tr>
<tr>
<td>Assembly</td>
</tr>
<tr>
<td>Convenience Store</td>
</tr>
<tr>
<td>Office - Low Rise</td>
</tr>
<tr>
<td>Restaurant - Fast Food</td>
</tr>
<tr>
<td>Religious Facility</td>
</tr>
<tr>
<td>Restaurant - Full Service</td>
</tr>
<tr>
<td>Retail - Strip Mall</td>
</tr>
<tr>
<td>Retail - Department Store</td>
</tr>
</tbody>
</table>

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 criteria for this measure is established by optimizing heating/cooling temperature setbacks and fan operation with a commercial programmable thermostat or building automation system, which reprogrammed to match actual facility occupancy.

**DEFINITION OF BASELINE EQUIPMENT**

The baseline for this measure is a commercial programmable thermostat or building automation system that is currently operating packaged HVAC units with heating/cooling temperature setbacks and fan operation that do not align with a facilities actual occupancy.

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The expected measure life of a programmable thermostat is assumed to be 8 years\(^{418}\) based upon equipment life only\(^{419}\). For the purposes of claiming savings for a adjustment of an existing programmable thermostat, this is

\(^{418}\) Table 1, HVAC Controls, Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007

\(^{419}\) Future evaluation is strongly encouraged to inform the persistence of savings to further refine measure life assumption.
reduced to a 25% persistence factor to give a final measure life of 2 years. It is recommended that this assumption be evaluated by future energy measurement and verification activities.

**DEEMED MEASURE COST**

Actual labor costs should be used if the implementation method allows. If unknown the labor cost for this measure is assumed to be $70.34 per thermostat, as summarized in the table below.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Units</th>
<th>Materials</th>
<th>Labor</th>
<th>Total Cost (including O&amp;P)</th>
<th>City Cost Index (Install Only)*</th>
<th>Total</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adjust Temperature Set Points</td>
<td>4</td>
<td>$0.00</td>
<td>$5.95</td>
<td>$6.55</td>
<td>134.5%</td>
<td>$35.24</td>
<td>RS Means 2010 (pg 255, Section 23-09-8100)</td>
</tr>
<tr>
<td>Adjust Fan Schedule</td>
<td>2</td>
<td>$0.00</td>
<td>$11.86</td>
<td>$13.05</td>
<td>134.5%</td>
<td>$35.10</td>
<td>RS Means 2010 (pg 255, Section 23-09-8120)</td>
</tr>
<tr>
<td>Totals</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$70.34</td>
<td></td>
</tr>
</tbody>
</table>

* Chicago, IL - Division 23

**LOADSHAPE**

N/A

**COINCIDENCE FACTOR**

N/A

---

Algorithm

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

\[ \Delta \text{kWh} = [\text{Baseline Energy Use (kWh/Ton)} - \text{Proposed Energy Use (kWh/Ton)}] \times \text{Cooling Capacity (Tons)} \]

The following equations are used to calculate baseline and proposed electric energy use. The savings is the difference between the proposed and baseline calculated usage. This approach allows the savings estimate to account for the operational attributes of the baseline as well as the proposed case, yielding a better estimate than an approach that assumes a particular baseline or proposed energy use to determine savings.

**Electric Energy Use Equations (kWh / ton)**

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Fan Mode During Occupied Period (Fo)</th>
<th>Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assembly</td>
<td>Continuous</td>
<td>( CZ + Fu^* (0.83^* Tc + 0.83^* Th + 1.67^* Ws - 293.018) - 0.092^* Tc^* Th + 1.291^* Ws )</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>( CZ + Fu^* (1.911 - 0.12^* Tc^* + Th^* (0.00311^* Ws - 0.229^* ) + 0.11^* Ws )</td>
</tr>
<tr>
<td>Convenience Store</td>
<td>Continuous</td>
<td>( CZ + Fu^* (-28.629^* Tc + 11.69^* Th + 19.118^* Ws - 2935.12) + 0.909^* Ws )</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>( CZ + Tc^* (0.0863^* Ws - 12.688^* ) + Th^* (0.043^* Ws - 6.38^* ) + 1.669^* Ws )</td>
</tr>
<tr>
<td>Office – Low Rise</td>
<td>Continuous</td>
<td>( CZ + Fu^* (7.082^* Tc + 41.199^* Th + 18.734^* Ws - 3288.55) + Tc^* (0.205^* Ws - 34.929^* ) )</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>( CZ + Tc^* (0.0806^* Ws - 8.984^* ) + Th^* (0.00311^* Ws - 6.38^* ) + 1.178^* Ws )</td>
</tr>
<tr>
<td>Religious</td>
<td>Continuous</td>
<td>( CZ + Fu^* (-1.579^* Tc - 18.14^* Th + 15.01^* Ws - 2417.74) + Tc^* (0.177^* Ws - 12.688^* ) )</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>( CZ + Tc^* (0.0863^* Ws - 12.688^* ) + Th^* (0.043^* Ws - 6.38^* ) + 1.669^* Ws )</td>
</tr>
<tr>
<td>Restaurant – Fast Food</td>
<td>Continuous</td>
<td>( CZ + Fu^* (0.678^* Tc + 0.257^* Th + 2.88^* Ws - 494.006^* ) + Tc^* (0.00311^* Ws - 6.38^* ) + 0.11^* Ws )</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>( CZ + Fu^* (0.377^* Tc + 0.124^* Th + 0.13^* Ws - 24.893^* ) + Tc^* (0.0143^* Th + 0.0166^* Ws - 2.691^* ) + 0.898^* Ws )</td>
</tr>
<tr>
<td>Restaurant – Sit Down</td>
<td>Continuous</td>
<td>( CZ + Fu^* (-8.41^* Th + 11.766^* Ws - 1910.81^* ) + Tc^* (0.0282^* Ws - 43.851^* ) )</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>( CZ + Fu^* (-0.123^* Tc + Tc^* (0.0561^* Ws - 8.237^* ) + Th^* (0.0219^* Ws - 3.284^* ) + 1.038^* Ws )</td>
</tr>
<tr>
<td>Retail – Large</td>
<td>Continuous</td>
<td>( CZ + Fu^* (-1.475^* Th + 0.755^* Ws - 114.373^* ) + Th^* (0.151^* Ws - 24.016^* ) + 1.612^* Ws )</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>( CZ + Tc^* (0.0173^* Ws - 1.912^* ) + Th^* (0.0249^* Ws - 3.29^* ) + 0.511^* Ws )</td>
</tr>
<tr>
<td>Retail – Strip Mall</td>
<td>Continuous</td>
<td>( CZ + Fu^* (1.077^* Tc + 10.697^* Th + 6.91^* Ws - 1117.18^* ) + Tc^* (0.0583^* Ws - 7.54^* ) + 1.231^* Ws )</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>( CZ + Fu^* (-0.0894^* Tc + Tc^* (0.0142^* Tc + 0.04^* Ws - 5.278^* ) + 0.884^* Ws )</td>
</tr>
</tbody>
</table>

Where:

\[ CZ = \text{Climate Zone Coefficient} \]
\[ = \text{Depends on Building Type and Fan Mode During Occupied Period (see table below)} \]

4.4.25 Small Commercial Programmable Thermostat Adjustments

- $T_c$ = Degrees of Cooling Setback °F
- $T_h$ = Degrees of Heating Setback °F
- $F_o$ = Fan Mode During Occupied Period (Note: Commercial mechanical code requires continuous fan operation during occupied periods to meet ventilation requirements.)
  - Continuous for occupied fan that runs continuously (e.g. Fan Mode Set to ‘On’)
  - Intermittent for occupied fan that runs intermittently (e.g. Fan Mode Set to ‘Auto’)

- $F_u$ = Fan Mode during Unoccupied Period
  - 0 for unoccupied fan that runs continuously (e.g. Fan Mode Set to ‘On’)
  - 1 for unoccupied fan that runs intermittently (e.g. Fan Mode Set to ‘Auto’)

- $W_s$ = Weekly Hours thermostat is in Occupied mode
  - Minimum values depend on Building Type (see table below), maximum value of 168 (24/7)

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Fan Mode During Occupied Period ($F_o$)</th>
<th>Climate Zone Coefficient ($C_Z$)</th>
<th>Minimum $W_s$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assembly</td>
<td>Continuous</td>
<td>911.366  928.924  1152.83  1208.999  1210.173</td>
<td>98</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>735.752  762.831  966.562  998.927  1028.906</td>
<td></td>
</tr>
<tr>
<td>Conveniences Store</td>
<td>Continuous</td>
<td>4817.094  4832.784  5139.133  5182.161  5208.608</td>
<td>108</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>1478.133  1514.568  1784.384  1843.463  1930.47</td>
<td></td>
</tr>
<tr>
<td>Office - Low Rise</td>
<td>Continuous</td>
<td>5047.662  5039.592  5187.924  5217.672  5177.449</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>825.072  808.965  946.571  979.421  945.418</td>
<td></td>
</tr>
<tr>
<td>Religious Facility</td>
<td>Continuous</td>
<td>4197.117  4172.858  4380.025  4370.008  4356.054</td>
<td>133</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>632.404  603.395  678.294  664.717  616.853</td>
<td></td>
</tr>
<tr>
<td>Restaurant – Fast Food</td>
<td>Continuous</td>
<td>1342.988  1378.661  1664.018  1714.201  1727.841</td>
<td>108</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>993.764  1039.643  1307.8  1340.544  1389.791</td>
<td></td>
</tr>
<tr>
<td>Restaurant – Full Service</td>
<td>Continuous</td>
<td>4070.35  4094.742  4428.966  4501.829  4522.522</td>
<td>117</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>1472.014  1516.05  1856.108  1938.441  2056.45</td>
<td></td>
</tr>
<tr>
<td>Retail – Department Store</td>
<td>Continuous</td>
<td>1510.201  1496.47  1706.105  1716.128  1688.464</td>
<td>93</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>701.27  702.129  847.735  875.12  881.677</td>
<td></td>
</tr>
<tr>
<td>Retail – Strip Mall</td>
<td>Continuous</td>
<td>1926.294  1930.137  2156.856  2174.435  2165.03</td>
<td>93</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>656.479  673.257  835.906  850.322  869.921</td>
<td></td>
</tr>
</tbody>
</table>
EXAMPLE

A low rise office building in Rockford (Climate Zone 1) is occupied Mon-Fri 7AM-6PM and is heated and cooled with a packaged Gas (150 kbtu output) / DX (10 Ton) RTU which is controlled by a programmable thermostat. When the technician reviews the thermostat schedule they find the unoccupied schedule is programmed incorrectly. During the unoccupied periods the fan is programmed correctly, and runs in intermittent “auto” mode, although the heating and cooling temperature setpoints are not setback.

The technician adjusts the unoccupied schedule to include a 10°F cooling and heating temperature setback during the unoccupied periods.

\[ \Delta k\text{Wh} = (\text{Baseline Energy Use (kWh/Ton)} - \text{Proposed Energy Use (kWh/Ton)}) \times \text{Cooling Capacity (Tons)} \]

Baseline Energy Use (kWh/Ton) = Equation for Office Low Rise, \( F_o = \text{Continuous} \)

\[ = CZ + Fu \times (7.082 \times T_c - 41.199 \times Th + 18.734 \times W_s - 3288.55) + T_c \times (0.205 \times W_s - 34.929) \]

\[ = 5047.662 + 1 \times (7.082 \times 0 - 41.199 \times 0 + 18.734 \times 55 - 3288.55) + 0 \times (0.205 \times 55 - 34.929) \]

\[ = 2,789.482 \text{ kWh/Ton} \]

Proposed Energy Use (kWh/Ton) = Equation for Office Low Rise, \( F_o = \text{Continuous} \)

\[ = CZ + Fu \times (7.082 \times T_c - 41.199 \times Th + 18.734 \times W_s - 3288.55) + T_c \times (0.205 \times W_s - 34.929) \]

\[ = 5047.662 + 10 \times (7.082 \times 10 - 41.199 \times 10 + 18.734 \times 55 - 3288.55) + 10 \times (0.205 \times 55 - 34.929) \]

\[ = 2,211.722 \text{ kWh/Ton} \]

\[ \Delta k\text{Wh} = [2,789.482 \text{ (kWh/Ton)} - 2,211.722 \text{ (kWh/Ton)}] \times 10 \text{ Tons} \]

\[ = 577.71 \text{ kWh/Ton} \times 10 \text{ Tons} \]

\[ = 5777.1 \text{ kWh} \]
\[ \Delta \text{Therms} = \left[ \text{Baseline Energy Use (Therms/kBtuh)} - \text{Proposed Energy Use(Therms/kBtuh)} \right] \times \text{Output Heating Capacity (kBtuh)} \]

The following equations are used to calculate baseline and proposed natural gas energy use. The savings is the difference between the proposed and baseline calculated usage. This approach allows the savings estimate to account for the operational attributes of the baseline as well as the proposed case, yielding a better estimate than an approach that assumes a particular baseline or proposed energy use to determine savings.

### Natural Gas Energy Use Equations (therms / kbtu)

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Fan Mode During Occupied Period (Fo)</th>
<th>Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assembly</td>
<td>Continuous</td>
<td>[ CZ + Fu \times (0.232 \times Th + 0.0984 \times Ws - 18.79) + Th \times (0.00271 \times Ws - 0.535) + 0.0142 \times Ws ]</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>[ CZ + Fu \times (0.00405 \times Th + 0.000519 \times Ws - 0.11) + Th \times (0.0000689 \times Ws - 0.0118) + 0.0022 \times Ws ]</td>
</tr>
<tr>
<td>Convenience Store</td>
<td>Continuous</td>
<td>[ CZ + Fu \times (0.00545 \times Th - 0.00251 \times Ws + 0.416) + Th \times (0.000123 \times Ws - 0.0204) + 0.00183 \times Ws ]</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>[ CZ + Fu \times (0.00231 \times Th - 0.0349) + Th \times (0.0000309 \times Ws - 0.0494) + 0.00266 \times Ws ]</td>
</tr>
<tr>
<td>Office – Low Rise</td>
<td>Continuous</td>
<td>[ CZ + Fu \times (0.00745 \times Th - 0.142) + Th \times (0.00077 \times Ws - 0.111) + 0.00199 \times Ws ]</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>[ CZ + Fu \times (0.00205 \times Th - 0.364) + Th \times (0.00046 \times Ws - 0.0554) + 0.00169 \times Ws ]</td>
</tr>
<tr>
<td>Religious</td>
<td>Continuous</td>
<td>[ CZ + Fu \times (0.00096 \times Ws - 0.167) + 0.00184 \times Ws ]</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>[ CZ + Fu \times (0.00143 \times Th - 0.0309) + Th \times (0.0008 \times Ws - 0.134) + 0.00219 \times Ws ]</td>
</tr>
<tr>
<td>Restaurant – Fast Food</td>
<td>Continuous</td>
<td>[ CZ + Fu \times (0.0431 \times Th - 0.0424 \times Ws - 7.517) + Th \times (0.00113 \times Ws - 0.213) + 0.0119 \times Ws ]</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>[ CZ + Fu \times (0.0125 \times Th - 0.0036 \times Ws - 0.71) + Th \times (0.000329 \times Ws - 0.0615) + 0.00738 \times Ws ]</td>
</tr>
<tr>
<td>Restaurant – Sit Down</td>
<td>Continuous</td>
<td>[ CZ + Fu \times (0.00445 \times Ws - 0.535) + Th \times (0.0000679 \times Ws - 0.1) + 0.00218 \times Ws ]</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>[ CZ + Fu \times (0.00144 \times Th - 0.000262 \times Ws - 0.0553) + Th \times (0.00018 \times Ws - 0.0299) + 0.00166 \times Ws ]</td>
</tr>
<tr>
<td>Retail – Large</td>
<td>Continuous</td>
<td>[ CZ + Fu \times (0.000203 \times Ws - 0.0812) + 0.00194 \times Ws ]</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>[ CZ + Th \times (0.000406 \times Ws - 0.0611) + 0.00228 \times Ws ]</td>
</tr>
<tr>
<td>Retail – Strip Mall</td>
<td>Continuous</td>
<td>[ CZ + Fu \times (0.00098 \times Th - 0.00207 \times Ws - 0.206) + Th \times (0.0000665 \times Ws - 0.101) + 0.00292 \times Ws ]</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>[ CZ + Fu \times (0.00383 \times Th - 0.0656) + Th \times (0.0000575 \times Ws - 0.0912) + 0.00249 \times Ws ]</td>
</tr>
</tbody>
</table>

Where:

- **CZ** = Climate Zone Coefficient
  - Depends on Building Type and Fan Mode During Occupied Period (see table below)
- **Th** = Degrees of Heating Setback °F
  - Must be between 0-15°F
- **Fo** = Fan Mode During Occupied Period (Note: Commercial mechanical code requires continuous fan operation during occupied periods to meet ventilation requirements.)
  - Continuous for occupied fan that runs continuously (e.g. Fan Mode Set to ‘On’)

---

**Small Commercial Programmable Thermostat Adjustments**

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

N/A
= Intermittent for occupied fan that runs intermittently (e.g. Fan Mode Set to ‘Auto’)

\( Fu \) = Fan Mode during Unoccupied Period

= 0 for unoccupied fan that runs continuously (e.g. Fan Mode Set to ‘On’)

= 1 for unoccupied fan that runs intermittently (e.g. Fan Mode Set to ‘Auto’)

\( Ws \) = Weekly Hours thermostat is in Occupied mode,

= Minimum values depends on Building Type (see table below), maximum value of 168 (24/7)

\[ \text{ex: Weekly occupancy schedule of Mon-Sat 8AM-5PM, Sun 9AM-2PM, Ws = 59.} \]

### Natural Gas Energy Use Climate Zone Coefficients and Minimum Weekly Hours Occupied

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Fan Mode During Occupied Period (Fo)</th>
<th>Climate Zone Coefficient (CZ)</th>
<th>Minimum Ws</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Assembly</td>
<td>Continuous</td>
<td>19.872</td>
<td>17.83</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>0.237</td>
<td>0.0989</td>
</tr>
<tr>
<td>Convenience Store</td>
<td>Continuous</td>
<td>1.493</td>
<td>1.081</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>1.128</td>
<td>0.854</td>
</tr>
<tr>
<td>Office - Low Rise</td>
<td>Continuous</td>
<td>1.718</td>
<td>1.317</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>3.447</td>
<td>3.022</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>5.914</td>
<td>5.368</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>1.227</td>
<td>0.636</td>
</tr>
<tr>
<td>Restaurant – Full Service</td>
<td>Continuous</td>
<td>5.247</td>
<td>4.484</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>0.951</td>
<td>0.704</td>
</tr>
<tr>
<td>Retail – Department Store</td>
<td>Continuous</td>
<td>4.385</td>
<td>3.854</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>3.061</td>
<td>2.672</td>
</tr>
<tr>
<td>Retail – Strip Mall</td>
<td>Continuous</td>
<td>3.917</td>
<td>3.394</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
<td>2.659</td>
<td>2.292</td>
</tr>
</tbody>
</table>
EXAMPLE

A low rise office building in Rockford (Climate Zone 1) is occupied Mon-Fri 7AM-6PM and is heated and cooled with a packaged Gas (150 kBtu output) / DX (10 Ton) RTU which is controlled by a programmable thermostat. When the technician reviews the thermostat schedule they find the unoccupied schedule is programmed incorrectly. During the unoccupied periods the fan is programmed correctly, and runs in intermittent “auto” mode, although the heating and cooling temperature setpoints are not setback.

The technician adjusts the unoccupied schedule to include a 10°F cooling and heating temperature setback during the unoccupied periods.

\[ \Delta \text{Therms} = \left( \text{Baseline Energy Use (Therms/kBtuh)} - \text{Proposed Energy Use (Therms/kBtuh)} \right) \times \text{Output Heating Capacity (kBtuh)} \]

Baseline Energy Use (Therms/kBtuh) = Equation for Office Low Rise, \( F_0 = \text{Continuous} \)

\[
= CZ + Fu \times (0.0205 \times Th + 0.364) + Th \times (0.00046 \times Ws - 0.0554) + 0.00169 \times Ws
\]

\[
= 1.718 + 1 \times (0.0205 \times 10 + 0.364) + 10 \times (0.00046 \times 55 - 0.0554) + 0.00169 \times 55
\]

\[ = 2.17495 \text{ Therms/kBtuh output} \]

Proposed Energy Use (Therms/kBtuh) = Equation for Office Low Rise, \( F_0 = \text{Continuous} \)

\[
= CZ + Fu \times (0.0205 \times Th + 0.364) + Th \times (0.00046 \times Ws - 0.0554) + 0.00169 \times Ws
\]

\[ = 1.718 + 1 \times (0.0205 \times 10 + 0.364) + 10 \times (0.00046 \times 55 - 0.0554) + 0.00169 \times 55
\]

\[ = 2.07895 \text{ Therms/kBtuh output} \]

\[ \Delta \text{Therms} = \left( 2.17495 \text{ (Therms/kBtuh output)} - 2.07895 \text{ (Therms/kBtuh output)} \right) \times 150 \text{kBtuh output} \]

\[ = 0.096 \text{ (Therms/kBtuh output)} \times 150 \text{kBtuh output} \]

\[ = 14.4 \text{ Therms} \]

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-PRGA-V01-150601
4.4.26 Variable Speed Drives for HVAC Supply and Return Fans

DESCRIPTION

This measure is applied to variable speed drives (VSD) which are installed on HVAC supply fans and return fans. There is a separate measure for HVAC pumps and cooling tower fans. All other VSD applications require custom analysis by the program administrator. 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 2012 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;\textsuperscript{422} measure life for process is 10 years.\textsuperscript{423}

DEEMED MEASURE COST

Customer provided costs will be used when available. Default measure costs\textsuperscript{424} are noted below for up to 20 hp motors. Custom costs must be gathered from the customer for motor sizes not listed below.

<table>
<thead>
<tr>
<th>HP</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-5 HP</td>
<td>$1,330</td>
</tr>
<tr>
<td>7.5 HP</td>
<td>$1,622</td>
</tr>
<tr>
<td>10 HP</td>
<td>$1,898</td>
</tr>
<tr>
<td>15 HP</td>
<td>$2,518</td>
</tr>
<tr>
<td>20 HP</td>
<td>$3,059</td>
</tr>
</tbody>
</table>

LOADSHAPE

Loadshape C39 - VFD - Supply fans <10 HP
Loadshape C40 - VFD - Return fans <10 HP

\textsuperscript{422} Efficiency Vermont TRM 10/26/11 for HVAC VSD motors
\textsuperscript{423} DEER 2008
\textsuperscript{424} 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.
COINCIDENCE FACTOR

The demand savings factor (DSF) is already based upon coincident savings, and thus there is no additional coincidence factor for this characterization.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

\[
\text{kWh}_\text{Base} = (0.746 \times HP \times \frac{LF}{\eta_{\text{motor}}}) \times RHRS_{\text{Base}} \times \sum_{0\%}^{100\%} (\%FF \times PLR_{\text{Base}}) \\
\text{kWh}_\text{Retrofit} = (0.746 \times HP \times \frac{LF}{\eta_{\text{motor}}}) \times RHRS_{\text{Base}} \times \sum_{0\%}^{100\%} (\%FF \times PLR_{\text{Retrofit}}) \\
\Delta \text{kWh}_\text{fan} = \text{kWh}_\text{Base} - \text{kWh}_\text{Retrofit} \\
\Delta \text{kWh}_\text{total} = \Delta \text{kWh}_\text{fan} \times (1 + IE_{\text{energy}})
\]

Where:

- \(\text{kWh}_\text{Base}\) = Baseline annual energy consumption (kWh/yr)
- \(\text{kWh}_\text{Retrofit}\) = Retrofit annual energy consumption (kWh/yr)
- \(\Delta \text{kWh}_\text{fan}\) = Fan-only annual energy savings
- \(\Delta \text{kWh}_\text{total}\) = Total project annual energy savings
- 0.746 = Conversion factor for HP to kWh
- \(HP\) = Nominal horsepower of controlled motor
- \(LF\) = Load Factor; Motor Load at Fan Design CFM (Default = 65%)\(^{426}\)
- \(\eta_{\text{motor}}\) = Installed nominal/nameplate motor efficiency

\(^{425}\) Methodology developed and tested in Del Balso, Ryan Joseph. “Investigation into the Reliability of Energy Efficiency/Demand Side Management Savings Estimates for Variable Frequency Drives in Commercial Applications”. A project report submitted to the Faculty of the Graduate School of the University of Colorado, 2013.

Default motor is a NEMA Premium Efficiency, ODP, 4-pole/1800 RPM fan motor

**NEMA Premium Efficiency Motors Default Efficiencies**

<table>
<thead>
<tr>
<th>Size HP</th>
<th>Open Drip Proof (ODP)</th>
<th>Totally Enclosed Fan-Cooled (TEFC)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td># of Poles</td>
<td># of Poles</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>1200</td>
<td>1800 Default</td>
</tr>
<tr>
<td></td>
<td>3600</td>
<td>1800</td>
</tr>
<tr>
<td>1</td>
<td>0.825</td>
<td>0.855</td>
</tr>
<tr>
<td>1.5</td>
<td>0.865</td>
<td>0.865</td>
</tr>
<tr>
<td>2</td>
<td>0.875</td>
<td>0.865</td>
</tr>
<tr>
<td>3</td>
<td>0.885</td>
<td>0.895</td>
</tr>
<tr>
<td>5</td>
<td>0.895</td>
<td>0.895</td>
</tr>
<tr>
<td>7.5</td>
<td>0.902</td>
<td>0.910</td>
</tr>
<tr>
<td>10</td>
<td>0.917</td>
<td>0.917</td>
</tr>
<tr>
<td>15</td>
<td>0.917</td>
<td>0.930</td>
</tr>
<tr>
<td>20</td>
<td>0.924</td>
<td>0.930</td>
</tr>
<tr>
<td>25</td>
<td>0.930</td>
<td>0.936</td>
</tr>
<tr>
<td>30</td>
<td>0.936</td>
<td>0.941</td>
</tr>
<tr>
<td>40</td>
<td>0.941</td>
<td>0.941</td>
</tr>
<tr>
<td>50</td>
<td>0.941</td>
<td>0.945</td>
</tr>
<tr>
<td>60</td>
<td>0.945</td>
<td>0.950</td>
</tr>
<tr>
<td>75</td>
<td>0.945</td>
<td>0.950</td>
</tr>
<tr>
<td>100</td>
<td>0.950</td>
<td>0.954</td>
</tr>
<tr>
<td>125</td>
<td>0.950</td>
<td>0.954</td>
</tr>
<tr>
<td>150</td>
<td>0.954</td>
<td>0.958</td>
</tr>
<tr>
<td>200</td>
<td>0.954</td>
<td>0.958</td>
</tr>
<tr>
<td>250</td>
<td>0.954</td>
<td>0.958</td>
</tr>
<tr>
<td>300</td>
<td>0.954</td>
<td>0.958</td>
</tr>
<tr>
<td>350</td>
<td>0.954</td>
<td>0.958</td>
</tr>
</tbody>
</table>

---

### 4.4.26 Variable Speed Drives for HVAC Supply and Return Fans

<table>
<thead>
<tr>
<th>Size HP</th>
<th>Open Drip Proof (ODP)</th>
<th>Totally Enclosed Fan-Cooled (TEFC)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td># of Poles</td>
<td># of Poles</td>
</tr>
<tr>
<td>6</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Speed (RPM)</td>
<td></td>
<td>Speed (RPM)</td>
</tr>
<tr>
<td>1200</td>
<td>0.958</td>
<td>0.958</td>
</tr>
<tr>
<td>1800 Default</td>
<td>0.958</td>
<td>0.962</td>
</tr>
<tr>
<td>3600</td>
<td>0.958</td>
<td>0.958</td>
</tr>
<tr>
<td>1200</td>
<td>0.958</td>
<td>0.962</td>
</tr>
<tr>
<td>1800</td>
<td>0.958</td>
<td>0.958</td>
</tr>
<tr>
<td>3600</td>
<td>0.958</td>
<td>0.958</td>
</tr>
</tbody>
</table>

\[ RHRS_{\text{Base}} \] = Annual operating hours for fan motor based on building type

Default hours are provided for HVAC applications which vary by HVAC application and building type. When available, actual hours should be used.

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Pumps and fans</th>
</tr>
</thead>
<tbody>
<tr>
<td>College/University</td>
<td>4216</td>
</tr>
<tr>
<td>Grocery</td>
<td>5840</td>
</tr>
<tr>
<td>Heavy Industry</td>
<td>3585</td>
</tr>
<tr>
<td>Hotel/Motel</td>
<td>6872</td>
</tr>
<tr>
<td>Light Industry</td>
<td>2465</td>
</tr>
<tr>
<td>Medical</td>
<td>6871</td>
</tr>
<tr>
<td>Office</td>
<td>2301</td>
</tr>
<tr>
<td>Restaurant</td>
<td>4654</td>
</tr>
<tr>
<td>Retail/Service</td>
<td>3438</td>
</tr>
<tr>
<td>School(K-12)</td>
<td>2203</td>
</tr>
<tr>
<td>Warehouse</td>
<td>3222</td>
</tr>
<tr>
<td>Average = Miscellaneous</td>
<td>4103</td>
</tr>
</tbody>
</table>

\[ \%FF \] = Percentage of run-time spent within a given flow fraction range

Default Fan Duty Cycle Based on 2012 ASHRAE Handbook; HVAC Systems and Equipment, page 45.11, Figure 12.

---

\textsuperscript{428} ComEd Trm June 1, 2010 page 139. The Office hours is based upon occupancy from the eQuest model developed for EFLH, since it was agreed the ComEd value was too low.
<table>
<thead>
<tr>
<th>Flow Fraction (% of design cfm)</th>
<th>Percent of Time at Flow Fraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>0% to 10%</td>
<td>0.0%</td>
</tr>
<tr>
<td>10% to 20%</td>
<td>1.0%</td>
</tr>
<tr>
<td>20% to 30%</td>
<td>5.5%</td>
</tr>
<tr>
<td>30% to 40%</td>
<td>15.5%</td>
</tr>
<tr>
<td>40% to 50%</td>
<td>22.0%</td>
</tr>
<tr>
<td>50% to 60%</td>
<td>25.0%</td>
</tr>
<tr>
<td>60% to 70%</td>
<td>19.0%</td>
</tr>
<tr>
<td>70% to 80%</td>
<td>8.5%</td>
</tr>
<tr>
<td>80% to 90%</td>
<td>3.0%</td>
</tr>
<tr>
<td>90% to 100%</td>
<td>0.5%</td>
</tr>
</tbody>
</table>

\[ PLR_{\text{Base}} \] = Part load ratio for a given flow fraction range based on the baseline flow control type

\[ PLR_{\text{Retrofit}} \] = Part load ratio for a given flow fraction range based on the retrofit flow control type

<table>
<thead>
<tr>
<th>Control Type</th>
<th>Flow Fraction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10% 20% 30% 40% 50% 60% 70% 80% 90% 100%</td>
</tr>
<tr>
<td>No Control or Bypass Damper</td>
<td>1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00</td>
</tr>
<tr>
<td>Discharge Dampers</td>
<td>0.46 0.55 0.63 0.70 0.77 0.83 0.88 0.93 0.97 1.00</td>
</tr>
<tr>
<td>Outlet Damper, BI &amp; Airfoil Fans</td>
<td>0.53 0.53 0.57 0.64 0.72 0.80 0.89 0.96 1.02 1.05</td>
</tr>
<tr>
<td>Inlet Damper Box</td>
<td>0.56 0.60 0.62 0.64 0.66 0.69 0.74 0.81 0.92 1.07</td>
</tr>
<tr>
<td>Inlet Guide Vane, BI &amp; Airfoil Fans</td>
<td>0.53 0.56 0.57 0.59 0.60 0.62 0.67 0.74 0.85 1.00</td>
</tr>
<tr>
<td>Inlet Vane Dampers</td>
<td>0.38 0.40 0.42 0.44 0.48 0.53 0.60 0.70 0.83 0.99</td>
</tr>
<tr>
<td>Outlet Damper, FC Fans</td>
<td>0.22 0.26 0.30 0.37 0.45 0.54 0.65 0.77 0.91 1.06</td>
</tr>
<tr>
<td>Eddy Current Drives</td>
<td>0.17 0.20 0.25 0.32 0.41 0.51 0.63 0.76 0.90 1.04</td>
</tr>
<tr>
<td>Inlet Guide Vane, FC Fans</td>
<td>0.21 0.22 0.23 0.26 0.31 0.39 0.49 0.63 0.81 1.04</td>
</tr>
<tr>
<td>VFD with duct static pressure controls</td>
<td>0.09 0.10 0.11 0.15 0.20 0.29 0.41 0.57 0.76 1.01</td>
</tr>
<tr>
<td>VFD with low/no duct static pressure</td>
<td>0.05 0.06 0.09 0.12 0.18 0.27 0.39 0.55 0.75 1.00</td>
</tr>
</tbody>
</table>

Provided below is the resultant values based upon the defaults provided above:
### Variable Speed Drives for HVAC Supply and Return Fans

<table>
<thead>
<tr>
<th>Control Type</th>
<th>( \sum \frac{\text{Energy}}{\text{Discharge}} \times \text{PLR}_{\text{Base}} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Control or Bypass Damper</td>
<td>1.00</td>
</tr>
<tr>
<td>Discharge Dampers</td>
<td>0.80</td>
</tr>
<tr>
<td>Outlet Damper, BI &amp; Airfoil Fans</td>
<td>0.78</td>
</tr>
<tr>
<td>Inlet Damper Box</td>
<td>0.69</td>
</tr>
<tr>
<td>Inlet Guide Vane, BI &amp; Airfoil Fans</td>
<td>0.63</td>
</tr>
<tr>
<td>Inlet Vane Dampers</td>
<td>0.53</td>
</tr>
<tr>
<td>Outlet Damper, FC Fans</td>
<td>0.53</td>
</tr>
<tr>
<td>Eddy Current Drives</td>
<td>0.49</td>
</tr>
<tr>
<td>Inlet Guide Vane, FC Fans</td>
<td>0.39</td>
</tr>
<tr>
<td>VFD with duct static pressure controls</td>
<td>0.30</td>
</tr>
<tr>
<td>VFD with low/no duct static pressure</td>
<td>0.27</td>
</tr>
</tbody>
</table>

\( I_{\text{energy}} \) = HVAC interactive effects factor for energy (default = 15.7%)

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

\[
\begin{align*}
  kW_{\text{Base}} &= \left( 0.746 \times HP \times \frac{LF}{\eta_{\text{motor}}} \right) \times PLR_{\text{Base,FFpeak}} \\
  kW_{\text{Retrofit}} &= \left( 0.746 \times HP \times \frac{LF}{\eta_{\text{motor}}} \right) \times PLR_{\text{Retrofit,FFpeak}} \\
  \Delta kW_{\text{fan}} &= kW_{\text{Base}} - kW_{\text{Retrofit}} \\
  \Delta kW_{\text{total}} &= \Delta kW_{\text{fan}} \times (1 + I_{\text{demand}})
\end{align*}
\]

Where:

- \( kW_{\text{Base}} \) = Baseline summer coincident peak demand (kW)
- \( kW_{\text{Retrofit}} \) = Retrofit summer coincident peak demand (kW)
- \( \Delta kW_{\text{fan}} \) = Fan-only summer coincident peak demand impact
- \( \Delta kW_{\text{total}} \) = Total project summer coincident peak demand impact
- \( PLR_{\text{Base,FFpeak}} \) = The part load ratio for the average flow fraction between the peak daytime hours during the weekday peak time period based on the baseline flow control type (default average flow fraction during peak period = 90%)
- \( PLR_{\text{Retrofit,FFpeak}} \) = The part load ratio for the average flow fraction between the peak daytime hours during the weekday peak time period based on the retrofit flow control type (default average flow fraction during peak period = 90%)
- \( I_{\text{demand}} \) = HVAC interactive effects factor for summer coincident peak demand (default = 15.7%)
FOSSIL FUEL IMPACT DESCRIPTIONS AND CALCULATION

There are no expected fossil fuel impacts for this measure.

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-VSDF-V01-150601
4.4.27 Energy Recovery Ventilator

DESCRIPTION

This measure includes the addition of energy recovery equipment on existing or new unitary equipment, where energy recovery is not required by the IECC 2012. This measure analyzes the heating savings potential from recovering energy from exhaust or relief building air. This measure assumes during unoccupied hours of the building no exhaust or relief air is available for energy recovery.

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

Efficient equipment is unitary equipment that incorporates energy recovery not required by the IECC 2012.

DEFINITION OF BASELINE EQUIPMENT

The baseline is unitary equipment not require by IECC 2012 to incorporate energy recovery.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure life for the domestic energy recovery equipment is 15 years.

DEEMED MEASURE COST

The incremental cost for this measure assumes cost of cabinet and controls incorporated into packaged and built up air handler units. Additionally it assumes 1 to 1 ratio of fresh and exhausted air.

<table>
<thead>
<tr>
<th>Energy Recovery Equipment Type</th>
<th>Incremental Cost $/CFM&lt;sup&gt;430&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed Plate</td>
<td>$6</td>
</tr>
<tr>
<td>Rotary Wheel</td>
<td>$6</td>
</tr>
<tr>
<td>Heat Pipe</td>
<td>$6</td>
</tr>
</tbody>
</table>

DEEMED O&M COST ADJUSTMENTS

There are no expected O&M savings associated with this measure.

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

---

<sup>429</sup> Assumed service life limited by controls ." Demand Control Ventilation Using CO2 Sensors", pg. 19, by US Department of Energy Efficiency and Renewable Energy

<sup>430</sup> "Map to HVAC Solutions", by Michigan Air, Issue 3, 2006
Algorithm

**CALCULATION OF ENERGY SAVINGS**

**ELECTRIC ENERGY SAVINGS**

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

There are no anticipated electrical savings from this measure as it is assumed that the additional fan energy due to the increased static pressure drop offsets cooling energy savings. Where this is not expected to be the case, a custom calculation should be used to determine the savings.

**NATURAL GAS SAVINGS**

Gas savings algorithm is derived from the following:

\[
\Delta\text{Therm} = \frac{(\text{Design Heating Load} \times \text{TE}_{\text{ERV}} \times \text{EFLH} \times \text{OccHours}/24)}{(100,000 \times \mu_{\text{Heat}})}
\]

Where:

- **Design Heating Load** = \((1.08 \times \text{CFM} \times \Delta T)\)
- 1.08 = A constant for sensible heat equations (BTU/h/CFM•°F)
- **CFM** = Cubic Feet per Minute of Energy Recovery Ventilator
- **\Delta T** = \(T_{RA} - T_{DD}\)
- **T_{RA}** = Temperature of the Return Air = 70°F or custom
- **T_{DD}** = Temperature on design day of outside air\(^431\)
  = (see Table below) or custom

<table>
<thead>
<tr>
<th>Zone</th>
<th>Weather Station</th>
<th>T_DD, Temperature, °F</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Greater Rockford</td>
<td>-5.8</td>
</tr>
<tr>
<td>2</td>
<td>Chicago/O’Hare ARPT.</td>
<td>-1.5</td>
</tr>
<tr>
<td>3</td>
<td>Springfield/Capital</td>
<td>0.4</td>
</tr>
<tr>
<td>4</td>
<td>Scott AFB MidAmerica</td>
<td>9.0</td>
</tr>
<tr>
<td>5</td>
<td>Cape Girardeau Regional</td>
<td>9.7</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>2.4</td>
</tr>
</tbody>
</table>

\(\text{TE}_{\text{ERV}}\) = Thermal Effectiveness of Energy Recovery Equipment\(^432\)

\(^431\)Weather Station Data, 99.6% Heating DB - 2013 Fundamentals, ASHRAE Handbook
\(^432\)Energy Recovery Fact Sheet - Center Point Energy, MN
= (see Table below) or custom

<table>
<thead>
<tr>
<th>Heat Recovery Equipment Type</th>
<th>TEERV (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed Plate</td>
<td>0.65</td>
</tr>
<tr>
<td>Rotary Equipment</td>
<td>0.68</td>
</tr>
<tr>
<td>Heat Pipe</td>
<td>0.55</td>
</tr>
</tbody>
</table>

EFLH = Equivalent Full Load Hours for heating are provided in section 4.4 HVAC End Use
OccHour = Average Hours per day facility is occupied
= (see Table 4.4.1 EQuest Modeling Inputs by Building Type) or custom
μHeat = Efficiency of heating system
= Actual

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-HVC-ERVE-V01-150601**
4.4.28 Stack Economizer for Boilers Serving HVAC Loads

**Measure Description**
Stack economizers are designed to recover heat from hot boiler flue gasses. Recovered heat is used to preheat boiler feed water. This measure describes the retrofit of HVAC boilers with stack economizers. HVAC boilers are defined as those used for space heating applications. There is another, similar measure for boilers that serve process loads.

This measure was developed to be applicable to the following program types: NC, TOS, RF.

If applied to other program types, the measure savings should be verified.

**Definition of Efficient Equipment**
To qualify the economizer must be installed on a boiler exhaust stack. Heat captured by the economizer is to be used to pre-heat boiler feed water.

**Definition of Baseline Equipment**
The baseline boiler does not have an economizer installed.

**Deemed Lifetime of Efficient Equipment**
The measure life for the boiler stack economizer is 15 years.\(^{433}\)

**Deemed Measure Cost**
The incremental and full measure cost for this measure is custom.

**Deemed O&M Cost Adjustments**
The O&M cost for this measure is custom.

**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 Savings**
\[
\Delta \text{therms} = \text{SF} \times \text{MBH}_\text{In} \times \text{EFLH} / 100
\]

Where:

\[ SF = \frac{(T_{\text{existing}} - T_{\text{eff}})}{40^\circ F} \times \text{TRE} \]

= see default Savings Factor table below

Where:

\[ T_{\text{existing}} = \text{Existing Full Fire Boiler Flue Gas Temperature as it exits the Stack} \]
\[ = 425^\circ F^{434} \text{ (water, 81.9\% eff) or custom} \]
\[ = 480^\circ F^{3} \text{ (steam, 80.7\% eff) or custom} \]

\[ T_{\text{eff}} = \text{Efficient Full Fire Boiler Flue Gas Temperature as it exits the Stack} \]
\[ = 338^\circ F \text{ (conventional economizer – Water Boiler)}^{435} \text{ or custom} \]
\[ = 365^\circ F \text{ (conventional economizer – Steam Boiler)}^{436} \text{ or custom} \]
\[ = 280^\circ F \text{ (condensing economizer – Water Boiler)}^{437} \text{ or custom} \]
\[ = 308^\circ F \text{ (condensing economizer – Steam Boiler)}^{438} \text{ or custom} \]

\[ \text{TRE} = \% \text{ efficiency increase for } 40^\circ \text{F of stack temperature reduction} \]
\[ = 1\%^{439} \text{ or custom} \]

Based on defaults provided above:

434 Cleaver Brooks. March 2012, Boiler Efficiency Guide, Pg. 7, Figure 1.
435 The minimum stack temperature for a non-condensing economizer is 250°F from Department of Energy (DOE). January 2012, Steam Tip Sheet #26A, Consider Installing a Condensing Economizer. Advanced Manufacturing Office. Washington, DC: U.S. Department of Energy. The average temperature drop is assumed to be \(\frac{1}{2}\) way between the existing and efficient temperature minimum, \(\frac{425^\circ F + 250^\circ F}{2} = 338^\circ F\).
436 The minimum stack temperature for a non-condensing economizer is 250°F from Department of Energy (DOE). January 2012, Steam Tip Sheet #26A, Consider Installing a Condensing Economizer. Advanced Manufacturing Office. Washington, DC: U.S. Department of Energy. The average temperature drop is assumed to be \(\frac{1}{2}\) way between the existing and efficient temperature minimum, \(\frac{480^\circ F + 250^\circ F}{2} = 365^\circ F\).
437 The minimum stack temperature for a condensing economizer is 250°F from Department of Energy (DOE). January 2012, Steam Tip Sheet #26A, Consider Installing a Condensing Economizer. Advanced Manufacturing Office. Washington, DC: U.S. Department of Energy. The average temperature drop is assumed to be \(\frac{1}{2}\) way between the existing and efficient temperature minimum, \(\frac{425^\circ F + 135^\circ F}{2} = 280^\circ F\).
438 The minimum stack temperature for a condensing economizer is 250°F from Department of Energy (DOE). January 2012, Steam Tip Sheet #26A, Consider Installing a Condensing Economizer. Advanced Manufacturing Office. Washington, DC: U.S. Department of Energy. The average temperature drop is assumed to be \(\frac{1}{2}\) way between the existing and efficient temperature minimum, \(\frac{480^\circ F + 135^\circ F}{2} = 308^\circ F\).
440 These average values should be utilized in absence of actual temperature data. An economizer with a zero temperature change between the existing and the efficient temperatures would not be installed, so these average values are conservative.
4.4.29 Stack Economizer for Boilers Serving Process Loads

**MEASURE DESCRIPTION**

Stack economizers are designed to recover heat from hot boiler flue gases. Recovered heat is used to preheat boiler feed water. This measure describes the retrofit of process boilers with stack economizers. Process boilers are defined as those used for industrial, manufacturing, or other non-HVAC applications. There is another, similar measure for boilers that serve HVAC loads.

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

**DEFINITION OF EFFICIENT EQUIPMENT**

To qualify the economizer must be installed on a boiler exhaust stack. Heat captured by the economizer is to be used to pre-heat boiler feed water.

**DEFINITION OF BASELINE EQUIPMENT**

The baseline boiler does not have an economizer installed.

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The measure life for the boiler stack economizer is 15 years.\(^{441}\)

**DEEMED MEASURE COST**

The incremental and full measure cost for this measure is custom.

**DEEMED O&M COST ADJUSTMENTS**

The O&M cost for this measure is custom.

**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 SAVINGS**

\[
\Delta \text{therms} = SF \times MBH_{\text{In}} \times 8766 \times UF / 100
\]

Where:

- **SF** = \((T_{\text{existing}} - T_{\text{eff}})/40^\circ F \times TRE\)
  
  = see default Savings Factor table below

- **T_{\text{existing}}** = Existing Full Fire Boiler Flue Gas Temperature as it exits the Stack
  
  = 425°F (water, 81.9% eff per IL TRM) or custom
  
  = 480°F (steam, 80.7% eff per IL TRM) or custom

- **T_{\text{eff}}** = Efficient Full Fire Boiler Flue Gas Temperature as it exits the Stack
  
  = 338°F (conventional economizer – Water Boiler)\(^{442}\) or custom
  
  = 365°F (conventional economizer – Steam Boiler)\(^{444}\) or custom
  
  = 280°F (condensing economizer – Water Boiler)\(^{445}\) or custom
  
  = 308°F (condensing economizer – Water Boiler)\(^{446}\) or custom

---

\(^{442}\) Cleaver Brooks. March 2012, Boiler Efficiency Guide, Pg. 7, Figure 1.

\(^{443}\) The minimum stack temperature for a non-condensing economizer is 250°F from Department of Energy (DOE). January 2012, Steam Tip Sheet #26A, Consider Installing a Condensing Economizer. Advanced Manufacturing Office. Washington, DC: U.S. Department of Energy. The average temperature drop is assumed to be ½ way between the existing and efficient temperature minimum, \((425^\circ F + 250^\circ F) / 2 = 338^\circ F\).

\(^{444}\) The minimum stack temperature for a non-condensing economizer is 250°F from Department of Energy (DOE). January 2012, Steam Tip Sheet #26A, Consider Installing a Condensing Economizer. Advanced Manufacturing Office. Washington, DC: U.S. Department of Energy. The average temperature drop is assumed to be ½ way between the existing and efficient temperature minimum, \((480^\circ F + 250^\circ F) / 2 = 365^\circ F\).

\(^{445}\) The minimum stack temperature for a condensing economizer is 250°F from Department of Energy (DOE). January 2012, Steam Tip Sheet #26A, Consider Installing a Condensing Economizer. Advanced Manufacturing Office. Washington, DC: U.S. Department of Energy. The average temperature drop is assumed to be ½ way between the existing and efficient temperature minimum, \((425^\circ F + 135^\circ F) / 2 = 280^\circ F\).

\(^{446}\) The minimum stack temperature for a condensing economizer is 250°F from Department of Energy (DOE). January 2012,
TRE = % efficiency increase for 40°F of stack temperature reduction

= 1\%^{447} or custom

Based on defaults provided above:

<table>
<thead>
<tr>
<th>Boiler Type</th>
<th>Conventional Economizer</th>
<th>Condensing Economizer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot Water Boiler</td>
<td>2.19% average SF or custom</td>
<td>3.63% average SF or custom</td>
</tr>
<tr>
<td>Steam Boiler</td>
<td>2.88% average SF or custom</td>
<td>4.31% average SF or custom</td>
</tr>
</tbody>
</table>

MBH\_In = Rate boiler input capacity, in MBH

= Actual

8766 = Hours a year

UF = Utilization Factor

= 41.9\%^{449} or custom

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-HVC-PECO-V01-150601**
4.4.30 Notched V Belts for HVAC Systems

MEASURE DESCRIPTION

This measure is for replacement of smooth v-belts in non-residential package and split HVAC systems with notched v-belts. Typically there is a v-belt between the motor and the supply air fan and/or return air fan in larger package and split HVAC systems (RTU).

In general there are two styles of grooved v-belts, notched and synchronous. The DOE defines each as follows;

**Notched V-Belts** - A notched belt has grooves or notches that run perpendicular to the belt’s length, which reduces the bending resistance of the belt. Notched belts can use the same pulleys as cross-section standard V-belts. They run cooler, last longer, and are about 2% more efficient than standard V-belts.

**Synchronous Belts** - Synchronous belts (also called cogged, timing, positive-drive, or high-torque drive belts) are toothed and require the installation of mating grooved sprockets. These belts operate with a consistent efficiency of 98% and maintain their efficiency over a wide load range.

Smooth v-belts are usually referred to in five basic groups:

- “L” belts are low end belts that are for small, fractional horsepower motors and these are not used in RTUs.
- “A” and “B” belts are the two types typically used in RTUs. The “A” belt is a 3/8 inch width by 5/16 inch thickness and the “B” belt is larger, 21/32 inch wide and 12/32 inch thick so it can carry more power. V-belts come in a wide variety of lengths where 20 to 100 inches is typical.
- “C” and “D” belts are primarily for industrial applications with high power transmission requirements.
- V-belts are provided by various vendors. The notched version of these belts typically have an “X” added to the designation. For this HVAC fans notched v-belt Replacement measure, only the “A” and “B” v-belts are considered. A typical “A” v-belt is replaced by a notched “AX” v-belt and a “B” is replaced by a “BX.”

In general, smooth v-belts have an efficiency of 90% to 98% while notched v-belts have an efficiency of 95% to 98%. Because notched v-belts are more flexible they work with smaller diameter pulleys and they have less resistance to bending. Lower bending resistance increases the power transmission efficiency, lowers the waste heat, and allows the belt to last longer than a smooth belt.

Three research papers show that the notched v-belt efficiency is 2% to 5% better than a typical smooth v-belt. A fourth paper by USDOE’s Energy Efficiency and Renewable Energy group reviewed most of the earlier literature and recommended using a conservative 2% efficiency improvement for energy savings for calculations.

For this measure it is assumed that upgrading a standard smooth v-belt with a new notched v-belt will result in a fan energy reduction of 2%.

---

DEFINITION OF EFFICIENT EQUIPMENT

The Efficient Equipment is HVAC RTUs that have notched v-belts installed on the supply and/or return air fans.

DEFINITION OF BASELINE EQUIPMENT

The Baseline Equipment is HVAC RTUs that have smooth v-belts installed on the supply and/or return air fans (i.e. RTU does not already have a notched v-belt installed).

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

A v-belt has a life based on fan run hours which varies by building type based primarily on occupancy schedule because the fans are required by code to operate continuously during occupied hours. The supply and return fans will also run a few hours during unoccupied hours for heating and cooling as needed. For the notched v-belt EUL calculation, the default hours\(^{454}\) in the following table are used for a variety of building types and HVAC applications.

\[ \text{EUL} = \frac{\text{Belt Life}}{\text{Occupancy Hours per year}} \]

Where:

- Belt Life = 24,000 hours\(^{455}\)
- Occupancy Hours per year = values from Table below

The notched v-belt measure EUL is summarized by building type in the following table.

**Notched v-belt Effective Useful Life (EUL)**

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Pumps &amp; Fans (annual Hours of operation)</th>
<th>EUL (Years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>College/University</td>
<td>4216</td>
<td>5.7</td>
</tr>
<tr>
<td>Grocery</td>
<td>5840</td>
<td>4.1</td>
</tr>
<tr>
<td>Heavy Industry</td>
<td>3585</td>
<td>6.7</td>
</tr>
<tr>
<td>Hotel/Motel</td>
<td>6872</td>
<td>3.5</td>
</tr>
<tr>
<td>Light Industry</td>
<td>2465</td>
<td>9.7</td>
</tr>
<tr>
<td>Medical</td>
<td>6871</td>
<td>3.5</td>
</tr>
<tr>
<td>Office</td>
<td>2301</td>
<td>10.4</td>
</tr>
<tr>
<td>Restaurant</td>
<td>4654</td>
<td>5.2</td>
</tr>
</tbody>
</table>

\(^{454}\) ComEd Trm June 1, 2010 page 139. The Office hours is based upon occupancy from the eQuest model developed for EFLH, since it was agreed the ComEd value was too low.

DEEMED MEASURE COST

A review of the Grainger online\textsuperscript{456} pricing for “A,” “B,” “AX,” and “BX” v-belts showed the incremental cost to upgrade to notched v-belts would result in a 28% price increase. The notched v-belt incremental cost is summarized in the table below:

<table>
<thead>
<tr>
<th>Notched V-belt Incremental Cost Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smooth V-Belt Industry Number</td>
</tr>
<tr>
<td>----------------------------------</td>
</tr>
<tr>
<td>A30 (Item # 1A095)</td>
</tr>
<tr>
<td>B29 (Item # 6L208)</td>
</tr>
</tbody>
</table>

* Pricing based on Dayton Belts as found on Grainger Website 10/30/14

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape C05 - Commercial Electric Heating and Cooling

COINCIDENCE FACTOR

N/A

\textsuperscript{456} Grainger catalog on-line web-site for Dayton v-belt pricing
http://www.grainger.com/Grainger/ecatalog/N-1z0r596/Ntt-v-belts
CALCULATION OF ENERGY SAVINGS

Electric Energy Savings

\[ \Delta \text{kWh} = \text{kW}_{\text{connected}} \times \text{Hours} \times \text{ESF} \]

Where:

\[ \text{kW}_{\text{Connected}} = \text{kW of equipment is calculated using motor efficiency}^{457}. \]

\[ = (\text{HP} \times 0.746 \text{kW/HP} \times \text{Load Factor})/\text{Motor Efficiency} \]

\[ \text{Load Factor} = \text{Motors are assumed to have a load factor of 80\% for calculating KW if actual values cannot be determined}^{458}. \text{Custom load factor may be applied if known.} \]

\[ \text{Motor Efficiency} = \text{Actual motor efficiency shall be used to calculate KW. If not known a value from the motor efficiency reference tables below should be used}^{459}. \]

<table>
<thead>
<tr>
<th>Baseline Motor Efficiencies (EPACT)</th>
<th>Open Drip Proof (ODP)</th>
<th>Totally Enclosed Fan-Cooled (TEFC)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong># of Poles</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Speed (RPM)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1200</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1800</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3600</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1200</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1800</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3600</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/8</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1/6</td>
<td>44.00%</td>
<td>-</td>
</tr>
<tr>
<td>1/4</td>
<td>57.50%</td>
<td>62.00%</td>
</tr>
<tr>
<td>1/3</td>
<td>68.00%</td>
<td>68.00%</td>
</tr>
<tr>
<td>1/2</td>
<td>70.00%</td>
<td>70.00%</td>
</tr>
<tr>
<td>3/4</td>
<td>72.00%</td>
<td>80.00%</td>
</tr>
<tr>
<td>1</td>
<td>78.50%</td>
<td>74.00%</td>
</tr>
<tr>
<td>1.5</td>
<td>84.00%</td>
<td>84.00%</td>
</tr>
<tr>
<td>2</td>
<td>85.50%</td>
<td>84.00%</td>
</tr>
</tbody>
</table>

457 Note that kWConnected may be determined using various methodologies. The examples provided use rated HP and assumed load factor. Other methodologies include rated voltage and full load current with assumed load factor, or actual measured voltage and current.

458 Com Ed TRM June 1, 2010

### Baseline Motor Efficiencies (EPACT)

<table>
<thead>
<tr>
<th>Size HP</th>
<th>3</th>
<th>5</th>
<th>7.5</th>
<th>10</th>
<th>15</th>
<th>20</th>
<th>25</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>86.50%</td>
<td>87.50%</td>
<td>88.50%</td>
<td>90.20%</td>
<td>90.20%</td>
<td>91.00%</td>
<td>91.70%</td>
</tr>
<tr>
<td></td>
<td>86.50%</td>
<td>87.50%</td>
<td>88.50%</td>
<td>90.20%</td>
<td>90.20%</td>
<td>91.00%</td>
<td>91.70%</td>
</tr>
<tr>
<td></td>
<td>84.00%</td>
<td>85.50%</td>
<td>87.50%</td>
<td>89.50%</td>
<td>91.00%</td>
<td>90.20%</td>
<td>92.40%</td>
</tr>
<tr>
<td></td>
<td>87.50%</td>
<td>87.50%</td>
<td>89.50%</td>
<td>90.20%</td>
<td>91.00%</td>
<td>90.20%</td>
<td>91.00%</td>
</tr>
<tr>
<td></td>
<td>87.50%</td>
<td>87.50%</td>
<td>89.50%</td>
<td>90.20%</td>
<td>91.00%</td>
<td>90.20%</td>
<td>91.00%</td>
</tr>
<tr>
<td></td>
<td>85.50%</td>
<td>87.50%</td>
<td>89.50%</td>
<td>90.20%</td>
<td>91.00%</td>
<td>90.20%</td>
<td>91.00%</td>
</tr>
</tbody>
</table>

### Efficient Motor Efficiencies (NEMA Premium)

<table>
<thead>
<tr>
<th>Size HP</th>
<th>0.125 *</th>
<th>1/6</th>
<th>1/4</th>
<th>1/3</th>
<th>1/2</th>
<th>3/4</th>
<th>1</th>
<th>1.5</th>
<th>2</th>
<th>3</th>
<th>5</th>
<th>7.5</th>
<th>10</th>
<th>15</th>
<th>20</th>
<th>25</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>44.00%</td>
<td>57.50%</td>
<td>68.00%</td>
<td>70.00%</td>
<td>78.50%</td>
<td>77.00%</td>
<td>82.50%</td>
<td>86.50%</td>
<td>87.50%</td>
<td>88.50%</td>
<td>89.50%</td>
<td>90.20%</td>
<td>91.70%</td>
<td>92.40%</td>
<td>93.00%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>62.00%</td>
<td>68.00%</td>
<td>70.00%</td>
<td>80.00%</td>
<td>78.50%</td>
<td>85.50%</td>
<td>86.50%</td>
<td>86.50%</td>
<td>85.50%</td>
<td>89.50%</td>
<td>91.00%</td>
<td>91.70%</td>
<td>93.00%</td>
<td>93.00%</td>
<td>91.70%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>64.00%</td>
<td>68.00%</td>
<td>68.00%</td>
<td>74.00%</td>
<td>77.00%</td>
<td>84.00%</td>
<td>87.50%</td>
<td>88.50%</td>
<td>89.50%</td>
<td>91.00%</td>
<td>91.70%</td>
<td>92.40%</td>
<td>91.00%</td>
<td>91.70%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>68.00%</td>
<td>72.00%</td>
<td>72.00%</td>
<td>74.00%</td>
<td>84.00%</td>
<td>87.50%</td>
<td>88.50%</td>
<td>89.50%</td>
<td>91.00%</td>
<td>91.70%</td>
<td>92.40%</td>
<td>91.00%</td>
<td>91.70%</td>
</tr>
</tbody>
</table>
= When available, actual hours should be used. If actual hours are not available default hours are provided in table below for HVAC fan operation which varies by building type:

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Pumps &amp; Fans (annual Hours of operation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>College/University</td>
<td>4216</td>
</tr>
<tr>
<td>Grocery</td>
<td>5840</td>
</tr>
<tr>
<td>Heavy Industry</td>
<td>3585</td>
</tr>
<tr>
<td>Hotel/Motel</td>
<td>6872</td>
</tr>
<tr>
<td>Light Industry</td>
<td>2465</td>
</tr>
<tr>
<td>Medical</td>
<td>6871</td>
</tr>
<tr>
<td>Office</td>
<td>2301</td>
</tr>
<tr>
<td>Restaurant</td>
<td>4654</td>
</tr>
<tr>
<td>Retail/Service</td>
<td>3438</td>
</tr>
<tr>
<td>School(K-12)</td>
<td>2203</td>
</tr>
<tr>
<td>Warehouse</td>
<td>3222</td>
</tr>
<tr>
<td>Average=Miscellaneous</td>
<td>4103</td>
</tr>
</tbody>
</table>

ESF = Energy Savings Factor, the ESF for notched v-belt Installation is assumed to be 2%

---

460 ComEd Trm June 1, 2010 page 139. The Office hours is based upon occupancy from the eQuest model developed for EFLH, since it was agreed the ComEd value was too low.
EXAMPLE
For example, an office building RTU with a 5 HP NEMA premium efficiency motor using the default hours of operation, motor load and 89.5% motor efficiency;

\[ \Delta \text{kWh} = \text{kW}_{\text{connected}} \times \text{Hours} \times \text{ESF} \]

\[ = \left( \frac{\text{HP} \times 0.746 \text{ kW/HP} \times \text{Load Factor}}{\text{Motor Efficiency}} \right) \times \text{Hours} \times \text{ESF} \]

\[ = \left( \frac{5 \text{ HP} \times 0.746 \text{ kW/HP} \times 80\%}{89.5\%} \right) \times 1766 \times 2\% \]

\[ = 117.8 \text{ kWh Savings} \]

SUMMER COINCIDENT PEAK DEMAND SAVINGS

\[ \Delta \text{kW} = \text{kW}_{\text{connected}} \times \text{ESF} \]

Where:

\[ \text{kW}_{\text{connected}} = \text{kW of equipment is calculated using motor efficiency.} \]

\[ = \left( \frac{\text{HP} \times 0.746 \text{ kW/HP} \times \text{Load Factor}}{\text{Motor Efficiency}} \right) \]

Variables as provided above

EXAMPLE
For example, an office building RTU with a 5 HP NEMA premium efficiency motor using the default motor load and 89.5% motor efficiency;

\[ \Delta \text{kW} = \text{kW}_{\text{connected}} \times \text{ESF} \]

\[ = \left( \frac{\text{HP} \times 0.746 \text{ kW/HP} \times \text{Load Factor}}{\text{Motor Efficiency}} \right) \times \text{ESF} \]

\[ = \left( \frac{5 \text{ HP} \times 0.746 \text{ kW/HP} \times 80\%}{89.5\%} \right) \times 2\% \]

\[ = 0.0667 \text{ kW Savings} \]

NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-MSC-NVBE-V01-150601
4.4.31 Small Business Furnace Tune-Up

DESCRIPTION

This measure is for a natural gas Small Business furnace that provides space heating. The tune-up will improve furnace performance by inspecting, cleaning and adjusting the furnace and appurtenances for correct and efficient operation. Additional savings maybe realized through a complete system tune-up.

This measure was developed to be applicable to the following program types: Small business.

If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure an approved technician must complete the tune-up requirements listed below:

- Measure combustion efficiency using an electronic flue gas analyzer
- Check and clean blower assembly and components per manufacturer’s recommendations
- Where applicable Lubricate motor and inspect and replace fan belt if required
- Inspect for gas leaks
- Clean burner per manufacturer’s recommendations and adjust as needed
- Check ignition system and safety systems and clean and adjust as needed
- Check and clean heat exchanger per manufacturer’s recommendations
- Inspect exhaust/flue for proper attachment and operation
- Inspect control box, wiring and controls for proper connections and performance
- Check air filter and clean or replace per manufacturer’s
- Inspect duct work connected to furnace for leaks or blockages
- Measure temperature rise and adjust flow as needed
- Check for correct line and load volts/amps
- Check thermostat operation is per manufacturer’s recommendations (if adjustments made, refer to ‘Small Commercial Programmable Thermostat Adjustment’ measure for savings estimate)
- Perform Carbon Monoxide test and adjust heating system until results are within standard industry acceptable limits

DEFINITION OF BASELINE EQUIPMENT

The baseline is furnace assumed not to have had a tune-up in the past 2 years.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure life for the tune up is 2 years.  

DEEMED MEASURE COST

The incremental cost for this measure should be the actual cost of tune up.

---

**DEEMED O&M COST ADJUSTMENTS**

There are no expected O&M savings associated with this measure.

**LOADSHAPE**

Loadshape C04 - Commercial Electric Heating

**COINCIDENCE FACTOR**

N/A

---

### Algorithms

#### CALCULATION OF ENERGY SAVINGS

**ELECTRIC ENERGY SAVINGS**

\[
\Delta \text{kWh} = \Delta \text{Therms} \times F_e \times 29.3
\]

Where:

- \(\Delta \text{Therms}\) = as calculated below
- \(F_e\) = Furnace Fan energy consumption as a percentage of annual fuel consumption
  
  \[= 3.14\%^{463}\]
  
  \[29.3\] = kWh per therm

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

N/A

**NATURAL GAS SAVINGS**

\[
\Delta \text{therms} = \left(\text{Capacity} \times \text{EFLH} \times (((\text{Effbefore} + \text{Ei})/ \text{Effbefore}) – 1)) / 100,000
\]

Where:

- Capacity = Furnace gas input size (Btu/hr)

---

\(^{463} F_e\) 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.
EFLH = Equivalent Full Load Hours for heating are provided in section 4.4 HVAC End Use

Effbefore = Efficiency of the furnace before the tune-up

El = Efficiency Improvement of the furnace tune-up measure

100,000 = Converts Btu to therms

**EXAMPLE**

A 200 kBtu furnace in a Rockford low rise office records an efficiency prior to tune up of 82% AFUE and a 1.8% improvement in efficiency are tune up:

\[
\Delta\text{therms} = \frac{200,000 \times 1428 \times \left(\frac{(0.82 + 0.018)/0.82 - 1)}{100,000}\right)}{100,000}
\]

\[
= \frac{62.3}{100,000}
\]

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**O&M COST ADJUSTMENT CALCULATION**

N/A

**Measure Code:** CI-HVC-FTUN-V01-150601
4.4.32 Combined Heat and Power

**DESCRIPTION**

The Combined Heat and Power (CHP) measure can provide energy savings within the State of Illinois through the development and operation of CHP projects. This measure is applicable for Conventional or Topping Cycle CHP systems, as well as Waste Heat-to-Power (WHP) or Bottoming Cycle CHP systems. The measure will reduce the total Btu’s of energy required to meet the end use needs of the facility.

It is recognized that CHP system design and configuration may be complex, and as such the calculation of energy savings may not be reducible to the equations within this measure. In such cases a more comprehensive engineering and financial analysis may be developed that more accurately incorporates the attributes of complex CHP configurations such as variable-capacity systems, and partial combined-cycle CHP systems. Where noted, the use of values that are determined through an external engineering analysis may be substituted by agreement between the participant, the program administrator and independent evaluator. This substitution of values does not eliminate ex post evaluation risk (retroactive adjustments to savings claims) that exists when using custom inputs.

This measure was developed to be applicable to the following program types: Retrofit (RF), New Construction (NC). If applied to other program types, the measure savings should be verified.

**DEFINITION OF EFFICIENT EQUIPMENT**

Conventional or Topping Cycle CHP is defined as an integrated system that is located at or near the building or facility (on-site, on the customer side of the meter) that utilizes a prime mover (reciprocating engine, gas turbine, micro-turbine, fuel cell, boiler/steam turbine combination) for the purpose of generating electricity and useful thermal energy (such as steam, hot water, or chilled water) where the primary function of the facility where the CHP is located is not to generate electricity for use on the grid. An eligible system must demonstrate a minimum total system efficiency of 60% (HHV) with at least 20% of the system’s total useful energy output in the form of useful thermal energy on an annual basis.

**Measuring and Calculating Conventional CHP Total System Efficiency:**

CHP efficiency is calculated using the following equation:

\[
CHP_{efficiency} (HHV) = \frac{CHP_{thermal} \left( \frac{Btu}{yr} \right) + E_{CHP} \left( \frac{kWh}{yr} \right) \times 3.412 \left( \frac{kBtu}{kWh} \right)}{F_{totalCHP} \left( \frac{kBtu}{yr} \right)}
\]

Where:

- \( CHP_{thermal} \) = Useful annual thermal energy output from the CHP system, defined as the annual thermal energy output of the CHP system that is actually recovered and utilized in the facility/process.
- \( E_{CHP} \) = Useful annual electricity output produced by the CHP system, defined as the annual electric energy output of the CHP system that is actually utilized to replace purchased electricity required to meet the requirements of the facility/process.
- \( F_{totalCHP} \) = Total annual fuel consumed by the CHP system

---

464 Higher Heating Value (HHV): refers to the heating value of the fuel and is defined as the total thermal energy available, including the heat of condensation of water vapors, resulting from complete combustion of the fuel versus the Lower Heating Value (LHV) which assumes the heat of condensation is not available
For further definition of the terms, please see “Calculation of Energy Savings” Section below.

**Waste Heat-to-Power or Bottoming Cycle CHP** is defined as an integrated system that is located at or near the building or facility (on-site, on the customer side of the meter) that does one of the following:

- Utilizes exhaust heat from an industrial/commercial process to generate electricity (except for exhaust heat from a facility whose primary purpose is the generation of electricity for use on the grid); or
- Utilizes the pressure drop in an industrial/commercial facility to generate electricity through a backpressure steam turbine where the facility normally uses a pressure reducing valve (PRV) to reduce the pressure in their facility; or
- Utilizes the pressure reduction in natural gas pipelines (located at natural gas compressor stations) before the gas is distributed through the pipeline to generate electricity, provided that the conversion of energy to electricity is achieved without using additional fossil fuels.

Since these types of systems utilize waste heat as their fuel, they do not have to meet any specific total system efficiency level (assuming they use no additional fossil fuel in their operation). If additional fuel is used onsite, it should be accounted for using the following methodology:

- Treat the portion of Waste-Heat-to-Power that does not require any additional fuel using the Waste-Heat-to-Power methodology outlined in this document.
- Treat the portion of Waste-Heat-to-Power that requires additional fuel (if natural gas) using the Conventional CHP methodology outlined in this document. If the additional fuel is not natural gas, custom carbon equivalency calculations would be needed – refer to section “Calculation of Energy Savings” for more details.
- Add the energy savings together.

These systems may export power to the grid.

**Definition of Baseline Equipment**

**Electric Baseline:** The baseline facility would be a facility that purchases its electric power from the grid.

**Heating Baseline (for CHP applications that displace onsite heat):** The baseline equipment would be the boiler/furnace operating onsite, or a boiler/furnace meeting the baseline equipment defined in the High Efficiency Boiler (Section 4.4.10)/Furnace (Section 4.4.11) measures of this TRM.

**Cooling Baseline (for CHP applications that displace onsite cooling demands):** The baseline equipment would be the chiller (or chillers) operating onsite, or a chiller (or chillers) meeting the definition of baseline equipment defined in the Electric Chiller (Section 4.4.6) measure of this TRM.

**Facilities that use biogas or waste gas:** Facilities that use (but are not purchasing) biogas or waste gas that is not otherwise used, whether they are using biogas or waste gas only or a combination of biogas or waste gas and natural gas to meet their energy demands are also eligible for this measure. If additional fuel is purchased to power the CHP system, then the additional natural gas should be taken into account using the following methodology:

- Treat the portion of CHP system that does not require any additional fuel, or that requires additional fuel that would otherwise be wasted (e.g. flared), using the Waste-Heat-to-Power methodology outlined in this document.
- Treat the portion of CHP that requires additional fuel (if natural gas) using the Conventional CHP methodology outlined in this document. If the additional fuel is not natural gas, custom carbon equivalency calculations would be needed – refer to section “Calculation of Energy Savings” for more details.
- Add the energy savings together.

Consumption of any biogas or waste gas that would not otherwise being wasted (e.g., flared) will be accounted for
in the overall net BTU savings calculations the same as for purchased natural gas.

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

Measure life is a custom assumption, dependent on the technology selected and the system installation.

**DEEMED MEASURE COST**

Custom installation and equipment cost will be used. These costs should include the cost of the equipment and the cost of installing the equipment. Equipment costs include, but are not limited to: prime mover, heat recovery system(s), exhaust gas treatment system(s), controls, and any interconnection/electrical connection costs.

The installations costs include labor and material costs such as, but not limited to: labor costs, materials such as ductwork, piping, and wiring, project and construction management, engineering costs, commissioning costs, and other fees.

Measure costs will also include the present value of expected maintenance costs over the life of the CHP system.

**LOADSHAPE**

Use Custom Loadshape. The loadshape should be obtained from the actual CHP operation strategy, based on the On-Peak and Off-Peak Energy definitions specified in Table 3.3 of “Section 3.5 Electrical Loadshapes” of the TRM.

**COINCIDENCE FACTOR**

Custom coincidence factor will be used. Actual value based on the CHP operation strategy will be used.

---

**Algorithm**

**CALCULATION OF ENERGY SAVINGS**

i)  **Conventional or Topping Cycle CHP Systems:**

**Step 1: (Calculating Total Annual Source Fuel Savings in Btus)**

The first step is to calculate the total annual source fuel savings associated with the CHP installation, in order to ensure the CHP project produces positive total annual source fuel savings (i.e. reduction in source Btus):

\[
S_{\text{FuelCHP}} = \text{Annual fuel savings (Btu) associated with the use of a Conventional CHP system to generate the useful electricity output (kWh, converted to Btu) and useful thermal energy output (Btu) versus the use of the equivalent electricity generated and delivered by the local grid and the equivalent thermal energy provided by the onsite boiler/furnace.}
\]

\[
= (F_{\text{grid}} + F_{\text{thermalCHP}}) - F_{\text{total CHP}}
\]

Where:

\[
F_{\text{grid}} = \text{Annual fuel in Btu that would have been used to generate the useful electricity output of the CHP system if that useful electricity output was provided by the local utility grid.}
\]

\[
= E_{\text{CHP}} * H_{\text{grid}}
\]

Where:
\[E_{\text{CHP}} = \text{Useful annual electricity output produced by the CHP system, defined as the annual electric energy output of the CHP system that is actually utilized to replace purchased electricity required to meet the requirements of the facility/process.}\]

\[= ( C_{\text{CHP}} \times \text{Hours} ) - E_{\text{Parasitic}}\]

- \(C_{\text{CHP\ capacity}}\) = CHP nameplate capacity
- \(\text{Hours}\) = Annual operating hours of the system
- \(E_{\text{Parasitic}}\) = The electricity required to operate the CHP system that would otherwise not be required by the facility/process

\[H_{\text{grid}} = \text{Heat rate of the grid in Btu/kWh, based on the average fossil heat rate for the EPA eGRID subregion, adjusted to take into account T&D losses.}\]

For systems operating less than 6,500 hrs per year:

Use the Non-baseload heat rate provided by EPA eGRID for RFC West region for ComEd territory (including independent providers connected to RFC West), and SERC Midwest region for Ameren territory (including independent providers connected to SERC Midwest). Also include any line losses.

For systems operating more than 6,500 hrs per year:

Use the All Fossil Average heat rate provided by EPA eGRID for RFC West region for ComEd territory (including independent providers connected to RFC West), and SERC Midwest region for Ameren territory (including independent providers connected to SERC Midwest). Also include any line losses.

\[F_{\text{thermalCHP}} = \text{Annual fuel in Btu that would have been used on-site by a boiler/furnace to provide the useful thermal energy output of the CHP system.}\]

\[= C_{\text{thermal}} / \text{Boiler}_{\text{eff}} \text{ (or } C_{\text{thermal}} / \text{Furnace}_{\text{eff}} \text{)}\]

For complex systems this value may be obtained from a CHP System design/financial analysis study.


Current values are:

- Non-Baseload RFC West: 9,811 Btu/kWh * (1 + Line Losses)
- Non-Baseload SERC Midwest: 10,511 Btu/kWh * (1 + Line Losses)
- All Fossil Average RFC West: 10,038 Btu/kWh * (1 + Line Losses)
- All Fossil Average SERC Midwest: 10,364 Btu/kWh * (1 + Line Losses)

For complex systems this value may be obtained from a CHP System design/financial analysis study.
CHP<sub>thermal</sub> = Useful annual thermal energy output from the CHP system, defined as the annual thermal energy output of the CHP system that is actually recovered and utilized in the facility/process.

= Custom input

Boiler<sub>eff</sub>/Furnace<sub>eff</sub> = Efficiency of the on-site Boiler/Furnace that is displaced by the CHP system or if unknown, the baseline equipment value stated in the High Efficiency Boiler (Section 4.4.10) measure or High Efficiency Furnace (Section 4.4.11) measure in this TRM.

= Custom input

F<sub>total CHP</sub> = Total fuel in Btus consumed by the CHP system

= Custom input

**Step 2: (Savings Allocation to Program Administrators for Purposes of Assessing Compliance with Energy Savings Goals (Not for Use in Load Reduction Forecasting))**

Savings claims are a function of the electric output of the CHP system (E<sub>CHP</sub>), the used thermal output of the CHP system (F<sub>thermalCHP</sub>), and the CHP system efficiency (CHP<sub>Eff</sub>(HHV)). The percentages of electric output and used thermal output that can be claimed also differ slightly depending on whether the project was included in both electric and gas Energy Efficiency Portfolio Standard (EEPS) efficiency programs, only an electric EEPS program or only a gas EEPS program. The tables below provide the specific percentages of electric and/or thermal output that can be claimed under each of those three scenarios. These percentages apply only to cases in which natural gas is the fuel used by the CHP system. Saving estimates for systems using other fuels should be calculated on a custom basis. If the waste heat recovered from the CHP system is offsetting electric equipment, such as an absorption chiller offsetting an electric chiller, then the net change in electricity consumption associated with the electric equipment should be added to the allocated electric savings.

1) For systems participating in both electric EEPS and gas EEPS programs:

<table>
<thead>
<tr>
<th>CHP Annual System Efficiency (HHV)</th>
<th>Allocated Electric Savings</th>
<th>Allocated Gas Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>60%</td>
<td>65% of E&lt;sub&gt;CHP&lt;/sub&gt; (kWh)</td>
<td>No gas savings</td>
</tr>
<tr>
<td>&gt;60% to 65%</td>
<td>65% of E&lt;sub&gt;CHP&lt;/sub&gt; (kWh) + one percentage point increase for every one percentage point increase in CHP system efficiency (max 70% of E&lt;sub&gt;CHP&lt;/sub&gt;)</td>
<td>No gas Savings</td>
</tr>
</tbody>
</table>

468 220 ILCS 5/8-103; 220 ILCS 5/16-111.5B

469 220 ILCS 5/8-104

470 As used in this measure characterization, EEPS programs are defined as those energy efficiency programs implemented pursuant to Sections 8-103, 8-104, and 16-111.5B of the Illinois Public Utilities Act. Technically, EEPS programs pertain to energy efficiency programs implemented pursuant to 220 ILCS 5/8-103 and 220 ILCS 5/8-104. However, for simplicity in presentation, this measure defines EEPS programs as also including those programs implemented pursuant to 220 ILCS 5/16-111.5B (these programs are funded through the same energy efficiency riders established pursuant to Section 8-103).
CHP Annual System Efficiency (HHV) | Allocated Electric Savings | Allocated Gas Savings
--- | --- | ---
>65% | 70% of $E_{CHP}$ (kWh) | 2.5% of $F_{thermal}$ (useful thermal output of the CHP system) for every one percentage point increase in CHP system efficiency above 65%

Example: System with measured annual system efficiency (HHV) of 70%: Electric savings (kWh) = 70% of $E_{CHP}$ measured over 12 months, and Gas savings (therms) = 12.5% of $F_{thermal}$ measured over 12 months (70% - 65% = 5 X 2.5% = 12.5%)

2) For systems participating in only an electric EEPS program:

CHP Annual System Efficiency (HHV) | Allocated Electric Savings | Allocated Gas Savings
--- | --- | ---
60% | 65% of $E_{CHP}$ (useful electric output of CHP system in kWh) | No gas Savings
Greater than 60% | 65% + one percentage point increase for every one percentage point increase in CHP system efficiency (no max) | No gas Savings

Example: System with measured annual fuel use efficiency of 75%: Electric savings (kWh) = 65% + 15% = 80% of $E_{CHP}$ measured over 12 months (15% = 1% for every 1% increase in system efficiency). No gas savings (therms).

3) For systems participating in only a gas EEPS program:

CHP Annual System Efficiency (HHV) | Allocated Electric Savings | Allocated Gas Savings
--- | --- | ---
60% or greater | No electric savings | 2.5% of $F_{thermal}$ (useful thermal output of the CHP system) for every one percentage point increase in CHP system efficiency above 60%.

Example: System with measured annual system efficiency (HHV) of 70%: No Electric savings (kWh). Gas savings (therms) = 25% of $F_{thermal}$ measured over 12 months (70% - 60% = 10 X 2.5% = 25%)

Conventional or topping cycle CHP systems virtually always require an increase in the use of fuel on-site in order to produce electricity. Different jurisdictions and experts across the country have employed and/or put forward a variety of approaches to address how increased on-site fuel consumption should be reflected in the attribution of electric savings to CHP systems. The approach reflected in the tables above is generally consistent – for CHP systems consuming natural gas – with approaches recently put forward by the Southwest Energy Efficiency Project (SWEEP) and Institute for Industrial Productivity (IIP) that determine reduced electric savings based on the

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Approaches range from ignoring the increased gas use entirely (i.e., no “penalty”) to applying approximately 40-60% “penalties”, depending on the CHP efficiency and based on the equivalent grid kWh that the increased gas use represents.
There are a variety of ways one could treat the potential for gas utilities to claim savings from CHP projects in their EEPS portfolios. For projects in which a natural gas EEPS program is involved, the tables above treat savings from CHP installations in two steps: (1) a fuel-switch from electricity to natural gas (i.e. using more natural gas to eliminate the need to generate as much electricity on the grid); and (2) possible increases in CHP efficiency above a “benchmark” level. When both electric EEPS and natural gas EEPS programs are involved in a project, the program administrator claims all the electricity savings associated with a fuel-switch up to a “benchmark” 65% efficient CHP system. All the savings associated with increasing CHP efficiencies above that benchmark level are allocated to natural gas (e.g. if the CHP efficiency is 75%, the natural gas savings associated with an increase in CHP efficiency from 65% to 75% are allocated to natural gas). That is consistent with the notion that CHP efficiency typically increases primarily by increasing the use of the thermal output of the system (increasing the displacement of baseline gas use). For projects that involve only a natural gas EEPS program, the “benchmark” above which the gas utility can claim savings is lowered to 60%.

ii) Waste-Heat-to-Power CHP Systems:

**ELECTRIC ENERGY SAVINGS:**

\[ \Delta \text{kWh} = E_{\text{CHP}} \]

Where:

- \( E_{\text{CHP}} \): Useful annual electricity output produced by the CHP system, defined as the annual electric energy output of the CHP system that is actually utilized to replace purchased electricity required to meet the requirements of the facility/process.

- Custom input

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

\[ \Delta \text{kW} = \text{CF} \times \text{CHP} \text{capacity} \]

Where:

- \( \text{CF} \): Summer Coincidence factor. This factor should also consider any displaced chiller capacity.

- Custom input

---

472 Consider, for example, a hypothetical CHP system that produces 5 million kWh annually, consumes 50 million kBtu of gas annual to generate that electricity (i.e. electric efficiency of approximately 34.8% HHV), reduces on-site gas use for space heating by 26 million kBtu of gas (i.e. equivalent to approximately 81.5% CHP thermal output utilization displacing gas used in a 70% efficient space heating boiler) and has a total annual CHP efficiency of 70.6% HHV. In this example, the net increase in on-site gas use is 24 million kBtu. At a carbon dioxide emission rate of 53.06 kg/MMBtu for burning natural gas, that translates to an increase in on-site carbon dioxide emissions of 1404 tons per year. At an estimated marginal emission rate of 1.098 tons of carbon dioxide per MWh in Illinois, that is equivalent to electric grid production of approximately 1.28 million kWh, or penalty of about 25.6% of the CHP system’s electrical output if a precise calculation of carbon equivalency was utilized to assign savings. In comparison, the simplified table above would entitle an electric utility to claim savings equal to 75.6% of the electric output (i.e. a penalty of 24.4% of electrical output) if it was the only utility promoting the system. In a gas and electric example, the electric savings claimed would be 70% of the production (a penalty of 30% of the CHP system’s electrical output) and 12.5% of the recovered thermal output, equivalent to 2.23 million kBTu. The difference between the electric only scenario and the electric and gas, on the electric side, is 5% of the electric output or 250,000 kWh, which would require 2.45 million kBTu input at an efficiency of 34.8% HHV.

473 If some or all of the existing electric chiller peak demand is no longer needed due to new waste heat powered chillers (e.g., absorption), the coincidence factor should be adjusted appropriately.
**Combination Heat and Power**

**CHP Capacity** = CHP nameplate capacity

= Custom input

**Natural Gas Energy Savings:**

\[ \Delta \text{Therms} = \frac{F_{\text{thermalCHP}}}{100,000} \]

Where:

- \( F_{\text{thermalCHP}} \) = Net savings in annual purchased fuel in Btu, if any, that would have been used on-site by a boiler/furnace to provide some or all of the useful thermal energy output of the CHP system.

- 100,000 = Conversion factor for Btu to therms

**Water Impact Descriptions and Calculation**

N/A

**Deemed O&M Cost Adjustment Calculation**

Custom estimates of maintenance costs that will be incurred for the life of the measure will be used. Maintenance costs vary with type and size of the prime mover. These costs include, but are not limited to:

- Maintenance labor
- Engine parts and materials such as oil filters, air filters, spark plugs, gaskets, valves, piston rings, electronic components, etc. and consumables such as oil
- Minor and major overhauls

For screening purposes, the US EPA has published resource guides that provide average maintenance costs based on CHP technology and system size.

**Cost-Effectiveness Screening and Load Reduction Forecasting**

For the purposes of forecasting load reductions due to CHP projects per Section 16-111.5B, changes in site energy use at the customer’s meter – reduced consumption of utility provided electricity – adjusted for utility line losses (at-the-busbar savings), customer switching estimates, NTG, and any other adjustment factors deemed appropriate, should be used.

For the purposes of screening a CHP measure application for cost-effectiveness, changes in site energy use – reduced consumption of utility provided electricity and the net change in consumption of fuel – should be used.

In general, the benefit and cost components used in evaluating the cost-effectiveness of a CHP project would include at least the following terms:

- **Benefits:** \( E_{\text{CHP}} + \Delta kW + F_{\text{thermalCHP}} \)
- **Costs:** \( F_{\text{totalCHP}} + \text{CHP Costs} + \text{O&M Costs} \)

Where:

- \( E_{\text{CHP}} \) = Energy produced by the CHP system
- \( \Delta kW \) = Additional capacity
- \( F_{\text{thermalCHP}} \) = Net savings in annual purchased fuel in Btu
- \( F_{\text{totalCHP}} \) = Total cost of the CHP project
- \( \text{CHP Costs} \) = Costs associated with the CHP system
- \( \text{O&M Costs} \) = O&M costs associated with the CHP system

---

474 In most cases, it is expected that waste-heat-to-power systems will not provide any new net useful thermal energy output, since the CHP system will be driven by thermal energy that was otherwise being wasted. If additional natural gas or other purchased energy is used onsite, it should be properly accounted for.

CHP\textsubscript{Costs} = CHP equipment and installation costs as defined in the “Deemed Measure Costs” section

O&M\textsubscript{Costs} = CHP operations and maintenance costs as defined in the “Deemed O&M Cost Adjustment Calculation” section

\textbf{MEASURE CODE: ci-hvc-chap-v01-150601}
4.5 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.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
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<td>5,950</td>
<td>1.25</td>
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<td>0.75</td>
<td>0.022</td>
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<td>0.248</td>
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<td>0.096</td>
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<td>1.097</td>
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<td>3,650</td>
<td>1.34</td>
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<td>0.69</td>
<td>0.022</td>
<td>0.504</td>
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<td>Elementary School</td>
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<td>1.31</td>
<td>1.40</td>
<td>0.22</td>
<td>0.028</td>
<td>0.634</td>
<td>0.317</td>
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<td>1.00</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
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<td>1.00</td>
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<td>0.010</td>
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<td>0.025</td>
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<td>4,207</td>
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<td>1.80</td>
<td>0.75</td>
<td>0.014</td>
<td>0.317</td>
<td>0.158</td>
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</tbody>
</table>

476 Fixtures hours of use are primarily derived from the default EPY4 values developed for ComEd based on DEER 2005, DEER 2008, EPY1 and EPY2 evaluation results. ‘Lighting intro wp.doc‘. Values for office, grocery, light industry, restaurant, retail/service and warehouse are an average of the EPY4 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.

477 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.

478 The Waste Heat Factor for Energy is developed using EQuest models for various building types averaged across 5 climate zones for Illinois. Exterior and garage values are 1, miscellaneous is an average of all indoor spaces.

479 Waste Heat Factor for Demand are not yet complete.

480 Coincident diversity factors are from the EPY4 values developed for ComEd based on DEER 2005, DEER 2008, EPY1 and EPY2 evaluation results. Miscellaneous value for Coincident Diversity Factor is from DEER 2008.

481 IFTherms value is developed using EQuest models consistent with methodology for Waste Heat Factor for Energy.

482 Electric heat penalty assumptions are based on converting the IFTherm multiplier value in to kWh and then applying relative heating system efficiencies. The gas efficiency was assumed to be 78% AFUE based upon standard TRM assumption for existing unit average efficiency, and the electric resistance is assumed to be 100%:

\[ \text{IFElectricHeat} = \text{IFTherms} \times 29.3 \text{kWh/therm} \times 78\% \text{ (Gas Heating Equipment Efficiency)} / 100\% \text{ (Electric Resistance Efficiency)} \]
<table>
<thead>
<tr>
<th>Building Type</th>
<th>Fixture Annual Operating Hours</th>
<th>Screw based bulb Annual Operating hours</th>
<th>Waste Heat Cooling Energy $WH_{Fe}$</th>
<th>Waste Heat Cooling Demand $WH_{Fd}$</th>
<th>Coincidence Factor $CF$</th>
<th>Waste Heat Gas Heating $IFT_{therms}$</th>
<th>Waste Heat Electric Resistance Heating $IFT_{kWh}$</th>
<th>Waste Heat Electric Heat Pump Heating $IFT_{kWh}$</th>
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</thead>
<tbody>
<tr>
<td>Hospital - CAV econ</td>
<td>6,038</td>
<td>4,207</td>
<td>1.37</td>
<td>1.80</td>
<td>0.75</td>
<td>0.014</td>
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<tr>
<td>Hospital - VAV econ</td>
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<td>1.47</td>
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<td>0.75</td>
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<td>5,950</td>
<td>1.37</td>
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<td>0.050</td>
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<tr>
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<td>5,950</td>
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<td>1.50</td>
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<td>0.022</td>
<td>0.505</td>
<td>0.253</td>
</tr>
<tr>
<td>Hotel/Motel - Guest</td>
<td>777</td>
<td>777</td>
<td>1.17</td>
<td>1.55</td>
<td>0.21</td>
<td>0.024</td>
<td>0.539</td>
<td>0.269</td>
</tr>
<tr>
<td>Hotel/Motel - Common</td>
<td>5,311</td>
<td>4,542</td>
<td>1.20</td>
<td>1.56</td>
<td>0.21</td>
<td>0.007</td>
<td>0.164</td>
<td>0.082</td>
</tr>
<tr>
<td>Movie Theater</td>
<td>5,475</td>
<td>5,475</td>
<td>1.22</td>
<td>1.59</td>
<td>0.75</td>
<td>0.033</td>
<td>0.762</td>
<td>0.381</td>
</tr>
<tr>
<td>Office - High Rise - CAV no econ</td>
<td>4,439</td>
<td>3,088</td>
<td>1.52</td>
<td>1.42</td>
<td>0.66</td>
<td>0.019</td>
<td>0.440</td>
<td>0.220</td>
</tr>
<tr>
<td>Office - High Rise - CAV econ</td>
<td>4,439</td>
<td>3,088</td>
<td>1.48</td>
<td>1.52</td>
<td>0.66</td>
<td>0.019</td>
<td>0.433</td>
<td>0.216</td>
</tr>
<tr>
<td>Office - High Rise - VAV econ</td>
<td>4,439</td>
<td>3,088</td>
<td>1.35</td>
<td>1.58</td>
<td>0.66</td>
<td>0.020</td>
<td>0.453</td>
<td>0.227</td>
</tr>
<tr>
<td>Office - High Rise - FCU</td>
<td>4,439</td>
<td>3,088</td>
<td>1.31</td>
<td>2.19</td>
<td>0.66</td>
<td>0.011</td>
<td>0.252</td>
<td>0.126</td>
</tr>
<tr>
<td>Office - Low Rise</td>
<td>4,439</td>
<td>3,088</td>
<td>1.46</td>
<td>1.59</td>
<td>0.66</td>
<td>0.022</td>
<td>0.494</td>
<td>0.247</td>
</tr>
<tr>
<td>Office - Mid Rise</td>
<td>4,439</td>
<td>3,088</td>
<td>1.34</td>
<td>1.41</td>
<td>0.66</td>
<td>0.021</td>
<td>0.489</td>
<td>0.244</td>
</tr>
<tr>
<td>Religious Building</td>
<td>1,664</td>
<td>1,664</td>
<td>1.48</td>
<td>1.44</td>
<td>0.66</td>
<td>0.017</td>
<td>0.396</td>
<td>0.198</td>
</tr>
<tr>
<td>Restaurant</td>
<td>3,673</td>
<td>4,784</td>
<td>1.36</td>
<td>1.33</td>
<td>0.80</td>
<td>0.025</td>
<td>0.567</td>
<td>0.284</td>
</tr>
<tr>
<td>Retail - Department Store</td>
<td>4,719</td>
<td>2,935</td>
<td>1.24</td>
<td>1.49</td>
<td>0.83</td>
<td>0.022</td>
<td>0.502</td>
<td>0.251</td>
</tr>
<tr>
<td>Retail - Strip Mall</td>
<td>4,719</td>
<td>2,935</td>
<td>1.24</td>
<td>1.50</td>
<td>0.83</td>
<td>0.020</td>
<td>0.463</td>
<td>0.232</td>
</tr>
<tr>
<td>Warehouse</td>
<td>4,746</td>
<td>4,293</td>
<td>1.09</td>
<td>1.46</td>
<td>0.70</td>
<td>0.023</td>
<td>0.535</td>
<td>0.267</td>
</tr>
<tr>
<td>Unknown</td>
<td>4,683</td>
<td>3,612</td>
<td>1.31</td>
<td>1.53</td>
<td>0.66</td>
<td>0.023</td>
<td>0.524</td>
<td>0.262</td>
</tr>
<tr>
<td>Exterior</td>
<td>4,903</td>
<td>4,903</td>
<td>1.00</td>
<td>1.00</td>
<td>0.00</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Low-Use Small Business</td>
<td>2,954</td>
<td>2,954</td>
<td>1.31</td>
<td>1.53</td>
<td>0.66</td>
<td>0.023</td>
<td>0.524</td>
<td>0.262</td>
</tr>
<tr>
<td>Uncooled Building</td>
<td>Varies</td>
<td>varies</td>
<td>1.00</td>
<td>1.00</td>
<td>0.66</td>
<td>0.014</td>
<td>0.320</td>
<td>0.160</td>
</tr>
<tr>
<td>Refrigerated Cases</td>
<td>5,802</td>
<td>n/a</td>
<td>1.29</td>
<td>1.29</td>
<td>0.69</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>----------------</td>
<td>--------------------------------</td>
<td>----------------------------------------</td>
<td>-----------------------------</td>
<td>-----------------------------</td>
<td>-----------------------</td>
<td>-------------------------------</td>
<td>----------------------------------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td>Freezer Cases</td>
<td>5,802</td>
<td>n/a</td>
<td>1.5</td>
<td>1.5</td>
<td>0.69</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
</tbody>
</table>
4.5.1 Commercial ENERGY STAR Compact Fluorescent Lamp (CFL)

DESCRIPTION

A low wattage ENERGY STAR qualified compact fluorescent screw-in bulb (CFL) is installed in place of a baseline screw-in bulb. This characterization assumes that the CFL is installed in a commercial location. If the implementation strategy does not allow for the installation location to be known a deemed split should be used. For Residential targeted programs (e.g. an upstream retail program), a deemed split of 96% Residential and 4% Commercial assumptions should be used\(^{(483)}\), and for Commercial targeted programs a deemed split of 4% Residential and 96% Commercial should be used\(^{(484)}\).

Federal legislation stemming from the Energy Independence and Security Act of 2007 (EISA) required all general-purpose light bulbs between 40W and 100W to be approximately 30% more energy efficient than current incandescent bulbs. Production of 100W, standard efficacy incandescent lamps ended in 2012 followed by restrictions on 75W in 2013 and 60W and 40W in 2014. The baseline for this measure has therefore become bulbs (improved incandescent or halogen) that meet the new standard.

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 an EISA qualified incandescent or halogen as provided in the table provided in the Electric Energy Savings section.

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\(^{(485)}\)) 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 under 2600 lumens is $1.25, from June 2014 – May 2015, $1.6 from June 2015 to May 2016 and $1.70 from June 2017 to May 2018\(^{(486)}\).

\(^{(483)}\) RES v C&I split is based on a weighted (by sales volume) average of ComEd PY-4-6 and Ameren PYS-6 in store intercept survey results.

\(^{(484)}\) Based upon final weighted (by sales volume) average of the BILD program (ComEd’s commercial lighting program) for PY 4 and PYS and PY6.

\(^{(485)}\) 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.

\(^{(486)}\) Based upon pricing forecast developed by Applied Proactive Technologies Inc (APT) based on industry input and provided to
For bulbs over 2600 lumens the assumed incremental capital cost is $5.

**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 section 4.5.

---

**Algorithm**

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

\[
\Delta \text{kWh} = \frac{(\text{WattsBase} - \text{WattsEE})}{1000} \times \text{ISR} \times \text{Hours} \times \text{WHFe}
\]

Where:

- \(\text{WattsBase}\) = Actual (if retrofit measure) or based on lumens of CFL bulb and program year installed:

---

Ameren.
**Minimum Lumens** | **Maximum Lumens** | **Incandescent Equivalent Post-EISA 2007 (WattsBase)**
--- | --- | ---
5280 | 6209 | 300
3000 | 5279 | 200
2601 | 2999 | 150
1490 | 2600 | 72
1050 | 1489 | 53
750 | 1049 | 43
310 | 749 | 29
250 | 309 | 25

WattsEE = Actual wattage of CFL purchased or installed

ISR = In Service Rate or the percentage of units rebated that get installed.

=100% 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:

<table>
<thead>
<tr>
<th>Weighted Average 1st year In Service Rate (ISR)</th>
<th>2nd year Installations</th>
<th>3rd year Installations</th>
<th>Final Lifetime In Service Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>71.2%</td>
<td>14.5%</td>
<td>12.3%</td>
<td>98.0%</td>
</tr>
</tbody>
</table>

Hours = Average hours of use per year are provided in Reference Table in Section 4.5,

---

487 Illinois evaluation of PY1 through PY3 has not found that fixtures or lamps placed into storage to be a significant enough issue to warrant an “In-Service Rate” when commercial customers complete an application form.

488 1st year in service rate is based upon review of PY4-6 evaluations from ComEd’s commercial lighting program (BILD) (see ‘IL Commercial Lighting ISR_2014.xls’ for more information. The average first year ISR was calculated weighted by the number of bulbs sold.

489 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. Note that this Final Install Rate does NOT account for leakage of purchased bulbs being installed outside of the utility territory. EM&V should assess how and if data from evaluation should adjust this final installation rate to account for this impact.
Screw based bulb annual operating hours, for each building type. If unknown use the Miscellaneous value.

\[ WHFe = \text{Waste heat factor for energy to account for cooling energy savings from efficient lighting are provided below for each building type in Reference Table in Section 4.5. If unknown, use the Miscellaneous value.} \]

For example, a 14W standard CFL is installed in an office in 2014 and sign off form provided:

\[ \Delta kWh = (((43 - 14)/1000)* 1.0 * 3088 * 1.25 \]
\[ = 111.9 \text{ kWh} \]

**HEATING PENALTY**

If electrically heated building:

\[ \Delta kWh_{\text{heatpenalty}} = \left(\frac{(\text{WattsBase} - \text{WattsEE})}{1000}\right) \times \text{ISR} \times \text{Hours} \times \text{-IFkWh} \]

Where:

\[ \text{IFkWh} = \text{Lighting-HVAC Interation Factor for electric heating impacts; this factor represents the increased electric space heating requirements due to the reduction of waste heat rejected by the efficent lighting. Values are provided in the Reference Table in Section 4.5. If unknown, use the Miscellaneous value.} \]

For example, a 14W standard CFL is installed in a heat pump heated office in 2014 and sign off form provided:

\[ \Delta kWh_{\text{heatpenalty}} = (((43 - 14)/1000)* 1.0*3088*-0.183 \]
\[ = - 16.4 \text{ kWh} \]

**DEFERRED INSTALLS**

As presented above, if a sign off form is not completed the characterization assumes that a percentage of bulbs purchased are not installed until Year 2 and Year 3 (see ISR assumption above). The Illinois Technical Advisory Committee has determined the following methodology for calculating the savings of these future installs.

- **Year 1 (Purchase Year) installs:** Characterized using assumptions provided above or evaluated assumptions if available.
- **Year 2 and 3 installs:** Characterized using delta watts assumption and hours of use from the Install Year i.e. the actual deemed (or evaluated if available) assumptions active in Year 2 and 3 should be applied.
- The NTG factor for the Purchase Year should be applied.

---

490 Based on ComEd analysis taking DEER 2008 values and averaging with PY1 and PY2 evaluation results.
491 Negative value because this is an increase in heating consumption due to the efficient lighting.
For example, for a 14W CFL (60W standard incandescent and 43W EISA qualified incandescent/halogen) purchased in 2014 and using miscellaneous hours assumption.

\[
\Delta kWH_{1st \ year \ installs} = ((43 - 14) / 1000) * 0.755 * 3198 * 1.06 \\
= 74.2 \text{ kWh}
\]

\[
\Delta kWH_{2nd \ year \ installs} = ((43 - 14) / 1000) * 0.121 * 3198 * 1.06 \\
= 11.9 \text{ kWh}
\]

Note: Here we assume no change in hours assumption. NTG value from Purchase year applied.

\[
\Delta kWH_{3rd \ year \ installs} = ((43 - 14) / 1000) * 0.103 * 3198 * 1.06 \\
= 10.1 \text{ kWh}
\]

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

\[
\Delta kW = ((\text{WattsBase}-\text{WattsEE})/1000) * \text{ISR} * \text{WHFd} * \text{CF}
\]

Where:

\[
\text{WHFd} = \text{Waste heat factor for demand to account for cooling savings from efficient lighting in cooled buildings is provided in the Reference Table in Section 4.5. If unknown, use the Miscellaneous value.}
\]

\[
\text{CF} = \text{Summer Peak Coincidence Factor for measure is provided in the Reference Table in Section 4.5. If unknown, use the Miscellaneous value.}
\]

Other factors as defined above

For example, a 14W standard CFL is installed in an office in 2014 and sign off form provided:

\[
\Delta kW = ((43 - 14)/1000)*1.0*1.3*0.66 \\
= 0.025 \text{ kW}
\]

**NATURAL GAS ENERGY SAVINGS**

Heating Penalty if fossil fuel heated building (or if heating fuel is unknown):

\[
\Delta \text{Therms}^{492} = (((\text{WattsBase}-\text{WattsEE})/1000) * \text{ISR} * \text{Hours} * - \text{IFTherms}
\]

Where:

\[
\text{IFTherms} = \text{Lighting-HVAC Iteration Factor for gas heating impacts; this factor represents the increased gas space heating requirements due to the reduction of waste heat rejected by the efficient lighting. Values are provided in the Reference Table in Section 4.5. If unknown, use the Miscellaneous value.}
\]

Other factors as defined above

\[492\] Negative value because this is an increase in heating consumption due to the efficient lighting.
For example, a 14W standard CFL is installed in an office in 2014 and sign off form provided:

\[
\Delta \text{Therms} = \left( \frac{(43 - 14)}{1000} \right) \times 1.0 \times 3088 \times 0.016 = -1.4 \text{ Therms}
\]

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

Bulb replacement costs assumed in the O&M calculations are provided below\(^{493}\).

<table>
<thead>
<tr>
<th>Location</th>
<th>Lumen Level</th>
<th>Std Inc.</th>
<th>EISA Compliant Halogen</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2014</td>
<td>2015</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$0.34</td>
<td>$0.34</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2016</td>
<td>2017</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$0.34</td>
<td>$0.34</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2018</td>
<td>2019</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$0.34</td>
<td>$0.34</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2020 &amp; after</td>
<td>N/A</td>
</tr>
</tbody>
</table>

In order to account for the falling EISA Qualified bulb replacement cost provided above, an equivalent annual levelized baseline replacement cost over the lifetime of the CFL bulb is calculated. Note that the measure life for these measures is capped to the number of years remaining until 2020.

The NPV for replacement lamps and annual levelized replacement costs using the statewide real discount rate of 5.23% are presented below:

<table>
<thead>
<tr>
<th>Location</th>
<th>Lumen Level</th>
<th>NPV of replacement costs for period</th>
<th>Levelized annual replacement cost savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial</td>
<td>Lumens &lt;310 or &gt;2600 (EISA exempt)</td>
<td>$2.83</td>
<td>$2.83</td>
</tr>
<tr>
<td>Commercial</td>
<td>Lumens ≥ 310 and ≤ 2600 (EISA compliant)</td>
<td>$8.60</td>
<td>$6.91</td>
</tr>
</tbody>
</table>

\(^{493}\) Based upon pricing forecast developed by Applied Proactive Technologies Inc (APT) based on industry input and provided to Ameren.
For halogen bulbs, we assume the same replacement cycle as incandescent bulbs. The replacement cycle is based on the miscellaneous hours of use. Both incandescent and halogen lamps are assumed to last for 1,000 hours before needing replacement.

**MEASURE CODE: CI-LTG-CCFL-V05-150601**

---

494 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.
4.5.2 Fluorescent Delamping

**DESCRIPTION**

This measure addresses the permanent removal of existing 8’, 4’, 3’ and 2’ fluorescent lamps. Unused lamps, lamp holders, and ballasts must be permanently removed from the fixture. This measure is applicable when retrofitting from T12 lamps to T8 lamps or simply removing lamps from a T8 fixture. Removing lamps from a T12 fixture that is not being retrofitted with T8 lamps are not eligible for this incentive.

Customers are responsible for determining whether or not to use reflectors in combination with lamp removal in order to maintain adequate lighting levels. Lighting levels are expected to meet the Illuminating Engineering Society of North America (IESNA) recommended light levels. Unused lamps, lamp holders, and ballasts must be permanently removed from the fixture and disposed of in accordance with local regulations. A pre-approval application is required for lamp removal projects.

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**

Savings are defined on a per removed lamp basis. The retrofit wattage (efficient conditioned) is therefore assumed to be zero. The savings numbers provided below are for the straight lamp removal measures, as well as the lamp removal and install reflector measures. The lamp installed/retrofit is captured in another measure.

**DEFINITION OF BASELINE EQUIPMENT**

The baseline condition is either a T12 or a T8 lamp with default wattages provided below. Note, if the program does not allow for the lamp type to be known, then a T12:T8 weighting of 80%:20% can be applied.

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The measure life is assumed to be 11 years per DEER 2005.

**DEEMED MEASURE COST**

The incremental capital cost is provided in the table below:

<table>
<thead>
<tr>
<th>Measure Category</th>
<th>Value</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-Foot Lamp Removal</td>
<td>$16.00</td>
<td>ComEd/KEMA regression</td>
</tr>
<tr>
<td>4-Foot Lamp Removal</td>
<td>$12.00</td>
<td>ICF Portfolio Plan</td>
</tr>
<tr>
<td>8-Foot Lamp Removal with reflector</td>
<td>$30.00</td>
<td>KEMA Assumption</td>
</tr>
<tr>
<td>4-Foot Lamp Removal with reflector</td>
<td>$25.00</td>
<td>KEMA Assumption</td>
</tr>
<tr>
<td>2-Foot or 3-Foot Removal</td>
<td>$12.35</td>
<td>KEMA Assumption</td>
</tr>
<tr>
<td>2-Foot or 3-Foot Removal with</td>
<td>$25.70</td>
<td>KEMA Assumption</td>
</tr>
</tbody>
</table>

495 Based on ComEd’s estimate of lamp type saturation.
496 Based on the assessment of active projects in the 2008-09 ComEd Smart Ideas Program. See files “ltg costs 12-10-10.xl.” and “Lighting Unit Costs 102605.doc”
### 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.
Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

\[ \Delta \text{kWh} = \frac{(\text{WattsBase} - \text{WattsEE})}{1000} \times \text{ISR} \times \text{Hours} \times \text{WHFe} \]

Where:

- **WattsBase**: Assume wattage reduction of lamp removed
- **WattsEE**: = 0
- **ISR**: In Service Rate or the percentage of units rebated that get installed.
  - = 100% if application form completed with sign off that equipment permanently removed and disposed of.
- **Hours**: Average hours of use per year are provided in Reference Table in Section 4.5. 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 4.5. If unknown, use the Miscellaneous value.

<table>
<thead>
<tr>
<th>Wattage of lamp removed</th>
<th>Weighted average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>80% T12, 20% T8</td>
</tr>
<tr>
<td><strong>T8</strong></td>
<td><strong>T12</strong></td>
</tr>
<tr>
<td>8-ft T8</td>
<td>38.6</td>
</tr>
<tr>
<td>4-ft T8</td>
<td>19.4</td>
</tr>
<tr>
<td>3-ft T8</td>
<td>14.6</td>
</tr>
<tr>
<td>2-ft T8</td>
<td>9.8</td>
</tr>
</tbody>
</table>

For example, delamping a 4 ft T8 fixture in an office building:

\[ \Delta \text{kWh} = \frac{(19.4 - 0)}{1000} \times 1.0 \times 4439 \times 1.25 \]

\[ = 107.6 \text{ kWh} \]

HEATING PENALTY

If electrically heated building:

\[ \text{497 Default wattage reduction is based on averaging the savings from moving from a 2 to 1, 3 to 2 and 4 to 3 lamp fixture, as provided in the Standard Performance Contract Procedures Manual: Appendix B: Table of Standard Fixture Wattages (http://www.sce.com/NR/rdonlyres/7A3455F0-A337-439B-9607-10A016D32D48/0/spc_B_Std_Fixture_Watts.pdf). An adjustment is made to the T8 delamped fixture to account for the significant increase in ballast factor. See 'Delamping calculation.xls' for details.} \]
\[ \Delta kW_{\text{heatpenalty}}^{498} = \left(\frac{\text{WattsBase} - \text{WattsEE}}{1000}\right) \times \text{ISR} \times \text{Hours} \times -\text{IF kWh} \]

Where:

\[ \text{IF kWh} \]

= Lighting-HVAC Interaction Factor for electric heating impacts; this factor represents the increased electric space heating requirements due to the reduction of waste heat rejected by the efficient lighting. Values are provided in the Reference Table in Section 4.5. If unknown, use the Miscellaneous value.

For example, delamping a 4 ft T8 fixture in a heat pump heated office building:

\[ \Delta kW_{\text{heatpenalty}} = \left(\frac{19.4 - 0}{1000}\right) \times 1.0 \times 4439 \times -0.151 \]
\[ = -13.0 \text{ kWh} \]

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

\[ \Delta kW = \left(\frac{\text{WattsBase} - \text{WattsEE}}{1000}\right) \times \text{ISR} \times \text{WHFd} \times \text{CF} \]

Where:

\[ \text{WHFd} \]

= Waste heat factor for demand to account for cooling savings from efficient lighting in cooled buildings is provided in the Reference Table in Section 4.5. If unknown, use the Miscellaneous value.

\[ \text{CF} \]

= Summer Peak Coincidence Factor for measure is provided in the Reference Table in Section 4.5. If unknown, use the Miscellaneous value.

Other factors as defined above

For example, delamping a 4 ft T8 fixture in an office building:

\[ \Delta kW = \left(\frac{19.4 - 0}{1000}\right) \times 1.0 \times 1.3 \times 0.66 \]
\[ = 0.017 \text{ kW} \]

**NATURAL GAS ENERGY SAVINGS**

Heating Penalty if fossil fuel heated building (or if heating fuel is unknown):

\[ \Delta \text{Therms}^{499} = \left(\frac{\text{WattsBase} - \text{WattsEE}}{1000}\right) \times \text{ISR} \times \text{Hours} \times -\text{IFTherms} \]

Where:

\[ \text{IFTherms} \]

= Lighting-HVAC Interaction 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 Reference Table in Section 4.5. If unknown, use the Miscellaneous value.

Other factors as defined above

\[^{498}\text{Negative value because this is an increase in heating consumption due to the efficient lighting.}\]

\[^{499}\text{Negative value because this is an increase in heating consumption due to the efficient lighting.}\]
For example, delamping a 4 ft T8 fixture in an office building:

\[
\Delta \text{Therms} = \frac{(19.4 - 0)}{1000} \times 1.0 \times 4439 \times -0.016
\]

\[=-1.4 \text{ therms}\]

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-LTG-DLMP-V02-140601**
4.5.3 High Performance and Reduced Wattage T8 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.

If the implementation strategy does not allow for the installation location to be known, a deemed split of 99% Commercial and 1% Residential should be used. This measure was developed to be applicable to the following program types: TOS, RF, DI.

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.

<table>
<thead>
<tr>
<th>Time of Sale (TOS)</th>
<th>Retrofit (RF) and Direct Install (DI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
<td>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. 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</td>
</tr>
</tbody>
</table>
### Time of Sale (TOS) vs. Retrofit (RF) and Direct Install (DI)

<table>
<thead>
<tr>
<th>Time of Sale (TOS)</th>
<th>Retrofit (RF) and Direct Install (DI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ballast factor ballasts may be used when appropriate light levels are provided and overall wattage is reduced.</td>
<td></td>
</tr>
</tbody>
</table>

#### Definition of Efficient Equipment

The definition of efficient equipment varies based on the program and is defined below:

<table>
<thead>
<tr>
<th>Time of Sale (TOS)</th>
<th>Retrofit (RF) and Direct Install (DI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>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 list (<a href="http://www.cee1.org/com/com-lt/com-lt-main.php3">http://www.cee1.org/com/com-lt/com-lt-main.php3</a>). 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. High bay fixtures must have fixture efficiencies of 85% or greater. 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. (<a href="http://library.cee1.org/content/commercial-lighting-qualifying-products-lists">http://library.cee1.org/content/commercial-lighting-qualifying-products-lists</a>). 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.</td>
<td></td>
</tr>
<tr>
<td>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 (<a href="http://www.cee1.org/com/com-lt/com-lt-main.php3">http://www.cee1.org/com/com-lt/com-lt-main.php3</a>). 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. High bay fixtures will have fixture efficiencies of 85% or greater. 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. (<a href="http://library.cee1.org/content/commercial-lighting-qualifying-products-lists">http://library.cee1.org/content/commercial-lighting-qualifying-products-lists</a>). 2’, 3’ and 8’ lamps must meet the wattage requirements specified in the RWT8 new and baseline assumptions table.</td>
<td></td>
</tr>
</tbody>
</table>

#### Definition of Baseline Equipment

The definition of baseline equipment varies based on the program and is defined below:
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 efficiency troffer.

The baseline is the existing system. In July 14, 2012, Federal Standards were enacted that were expected to eliminate T-12s as an option for linear fluorescent fixtures. Through v3.0 of the TRM, it was assumed that the T-12 would no longer be baseline for retrofits from 1/1/2016. However, due to significant loopholes in the legislation, T-12 compliant product is still freely available and in Illinois T-12s continue to hold a significant share of the existing and replacement lamp market. Therefore the timing of the sunsetting of T-12s as a viable baseline has been pushed back in v4.0 until 6/1/2016 and will be revisited in future update sessions.

There will be a baseline shift applied to all measures installed before 2016. See table C-1.

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The deemed lifetime of efficient equipment varies based on the program and is defined below:

<table>
<thead>
<tr>
<th>Time of Sale (TOS)</th>
<th>Retrofit (RF) and Direct Install (DI)</th>
</tr>
</thead>
</table>
| Fixture lifetime is 15 years.  
Fixtures 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.  
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. | Fixture lifetime is 15 years.  
As per explanation above, for existing T12 fixtures, a mid life baseline shift should be applied in Jan 2016 as described in table C-1.  
Note, since the fixture lifetime is deemed at 15 years, the replacement cost of both the lamp and ballast should be incorporated in to the O&M calculation. |

**LOADSHAPE**

Loadshape C06 - Commercial Indoor Lighting

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501 15 years from GDS Measure Life Report, June 2007
502 ibid
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

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

\[ \Delta kWh = \frac{Watts_{base} - Watts_{EE}}{1000} \times \text{Hours} \times WHF \times ISR \]

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, or a custom value can be entered if the configurations in the tables is not representative of the existing 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, or a custom value can be entered if the configurations in the tables is not representative of the existing system.

<table>
<thead>
<tr>
<th>Program</th>
<th>Reference Table</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time of Sale</td>
<td>A-1: HPT8 New and Baseline Assumptions</td>
</tr>
<tr>
<td>Retrofit</td>
<td>A-2: HPT8 New and Baseline Assumptions</td>
</tr>
<tr>
<td>Reduced Wattage T8, time of sale or retrofit</td>
<td>A-3: RWT8 New and Baseline Assumptions</td>
</tr>
</tbody>
</table>

Hours = Average hours of use per year as provided by the customer or selected from the Reference Table in Section 4.5. Fixture annual operating hours. If hours or building type are unknown, use the Miscellaneous value.

\[ WHF_e = \text{Waste heat factor for energy to account for cooling energy savings from efficient lighting is selected from the Reference Table in Section 4.5 for each building type. If building is un-cooled, the value is 1.0.} \]

ISR = In Service Rate or the percentage of units rebated that get installed.

=100%\(^{503}\) 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:

<table>
<thead>
<tr>
<th>Weighted Average 1st year In Service Rate (ISR)</th>
<th>2nd year Installations</th>
<th>3rd year Installations</th>
<th>Final Lifetime In Service Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>98%(^{504})</td>
<td>0%</td>
<td>0%</td>
<td>98.0%(^{505})</td>
</tr>
</tbody>
</table>

\(^{503}\) 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.

\(^{504}\) 1\(^{st}\) year in service rate is based upon review of PY5-6 evaluations from ComEd’s commercial lighting program (BILD) (see ‘IL Commercial Lighting ISR_2014.xls’ for more information

\(^{505}\) 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 2\(^{nd}\) and 3\(^{rd}\) year installations should be counted as part of those future program year savings. Note that this Final Install Rate does NOT account for leakage of purchased bulbs being installed outside of the utility territory. EM&V should assess how and if data from evaluation should adjust this final installation rate to account for this impact.
HEATING PENALTY

If electrically heated building:

\[ \Delta \text{kWh}_{\text{heatpenalty}} = \left(\frac{(\text{Watts}_{\text{base}} - \text{Watts}_{\text{EE}})}{1000}\right) \times \text{ISR} \times \text{Hours} \times \text{IFkWh} \]

Where:

\( \text{IFkWh} = \) Lighting-HVAC Iteration Factor for electric heating impacts; this factor represents the increased electric space heating requirements due to the reduction of waste heat rejected by the efficient lighting. Values are provided in the Reference Table in Section 4.5. If unknown, use the Miscellaneous value.

SUMMER COINCIDENT DEMAND SAVINGS

\[ \Delta \text{kW} = \left(\frac{(\text{Watts}_{\text{base}} - \text{Watts}_{\text{EE}})}{1000}\right) \times \text{WHF}_d \times \text{CF} \times \text{ISR} \]

Where:

\( \text{WHF}_d \) = Waste Heat Factor for Demand to account for cooling savings from efficient lighting in cooled buildings is selected from the Reference Table in Section 4.5 for each building type. If the building is not cooled WHF\(_d\) is 1.

\( \text{CF} \) = Summer Peak Coincidence Factor for measure is selected from the Reference Table in Section 4.5 for each building type. If the building type is unknown, use the Miscellaneous value of 0.66.

Other factors as defined above

NATURAL GAS SAVINGS

\[ \Delta \text{Therms} = \left(\frac{(\text{Watts}_{\text{base}} - \text{Watts}_{\text{EE}})}{1000}\right) \times \text{ISR} \times \text{Hours} \times \text{IFTherms} \]

Where:

\( \text{IFTherms} \) = 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 4.5 for each building type.

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

See Reference tables for Operating and Maintenance Values

\(^{506}\) Negative value because this is an increase in heating consumption due to the efficient lighting.

\(^{507}\) Negative value because this is an increase in heating consumption due to the efficient lighting.
<table>
<thead>
<tr>
<th>Program</th>
<th>Reference Table</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time of Sale</td>
<td>B-1: HPT8 Component Costs and Lifetime</td>
</tr>
<tr>
<td>Retrofit</td>
<td>B-2: HPT8 Component Costs and Lifetime</td>
</tr>
<tr>
<td>Reduced Wattage T8, time of sale or retrofit</td>
<td>B-3: HPT8 Component Costs and Lifetime</td>
</tr>
</tbody>
</table>

**REFERENCE TABLES**

See following page
A-1: Time of Sale: HPT8 New and Baseline Assumptions

<table>
<thead>
<tr>
<th>EE Measure Description</th>
<th>Watts&lt;sub&gt;EE&lt;/sub&gt;</th>
<th>Baseline Description</th>
<th>Watts&lt;sub&gt;BASE&lt;/sub&gt;</th>
<th>Measure Cost</th>
<th>Watts&lt;sub&gt;SAVE&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-Lamp HPT8 w/ High-BF Ballast High-Bay</td>
<td>146</td>
<td>200 Watt Pulse Start Metal-Halide</td>
<td>232</td>
<td>$75</td>
<td>86</td>
</tr>
<tr>
<td>6-Lamp HPT8 w/ High-BF Ballast High-Bay</td>
<td>221</td>
<td>320 Watt Pulse Start Metal-Halide</td>
<td>350</td>
<td>$75</td>
<td>129</td>
</tr>
<tr>
<td>8-Lamp HPT8 w/ High-BF Ballast High-Bay</td>
<td>280</td>
<td>Proportionally Adjusted according to 6-Lamp HPT8 Equivalent to 320 PSMH</td>
<td>455</td>
<td>$75</td>
<td>175</td>
</tr>
<tr>
<td>1-Lamp HPT8-high performance 32 w lamp</td>
<td>25</td>
<td>1-Lamp Standard F32T8 w/ Elec. Ballast</td>
<td>32</td>
<td>$15</td>
<td>7</td>
</tr>
<tr>
<td>1-Lamp HPT8-high performance 28 w lamp</td>
<td>22</td>
<td>1-Lamp Standard F32T8 w/ Elec. Ballast</td>
<td>32</td>
<td>$15</td>
<td>10</td>
</tr>
<tr>
<td>2-Lamp HPT8-high performance 32 w lamp</td>
<td>49</td>
<td>2-Lamp Standard F32T8 w/ Elec. Ballast</td>
<td>59</td>
<td>$18</td>
<td>10</td>
</tr>
<tr>
<td>2-Lamp HPT8-high performance 28 w lamp</td>
<td>43</td>
<td>2-Lamp Standard F32T8 w/ Elec. Ballast</td>
<td>59</td>
<td>$18</td>
<td>16</td>
</tr>
<tr>
<td>2-Lamp HPT8-high performance 25 w lamp</td>
<td>35</td>
<td>2-Lamp Standard F32T8 w/ Elec. Ballast</td>
<td>59</td>
<td>$18</td>
<td>24</td>
</tr>
<tr>
<td>3-Lamp HPT8-high performance 32 w lamp</td>
<td>72</td>
<td>3-Lamp Standard F32T8 w/ Elec. Ballast</td>
<td>88</td>
<td>$20</td>
<td>16</td>
</tr>
<tr>
<td>3-Lamp HPT8-high performance 28 w lamp</td>
<td>65</td>
<td>3-Lamp Standard F32T8 w/ Elec. Ballast</td>
<td>88</td>
<td>$20</td>
<td>23</td>
</tr>
<tr>
<td>3-Lamp HPT8-high performance 25 w lamp</td>
<td>58</td>
<td>3-Lamp Standard F32T8 w/ Elec. Ballast</td>
<td>88</td>
<td>$20</td>
<td>30</td>
</tr>
</tbody>
</table>

## 4.5.3 High Performance and Reduced Wattage T8 Fixtures and Lamps

<table>
<thead>
<tr>
<th>EE Measure Description</th>
<th>Watts&lt;sub&gt;EE&lt;/sub&gt;</th>
<th>Baseline Description</th>
<th>Watts&lt;sub&gt;BASE&lt;/sub&gt;</th>
<th>Measure Cost</th>
<th>Watts&lt;sub&gt;SAVE&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-Lamp HPT8 - high performance 32 w lamp</td>
<td>94</td>
<td>4-Lamp Standard F32T8 w/ Elec. Ballast</td>
<td>114</td>
<td>$23</td>
<td>20</td>
</tr>
<tr>
<td>4-Lamp HPT8 - high performance 28 w lamp</td>
<td>86</td>
<td>4-Lamp Standard F32T8 w/ Elec. Ballast</td>
<td>114</td>
<td>$23</td>
<td>28</td>
</tr>
<tr>
<td>4-Lamp HPT8 - high performance 25 w lamp</td>
<td>77</td>
<td>4-Lamp Standard F32T8 w/ Elec. Ballast</td>
<td>114</td>
<td>$23</td>
<td>37</td>
</tr>
<tr>
<td>2-lamp High-Performance HPT8 Troffer</td>
<td>49</td>
<td>3-Lamp F32T8 w/ Elec. Ballast</td>
<td>88</td>
<td>$100</td>
<td>39</td>
</tr>
</tbody>
</table>

Table developed using a constant ballast factor of .77. Input wattages are an average of manufacturer inputs that account for ballast efficacy.
A-2: Retrofit HPT8 New and Baseline Assumptions \(^{509}\) (Note see definition for validity after 2016)

<table>
<thead>
<tr>
<th>EE Measure Description</th>
<th>Watts</th>
<th>Baseline Description</th>
<th>Watts</th>
<th>Incremental cost</th>
<th>Watts</th>
<th>w/c</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-Lamp HPT8 w/ High-BF Ballast High-Bay</td>
<td>116</td>
<td>200 Watt Pulse Start Metal Halide</td>
<td>232</td>
<td>$200</td>
<td>86</td>
<td></td>
</tr>
<tr>
<td>4-Lamp HPT8 w/ High-BF Ballast High-Bay</td>
<td>146</td>
<td>250 Watt Metal Halide</td>
<td>295</td>
<td>$200</td>
<td>149</td>
<td></td>
</tr>
<tr>
<td>6-Lamp HPT8 w/ High-BF Ballast High-Bay</td>
<td>206</td>
<td>320 Watt Pulse Start Metal Halide</td>
<td>350</td>
<td>$225</td>
<td>114</td>
<td></td>
</tr>
<tr>
<td>6-Lamp HPT8 w/ High-BF Ballast High-Bay</td>
<td>206</td>
<td>400 Watt Metal Halide</td>
<td>455</td>
<td>$225</td>
<td>249</td>
<td></td>
</tr>
<tr>
<td>8-Lamp HPT8 w/ High-BF Ballast High-Bay</td>
<td>280</td>
<td>Proportionally Adjusted according to 6-Lamp HPT8 Equivalent to 320 PSMB</td>
<td>476</td>
<td>$250</td>
<td>106</td>
<td></td>
</tr>
<tr>
<td>8-Lamp HPT8 w/ High-BF Ballast High-Bay</td>
<td>280</td>
<td>Proportionally Adjusted according to 6-Lamp HPT8 Equivalent to 400 W Metal halide</td>
<td>618</td>
<td>$250</td>
<td>338</td>
<td></td>
</tr>
<tr>
<td>4-Lamp Relamp/Reballast T12 to HPT8</td>
<td>25</td>
<td>4-Lamp F34-T12 w/ EEMag Ballast</td>
<td>40</td>
<td>$50</td>
<td>15</td>
<td></td>
</tr>
<tr>
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### A– 3: RWT8 New and Baseline Assumptions

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<th>EE Measure Description</th>
<th>EE Cost</th>
<th>System Watts</th>
<th>EE Basalt Life</th>
<th>EE Ballast Life</th>
<th>EE Ballast Rep. Cost per lamp</th>
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<th>Base Cost</th>
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<td>F32T8 Standard Utube Lamp</td>
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<td>RWT8 - F96T8 Lamp - 8 Foot</td>
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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

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<td>$2.50</td>
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<td>$2.50</td>
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<td>70000</td>
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510 Ibid.
B-2: T8 Retrofit Component Costs and Lifetime

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<td>290-Watt Pulse Start Metal Halide</td>
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<td>290-Watt Pulse Start Metal Halide</td>
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<td>20000</td>
<td>$6.67</td>
<td>$109</td>
<td>40000</td>
<td>$22.50</td>
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<td>8-Lamp HP10 w/ High-Ballast High-Day</td>
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<td>$6.67</td>
<td>$114</td>
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<td>1 Lamp Retamp/Ballast 112 to HP18 (all ballast/lamp combinations)</td>
<td>$5.08</td>
<td>24000</td>
<td>6.67</td>
<td>$32.50</td>
<td>70000</td>
<td>$15.00</td>
<td>1 Lamp 112 all lamp/ballast combinations</td>
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<td>20000</td>
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<td>$20</td>
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<td>24000</td>
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<td>$32.50</td>
<td>70000</td>
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<td>2 Lamp 112 all lamp/ballast combinations</td>
<td>$2.70</td>
<td>20000</td>
<td>$2.47</td>
<td>$20</td>
<td>40000</td>
<td>$15.00</td>
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<td>3 Lamp Retamp/Ballast 112 to HP18 (all lamp/ballast combinations)</td>
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<td>24000</td>
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<td>$32.50</td>
<td>70000</td>
<td>$15.00</td>
<td>3 Lamp 112 all lamp/ballast combinations</td>
<td>$2.70</td>
<td>20000</td>
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<td>$20</td>
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<td>70000</td>
<td>$15.00</td>
<td>5 Lamp 112 all lamp/ballast combinations</td>
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<td>6 Lamp Retamp/Ballast 112 to HP18 (all lamp/ballast combinations)</td>
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<td>40000</td>
<td>$15.00</td>
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B-3: Reduced Wattage T8 Component Costs and Lifetime

<table>
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<tr>
<th>EE Measure Description</th>
<th>EE Lamp Cost</th>
<th>EE Lamp Life (hrs)</th>
<th>Baseline Description</th>
<th>Base Lamp Cost</th>
<th>Base Lamp Life (hrs)</th>
<th>Base Lamp Rep. Labor Cost</th>
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<tr>
<td>RWT8 - F28T8 Lamp</td>
<td>$4.50</td>
<td>30000</td>
<td>F32T8 Standard Lamp</td>
<td>$2.50</td>
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<td>$2.67</td>
</tr>
<tr>
<td>RWT8 - F28T8 Extra Life Lamp</td>
<td>$4.50</td>
<td>36000</td>
<td>F32T8 Standard Lamp</td>
<td>$2.50</td>
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<td>RWT8 - F32/25W T8 Lamp</td>
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<td>30000</td>
<td>F32T8 Standard Lamp</td>
<td>$2.50</td>
<td>15000</td>
<td>$2.67</td>
</tr>
<tr>
<td>RWT8 - F32/25W T8 Lamp Extra Life</td>
<td>$4.50</td>
<td>36000</td>
<td>F32T8 Standard Lamp</td>
<td>$2.50</td>
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<td>F17T8 Standard Lamp - 2 foot</td>
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<td>18000</td>
<td>F25T8 Standard Lamp - 3 foot</td>
<td>$3.10</td>
<td>15000</td>
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<tr>
<td>RWT8 - F30T8 Lamp - 6&quot; UTube</td>
<td>$11.31</td>
<td>24000</td>
<td>F32T8 Standard Utube Lamp</td>
<td>$9.31</td>
<td>15000</td>
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<td>RWT8 - F29T8 Lamp - UTube</td>
<td>$11.31</td>
<td>24000</td>
<td>F32T8 Standard Utube Lamp</td>
<td>$9.31</td>
<td>15000</td>
<td>$2.67</td>
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<td>F96T8 Standard Lamp - 8 foot</td>
<td>$7.00</td>
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<td>$2.67</td>
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C-1: T12 Baseline Adjustment:

For measures installed up to 6/1/2016, the full savings (as calculated above in the Algorithm section) will be claimed up to 6/1/2016. 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

<table>
<thead>
<tr>
<th>EE Measure Description</th>
<th>Savings Adjustment T12 EE mag ballast and 34 w lamps to HPT8</th>
<th>Savings Adjustment T12 EE mag ballast and 40 w lamps to HPT8</th>
<th>Savings Adjustment T12 mag ballast and 40 w lamps to HPT8</th>
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<td>1-Lamp Relamp/Reballast T12 to HPT8</td>
<td>47%</td>
<td>30%</td>
<td>20%</td>
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<tr>
<td>2-Lamp Relamp/Reballast T12 to HPT8</td>
<td>53%</td>
<td>30%</td>
<td>22%</td>
</tr>
<tr>
<td>3-Lamp Relamp/Reballast T12 to HPT8</td>
<td>42%</td>
<td>38%</td>
<td>21%</td>
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<tr>
<td>4-Lamp Relamp/Reballast T12 to HPT8</td>
<td>44%</td>
<td>29%</td>
<td>23%</td>
</tr>
</tbody>
</table>

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 6/12/2016 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’.

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-V04-150601**

---


4.5.4 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.

If the implementation strategy does not allow for the installation location to be known, a deemed split of 96% Commercial and 4% Residential should be used.\(^{514}\)

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) required 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.

**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.

**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

\(^{514}\) Based on final ComEd’s BILD program data from PY4, PY5 and PY6. For Residential installations, hours of use assumptions from ‘5.5.6 LED Downlights’ should be used for LED fixtures and ‘5.5.8 LED Screw Based Omnidirectional Bulbs’ should be used for LED bulbs.
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.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

\[ \Delta \text{kWh} = \left( \frac{\text{Watts}_{\text{base}} - \text{Watts}_{\text{EE}}}{1000} \right) \times \text{Hours} \times \text{WHF} \times \text{ISR} \]

Where:

\( \text{Watts}_{\text{base}} \) = Input wattage of the existing or baseline system. Reference the “LED New and Baseline Assumptions” table for default values.

\( \text{Watts}_{\text{EE}} \) = Actual wattage of LED purchased / installed. If unknown, use default provided below:

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.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>5280</td>
<td>6209</td>
<td>5745</td>
<td>104.4</td>
<td>300.0</td>
<td>195.6</td>
<td>300.0</td>
<td>195.6</td>
</tr>
<tr>
<td>3000</td>
<td>5279</td>
<td>4140</td>
<td>75.3</td>
<td>200.0</td>
<td>124.7</td>
<td>200.0</td>
<td>124.7</td>
</tr>
<tr>
<td>2601</td>
<td>2999</td>
<td>2800</td>
<td>50.9</td>
<td>150.0</td>
<td>99.1</td>
<td>150.0</td>
<td>99.1</td>
</tr>
<tr>
<td>1490</td>
<td>2600</td>
<td>2045</td>
<td>37.2</td>
<td>72.0</td>
<td>34.8</td>
<td>45.4</td>
<td>8.3</td>
</tr>
<tr>
<td>1050</td>
<td>1489</td>
<td>1270</td>
<td>23.1</td>
<td>53.0</td>
<td>29.9</td>
<td>28.2</td>
<td>5.1</td>
</tr>
<tr>
<td>750</td>
<td>1049</td>
<td>900</td>
<td>16.4</td>
<td>43.0</td>
<td>26.6</td>
<td>20.0</td>
<td>3.6</td>
</tr>
<tr>
<td>310</td>
<td>749</td>
<td>530</td>
<td>9.6</td>
<td>29.0</td>
<td>19.4</td>
<td>11.8</td>
<td>2.1</td>
</tr>
<tr>
<td>250</td>
<td>309</td>
<td>280</td>
<td>5.6</td>
<td>25.0</td>
<td>19.4</td>
<td>25.0</td>
<td>19.4</td>
</tr>
</tbody>
</table>

Decorative Lamps - ENERGY STAR Minimum Luminous Efficacy = 40Lm/W for all lamps

<table>
<thead>
<tr>
<th>Nominal wattage of lamp to be replaced (Watts&lt;sub&gt;base&lt;/sub&gt;)</th>
<th>Minimum initial light output of LED lamp (lumens)</th>
<th>LED Wattage (WattsEE)</th>
<th>Delta Watts</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>70</td>
<td>1.75</td>
<td>8.25</td>
</tr>
<tr>
<td>15</td>
<td>90</td>
<td>2.25</td>
<td>12.75</td>
</tr>
<tr>
<td>25</td>
<td>150</td>
<td>3.75</td>
<td>21.25</td>
</tr>
<tr>
<td>40</td>
<td>300</td>
<td>7.5</td>
<td>32.5</td>
</tr>
<tr>
<td>60</td>
<td>500</td>
<td>12.5</td>
<td>47.5</td>
</tr>
</tbody>
</table>

Decorative lamps are exempt from EISA regulations.

<sup>515</sup> Based on ENERGY STAR specs – minimum luminous efficacy for Omnidirectional Lamps. For LED lamp power <10W = 50lm/W and for LED lamp power >=10W = 55lm/W.

<sup>516</sup> Calculated as 45lm/W for all EISA non-exempt bulbs.
**Directional Lamps** - ENERGY STAR Minimum Luminous Efficacy = 40Lm/W for lamps with rated wattages less than 20W and 50 Lm/W for lamps with rated wattages >= 20 watts\(^{517}\).

For Directional R, BR, and ER lamp types\(^{518}\):

<table>
<thead>
<tr>
<th>Bulb Type</th>
<th>Lower Lumen Range</th>
<th>Upper Lumen Range</th>
<th>WattsBase</th>
<th>Lumens used to calculate LED Wattage (midpoint)</th>
<th>LED Wattage (Watts(_{EE}))</th>
<th>Delta Watts</th>
</tr>
</thead>
<tbody>
<tr>
<td>R, ER, BR with medium screw bases w/ diameter &gt;2.25&quot; (*see exceptions below)</td>
<td>420</td>
<td>472</td>
<td>40</td>
<td>446</td>
<td>11</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td>473</td>
<td>524</td>
<td>45</td>
<td>499</td>
<td>12</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>525</td>
<td>714</td>
<td>50</td>
<td>620</td>
<td>15</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>715</td>
<td>937</td>
<td>65</td>
<td>826</td>
<td>21</td>
<td>44</td>
</tr>
<tr>
<td></td>
<td>938</td>
<td>1259</td>
<td>75</td>
<td>1099</td>
<td>22</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td>1260</td>
<td>1399</td>
<td>90</td>
<td>1330</td>
<td>27</td>
<td>63</td>
</tr>
<tr>
<td></td>
<td>1400</td>
<td>1739</td>
<td>100</td>
<td>1570</td>
<td>31</td>
<td>69</td>
</tr>
<tr>
<td></td>
<td>1740</td>
<td>2174</td>
<td>120</td>
<td>1957</td>
<td>39</td>
<td>81</td>
</tr>
<tr>
<td></td>
<td>2175</td>
<td>2624</td>
<td>150</td>
<td>2400</td>
<td>48</td>
<td>102</td>
</tr>
<tr>
<td></td>
<td>2625</td>
<td>2999</td>
<td>175</td>
<td>2812</td>
<td>56</td>
<td>119</td>
</tr>
<tr>
<td></td>
<td>3000</td>
<td>4500</td>
<td>200</td>
<td>3750</td>
<td>75</td>
<td>125</td>
</tr>
<tr>
<td>*R, BR, and ER with medium screw bases w/ diameter &lt;=2.25&quot;</td>
<td>400</td>
<td>449</td>
<td>40</td>
<td>425</td>
<td>11</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td>450</td>
<td>499</td>
<td>45</td>
<td>475</td>
<td>12</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>500</td>
<td>649</td>
<td>50</td>
<td>575</td>
<td>14</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>650</td>
<td>1199</td>
<td>65</td>
<td>925</td>
<td>23</td>
<td>42</td>
</tr>
<tr>
<td>*ER30, BR30, BR40, or ER40</td>
<td>400</td>
<td>449</td>
<td>40</td>
<td>425</td>
<td>11</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td>450</td>
<td>499</td>
<td>45</td>
<td>475</td>
<td>12</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>500</td>
<td>649</td>
<td>50</td>
<td>575</td>
<td>14</td>
<td>36</td>
</tr>
<tr>
<td>*BR30, BR40, or ER40</td>
<td>650</td>
<td>1419</td>
<td>65</td>
<td>1035</td>
<td>21</td>
<td>44</td>
</tr>
<tr>
<td>*R20</td>
<td>400</td>
<td>449</td>
<td>40</td>
<td>425</td>
<td>11</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td>450</td>
<td>719</td>
<td>45</td>
<td>585</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td>*All reflector lamps below lumen ranges specified above</td>
<td>200</td>
<td>299</td>
<td>20</td>
<td>250</td>
<td>6</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>300</td>
<td>399</td>
<td>30</td>
<td>350</td>
<td>9</td>
<td>21</td>
</tr>
</tbody>
</table>

Directional lamps are exempt from EISA regulations.

---

\(^{517}\) From pg 10 of the Energy Star Specification for lamps v1.1

\(^{518}\) From pg 11 of the Energy Star Specification for lamps v1.1
For PAR, MR, and MRX Lamps Types:

For these highly focused directional lamp types, it is necessary to have Center Beam Candle Power (CBCP) and beam angle measurements to accurately estimate the equivalent baseline wattage. The formula below is based on the Energy Star Center Beam Candle Power tool.\(^{519}\) If CBCP and beam angle information are not available, refer to the R, BR, and ER lumen based method above.

\[
\text{Wattbase} = 375.1 - 4.355(D) - \sqrt{227,800 - 937.9(D) - 0.9903(D^2) - 1479(BA)} - 12.02(D*BA) + 14.69(BA^2) - 16,720 * \ln(CBCP)
\]

Where:

- \(D\) = Bulb diameter (e.g. for PAR20 \(D = 20\))
- \(BA\) = Beam angle
- \(CBCP\) = Center beam candle power

The result of the equation above should be rounded DOWN to the nearest wattage established by Energy Star:

<table>
<thead>
<tr>
<th>Diameter</th>
<th>Permitted Wattages</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>20, 35, 40, 45, 50, 60, 75</td>
</tr>
<tr>
<td>20</td>
<td>50</td>
</tr>
<tr>
<td>30S</td>
<td>40, 45, 50, 60, 75</td>
</tr>
<tr>
<td>30L</td>
<td>50, 75</td>
</tr>
<tr>
<td>38</td>
<td>40, 45, 50, 55, 60, 65, 75, 85, 90, 100, 120, 150, 250</td>
</tr>
</tbody>
</table>

**Hours** = Average hours of use per year are provided in the Reference Table in Section 4.5, 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 Reference Table in Section 4.5. If unknown, use the Miscellaneous value.

**ISR** = In Service Rate - the percentage of units rebated that actually get installed.

=100\(^{520}\) 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:

---


\(^{520}\) 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.
### Weighted Average 1st year In Service Rate (ISR) | 2nd year Installations | 3rd year Installations | Final Lifetime In Service Rate
---|---|---|---
95.7\%\(^{521}\) | 1.2\% | 1.1\% | 98.0\%\(^{522}\)

#### HEATING PENALTY

If electrically heated building:

\[ \Delta\text{kWh}_{\text{heatpenalty}} = (((\text{WattsBase}-\text{WattsEE})/1000) \times \text{ISR} \times \text{Hours} \times -\text{IFkWh} \]

Where:

- \( \text{IFkWh} \) = Lighting-HVAC Iteration Factor for electric heating impacts; this factor represents the increased electric space heating requirements due to the reduction of waste heat rejected by the efficient lighting. Values are provided in the Reference Table in Section 4.5. If unknown, use the Miscellaneous value.

For example, For example, a 9W LED lamp, 450 lumens, is installed in a heat pump heated office in 2014 and sign off form provided:

\[ \Delta\text{kWh}_{\text{heatpenalty}} = ((29-9/1000)\times1.0\times3088\times-0.151 \]

\[ = -9.3 \text{ kWh} \]

#### DEFERRED INSTALLS

As presented above, if a sign off form is not completed the characterization assumes that a percentage of bulbs purchased are not installed until Year 2 and Year 3 (see ISR assumption above). The Illinois Technical Advisory Committee has determined the following methodology for calculating the savings of these future installs.

- **Year 1 (Purchase Year) installs:** Characterized using assumptions provided above or evaluated assumptions if available.
- **Year 2 and 3 installs:** Characterized using delta watts assumption and hours of use from the Install Year i.e. the actual deemed (or evaluated if available) assumptions active in Year 2 and 3 should be applied.

The NTG factor for the Purchase Year should be applied.

---

\(^{521}\) Based on ComEd’s BILD program data from PY5 and PY6, see “IL Commercial Lighting ISR_2014.xls”.

\(^{522}\) In the absence of any data for LEDs specifically it is assumed that the same proportion of bulbs eventually get installed as for CFLS. The 98\% CFL 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 2\text{nd} and 3\text{rd} year installations should be counted as part of those future program year savings. Note that this Final Install Rate does NOT account for leakage of purchased bulbs being installed outside of the utility territory. EM&V should assess how and if data from evaluation should adjust this final installation rate to account for this impact.

\(^{523}\) Negative value because this is an increase in heating consumption due to the efficient lighting.
**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

\[ \Delta kW = \left( \frac{\text{Watts}_{\text{base}} - \text{Watts}_{\text{EE}}}{1000} \right) \times \text{ISR} \times \text{WHF}_d \times \text{CF} \]

Where:

- \( \text{WHF}_d \) = Waste Heat Factor for Demand to account for cooling savings from efficient lighting in cooled buildings is provided in Reference Table in Section 4.5. If unknown, use the Miscellaneous value.
- \( \text{CF} \) = Summer Peak Coincidence Factor for measure is provided in the Reference Table in Section 4.5. If unknown, use the Miscellaneous value.

For example, for example, a 9W LED lamp, 450 lumens, is installed in an office in 2014 and sign off form provided:

\[ \Delta kW = \left( \frac{29 - 9}{1000} \right) \times 1.0 \times 1.3 \times 0.66 \]
\[ = 0.002 \text{ kW} \]

**NATURAL GAS ENERGY SAVINGS**

Heating Penalty if fossil fuel heated building (or if heating fuel is unknown):

\[ \Delta \text{Therms} = \left( \frac{\text{Watts}_{\text{base}} - \text{Watts}_{\text{EE}}}{1000} \right) \times \text{ISR} \times \text{Hours} \times \text{IFTherms} \]

Where:

- \( \text{IFTherms} \) = 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 Reference Table in Section 4.5. If unknown, use the Miscellaneous value.

For example, for example, a 9W LED lamp, 450 lumens, is installed in an office in 2014 and sign off form provided:

\[ \Delta \text{Therms} = \left( \frac{29 - 9}{1000} \right) \times 1.0 \times 3088 \times -0.016 \]
\[ = -0.99 \text{ therms} \]

**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\(^\text{524}\).

In order to account for the falling EISA Qualified bulb replacement cost provided above, an equivalent annual levelized baseline replacement cost over the lifetime of the LED bulb (assumed to be 25,000/4576 =5.5 years) is calculated (see “C&I OmniDirectional LED O&M Calc.xls”). The key assumptions used in this calculation are documented below\(^\text{525}\).

\(^\text{524}\) See “LED reference tables.xls” for breakdown of component cost assumptions.

\(^\text{525}\) Based upon pricing forecast developed by Applied Proactive Technologies Inc (APT) based on industry input and provided to
The NPV for replacement lamps and annual levelized replacement costs using the statewide real discount rate of 5.23% are presented below:

<table>
<thead>
<tr>
<th>Location</th>
<th>Lumen Level</th>
<th>NPV of replacement costs for period</th>
<th>Levelized annual replacement cost savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial</td>
<td>Lumens &lt;310 or &gt;2600 (EISA exempt)</td>
<td>$6.94</td>
<td>$1.49</td>
</tr>
<tr>
<td></td>
<td>Lumens ≥ 310 and ≤ 2600 (EISA compliant)</td>
<td>$16.86</td>
<td>$3.63</td>
</tr>
<tr>
<td>Multi Family</td>
<td>Lumens &lt;310 or &gt;2600 (non-EISA compliant)</td>
<td>$7.13</td>
<td>$1.93</td>
</tr>
<tr>
<td>Common Areas</td>
<td>Lumens ≥ 310 and ≤ 2600 (EISA compliant)</td>
<td>$18.75</td>
<td>$5.09</td>
</tr>
</tbody>
</table>

For halogen bulbs, we assume the same replacement cycle as incandescent bulbs. The replacement cycle is based on the miscellaneous hours of use. Both incandescent and halogen lamps are assumed to last for 1,000 hours before needing replacement and CFLs after 10,000 hours.

---

Ameren.

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

<table>
<thead>
<tr>
<th>LED Measure Description</th>
<th>WattsEE</th>
<th>Baseline Description</th>
<th>WattsBASE</th>
<th>Basis for Watt Assumptions</th>
<th>LED Lamp Cost</th>
<th>Baseline Cost (EISA 2012-2014, EISA 2020)</th>
<th>Incremental Cost (EISA 2012-2014, EISA 2020)</th>
<th>LED Minimum Lamp Life (hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LED Screw and Pin-based Bulbs, Omnidirectional, &lt; 10W</td>
<td></td>
<td>See tables above</td>
<td></td>
<td>$30.00</td>
<td>$0.34 ($1.25, $2.50)</td>
<td>$29.66 ($28.75, $27.50)</td>
<td></td>
<td>25,000</td>
</tr>
<tr>
<td>LED Screw and Pin-based Bulbs, Omnidirectional, &gt;= 10W</td>
<td></td>
<td></td>
<td></td>
<td>$40.00</td>
<td>$0.34 ($1.25, $2.50)</td>
<td>$39.66 ($38.75, $37.50)</td>
<td></td>
<td>25,000</td>
</tr>
<tr>
<td>LED Screw and Pin-based Bulbs, Decorative</td>
<td></td>
<td></td>
<td></td>
<td>$30.00</td>
<td>$1.00</td>
<td>$29.00</td>
<td></td>
<td>25,000</td>
</tr>
<tr>
<td>LED Screw-based Bulbs, Directional, &lt; 15W</td>
<td></td>
<td></td>
<td></td>
<td>$45.00</td>
<td>$5.00</td>
<td>$40.00</td>
<td></td>
<td>35,000</td>
</tr>
<tr>
<td>LED Screw-based Bulbs, Directional, &gt;= 15W</td>
<td></td>
<td></td>
<td></td>
<td>$55.00</td>
<td>$5.00</td>
<td>$50.00</td>
<td></td>
<td>35,000</td>
</tr>
<tr>
<td>LED Recessed, Surface, Pendant Downlights</td>
<td>17.6</td>
<td>Baseline LED Recessed, Surface, Pendant Downlights</td>
<td>54.3</td>
<td>2008-2010 EVT Historical Data of 947 Measures</td>
<td>50,000</td>
<td>$50.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LED Track Lighting</td>
<td>12.2</td>
<td>Baseline LED Track Lighting</td>
<td>60.4</td>
<td>2008-2010 EVT Historical Data of 242 Measures</td>
<td>50,000</td>
<td>$100.00</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Data is based on Efficiency Vermont derived cost and actual installed wattage information.
<table>
<thead>
<tr>
<th>LED Measure Description</th>
<th>WattsEE</th>
<th>Baseline Description</th>
<th>WattsBASE</th>
<th>Basis for Watt Assumptions</th>
<th>LED Lamp Cost</th>
<th>Baseline Cost (EISA 2012-2014, EISA 2020)</th>
<th>Incremental Cost (EISA 2012-2014, EISA 2020)</th>
<th>LED Minimum Lamp Life (hrs)</th>
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<tbody>
<tr>
<td>LED Wall-Wash Fixtures</td>
<td>8.3</td>
<td>Baseline LED Wall-Wash Fixtures</td>
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<tr>
<td>LED Refrigerated Case Light, Horizontal or Vertical (per foot of light bar)</td>
<td>7.6</td>
<td>Baseline LED Refrigerated Case Light, Horizontal or Vertical (per foot of light bar)</td>
<td>15.2</td>
<td>PG&amp;E Refrigerated Case Study[^528] normalized to per foot of light bar.</td>
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<tr>
<td>LED Freezer Case Light, Horizontal or Vertical (per foot)</td>
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<td>Baseline LED Freezer Case Light, Horizontal or Vertical (per foot)</td>
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[^528]: LED Refrigeration Case Ltg Workpaper 053007 rev1, May 30, 2007
<table>
<thead>
<tr>
<th>LED Measure Description</th>
<th>WattsEE</th>
<th>Baseline Description</th>
<th>WattsBASE</th>
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<th>LED Lamp Cost</th>
<th>Baseline Cost (EISA 2012-2014, EISA 2020)</th>
<th>Incremental Cost (EISA 2012-2014, EISA 2020)</th>
<th>LED Minimum Lamp Life (hrs)</th>
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<tbody>
<tr>
<td>LED Display Case Light Fixture (per foot)</td>
<td>7.1</td>
<td>Baseline LED Display Case Light Fixture</td>
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<td>T8 U-Tube 2L-FB32 w/ Elec - 2'</td>
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<td>Based on average watts of DLC qualified products as of 11/21/11</td>
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<td>Baseline LED Outdoor Pole/Arm Mounted Parking/Roadway, &lt; 30W</td>
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### LED Measure Description

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<th>WattsBASE</th>
<th>Basis for Watt Assumptions</th>
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<th>Incremental Cost (EISA 2012-2014, EISA 2020)</th>
<th>LED Minimum Lamp Life (hrs)</th>
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<td>LED Outdoor Pole/Arm Mounted Parking/Roadway, 30W - 75W</td>
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<td>Baseline LED Outdoor Pole/Arm Mounted Parking/Roadway, 30W - 75W</td>
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<tr>
<td>LED Outdoor Pole/Arm Mounted Parking/Roadway, &gt;= 75W</td>
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<td>Baseline LED Outdoor Pole/Arm Mounted Parking/Roadway, &gt;= 75W</td>
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<td>LED Outdoor Pole/Arm Mounted Decorative Parking/Roadway, &lt; 30W</td>
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<td>Baseline LED Parking Garage/Canopy, &gt;= 75W</td>
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<tr>
<td>LED Wall-Mounted Area Lights, &lt; 30W</td>
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<td>Baseline LED Wall-Mounted Area Lights, &lt; 30W</td>
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<td>2008-2010 EVT Historical Data of 2,813 Measures</td>
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<td>Baseline LED Wall-Mounted Area Lights, &gt;= 75W</td>
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<tr>
<td>---------------------------------</td>
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<tr>
<td>LED Flood Light, &lt; 15W</td>
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<td>Baseline LED Flood Light, &lt; 15W</td>
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<td>Consistent with LED Screw-base Directional</td>
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<td>$35.00</td>
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<td>LED Flood Light, &gt;= 15W</td>
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### LED Component Costs & Lifetime

<table>
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<tr>
<th>LED Measure Description</th>
<th>LED Minimum Lamp Life (hrs)</th>
<th>LED Lamp Cost Total</th>
<th>LED Driver Life (hrs)</th>
<th>LED Driver Cost Total</th>
<th>Baseline Technology (1)</th>
<th>Lamp (1) Life (hrs)</th>
<th>Lamp (1) Total Cost</th>
<th>Ballast (1) Life (hrs)</th>
<th>Ballast (1) Total Cost</th>
<th>Baseline Technology (2)</th>
<th>Lamp (2) Life (hrs)</th>
<th>Lamp (2) Total Cost</th>
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</thead>
<tbody>
<tr>
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<td>N/A</td>
<td>N/A</td>
<td>53W EISA Halogen</td>
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<td>N/A</td>
<td>N/A</td>
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<td>N/A</td>
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<td>$11.62</td>
<td>40,000</td>
<td>$36.00</td>
<td>85% Halogen PAR20</td>
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<td>$12.67</td>
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<td>$12.62</td>
<td>40,000</td>
<td>$36.00</td>
<td>85% Halogen PAR30/38</td>
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<td>$12.67</td>
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<tr>
<td>LED Recessed, Surface, Pendant Downlights</td>
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<td>$47.50</td>
<td>70,000</td>
<td>$47.50</td>
<td>40% CFL 26W Pin Base</td>
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<td>$12.62</td>
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<td>$36.00</td>
<td>60% Halogen PAR30/38</td>
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<td>$12.67</td>
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<td>LED Track Lighting</td>
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<td>10% CMH PAR38</td>
<td>12,000</td>
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<td>70,000</td>
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<td>70,000</td>
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<td>70,000</td>
<td>$47.50</td>
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<td>40,000</td>
<td>$45.00</td>
<td>50% 50W Halogen</td>
<td>2,500</td>
<td>$12.67</td>
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</table>

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.
<table>
<thead>
<tr>
<th>LED Measure Description</th>
<th>LED Minimum Lamp Life (hrs)</th>
<th>LED Lamp Cost (per foot)</th>
<th>LED Lamp Life (hrs)</th>
<th>LED Driver Life (hrs)</th>
<th>LED Driver Cost (per foot)</th>
<th>Baseline Technology (1)</th>
<th>Lamp (1) Life (hrs)</th>
<th>Lamp (1) Total Cost</th>
<th>Ballast (1) Life (hrs)</th>
<th>Ballast (1) Total Cost</th>
<th>Baseline Technology (2)</th>
<th>Lamp (2) Life (hrs)</th>
<th>Lamp (2) Total Cost</th>
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</thead>
<tbody>
<tr>
<td>LED Refrigerated Case Light, Horizontal or Vertical (per foot)</td>
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<td>$9.50</td>
<td>70,000</td>
<td>$9.50</td>
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<td>40,000</td>
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<td>70,000</td>
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<td>50% 2’ T5 Linear</td>
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<td>$9.92</td>
<td>40,000</td>
<td>$45.00</td>
<td>50% 50W Halogen</td>
<td>2,500</td>
<td>$12.67</td>
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<td>35,000</td>
<td>$47.50</td>
<td>70,000</td>
<td>$47.50</td>
<td>T8 U- Tube 2L-FB32 w/ Elec - 2’</td>
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<td>70,000</td>
<td>$47.50</td>
<td>T8 3L-F32 w/ Elec - 4’</td>
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<td>$17.00</td>
<td>40,000</td>
<td>$35.00</td>
<td>N/A</td>
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<td>70,000</td>
<td>$47.50</td>
<td>T8 2L-F32 w/ Elec - 4’</td>
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<td>LED High- and Low-Bay Fixtures</td>
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## 4.5.4 LED Bulbs and Fixtures

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<th>LED Lamp Cost Total</th>
<th>LED Driver Life (hrs)</th>
<th>LED Driver Cost Total</th>
<th>Baseline Technology (1)</th>
<th>Lamp (1) Life (hrs)</th>
<th>Lamp (1) Total Cost</th>
<th>Ballast (1) Life (hrs)</th>
<th>Ballast (1) Total Cost</th>
<th>Baseline Technology (2)</th>
<th>Lamp (2) Life (hrs)</th>
<th>Lamp (2) Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>75W</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LED Outdoor Pole/Arm Mounted Parking/Roadway, &gt;= 75W</td>
<td>50,000</td>
<td>$112.50</td>
<td>70,000</td>
<td>$62.50</td>
<td>250W MH</td>
<td>10,000</td>
<td>$41.25</td>
<td>40,000</td>
<td>$130.25</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>LED Outdoor Pole/Arm Mounted Decorative Parking/Roadway, &lt; 30W</td>
<td>50,000</td>
<td>$62.50</td>
<td>70,000</td>
<td>$62.50</td>
<td>100W MH</td>
<td>10,000</td>
<td>$54.25</td>
<td>40,000</td>
<td>$166.70</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>LED Outdoor Pole/Arm Mounted Decorative Parking/Roadway, 30W - 75W</td>
<td>50,000</td>
<td>$87.50</td>
<td>70,000</td>
<td>$62.50</td>
<td>175W MH</td>
<td>10,000</td>
<td>$48.25</td>
<td>40,000</td>
<td>$110.00</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>LED Outdoor Pole/Arm Mounted Decorative Parking/Roadway, &gt;= 75W</td>
<td>50,000</td>
<td>$112.50</td>
<td>70,000</td>
<td>$62.50</td>
<td>250W MH</td>
<td>10,000</td>
<td>$41.25</td>
<td>40,000</td>
<td>$130.25</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>LED Parking Garage/Canopy, &lt; 30W</td>
<td>50,000</td>
<td>$47.50</td>
<td>70,000</td>
<td>$47.50</td>
<td>100W MH</td>
<td>10,000</td>
<td>$36.92</td>
<td>40,000</td>
<td>$151.70</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>LED Parking Garage/Canopy, 30W - 75W</td>
<td>50,000</td>
<td>$72.50</td>
<td>70,000</td>
<td>$47.50</td>
<td>175W MH</td>
<td>10,000</td>
<td>$30.92</td>
<td>40,000</td>
<td>$95.00</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>LED Parking Garage/Canopy, &gt;= 75W</td>
<td>50,000</td>
<td>$97.50</td>
<td>70,000</td>
<td>$47.50</td>
<td>250W MH</td>
<td>10,000</td>
<td>$23.92</td>
<td>40,000</td>
<td>$115.25</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>LED Wall-Mounted Area</td>
<td>50,000</td>
<td>$47.50</td>
<td>70,000</td>
<td>$47.50</td>
<td>100W MH</td>
<td>10,000</td>
<td>$36.92</td>
<td>40,000</td>
<td>$151.70</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>
### 4.5.4 LED Bulbs and Fixtures

#### LED Measure Description:

<table>
<thead>
<tr>
<th>Measure Description</th>
<th>LED Minimum Lamp Life (hrs)</th>
<th>LED Lamp Cost Total</th>
<th>LED Lamp Life (hrs)</th>
<th>LED Driver Life (hrs)</th>
<th>Baseline Technology (1)</th>
<th>Lamp (1) Life (hrs)</th>
<th>Lamp (1) Total Cost</th>
<th>Ballast (1) Life (hrs)</th>
<th>Ballast (1) Total Cost</th>
<th>Baseline Technology (2)</th>
<th>Lamp (2) Life (hrs)</th>
<th>Lamp (2) Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lights, &lt; 30W</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LED Wall-Mounted Area Lights, 30W - 75W</td>
<td>50,000</td>
<td>$72.50</td>
<td>70,000</td>
<td>$47.50</td>
<td>175W MH</td>
<td>10,000</td>
<td>$30.92</td>
<td>40,000</td>
<td>$95.00</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>LED Wall-Mounted Area Lights, &gt;= 75W</td>
<td>50,000</td>
<td>$97.50</td>
<td>70,000</td>
<td>$47.50</td>
<td>250W MH</td>
<td>10,000</td>
<td>$23.92</td>
<td>40,000</td>
<td>$115.25</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>LED Bollard, &lt; 30W</td>
<td>50,000</td>
<td>$47.50</td>
<td>70,000</td>
<td>$47.50</td>
<td>50W MH</td>
<td>10,000</td>
<td>$36.92</td>
<td>40,000</td>
<td>$135.50</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>LED Bollard, &gt;= 30W</td>
<td>50,000</td>
<td>$72.50</td>
<td>70,000</td>
<td>$47.50</td>
<td>70W MH</td>
<td>10,000</td>
<td>$36.92</td>
<td>40,000</td>
<td>$142.50</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>LED Flood Light, &lt; 15W</td>
<td>50,000</td>
<td>$47.50</td>
<td>70,000</td>
<td>$47.50</td>
<td>25% 50W MH</td>
<td>10,000</td>
<td>$36.92</td>
<td>40,000</td>
<td>$135.50</td>
<td>75% Halogen PAR20</td>
<td>2,500</td>
<td>$12.67</td>
</tr>
<tr>
<td>LED Flood Light, &gt;= 15W</td>
<td>50,000</td>
<td>$47.50</td>
<td>70,000</td>
<td>$47.50</td>
<td>50% 50W MH</td>
<td>10,000</td>
<td>$36.92</td>
<td>40,000</td>
<td>$135.50</td>
<td>50% Halogen PAR30/38</td>
<td>2,500</td>
<td>$12.67</td>
</tr>
</tbody>
</table>

**Measure Code:** CI-LTG-LEDB-V04-150601
4.5.5 Commercial LED Exit Signs

DESCRIPTION

This measure characterizes the savings associated with installing a Light Emitting Diode (LED) exit sign in place of a fluorescent or incandescent exit sign in a Commercial building. 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: 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\textsuperscript{530}.

DEEMED MEASURE COST

The incremental cost for this measure is assumed to be $30\textsuperscript{531}.

LOADSHAPE

Loadshape C53 - Flat

COINCIDENCE FACTOR

The summer peak coincidence factor for this measure is assumed to be 100\%\textsuperscript{532}.


\textsuperscript{531} NYSERDA Deemed Savings Database, Labor cost assumes 25 minutes @ $18/hr.

\textsuperscript{532} Assuming continuous operation of an LED exit sign, the Summer Peak Coincidence Factor is assumed to equal 1.0.
**Algorithm**

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

\[ \Delta kWh = \left( \frac{\text{WattsBase} - \text{WattsEE}}{1000} \right) \times \text{HOURS} \times \text{WHF}_e \]

Where:

- \( \text{WattsBase} \) = Actual wattage if known, if unknown assume the following:

<table>
<thead>
<tr>
<th>Baseline Type</th>
<th>WattsBase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incandescent</td>
<td>35W(^{533})</td>
</tr>
<tr>
<td>Fluorescent</td>
<td>11W(^{534})</td>
</tr>
<tr>
<td>Unknown (e.g. time of sale)</td>
<td>23W(^{535})</td>
</tr>
</tbody>
</table>

- \( \text{WattsEE} \) = Actual wattage if known, if unknown assume 2W\(^{536}\)
- \( \text{HOURS} \) = Annual operating hours = 8766
- \( \text{WHF}_e \) = Waste heat factor for energy to account for cooling energy savings from efficient lighting are provided for each building type in the Reference Table in Section 4.5. If unknown, use the Miscellaneous value.

For example, replacing incandescent fixture in an office

\[ \Delta kWH = \frac{(35 - 2)}{1000} \times 8766 \times 1.25 \]
\[ = 362 \ kWh \]

For example, replacing fluorescent fixture in a hospital

\[ \Delta kWH = \frac{(11 - 2)}{1000} \times 8766 \times 1.35 \]
\[ = 106.5 \ kWh \]

**HEATING PENALTY**

If electrically heated building:

\[ \Delta kWH_{\text{heating penalty}} = \left( \frac{\text{WattsBase} - \text{WattsEE}}{1000} \right) \times \text{Hours} \times \text{IFkWh} \]

\(^{533}\) Based on review of available product.


\(^{535}\) ComEd has been using a weighted baseline of 70 percent incandescent and 30 percent compact fluorescent, reflecting program experience and a limited sample of evaluation verification findings that we consider to be reasonable (Navigant, through comment period February 2013)

Where:

- \( IF_{kWh} \) = Lighting-HVAC Iteration Factor for electric heating impacts; this factor represents the increased electric space heating requirements due to the reduction of waste heat rejected by the efficient lighting. Values are provided in the Reference Table in Section 4.5. If unknown, use the Miscellaneous value.

For example, replacing incandescent fixture in a heat pump heated office

\[
\Delta kWh_{\text{heat penalty}} = \frac{(35 - 2)}{1000} \times 8766 \times -0.151
\]

\( = -43.7 \text{ kWh} \)

For example, replacing fluorescent fixture in a heat pump heated hospital

\[
\Delta kWh_{\text{heat penalty}} = \frac{(11 - 2)}{1000} \times 8766 \times -0.104
\]

\( = -8.2 \text{ kWh} \)

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

\[
\Delta kW = \frac{(\text{WattsBase} - \text{WattsEE})}{1000} \times WHF_d \times CF
\]

Where:

- \( WHF_d \) = Waste heat factor for demand to account for cooling savings from efficient lighting in cooled buildings is provided in the Reference Table in Section 4.5. If unknown, use the Miscellaneous value.
- \( CF \) = Summer Peak Coincidence Factor for measure
  \( = 1.0 \)

For example, replacing incandescent fixture in an office

\[
\Delta kW = \frac{(35 - 2)}{1000} \times 1.3 \times 1.0
\]

\( = 0.043 \text{ kW} \)

For example, replacing fluorescent fixture in a hospital

\[
\Delta kW = \frac{(11 - 2)}{1000} \times 1.69 \times 1.0
\]

\( = 0.015 \text{ kW} \)

**NATURAL GAS SAVINGS**

Heating Penalty if natural gas heated building (or if heating fuel is unknown):

\[
\Delta \text{therms} = \frac{((\text{WattsBase}-\text{WattsEE}) \times \text{Hours})}{1000} \times \text{IFTherms}
\]

Where:

- \( \text{IFTherms} \) = 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

537 Negative value because this is an increase in heating consumption due to the efficient lighting.
by the efficient lighting. Values are provided in the Reference Table in Section 4.5. If unknown, use the Miscellaneous value.

<table>
<thead>
<tr>
<th>For example, replacing incandescent fixture in an office</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta$Therms = (35 – 2)/1000 * 8766 * -0.016</td>
</tr>
<tr>
<td>= -4.63 Therms</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>For example, replacing fluorescent fixture in a hospital</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta$Therms = (11 – 2)/1000 * 8766 * -0.011</td>
</tr>
<tr>
<td>= - 0.87 Therms</td>
</tr>
</tbody>
</table>

**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.

<table>
<thead>
<tr>
<th>Baseline Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Component</td>
</tr>
<tr>
<td>Lamp</td>
</tr>
</tbody>
</table>

**MEASURE CODE: CI-LTG-LEDE-V02-140601**

---

538 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).

539 Assumes a lamp life of 12,000 hours and 8766 run hours 12000/8766 = 1.37 years.
4.5.6 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. 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).

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**

The summer peak coincidence factor (CF) for this measure is dependent on lamp type as below:

<table>
<thead>
<tr>
<th>Lamp Type</th>
<th>CF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red Round, always changing or flashing</td>
<td>0.55</td>
</tr>
<tr>
<td>Red Arrows</td>
<td>0.90</td>
</tr>
<tr>
<td>Green Arrows</td>
<td>0.10</td>
</tr>
<tr>
<td>Yellow Arrows</td>
<td>0.03</td>
</tr>
<tr>
<td>Green Round, always changing or flashing</td>
<td>0.43</td>
</tr>
<tr>
<td>Flashing Yellow</td>
<td>0.50</td>
</tr>
<tr>
<td>Yellow Round, always changing</td>
<td>0.02</td>
</tr>
<tr>
<td>“Hand” Don’t Walk Signal</td>
<td>0.75</td>
</tr>
<tr>
<td>&quot;Man” Walk Signal</td>
<td>0.21</td>
</tr>
</tbody>
</table>

**Algorithm**

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

\[
\Delta kWh = (W_{base} - W_{eff}) \times \text{HOURS} / 1000
\]

Where:

- \( W_{base} \) = The connected load of the baseline equipment
  = see Table ‘Traffic Signals Technology Equivalencies’

- \( W_{eff} \) = The connected load of the 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)

---

541 Ibid
EXAMPLE
For example, an 8 inch red, round signal:

\[
\Delta \text{kWh} \quad = \frac{(69 - 7) \times 4818}{1000} \\
= 299 \text{kWh}
\]

SUMMER COINCIDENT PEAK DEMAND SAVINGS

\[
\Delta \text{kW} \quad = \frac{(\text{Wbase} - \text{Weff}) \times \text{CF}}{1000}
\]

Where:

- \( \text{Wbase} \): The connected load of the baseline equipment
  - = see Table 'Traffic Signals Technology Equivalencies'
- \( \text{Weff} \): The connected load of the efficient equipment
  - = see Table ‘Traffic Signals Technology Equivalencies’
- \( \text{CF} \): Summer Peak Coincidence Factor for measure

EXAMPLE
For example, an 8 inch red, round signal:

\[
\Delta \text{kW} \quad = \frac{(69 - 7) \times 0.55}{1000} \\
= 0.0341 \text{kW}
\]

NATURAL GAS ENERGY SAVINGS
N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION
N/A
### REFERENCE TABLES

#### Traffic Signals Technology Equivalencies

<table>
<thead>
<tr>
<th>Traffic Fixture Type</th>
<th>Fixture Size and Color</th>
<th>Efficient Lamps</th>
<th>Baseline Lamps</th>
<th>HOURS</th>
<th>Efficient Fixture Wattage</th>
<th>Baseline Fixture Wattage</th>
<th>Energy Savings (in kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Round Signals</td>
<td>8” Red</td>
<td>LED</td>
<td>Incandescent</td>
<td>4818</td>
<td>7</td>
<td>69</td>
<td>299</td>
</tr>
<tr>
<td>Round Signals</td>
<td>12” Red</td>
<td>LED</td>
<td>Incandescent</td>
<td>4818</td>
<td>6</td>
<td>150</td>
<td>694</td>
</tr>
<tr>
<td>Flashing Signal</td>
<td>8” Red</td>
<td>LED</td>
<td>Incandescent</td>
<td>4380</td>
<td>7</td>
<td>69</td>
<td>272</td>
</tr>
<tr>
<td>Flashing Signal</td>
<td>12” Red</td>
<td>LED</td>
<td>Incandescent</td>
<td>4380</td>
<td>6</td>
<td>150</td>
<td>631</td>
</tr>
<tr>
<td>Flashing Signal</td>
<td>8” Yellow</td>
<td>LED</td>
<td>Incandescent</td>
<td>4380</td>
<td>10</td>
<td>69</td>
<td>258</td>
</tr>
<tr>
<td>Flashing Signal</td>
<td>12” Yellow</td>
<td>LED</td>
<td>Incandescent</td>
<td>4380</td>
<td>13</td>
<td>150</td>
<td>600</td>
</tr>
<tr>
<td>Round Signals</td>
<td>8” Yellow</td>
<td>LED</td>
<td>Incandescent</td>
<td>175</td>
<td>10</td>
<td>69</td>
<td>10</td>
</tr>
<tr>
<td>Round Signals</td>
<td>12” Yellow</td>
<td>LED</td>
<td>Incandescent</td>
<td>175</td>
<td>13</td>
<td>150</td>
<td>24</td>
</tr>
<tr>
<td>Round Signals</td>
<td>8” Green</td>
<td>LED</td>
<td>Incandescent</td>
<td>3767</td>
<td>9</td>
<td>69</td>
<td>266</td>
</tr>
<tr>
<td>Round Signals</td>
<td>12” Green</td>
<td>LED</td>
<td>Incandescent</td>
<td>3767</td>
<td>12</td>
<td>150</td>
<td>520</td>
</tr>
<tr>
<td>Turn Arrows</td>
<td>8” Yellow</td>
<td>LED</td>
<td>Incandescent</td>
<td>701</td>
<td>7</td>
<td>116</td>
<td>76</td>
</tr>
<tr>
<td>Turn Arrows</td>
<td>12” Yellow</td>
<td>LED</td>
<td>Incandescent</td>
<td>701</td>
<td>9</td>
<td>116</td>
<td>75</td>
</tr>
<tr>
<td>Turn Arrows</td>
<td>8” Green</td>
<td>LED</td>
<td>Incandescent</td>
<td>701</td>
<td>7</td>
<td>116</td>
<td>76</td>
</tr>
<tr>
<td>Turn Arrows</td>
<td>12” Green</td>
<td>LED</td>
<td>Incandescent</td>
<td>701</td>
<td>7</td>
<td>116</td>
<td>76</td>
</tr>
<tr>
<td>Pedestrian Sign</td>
<td>12” Hand-Man</td>
<td>LED</td>
<td>Incandescent</td>
<td>8766</td>
<td>8</td>
<td>116</td>
<td>946</td>
</tr>
</tbody>
</table>

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
4. 8” and 12” LED traffic signals: Leotek Models TSL-ES08 and TSL-ES12
5. 8” LED Yellow Arrow: General Electric Model DR4-YTA2-01A
6. 8” LED Green Arrow: General Electric Model DR4-GCA2-01A
7. 12” LED Yellow Arrow: Dialight Model 431-3334-001X
8. 12” LED Green Arrow: Dialight Model 432-2324-001X
9. LED Hand/Man Pedestrian Sign: Dialight 430-6450-001X

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543 Technical Reference Manual for Ohio, August 6, 2010
MEASURE CODE: CI-LTG-LEDT-V01-120601
4.5.7 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 or Space by Space method as defined in IECC 2012 can be used for calculating the Interior Lighting Power Density\(^{544}\). 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 2012, 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 2012, the State of Illinois Energy Code requirements.

**DEEMED CALCULATION FOR THIS MEASURE**

Annual kWh Savings

\[ \Delta \text{kWh} = \frac{(\text{WSF}_{\text{base}} - \text{WSF}_{\text{effic}})}{1000} \times \text{SF} \times \text{Hours} \times \text{WHF}_e \]

Summer Coincident Peak kW Savings

\[ \Delta \text{kW} = \frac{(\text{WSF}_{\text{base}} - \text{WSF}_{\text{effic}})}{1000} \times \text{SF} \times \text{CF} \times \text{WHF}_d \]

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The expected measure life is assumed to be 15 years\(^{545}\).

**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.

**LOADSHAPE**

Loadshape C06 - Commercial Indoor Lighting

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\(^{544}\) 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).

COINCIDENCE FACTOR

The summer peak coincidence factor for this measure is dependent on the building type.

Algorithm

CALCULATION OF SAVINGS

ENERGY SAVINGS

\[ \Delta \text{kWh} = \frac{(\text{WSF}_{\text{base}} - \text{WSF}_{\text{effic}})}{1000} \times \text{SF} \times \text{Hours} \times \text{WHF}_e \]

Where:

- \( \text{WSF}_{\text{base}} \) = 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.
- \( \text{WSF}_{\text{effic}} \) = The actual installed lighting watts per square foot or linear foot.
- \( \text{SF} \) = Provided by customer based on square footage of the building area applicable to the lighting design for new building.
- \( \text{Hours} \) = 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 4.5, Fixture annual operating hours.
- \( \text{WHF}_e \) = Waste Heat Factor for Energy to account for cooling savings from efficient lighting is as

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546 IECC 2012 - Reference Code documentation for additional information.
provided in the Reference Table in Section 4.5 by building type. If building is not cooled WHF_e is 1.

**HEATING PENALTY**

If electrically heated building:

\[
\Delta \text{kWh}_{\text{heatpenalty}} = \frac{(\text{WSF}_{\text{base}} - \text{WSF}_{\text{effic}})}{1000 \times \text{SF} \times \text{Hours} \times -\text{IFkWh}}
\]

Where:

\text{IFkWh} = \text{Lighting-HVAC Iteration Factor for electric heating impacts; this factor represents the increased electric space heating requirements due to the reduction of waste heat rejected by the efficient lighting. Values are provided in the Reference Table in Section 4.5. If unknown, use the Miscellaneous value.}

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

\[
\Delta \text{kW} = \frac{(\text{WSF}_{\text{base}} - \text{WSF}_{\text{effic}})}{1000 \times \text{SF} \times \text{CF} \times \text{WHF}_d}
\]

Where:

\text{WHF}_d = \text{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 4.5 by building type. If building is not cooled WHF}_d is 1.

\text{CF} = \text{Summer Peak Coincidence Factor for measure is as provided in the Reference Table in Section 4.5 by building type. If the building type is unknown, use the Miscellaneous value of 0.66.}

Other factors as defined above

**NATURAL GAS ENERGY SAVINGS**

\[
\Delta \text{Therms} = \frac{(\text{WSF}_{\text{base}} - \text{WSF}_{\text{effic}})}{1000 \times \text{SF} \times \text{Hours} \times -\text{IFTherms}}
\]

Where:

\text{IFTherms} = \text{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 4.5 by building type.}

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

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\(^{547}\) Negative value because this is an increase in heating consumption due to the efficient lighting.
### Reference Tables

Lighting Power Density Values from IECC 2012 for Interior Commercial New Construction and Substantial Renovation Building Area Method:

<table>
<thead>
<tr>
<th>Building Area Type</th>
<th>Lighting Power Density (w/ft²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automotive Facility</td>
<td>0.9</td>
</tr>
<tr>
<td>Convention Center</td>
<td>1.2</td>
</tr>
<tr>
<td>Court House</td>
<td>1.2</td>
</tr>
<tr>
<td>Dining: Bar Lounge/Leisure</td>
<td>1.3</td>
</tr>
<tr>
<td>Dining: Cafeteria/Fast Food</td>
<td>1.4</td>
</tr>
<tr>
<td>Dining: Family</td>
<td>1.6</td>
</tr>
<tr>
<td>Dormitory</td>
<td>1.0</td>
</tr>
<tr>
<td>Exercise Center</td>
<td>1.0</td>
</tr>
<tr>
<td>Fire station</td>
<td>0.8</td>
</tr>
<tr>
<td>Gymnasium</td>
<td>1.1</td>
</tr>
<tr>
<td>Healthcare – clinic</td>
<td>1.0</td>
</tr>
<tr>
<td>Hospital</td>
<td>1.2</td>
</tr>
<tr>
<td>Hotel</td>
<td>1.0</td>
</tr>
<tr>
<td>Library</td>
<td>1.3</td>
</tr>
<tr>
<td>Manufacturing Facility</td>
<td>1.3</td>
</tr>
<tr>
<td>Motel</td>
<td>1.0</td>
</tr>
<tr>
<td>Motion Picture Theater</td>
<td>1.2</td>
</tr>
<tr>
<td>Multifamily</td>
<td>0.7</td>
</tr>
<tr>
<td>Museum</td>
<td>1.1</td>
</tr>
<tr>
<td>Office</td>
<td>0.9</td>
</tr>
<tr>
<td>Parking Garage</td>
<td>0.3</td>
</tr>
<tr>
<td>Penitentiary</td>
<td>1.0</td>
</tr>
<tr>
<td>Performing Arts Theater</td>
<td>1.6</td>
</tr>
<tr>
<td>Police Station</td>
<td>1.0</td>
</tr>
<tr>
<td>Post Office</td>
<td>1.1</td>
</tr>
<tr>
<td>Religious Building</td>
<td>1.3</td>
</tr>
</tbody>
</table>

548 IECC 2012 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.
### 4.5.7 Lighting Power Density

<table>
<thead>
<tr>
<th>Building Area Type</th>
<th>Lighting Power Density (w/ft²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retail</td>
<td>1.4</td>
</tr>
<tr>
<td>School/University</td>
<td>1.2</td>
</tr>
<tr>
<td>Sports Arena</td>
<td>1.1</td>
</tr>
<tr>
<td>Town Hall</td>
<td>1.1</td>
</tr>
<tr>
<td>Transportation</td>
<td>1.0</td>
</tr>
<tr>
<td>Warehouse</td>
<td>0.6</td>
</tr>
<tr>
<td>Workshop</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Lighting Power Density Values from IECC 2012 for Interior Commercial New Construction and Substantial Renovation Space by Space Method:

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549 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.
### Commercial Energy Efficiency

#### Table C405.5.2(2) - Interior Lighting Power Allowances: Space-by-Space Method

<table>
<thead>
<tr>
<th>Common Space-by-Space Types</th>
<th>LPO (W/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atrium - First 40 feet in height</td>
<td>0.03 per ft. hr.</td>
</tr>
<tr>
<td>Atrium - Above 40 feet in height</td>
<td>0.02 per ft. hr.</td>
</tr>
<tr>
<td>Audience/seating area – permanent</td>
<td>0.9</td>
</tr>
<tr>
<td>For auditorium</td>
<td>2.6</td>
</tr>
<tr>
<td>For performing arts theater</td>
<td>1.2</td>
</tr>
<tr>
<td>For motion picture theater</td>
<td>1.3</td>
</tr>
<tr>
<td>Conference/meeting/multipurpose</td>
<td>1.2</td>
</tr>
<tr>
<td>Corridor/transition</td>
<td>0.7</td>
</tr>
<tr>
<td>Dining area</td>
<td>1.4</td>
</tr>
<tr>
<td>Bar/lounge/leisure dining</td>
<td>1.0</td>
</tr>
<tr>
<td>Family dining area</td>
<td>1.4</td>
</tr>
<tr>
<td>Dressing/fitting room performing arts theater</td>
<td>1.1</td>
</tr>
<tr>
<td>Electrical/mechanical</td>
<td>1.1</td>
</tr>
<tr>
<td>Food preparation</td>
<td>1.2</td>
</tr>
<tr>
<td>Laboratory for classrooms</td>
<td>1.3</td>
</tr>
<tr>
<td>Laboratory for medical/industrial/research</td>
<td>1.8</td>
</tr>
<tr>
<td>Lobby</td>
<td>1.1</td>
</tr>
<tr>
<td>Lobby for performing arts theater</td>
<td>3.3</td>
</tr>
<tr>
<td>Lobby for motion picture theater</td>
<td>1.0</td>
</tr>
<tr>
<td>Locker room</td>
<td>0.8</td>
</tr>
<tr>
<td>Lounge recreation</td>
<td>0.8</td>
</tr>
<tr>
<td>Office - enclosed</td>
<td>1.1</td>
</tr>
<tr>
<td>Office - open plan</td>
<td>1.0</td>
</tr>
<tr>
<td>Restroom</td>
<td>1.0</td>
</tr>
<tr>
<td>Sales area</td>
<td>1.0</td>
</tr>
<tr>
<td>Stairway</td>
<td>0.7</td>
</tr>
<tr>
<td>Storage</td>
<td>0.8</td>
</tr>
<tr>
<td>Workshop</td>
<td>1.0</td>
</tr>
<tr>
<td>Courthouse/police station/penetentiary</td>
<td>1.9</td>
</tr>
<tr>
<td>Courtroom</td>
<td>1.1</td>
</tr>
<tr>
<td>Confinement cells</td>
<td>1.3</td>
</tr>
<tr>
<td>Judge chambers</td>
<td>0.5</td>
</tr>
<tr>
<td>Penitentiary audience seating</td>
<td>1.5</td>
</tr>
<tr>
<td>Penitentiary classroom</td>
<td>1.1</td>
</tr>
<tr>
<td>Penitentiary dining</td>
<td>1.1</td>
</tr>
</tbody>
</table>

#### Building Specific Space-by-Space Types

<table>
<thead>
<tr>
<th>Common Space-by-Space Types</th>
<th>LPO (W/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Courthouse/police station/penetentiary</td>
<td>1.9</td>
</tr>
<tr>
<td>Courtroom</td>
<td>1.1</td>
</tr>
<tr>
<td>Confinement cells</td>
<td>1.3</td>
</tr>
<tr>
<td>Judge chambers</td>
<td>0.5</td>
</tr>
<tr>
<td>Penitentiary audience seating</td>
<td>1.5</td>
</tr>
<tr>
<td>Penitentiary classroom</td>
<td>1.1</td>
</tr>
<tr>
<td>Penitentiary dining</td>
<td>1.1</td>
</tr>
</tbody>
</table>

(continued)
The exterior lighting design will be based on the building location and the applicable “Lighting Zone” as defined in IECC 2012 Table C405.6.2(1) which follows.

**TABLE C405.6.2(1)**
**EXTERIOR LIGHTING ZONES**

<table>
<thead>
<tr>
<th>LIGHTING ZONE</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Developed areas of national parks, state parks, forest land, and rural areas</td>
</tr>
<tr>
<td>2</td>
<td>Areas predominantly consisting of residential zoning, neighborhood business districts, light industrial with limited nighttime use and residential mixed use areas</td>
</tr>
<tr>
<td>3</td>
<td>All other areas</td>
</tr>
<tr>
<td>4</td>
<td>High-activity commercial districts in major metropolitan areas as designated by the local land use planning authority</td>
</tr>
</tbody>
</table>

The lighting power density savings will be based on reductions below the allowable design levels as specified in IECC 2012 Table 405.6.2(2) which follows.
### TABLE C405.E.2(2)
#### INDIVIDUAL LIGHTING POWER ALLOWANCES FOR BUILDING EXTERIORS

<table>
<thead>
<tr>
<th>Lighting Zones</th>
<th>Zone 1</th>
<th>Zone 2</th>
<th>Zone 3</th>
<th>Zone 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Uncovered Parking Areas</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parking areas and drives</td>
<td>0.04 W/ft²</td>
<td>0.06 W/ft²</td>
<td>0.10 W/ft²</td>
<td>0.13 W/ft²</td>
</tr>
<tr>
<td><strong>Building Grounds</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walkways less than 10 feet wide</td>
<td>0.7 W/linear foot</td>
<td>0.7 W/linear foot</td>
<td>0.8 W/linear foot</td>
<td>1.0 W/linear foot</td>
</tr>
<tr>
<td>Walkways 10 feet wide or greater, plaza areas special feature areas</td>
<td>0.14 W/ft²</td>
<td>0.14 W/ft²</td>
<td>0.16 W/ft²</td>
<td>0.2 W/ft²</td>
</tr>
<tr>
<td>Stairways</td>
<td>0.75 W/ft²</td>
<td>1.0 W/ft²</td>
<td>1.0 W/ft²</td>
<td>1.0 W/ft²</td>
</tr>
<tr>
<td>Pedestrian tunnels</td>
<td>0.15 W/ft²</td>
<td>0.15 W/ft²</td>
<td>0.2 W/ft²</td>
<td>0.3 W/ft²</td>
</tr>
<tr>
<td><strong>Building Entrances and Exits</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main entries</td>
<td>20 W/linear foot of door width</td>
<td>20 W/linear foot of door width</td>
<td>30 W/linear foot of door width</td>
<td>30 W/linear foot of door width</td>
</tr>
<tr>
<td>Other doors</td>
<td>20 W/linear foot of door width</td>
<td>20 W/linear foot of door width</td>
<td>20 W/linear foot of door width</td>
<td>20 W/linear foot of door width</td>
</tr>
<tr>
<td>Entry canopies</td>
<td>0.25 W/ft²</td>
<td>0.25 W/ft²</td>
<td>0.4 W/ft²</td>
<td>0.4 W/ft²</td>
</tr>
<tr>
<td><strong>Sales Canopies</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Free-standing and attached</td>
<td>0.6 W/ft²</td>
<td>0.6 W/ft²</td>
<td>0.8 W/ft²</td>
<td>1.0 W/ft²</td>
</tr>
<tr>
<td><strong>Outdoor Sales</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open areas (including vehicle sales lots)</td>
<td>0.25 W/ft²</td>
<td>0.25 W/ft²</td>
<td>0.5 W/ft²</td>
<td>0.7 W/ft²</td>
</tr>
<tr>
<td>Street frontage for vehicle sales lots in addition to &quot;open area&quot; allowance</td>
<td>No allowance</td>
<td>10 W/linear foot</td>
<td>10 W/linear foot</td>
<td>30 W/linear foot</td>
</tr>
<tr>
<td><strong>Nontradable Surfaces</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Building facades</td>
<td>No allowance</td>
<td>0.1 W/ft² for each illuminated wall or surface or 2.5 W/linear foot for each illuminated wall or surface length</td>
<td>0.15 W/ft² for each illuminated wall or surface or 3.75 W/linear foot for each illuminated wall or surface length</td>
<td>0.2 W/ft² for each illuminated wall or surface or 5.0 W/linear foot for each illuminated wall or surface length</td>
</tr>
<tr>
<td>Automated teller machines and night depositories</td>
<td>2.70 W per location plus 0.90 W per additional ATM per location</td>
<td>2.70 W per location plus 0.90 W per additional ATM per location</td>
<td>2.70 W per location plus 0.90 W per additional ATM per location</td>
<td>2.70 W per location plus 0.90 W per additional ATM per location</td>
</tr>
<tr>
<td>Entrance and gatehouse inspection stations at guarded facilities</td>
<td>0.75 W/ft² of covered and uncovered area</td>
<td>0.75 W/ft² of covered and uncovered area</td>
<td>0.75 W/ft² of covered and uncovered area</td>
<td>0.75 W/ft² of covered and uncovered area</td>
</tr>
<tr>
<td>Loading areas for law enforcement, fire alarm, ambulance and other emergency service vehicles</td>
<td>0.5 W/ft² of covered and uncovered area</td>
<td>0.5 W/ft² of covered and uncovered area</td>
<td>0.5 W/ft² of covered and uncovered area</td>
<td>0.5 W/ft² of covered and uncovered area</td>
</tr>
<tr>
<td>Drive-up windows/doors</td>
<td>400 W per drive-through</td>
<td>400 W per drive-through</td>
<td>400 W per drive-through</td>
<td>400 W per drive-through</td>
</tr>
<tr>
<td>Parking near 24-hour retail entrances</td>
<td>800 W per main entry</td>
<td>800 W per main entry</td>
<td>800 W per main entry</td>
<td>800 W per main entry</td>
</tr>
</tbody>
</table>

For SI: 1 foot = 304.8 mm, 1 watt per square foot = W/0.0929 m².

**MEASURE CODE:** CI-LTG-LPDE-V02-1406
4.5.8  Miscellaneous Commercial/Industrial Lighting

**DESCRIPTION**

This measure is designed to calculate savings from energy efficient lighting upgrades that are not captured in other measures within the TRM. If a lighting project fits the measure description in sections 4.5.1-4.5.4, then those criteria, definitions, and calculations should be used.

Unlike other lighting measures this one applies only to RF applications (because there is no defined baseline for TOS or NC applications).

**DEFINITION OF EFFICIENT EQUIPMENT**

A lighting fixture that replaces an existing fixture to provide the same or greater lumen output at a lower kW consumption.

**DEFINITION OF BASELINE EQUIPMENT**

The definition of baseline equipment is the existing lighting fixture.

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The deemed lifetime of the efficient equipment fixture, regardless of program type is 15 years550.

**DEEMED MEASURE COST**

The actual cost of the efficient light fixture should be used.

**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

550 15 years from GDS Measure Life Report, June 2007
COINCIDENCE FACTOR

The summer peak coincidence factor for this measure is dependent on the location type. Values are provided for each building type in section 4.5.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

\[ \Delta kWh = \left( \frac{Watts_{base} - Watts_{EE}}{1000} \right) \times \text{Hours} \times WHF_e \times ISR \]

Where:

- \( Watts_{base} \) = Input wattage of the existing system which depends on the baseline fixture configuration (number and type of lamp) and ballast factor (if applicable) and number of fixtures.
  
  = Actual

- \( Watts_{EE} \) = New input wattage of EE fixture which depends on new fixture configuration (number of lamps) and ballast factor (if applicable) (if applicable) and number of fixtures.
  
  = Actual

- \( \text{Hours} \) = Average hours of use per year as provided by the customer or selected from the Reference Table in Section 4.5, 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 4.5 for each building type. If building is un-cooled, the value is 1.0.

- \( ISR \) = In Service Rate or the percentage of units rebated that get installed.
  
  = 100\%\textsuperscript{551}\textsuperscript{551} 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:

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\textsuperscript{551} 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.
### Weighted Average

<table>
<thead>
<tr>
<th>1&lt;sup&gt;st&lt;/sup&gt; year In Service Rate (ISR)</th>
<th>2&lt;sup&gt;nd&lt;/sup&gt; year Installations</th>
<th>3&lt;sup&gt;rd&lt;/sup&gt; year Installations</th>
<th>Final Lifetime In Service Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>75.5%&lt;sup&gt;552&lt;/sup&gt;</td>
<td>12.1%</td>
<td>10.3%</td>
<td>98.0%&lt;sup&gt;553&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

#### Heating Penalty

If electrically heated building:

\[ \Delta k\text{Wh}_{\text{heating penalty}} = \left(\frac{(Watts\text{Base}-Watts\text{EE})}{1000}\right) \times ISR \times \text{Hours} \times IFkWh \]

Where:

- IFkWh = Lighting-HVAC Iteration Factor for electric heating impacts; this factor represents the increased electric space heating requirements due to the reduction of waste heat rejected by the efficient lighting. Values are provided in the Reference Table in Section 4.5. If unknown, use the Miscellaneous value.

#### Deferred Installs

As presented above, if a sign off form is not completed the characterization assumes that a percentage of bulbs purchased are not installed until Year 2 and Year 3 (see ISR assumption above). The Illinois Technical Advisory Committee has determined the following methodology for calculating the savings of these future installs.

- **Year 1 (Purchase Year) installs:** Characterized using assumptions provided above or evaluated assumptions if available.
- **Year 2 and 3 installs:** Characterized using delta watts assumption and hours of use from the Install Year i.e. the actual deemed (or evaluated if available) assumptions active in Year 2 and 3 should be applied. The NTG factor for the Purchase Year should be applied.

#### Summer Coincident Demand Savings

\[ \Delta kW = \left(\frac{(Watts\text{base} - Watts\text{EE})}{1000}\right) \times WHF_d \times CF \times ISR \]

Where:

- WHF<sub>d</sub> = Waste Heat Factor for Demand to account for cooling savings from efficient lighting in cooled buildings is selected from the Reference Table in Section 4.5 for each building type. If the building is not cooled WHF<sub>d</sub> is 1.

---

552 1<sup>st</sup> year in service rate is based upon review of PY4-5 evaluations from ComEd’s commercial lighting program (BILD) (see ‘IL Commercial Lighting ISR.xls’ for more information. The average first year ISR was calculated weighted by the number of bulbs sold.

553 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 2<sup>nd</sup> and 3<sup>rd</sup> year installations should be counted as part of those future program year savings.

554 Negative value because this is an increase in heating consumption due to the efficient lighting.
CF = Summer Peak Coincidence Factor for measure is selected from the Reference able in Section 4.5 for each building type. If the building type is unknown, use the Miscellaneous value of 0.66.

Other factors as defined above

**Natural Gas Energy Savings**

\[ \Delta \text{Therms}^{55} = \left( (\text{WattsBase}-\text{WattsEE})/1000 \right) \times \text{ISR} \times \text{Hours} - \text{IFTTherms} \]

Where:

- **IFTTherms** = 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 6.5 for each building type.

**Water Impact Descriptions and Calculation**

N/A

**Deemed O&M Cost Adjustment Calculation**

If there are differences between the maintenance of the efficient and baseline lighting system then they should be evaluated on a project-by-project basis.

**Measure Code: CI-LTG-MSCI-V02-140601**

---

55 Negative value because this is an increase in heating consumption due to the efficient lighting.
4.5.9 Multi-Level Lighting Switch

DESCRIPTION
This measure relates to the installation new multi-level lighting switches on an existing lighting system. This measure can only relate to the adding of a new control in an existing building, since multi-level switching is required in the Commercial new construction building energy code (IECC 2012). 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 system is assumed to be a lighting system controlled by multi-level lighting controls.

DEFINITION OF BASELINE EQUIPMENT
The baseline equipment is assumed to be an uncontrolled lighting system where all lights in a given area are on the same circuit or all circuits come on at the same time.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT
The expected measure life for all lighting controls is assumed to be 8 years$^{556}$.

DEEMED MEASURE COST
When available, the actual cost of the measure shall be used. When not available, the incremental capital cost for this measure is assumed to be $274$^{557}.

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)

$^{556}$ Consistent with Occupancy Sensor control measure.
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.

---

**Algorithm**

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

\[
\Delta kWh = \text{KW}_{\text{controlled}} \times \text{Hours} \times \text{ESF} \times \text{WHF}_e
\]

Where:

- \(\text{KW}_{\text{controlled}}\) = Total lighting load connected to the control in kilowatts.
  = Actual
- \(\text{Hours}\) = 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 4.5, Fixture annual operating hours, for each building type if customer specific information is not collected. If unknown building type, use the Miscellaneous value.
- \(\text{ESF}\) = Energy Savings factor (represents the percentage reduction to the KWcontrolled due to the use of multi-level switching).
  = Dependent on building type\(^{558}\):

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Energy Savings Factor (ESF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private Office</td>
<td>21.6%</td>
</tr>
<tr>
<td>Open Office</td>
<td>16.0%</td>
</tr>
<tr>
<td>Retail</td>
<td>14.8%</td>
</tr>
<tr>
<td>Classrooms</td>
<td>8.3%</td>
</tr>
</tbody>
</table>

WHFe = Waste heat factor for energy to account for cooling energy savings from efficient lighting is provided in the Reference Table in Section 4.5 for each building type. If building is un-cooled, the value is 1.0.

**HEATING PENALTY**

If electrically heated building:

\[ \Delta kWh_{\text{heat penalty}} = KW_{\text{controlled}} \times \text{Hours} \times \text{ESF} \times -\text{IF WHF} \]

Where:

IF WHF = Lighting-HVAC Intervention Factor for electric heating impacts; this factor represents the increased electric space heating requirements due to the reduction of waste heat rejected by the efficient lighting. Values are provided in the Reference Table in Section 4.5. If unknown, use the Miscellaneous value.

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

\[ \Delta kW = KW_{\text{controlled}} \times \text{ESF} \times WHF_d \times \text{CF} \]

Where:

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 4.5. If the building is un-cooled WHFd is 1.

CF = Summer Peak Coincidence Factor for measure is provided in the Reference Table in Section 4.5. If unknown, use the Miscellaneous value of 0.66.

**NATURAL GAS ENERGY SAVINGS**

\[ \Delta \text{therms} = KW_{\text{controlled}} \times \text{Hours} \times \text{ESF} \times -\text{IF therm} \]

Where:

IF therm = 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 4.5 by building type.

---

559 Negative value because this is an increase in heating consumption due to the efficient lighting.

560 By applying the ESF and the same coincidence factor for general lighting savings we are in essence assuming that the savings from multi-level switching are as likely during peak periods as any other time. In the absence of better information this seems like a reasonable assumption and if anything may be on the conservative side since you might expect the peak periods to be generally sunnier and therefore more likely to have lower light levels. It is also consistent with the control type reducing the wattage lighting load, the same as the general lighting measures.
WATER IMPACT DESCRIPTIONS AND CALCULATION
N/A

DEEMED O&M COST ADJUSTMENT CALCULATION
N/A

MEASURE CODE: CI-LTG-MLLC-V02-140601
4.5.10 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.

A subset of occupancy sensors are those that are programmed as “vacancy” sensors. To qualify as a vacancy sensor, the control must be configured such that manual input is required to turn on the controlled lighting and the control automatically turns the lighting off. Additional savings are achieved compared to standard occupancy sensors because lighting does not automatically turn on and occupants may decide to not turn it on. Note that vacancy sensors are not a viable option for many applications where standard occupancy sensors should be used instead.

**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\textsuperscript{561}.

**DEEMED MEASURE COST**

When available, the actual cost of the measure shall be used. When not available, the following default values are provided:

<table>
<thead>
<tr>
<th>Lighting control type</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full cost of wall mounted occupancy sensor</td>
<td>$42\textsuperscript{562}</td>
</tr>
<tr>
<td>Full cost mounted occupancy sensor</td>
<td>$66\textsuperscript{563}</td>
</tr>
<tr>
<td>Full cost of fixture-mounted occupancy sensor</td>
<td>$125\textsuperscript{564}</td>
</tr>
</tbody>
</table>

\textsuperscript{561} DEER 2008
\textsuperscript{563} Ibid
\textsuperscript{564} 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 - Ind ust. 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

\[ \Delta k\text{Wh} = K_{\text{controlled}} \times \text{Hours} \times \text{ESF} \times \text{WHF} \]

Where:

\(K_{\text{controlled}}\) = 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;

<table>
<thead>
<tr>
<th>Lighting Control Type</th>
<th>Default kw controlled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall mounted occupancy sensor</td>
<td>0.3505</td>
</tr>
</tbody>
</table>

### 4.5.10 Occupancy Sensor Lighting Controls

<table>
<thead>
<tr>
<th>Lighting Control Type</th>
<th>Default kw controlled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Remote mounted occupancy sensor</td>
<td>0.587566</td>
</tr>
<tr>
<td>Fixture mounted sensor</td>
<td>0.073567</td>
</tr>
</tbody>
</table>

**Hours**

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 4.5, Fixture annual operating hours, for each building type if customer specific information is not collected. If unknown building type, use the Miscellaneous value.

**ESF**

ESF = Energy Savings factor (represents the percentage reduction to the operating Hours from the non-controlled baseline lighting system).

<table>
<thead>
<tr>
<th>Lighting Control Type</th>
<th>Energy Savings Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall or Ceiling-Mounted Occupancy Sensors</td>
<td>41% or custom</td>
</tr>
<tr>
<td>Fixture Mounted Occupancy Sensors</td>
<td>30% or custom</td>
</tr>
<tr>
<td>Wall-Mounted Occupancy Sensors Configured as “Vacancy Sensors”</td>
<td>53% or custom569</td>
</tr>
</tbody>
</table>

**WHF**

WHF = Waste heat factor for energy to account for cooling energy savings from efficient lighting is provided in the Reference Table in Section 4.5 for each building type. If building is un-cooled, the value is 1.0.

### HEATING PENALTY

If electrically heated building:

\[
\Delta kWh_{\text{heat penalty}} = KW_{\text{controlled}} \times Hours \times ESF \times -IFkWh
\]

Where:

IFkWh = Lighting-HVAC Iteration Factor for electric heating impacts; this factor represents the increased electric space heating requirements due to the reduction of waste heat rejected by the efficient lighting. Values are provided in the Reference Table in Section 4.5. If unknown, use the Miscellaneous value.

### SUMMER COINCIDENT PEAK DEMAND SAVINGS

\[
\Delta kW = KW_{\text{controlled}} \times WHF_d \times (CF_{\text{baseline}} - CFos)
\]

---

566 Ibid
567 Efficiency Vermont TRM 2/19/2010
569 Papamichael, Konstantions, Bi-Level Switching in Office Spaces, California Lighting Technology Center, February 1,2010. Note: See Figure 8 on page 10 for relevant study results. The study shows a 30% extra savings above a typical occupancy sensor; 41% * 1.3 = 53%.
570 Negative value because this is an increase in heating consumption due to the efficient lighting.
Where:

\[ \text{WHF}_d = \text{Waste Heat Factor for Demand to account for cooling savings from efficient lighting in cooled buildings is provided in the Reference Table in Section 4.5. If the building is un-cooled WHF}_d \text{ is 1.} \]

\[ \text{CF}_\text{baseline} = \text{Baseline Summer Peak Coincidence Factor for the lighting system without Occupancy Sensors installed selected from the Reference Table in Section 4.5 for each building type. If the building type is unknown, use the Miscellaneous value of 0.66} \]

\[ \text{CF}_\text{os} = \text{Retrofit Summer Peak Coincidence Factor the lighting system with Occupancy Sensors installed is 0.15 regardless of building type.} \]

**NATURAL GAS ENERGY SAVINGS**

\[ \Delta \text{therms} = \text{KW}_{\text{Controlled}} * \text{Hours} * \text{ESF} * - \text{IFThersms} \]

Where:

\[ \text{IFThersms} = \text{Lighting-HVAC Integration Factor for gas heating impacts; this factor represents the increased gas space heating requirements due to the reduction of waste heat rejected by the efficient lighting and provided in the Reference Table in Section 4.5 by building type.} \]

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-LTG-OSLC-V02-140601**

---

571 Coincidence Factor Study Residential and Commercial Industrial Lighting Measures, RLW Analytics, Spring 2007. Note, the connected load used in the calculation of the CF for occupancy sensor lights includes the average ESF.
4.5.11 Solar Light Tubes

**DESCRIPTION**

A tubular skylight which is 10” to 21” in diameter with a prismatic or translucent lens is installed on the roof of a commercial facility. The lens reflects light captured from the roof opening through a highly specular reflective tube down to the mounted fixture height. When in use, a light tube fixture resembles a metal halide fixture. Uses include grocery, school, retail and other single story commercial buildings.

In order that the savings characterized below apply, the electric illumination in the space must be automatically controlled to turn off or down when the tube is providing enough light.

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 a tubular skylight that concentrates and directs light from the roof to an area inside the facility.

**DEFINITION OF BASELINE EQUIPMENT**

The baseline equipment for this measure is a fixture with comparable luminosity. The specifications for the baseline lamp depend on the size of the Light Tube being installed.

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The estimated useful life for a light tube commercial skylight is 10 years.

**DEEMED MEASURE COST**

If available, the actual incremental cost should be used. For analysis purposes, assume an incremental cost for a light tube commercial skylight is $500.

**LOADSHAPE**

Loadshape C14 - Indus. 1-shift (8/5) (e.g., comp. air, lights)

**COINCIDENCE FACTOR**

The summer peak coincidence factor for this measure is dependent on location.

---

572 Equal to the manufacturers standard warranty
573 The savings from solar light tubes are only realized during the sunlight hours. It is therefore appropriate to apply the single shift (8/5) loadshape to this measure.
Algorithm

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

\[
\Delta \text{kWh} = kW_f \times \text{HOURS} \times \text{WHFe}
\]

Where:

- \( kW_f \) = Connected load of the fixture the solar tube replaces

<table>
<thead>
<tr>
<th>Size of Tube</th>
<th>Average Lumen output for Chicago Illinois (minimum)(^{574})</th>
<th>Equivalent fixture</th>
<th>kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>21”</td>
<td>9,775 (4,179)</td>
<td>50% 3 x 2 32W lamp CFL (207W, 9915 lumens) 50% 4 lamp F32 w/Elec 4’ T8 (114W, 8895 lumens)</td>
<td>0.161</td>
</tr>
<tr>
<td>14”</td>
<td>4,392 (1,887)</td>
<td>50% 2 42W lamp CFL (94W, 4406 lumens) 50% 2 lamp F32 w/Elec 4’ T8 (59W, 4448 lumens)</td>
<td>0.077</td>
</tr>
<tr>
<td>10”</td>
<td>2,157 (911)</td>
<td>50% 1 42W lamp CFL (46W, 2203 lumens) 50% 1 lamp F32 w/Elec 4’ T8 (32W, 2224 lumens)</td>
<td>0.039</td>
</tr>
</tbody>
</table>

**AVERAGE** 0.092

- \( \text{HOURS} \) = Equivalent full load hours
- \( \text{WHFe} \) = Waste heat factor for energy to account for cooling energy savings from efficient lighting is selected from the Reference Table in Section 4.5 for each building type. If building is un-cooled, the value is 1.0.

**HEATING PENALTY**

If electrically heated building:

\[
\Delta \text{kWh}_{\text{heatpenalty}} = kW_f \times \text{HOURS} \times -\text{IFkWh}
\]

Where:

- \( \text{IFkWh} \) = Lighting-HVAC Iteration Factor for electric heating impacts; this factor represents the increased electric space heating requirements due to the reduction of waste heat rejected by the efficient lighting. Values are provided in the Reference Table in Section 4.5. If unknown, use the Miscellaneous value.

---


\(^{575}\) Ibid. The lumen values presented in the kW table represent the average of the lightest 2400 hours.

\(^{576}\) Negative value because this is an increase in heating consumption due to the efficient lighting.
**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

\[
\Delta kW = \Delta kW_i \times WHFd \times CF
\]

Where:

- **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 4.5 for each building type. If the building is not cooled WHFd is 1.

- **CF** = Summer Peak Coincidence Factor for measure is selected from the Reference Table in Section 4.5 for each building type. If the building type is unknown, use the Miscellaneous value of 0.66.

**NATURAL GAS SAVINGS**

\[
\Delta \text{Therms}^{577} = \Delta kW_i \times \text{HOURS} \times \text{IFTherms}
\]

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 4.5 for each building type.

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-LTG-STUB-V02-140601**

---

\(^{577}\) Negative value because this is an increase in heating consumption due to the efficient lighting.
4.5.12 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.

If the implementation strategy does not allow for the installation location to be known, a deemed split of 99% Commercial and 1% Residential should be used.\(^{578}\)

This measure was developed to be applicable to the following program types: TOS, RF, DI.

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:

<table>
<thead>
<tr>
<th>Time of Sale (TOS)</th>
<th>Retrofit (RF) and DI</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
<td></td>
</tr>
<tr>
<td>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.</td>
<td></td>
</tr>
</tbody>
</table>

**DEFINITION OF EFFICIENT EQUIPMENT**

The definition of efficient equipment varies based on the program and is defined below:

---

\(^{578}\) Based on weighted average of Final ComEd’s BILD program data from PY5 and PY6. For Residential installations, hours of use assumptions from ‘5.5 Interior Hardwired Compact Fluorescent Lamp (CFL) Fixture’ measure should be used.
### Time of Sale (TOS) vs Retrofit (RF) and DI

<table>
<thead>
<tr>
<th>Time of Sale (TOS)</th>
<th>Retrofit (RF) and DI</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
<td>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.</td>
</tr>
</tbody>
</table>

### Definition of Baseline Equipment

The definition of baseline equipment varies based on the program and is defined below:

<table>
<thead>
<tr>
<th>Time of Sale (TOS)</th>
<th>Retrofit (RF) and DI</th>
</tr>
</thead>
<tbody>
<tr>
<td>The baseline is T8 with equivalent lumen output. In high-bay applications, the baseline is pulse start metal halide systems.</td>
<td>The baseline is the existing system. In July 14, 2012, Federal Standards were enacted that were expected to eliminate T-12s as an option for linear fluorescent fixtures. Through v3.0 of the TRM, it was assumed that the T-12 would no longer be baseline for retrofits from 1/1/2016. However, due to significant loopholes in the legislation, T-12 compliant product is still freely available and in Illinois T-12s continue to hold a significant share of the existing and replacement lamp market. Therefore the timing of the sunsetting of T-12s as a viable baseline has been pushed back in v4.0 until 6/1/2016 and will be revisited in future update sessions. 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.</td>
</tr>
</tbody>
</table>

### Deemed Lifetime of Efficient Equipment

The deemed lifetime of the efficient equipment fixture, regardless of program type is Fixture lifetime is 15 years\(^{579}\).

### 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

\(^{579}\) 15 years from GDS Measure Life Report, June 2007
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

Algorithm

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

\[
\Delta \text{kWh} = \frac{(Watts_{\text{base}} - Watts_{\text{EE}})}{1000} \times \text{Hours} \times WHF_e \times ISR
\]

Where:

- \( Watts_{\text{base}} \) = 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, or a custom value can be entered if the configurations in the tables is not representative of the existing system.

- \( Watts_{\text{EE}} \) = 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, or a custom value can be entered if the configurations in the tables is not representative of the existing system.

- \( \text{Hours} \) = Average hours of use per year as provided by the customer or selected from the Reference Table in Section 4.5, 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 4.5 for each building type. If building is un-cooled, the value is 1.0.
ISR = In Service Rate or the percentage of units rebated that get installed.

=100% 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:

<table>
<thead>
<tr>
<th>Weighted Average 1st year In Service Rate (ISR)</th>
<th>2nd year Installations</th>
<th>3rd year Installations</th>
<th>Final Lifetime In Service Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>98%²⁸¹</td>
<td>0%</td>
<td>0%</td>
<td>98.0%²⁸²</td>
</tr>
</tbody>
</table>

**HEATING PENALTY**

If electrically heated building:

\[ \Delta \text{kWh}_{\text{penalty}} = \left( \frac{(Watts_{\text{base}} - Watts_{\text{EE}})}{1000} \right) * \text{ISR} * \text{Hours} * -IF_{\text{kWh}} \]

Where:

- IF_{kWh} = Lighting-HVAC Iteration Factor for electric heating impacts; this factor represents the increased electric space heating requirements due to the reduction of waste heat rejected by the efficient lighting. Values are provided in the Reference Table in Section 4.5. If unknown, use the Miscellaneous value.

**SUMMER COINCIDENT DEMAND SAVINGS**

\[ \Delta kW = \left( \frac{(Watts_{\text{base}} - Watts_{\text{EE}})}{1000} \right) * WHF_{d} * CF * \text{ISR} \]

Where:

- WHF_{d} = Waste Heat Factor for Demand to account for cooling savings from efficient lighting in cooled buildings is selected from the Reference Table in Section 4.5 for each building type. If the building is not cooled WHF_{d} is 1.
- CF = Summer Peak Coincidence Factor for measure is selected from the Reference Table in Section 4.5 for each building type. If the building type is unknown, use the Miscellaneous value.

²⁸⁰ 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.
²⁸¹ 1st year in service rate is based upon review of PY5-6 evaluations from ComEd’s commercial lighting program (BILD) (see ‘IL Commercial Lighting ISR_2014.xls’ for more information.
²⁸² 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.
²⁸³ Negative value because this is an increase in heating consumption due to the efficient lighting.
**Natural Gas Energy Savings**

\[
\Delta T_{\text{erms}} = \frac{(W_{\text{base}} - W_{\text{EE}})}{1000} \times ISR \times \text{Hours} \times IF_{\text{therms}}
\]

Where:

- \( IF_{\text{therms}} \) = 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 4.5 for each building type.

**Water Impact Descriptions and Calculation**

N/A

**Deemed O&M Cost Adjustment Calculation**

See Reference tables for Operating and Maintenance Values

<table>
<thead>
<tr>
<th>Program</th>
<th>Reference Table</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time of Sale</td>
<td>B-1: T5 Component Costs and Lifetime</td>
</tr>
<tr>
<td>Retrofit, DI</td>
<td>B-2: T5 Component Costs and Lifetime</td>
</tr>
</tbody>
</table>

**Reference Tables**

See following page

---

\(584^{\text{584}}\) Negative value because this is an increase in heating consumption due to the efficient lighting.
# Illinois Statewide Technical Reference Manual - 4.5.12 T5 Fixtures and Lamps

A-1: Time of Sale: T5 New and Baseline Assumptions

<table>
<thead>
<tr>
<th>EE Measure Description</th>
<th>EE Cost</th>
<th>Watt\textsubscript{EE}</th>
<th>Baseline Description</th>
<th>Base Cost</th>
<th>Watt\textsubscript{BASE}</th>
<th>Measure Cost</th>
<th>Watt\textsubscript{SAVE}</th>
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<td>$200.00</td>
<td>180</td>
<td>200 Watt Pulse Start Metal-Halide</td>
<td>$100.00</td>
<td>232</td>
<td>$100.00</td>
<td>52</td>
</tr>
<tr>
<td>3-Lamp T5 High-Bay</td>
<td>$200.00</td>
<td>180</td>
<td>200 Watt Pulse Start Metal-Halide</td>
<td>$100.00</td>
<td>232</td>
<td>$100.00</td>
<td>52</td>
</tr>
<tr>
<td>4-Lamp T5 High-Bay</td>
<td>$225.00</td>
<td>240</td>
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<td>$125.00</td>
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<td>$250.00</td>
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<td>$150.00</td>
<td>476</td>
<td>$100.00</td>
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<tr>
<td>1-Lamp T5 Troffer/Wrap</td>
<td>$100.00</td>
<td>32</td>
<td>Proportionally adjusted according to 2-Lamp T5 Equivalent to 3-Lamp T8</td>
<td>$60.00</td>
<td>44</td>
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<td>2-Lamp T5 Troffer/Wrap</td>
<td>$100.00</td>
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<td>3-Lamp F32T8 Equivalent w/ Elec. Ballast</td>
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<td>$40.00</td>
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<tr>
<td>1-Lamp T5 Industrial/Strip</td>
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<tr>
<td>2-Lamp T5 Industrial/Strip</td>
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<td>3-Lamp F32T8 Equivalent w/ Elec. Ballast</td>
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<td>88</td>
<td>$30.00</td>
<td>24</td>
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<tr>
<td>3-Lamp T5 Industrial/Strip</td>
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A-2: Retrofit T5 New and Baseline Assumptions

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<th>EE Measure Description</th>
<th>EE Cost</th>
<th>Watts&lt;sub&gt;req&lt;/sub&gt;</th>
<th>Baseline Description</th>
<th>Watts&lt;sub&gt;req&lt;/sub&gt;</th>
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<td>1-Lamp T5 Troffer/Wrap</td>
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<td>400 Watt Metal halide</td>
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<td>400 Watt Pulse Start Metal-Halide</td>
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<sup>586</sup>Ibid.
### B-1: Time of Sale T5 Component Costs and Lifetime

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<tr>
<td>3-Lamp T5 High-Bay</td>
<td>$12.00</td>
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<td>$52.00</td>
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<td>320 Watt Pulse Start Metal-Halide</td>
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<td>20000</td>
<td>$6.67</td>
<td>1.00</td>
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<td>$52.00</td>
<td>70000</td>
<td>Proportionally adjusted according to 2-Lamp T5 Equivalent to 3-Lamp T8</td>
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<td>$2.50</td>
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<td>$2.67</td>
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### B-2: T5 Retrofit Component Costs and Lifetime

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<td>70000</td>
<td>15.00</td>
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<td>1.50</td>
<td>$5.50</td>
<td>20000</td>
<td>$2.67</td>
<td>0.50</td>
<td>$6</td>
</tr>
<tr>
<td>2 Lamp T5 Troffer Vap</td>
<td>$12.00</td>
<td>20000</td>
<td>$6.67</td>
<td>$25.00</td>
<td>70000</td>
<td>15.00</td>
<td>5 Lamp F25T10 Equivalent to 2 Lamp T5</td>
<td>1.50</td>
<td>$5.50</td>
<td>20000</td>
<td>$2.67</td>
<td>0.50</td>
<td>$6</td>
</tr>
<tr>
<td>3 Lamp T5 Industrial Vap</td>
<td>$12.00</td>
<td>20000</td>
<td>$6.67</td>
<td>$25.00</td>
<td>70000</td>
<td>15.00</td>
<td>Proportionally Adjusted according to 2 Lamp T5 Equivalent to 2 Lamp T5</td>
<td>1.50</td>
<td>$2.50</td>
<td>20000</td>
<td>$2.67</td>
<td>0.50</td>
<td>$6</td>
</tr>
<tr>
<td>2 Lamp T5 Industrial Vap</td>
<td>$12.00</td>
<td>20000</td>
<td>$6.67</td>
<td>$25.00</td>
<td>70000</td>
<td>15.00</td>
<td>5 Lamp F25T10 Equivalent to 2 Lamp T5</td>
<td>1.50</td>
<td>$5.50</td>
<td>20000</td>
<td>$2.67</td>
<td>0.50</td>
<td>$6</td>
</tr>
<tr>
<td>3 Lamp T5 Industrial Vap</td>
<td>$12.00</td>
<td>20000</td>
<td>$6.67</td>
<td>$25.00</td>
<td>70000</td>
<td>15.00</td>
<td>Proportionally Adjusted according to 2 Lamp T5 Equivalent to 2 Lamp T5</td>
<td>1.50</td>
<td>$2.50</td>
<td>20000</td>
<td>$2.67</td>
<td>0.50</td>
<td>$6</td>
</tr>
<tr>
<td>4 Lamp T5 Industrial Vap</td>
<td>$12.00</td>
<td>20000</td>
<td>$6.67</td>
<td>$25.00</td>
<td>70000</td>
<td>15.00</td>
<td>Proportionally Adjusted according to 2 Lamp T5 Equivalent to 2 Lamp T5</td>
<td>1.50</td>
<td>$2.50</td>
<td>20000</td>
<td>$2.67</td>
<td>0.50</td>
<td>$6</td>
</tr>
<tr>
<td>1 Lamp T5 Industrial</td>
<td>$12.00</td>
<td>20000</td>
<td>$6.67</td>
<td>$25.00</td>
<td>70000</td>
<td>15.00</td>
<td>Proportionally Adjusted according to 2 Lamp T5 Equivalent to 2 Lamp T5</td>
<td>1.50</td>
<td>$2.50</td>
<td>20000</td>
<td>$2.67</td>
<td>0.50</td>
<td>$6</td>
</tr>
<tr>
<td>2 Lamp T5 Indirect</td>
<td>$12.00</td>
<td>20000</td>
<td>$6.67</td>
<td>$25.00</td>
<td>70000</td>
<td>15.00</td>
<td>5 Lamp F25T10 Equivalent to 2 Lamp T5</td>
<td>1.50</td>
<td>$5.50</td>
<td>20000</td>
<td>$2.67</td>
<td>0.50</td>
<td>$6</td>
</tr>
</tbody>
</table>

C-1: T12 Baseline Adjustment:

Savings Adjustment Factors

<table>
<thead>
<tr>
<th>Measure Code</th>
<th>Equivalent T12 watts adjusted for lumen equivalency 34 w and 40 w with LUMMag ballast</th>
<th>Equivalent T12 watts adjusted for lumen equivalency 48 w with LUMMag ballast</th>
<th>Equivalent T12 watts adjusted for lumen equivalency 48 w with Mag ballast</th>
<th>Proportionally Adjusted for Lumens wattage for T8 equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-Lamp T5 Industrial/Strip</td>
<td>32</td>
<td>64</td>
<td>73</td>
<td>87</td>
</tr>
<tr>
<td>2-Lamp T5 Industrial/Strip</td>
<td>64</td>
<td>103</td>
<td>125</td>
<td>135</td>
</tr>
<tr>
<td>3-Lamp T5 Industrial/Strip</td>
<td>96</td>
<td>167</td>
<td>185</td>
<td>211</td>
</tr>
<tr>
<td>4-Lamp T5 Industrial/Strip</td>
<td>128</td>
<td>211</td>
<td>249</td>
<td>226</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Measure Code</th>
<th>Savings Factor Adjustment to the T8 baseline</th>
<th>Savings Factor Adjustment to the T8 baseline</th>
<th>Savings Factor Adjustment to the T8 baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-Lamp T5 Industrial/Strip</td>
<td>42%</td>
<td>29%</td>
<td>24%</td>
</tr>
<tr>
<td>2-Lamp T5 Industrial/Strip</td>
<td>61%</td>
<td>40%</td>
<td>34%</td>
</tr>
<tr>
<td>3-Lamp T5 Industrial/Strip</td>
<td>51%</td>
<td>40%</td>
<td>31%</td>
</tr>
<tr>
<td>4-Lamp T5 Industrial/Strip</td>
<td>60%</td>
<td>41%</td>
<td>51%</td>
</tr>
</tbody>
</table>

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-V03-150601**
4.5.13 Occupancy Controlled Bi-Level Lighting Fixtures

DESCRIPTION

This measure relates to replacing existing uncontrolled continuous lighting fixtures with new bi-level lighting fixtures. This measure can only relate to replacement in an existing building, since multi-level switching is required in the Commercial new construction building energy code (IECC 2012).

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 system is assumed to be an occupancy controlled lighting fixture that reduces light level during unoccupied periods.

DEFINITION OF BASELINE EQUIPMENT

The baseline equipment is assumed to be an uncontrolled lighting system on continuously, e.g. in stairwells and corridors for health and safety reasons.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life for all lighting controls is assumed to be 8 years.

DEEMED MEASURE COST

When available, the actual cost of the measure shall be used. When not available, the assumed measure cost is $274.

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)

589 DEER 2008.
Loadshape C17 - Indus. 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.

---

**Algorithm**

**CALCULATION OF SAVINGS**

**Electric Energy Savings**

\[ \Delta \text{kWh} = (\text{KW}_{\text{Baseline}} - (\text{KW}_{\text{Controlled}} \times (1 - \text{ESF}))) \times \text{Hours} \times \text{WHF}_e \]

Where:

- **KW\text{Baseline}** = Total baseline lighting load of the existing/baseline fixture
- **KW\text{Controlled}** = Total controlled lighting load at full light output of the new bi-level fixture
- **Hours** = Number of hours lighting is on. This measure is limited to 24/7 operation.
- **ESF** = Energy Savings factor (represents the percentage reduction to the KW\text{Controlled} due to the occupancy control).

\[ \text{ESF} = \% \text{Standby Mode} \times (1 - \% \text{Full Light at Standby Mode}) \]

\[ \% \text{Standby Mode} = \text{Represents the percentage of the time the fixture is operating in standby (i.e. low-wattage) mode.} \]

\[ \% \text{Full Light at Standby Mode} = \text{Represents the assumed wattage consumption during standby mode relative to the full wattage consumption. Can be achieved either through dimming or a stepped control strategy.} \]

\[ = \text{Dependent on application. If customer provided or metered data is available for both or either of these inputs a custom savings factor should be calculated. If not defaults are provided below:} \]

<table>
<thead>
<tr>
<th>Application</th>
<th>% Standby Mode</th>
<th>% Full Light at Standby Mode</th>
<th>Energy Savings Factor (ESF)</th>
</tr>
</thead>
</table>

---

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### HEATING PENALTY

If electrically heated building:

\[
\Delta k\text{Wh}_{\text{heatpenalty}} = (KW_{\text{Baseline}} - (KW_{\text{Controlled}} \times (1 - \text{ESF}))) \times \text{Hours} \times \text{IFkWh}
\]

Where:

\[
\text{IFkWh} = \text{Lighting-HVAC Iteration Factor for electric heating impacts; this factor represents the increased electric space heating requirements due to the reduction of waste heat rejected by the efficient lighting. Values are provided in the Reference Table in Section 4.5. If unknown, use the Miscellaneous value.}
\]

### SUMMER COINCIDENT PEAK DEMAND SAVINGS

\[
\Delta kW = (KW_{\text{Baseline}} - (KW_{\text{Controlled}} \times (1 - \text{ESF}))) \times \text{WHF}_d \times (\text{CF}_{\text{Baseline}} - \text{CF}_{\text{os}})
\]

---

591 Average found from the four buildings in the State of California Energy Commission Lighting Research Program Bi-Level Stairwell Fixture Performance Final Report: [http://www.archenergy.com/lrp/lightingperf_standards/project_5_1_reports.htm](http://www.archenergy.com/lrp/lightingperf_standards/project_5_1_reports.htm)


593 Conservative estimate.

594 Negative value because this is an increase in heating consumption due to the efficient lighting.
Where:

\[ WHF_d = \text{Waste Heat Factor for Demand to account for cooling savings from efficient lighting in cooled buildings is provided in the Reference Table in Section 4.5. If the building is un-cooled WHF}_d \text{ is 1.} \]

\[ CF_{\text{baseline}} = \text{Baseline Summer Peak Coincidence Factor for the lighting system without Occupancy Sensors installed selected from the Reference Table in Section 4.5 for each building type. If the building type is unknown, use the Miscellaneous value of 0.66} \]

\[ CF_{\text{os}} = \text{Retrofit Summer Peak Coincidence Factor the lighting system with Occupancy Sensors installed is 0.15 regardless of building type.} \]

**NATURAL GAS HEATING PENALTY**

If natural gas heating:

\[ \Delta \text{therms} = (\text{KW}_{\text{Baseline}} - (\text{KW}_{\text{Controlled}} \times (1 - \text{ESF}))) \times \text{Hours} \times \text{IFThersms} \]

Where:

\[ \text{IFThersms} = \text{Lighting-HVAC Integration Factor for gas heating impacts; this factor represents the increased gas space heating requirements due to the reduction of waste heat rejected by the efficient lighting and provided in the Reference Table in Section 4.5 by building type.} \]

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-LTG-OCBL-V01-140601**

---

595 Coincidence Factor Study Residential and Commercial Industrial Lighting Measures, RLW Analytics, Spring 2007. Note, the connected load used in the calculation of the CF for occupancy sensor lights includes the average ESF.
4.5.14 Commercial 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 in a commercial location. If the implementation strategy does not allow for the installation location to be known a deemed split should be used. For Residential targeted programs (e.g. an upstream retail program), a deemed split of 96% Residential and 4% Commercial assumptions should be used\(^{596}\), and for Commercial targeted programs a deemed split of 4% Residential and 96% Commercial should be used\(^{597}\).

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


DEFINITION OF BASELINE EQUIPMENT

The baseline is a specialty incandescent light bulb including those exempt of the EISA 2007 standard: three-way, plant light, daylight bulb, bug light, post light, globes G40 (<40W), candelabra base (<60W), vibration service bulb, decorative candle with medium or intermediate base (<40W), shatter resistant and reflector bulbs and standard bulbs greater than 2601 lumens, and those non-exempt from EISA 2007: dimmable, globes (less than 5” diameter and >40W), candle (shapes B, BA, CA >40W, candelabra base lamps >60W) and intermediate base lamps (>40W).

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\(^{598}\)) 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

For the Retail (Time of Sale) measure, the incremental capital cost for this measure is $5\(^{599}\).

For the Retrofit measures, the full cost of $8.50 should be used plus $5 labor\(^{600}\) for a total of $13.50. However actual program delivery costs should be utilized if available.

LOADSHAPE

Loadshape C06 - Commercial Indoor Lighting
Loadshape C07 - Grocery/Conv. Store Indoor Lighting
Loadshape C08 - Hospital Indoor Lighting
Loadshape C09 - Office Indoor Lighting

---

\(^{596}\) RES v C&I split is based on a weighted (by sales volume) average of ComEd PY4-6 and Ameren PYS-6 in store intercept survey results.

\(^{597}\) Based upon final weighted (by sales volume) average of the BILD program (ComEd’s commercial lighting program) for PY 4 and PYS and PY6.

\(^{598}\) 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.

\(^{599}\) NEEP Residential Lighting Survey, 2011

\(^{600}\) Based on 15 minutes at $20 per hour.
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 section 4.5.

**Algorithm**

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

\[ \Delta \text{kWh} = \left( \frac{\text{WattsBase} - \text{WattsEE}}{1000} \right) \times \text{ISR} \times \text{Hours} \times \text{WHFe} \]

Where:

- WattsBase = Actual wattage equivalent of incandescent specialty bulb, use the tables below to obtain the incandescent bulb equivalent wattage\(^{601}\); use 60W if unknown\(^{602}\)

EISA exempt bulb types:

<table>
<thead>
<tr>
<th>Bulb Type</th>
<th>Lower Lumen Range</th>
<th>Upper Lumen Range</th>
<th>WattsBase</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Standard Spirals &gt;=2601</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2601</td>
<td>2999</td>
<td>150</td>
</tr>
<tr>
<td></td>
<td>3000</td>
<td>5279</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td>5280</td>
<td>6209</td>
<td>300</td>
</tr>
<tr>
<td><strong>3-Way</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>250</td>
<td>449</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>450</td>
<td>799</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>800</td>
<td>1099</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>1100</td>
<td>1599</td>
<td>75</td>
</tr>
</tbody>
</table>


### Commercial ENERGY STAR Specialty Compact Fluorescent Lamp (CFL)

#### Bulb Type

<table>
<thead>
<tr>
<th>Bulb Type</th>
<th>Lower Lumen Range</th>
<th>Upper Lumen Range</th>
<th>WattsBase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Globe (medium and intermediate bases less than 750 lumens)</td>
<td>1600</td>
<td>1999</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>2000</td>
<td>2549</td>
<td>125</td>
</tr>
<tr>
<td></td>
<td>2550</td>
<td>2999</td>
<td>150</td>
</tr>
<tr>
<td>Globe (candelabra bases less than 1050 lumens)</td>
<td>90</td>
<td>179</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>180</td>
<td>249</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>250</td>
<td>349</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>350</td>
<td>749</td>
<td>40</td>
</tr>
<tr>
<td>Decorative (Shapes B, BA, C, CA, DC, F, G, medium and intermediate bases less than 750 lumens)</td>
<td>70</td>
<td>89</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>90</td>
<td>149</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>150</td>
<td>299</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>300</td>
<td>749</td>
<td>40</td>
</tr>
<tr>
<td>Globe (candelabra bases less than 1050 lumens)</td>
<td>90</td>
<td>179</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>180</td>
<td>249</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>250</td>
<td>349</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>350</td>
<td>499</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>500</td>
<td>1049</td>
<td>60</td>
</tr>
<tr>
<td>Decorative (Shapes B, BA, C, CA, DC, F, G, candelabra bases less than 1050 lumens)</td>
<td>70</td>
<td>89</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>90</td>
<td>149</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>150</td>
<td>299</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>300</td>
<td>499</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>500</td>
<td>1049</td>
<td>60</td>
</tr>
</tbody>
</table>

#### EISA non-exempt bulb types:

<table>
<thead>
<tr>
<th>Bulb Type</th>
<th>Lower Lumen Range</th>
<th>Upper Lumen Range</th>
<th>Incandescent Equivalent Post-EISA 2007 (WattsBase)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimmable Twist, Globe (less than 5&quot; in diameter and &gt; 749 lumens), candle (shapes B, BA, CA &gt; 749 lumens), Candelabra Base Lamps (&gt;1049 lumens), Intermediate Base Lamps (&gt;749 lumens)</td>
<td>310</td>
<td>749</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td>750</td>
<td>1049</td>
<td>43</td>
</tr>
<tr>
<td></td>
<td>1050</td>
<td>1489</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td>1490</td>
<td>2600</td>
<td>72</td>
</tr>
</tbody>
</table>

**Directional Lamps** - ENERGY STAR Minimum Luminous Efficacy = 40Lm/W for lamps with rated wattages less than 20W and 50 Lm/W for lamps with rated wattages >= 20 watts.\(^{603}\)

---

\(^{603}\) From pg 10 of the Energy Star Specification for lamps v1.1
For Directional R, BR, and ER lamp types:

<table>
<thead>
<tr>
<th>Bulb Type</th>
<th>Lower Lumen Range</th>
<th>Upper Lumen Range</th>
<th>WattsBase</th>
</tr>
</thead>
<tbody>
<tr>
<td>R, ER, BR with medium screw bases w/ diameter &gt;2.25&quot; (*see exceptions below)</td>
<td>420</td>
<td>472</td>
<td>40</td>
</tr>
<tr>
<td>R, BR, and ER with medium screw bases w/ diameter &lt;=2.25&quot;</td>
<td>400</td>
<td>449</td>
<td>40</td>
</tr>
<tr>
<td>ER30, BR30, BR40, or ER40</td>
<td>400</td>
<td>449</td>
<td>40</td>
</tr>
<tr>
<td>BR30, BR40, or ER40</td>
<td>400</td>
<td>449</td>
<td>40</td>
</tr>
<tr>
<td>*R20</td>
<td>400</td>
<td>449</td>
<td>40</td>
</tr>
<tr>
<td>*All reflector lamps below lumen ranges specified above</td>
<td>200</td>
<td>299</td>
<td>20</td>
</tr>
</tbody>
</table>

Directional lamps are exempt from EISA regulations.

For PAR, MR, and MRX Lamps Types:

For these highly focused directional lamp types, it is necessary to have Center Beam Candle Power (CBCP) and beam angle measurements to accurately estimate the equivalent baseline wattage. The formula below is based on the Energy Star Center Beam Candle Power tool. If CBCP and beam angle information are not available, refer to the R, BR, and ER lumen based method above.

---

604 From pg 11 of the Energy Star Specification for lamps v1.1

Wattbase = 
\[375.1 - 4.355(D) - \sqrt{227,800 - 937.9(D) - 0.9903(D^2) - 1479(BA) - 12.02(D + BA) + 14.69(BA^2) - 16,720 \cdot \ln(CBCP)}\]

Where:
- \(D\) = Bulb diameter (e.g. for PAR20 \(D = 20\))
- \(BA\) = Beam angle
- \(CBCP\) = Center beam candle power

The result of the equation above should be rounded DOWN to the nearest wattage established by Energy Star:

<table>
<thead>
<tr>
<th>Diameter</th>
<th>Permitted Wattages</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>20, 35, 40, 45, 50, 60, 75</td>
</tr>
<tr>
<td>20</td>
<td>50</td>
</tr>
<tr>
<td>30S</td>
<td>40, 45, 50, 60, 75</td>
</tr>
<tr>
<td>30L</td>
<td>50, 75</td>
</tr>
<tr>
<td>38</td>
<td>40, 45, 50, 55, 60, 65, 75, 85, 90, 100, 120, 150, 250</td>
</tr>
</tbody>
</table>

EISA non-exempt bulb types:

<table>
<thead>
<tr>
<th>Bulb Type</th>
<th>Lower Lumen Range</th>
<th>Upper Lumen Range</th>
<th>Incandescent Equivalent Post-EISA 2007 (WattsBase)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimmable Twist, Globe (less than 5” in diameter and &gt; 749 lumens), candle (shapes B, BA, CA &gt; 749 lumens), Candelabra Base Lamps (&gt;1049 lumens), Intermediate Base Lamps (&gt;749 lumens)</td>
<td>310</td>
<td>749</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td>750</td>
<td>1049</td>
<td>43</td>
</tr>
<tr>
<td></td>
<td>1050</td>
<td>1489</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td>1490</td>
<td>2600</td>
<td>72</td>
</tr>
</tbody>
</table>

\[WattsEE = \text{Actual wattage of energy efficient specialty bulb purchased, use 15W if unknown}\]

\[ISR = \text{In Service Rate or the percentage of units rebated that get installed.}\]
=100%\textsuperscript{607} 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:

<table>
<thead>
<tr>
<th>Weighted Average 1\textsuperscript{st} year In Service Rate (ISR)</th>
<th>2\textsuperscript{nd} year Installations</th>
<th>3\textsuperscript{rd} year Installations</th>
<th>Final Lifetime In Service Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>71.2\textsuperscript{608} %</td>
<td>14.5%</td>
<td>12.3%</td>
<td>98.0\textsuperscript{609} %</td>
</tr>
</tbody>
</table>

Hours = Average hours of use per year are provided in Reference Table in Section 4.5, Screw based bulb annual operating hours, for each building type\textsuperscript{610}. If unknown use the Miscellaneous value.

\textit{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 4.5. If unknown, use the Miscellaneous value.

**Deferred Installs**

As presented above, the characterization assumes that a percentage of bulbs purchased are not installed until Year 2 and Year 3 (see ISR assumption above). The Illinois Technical Advisory Committee has determined the following methodology for calculating the savings of these future installs.

Year 1 (Purchase Year) installs:
Characterized using assumptions provided above or evaluated assumptions if available.

Year 2 and 3 installs:
Characterized using delta watts assumption and hours of use from the Install Year i.e. the actual deemed (or evaluated if available) assumptions active in Year 2 and 3 should be applied.

The NTG factor for the Purchase Year should be applied.

\textsuperscript{607} 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.

\textsuperscript{608} 1\textsuperscript{st} year in service rate is based upon review of PY4-6 evaluations from ComEd’s commercial lighting program (BILD) (see ‘IL Commercial Lighting ISR_2014.xls’ for more information. The average first year ISR was calculated weighted by the number of bulbs sold.

\textsuperscript{609} 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 2\textsuperscript{nd} and 3\textsuperscript{rd} year installations should be counted as part of those future program year savings. Note that this Final Install Rate does NOT account for leakage of purchased bulbs being installed outside of the utility territory. EM&V should assess how and if data from evaluation should adjust this final installation rate to account for this impact.

\textsuperscript{610} Based on ComEd analysis taking DEER 2008 values and averaging with PY1 and PY2 evaluation results.
EXAMPLE

For example, for a 14W 500 lumen R20 reflector lamp is installed in an office and sign off form provided.

\[ \Delta kWh = \left( \frac{(45 - 14)}{1000} \right) \times 1.0 \times 3088 \times 1.25 \]
\[ = 119.7 \text{ kWh} \]

HEATING PENALTY

If electrically heated building:

\[ \Delta kWh_{\text{heatpenalty}} = \left( \frac{(\text{WattsBase}-\text{WattsEE})}{1000} \right) \times \text{ISR} \times \text{Hours} \times \text{-IFkWh} \]

Where:

- \text{IFkWh} = Lighting-HVAC Iteration Factor for electric heating impacts; this factor represents the increased electric space heating requirements due to the reduction of waste heat rejected by the efficient lighting. Values are provided in the Reference Table in Section 4.5. If unknown, use the Miscellaneous value.

EXAMPLE

For example, for a 14W 500 lumen R20 reflector lamp is installed in a heat pump heated office and sign off form provided.

\[ \Delta kWh_{\text{heatpenalty}} = \left( \frac{(45 - 14)}{1000} \right) \times 1.0 \times 3088 \times -0.183 \]
\[ = -17.5 \text{ kWh} \]

SUMMER COINCIDENT PEAK DEMAND SAVINGS

\[ \Delta kW = \left( \frac{(\text{WattsBase}-\text{WattsEE})}{1000} \right) \times \text{ISR} \times \text{WHFd} \times \text{CF} \]

Where:

- \text{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 4.5. If unknown, use the Miscellaneous value.

- \text{CF} = Summer Peak Coincidence Factor for measure is provided in the Reference Table in Section 4.5. If unknown, use the Miscellaneous value.

Other factors as defined above

\[ ^{611} \text{Negative value because this is an increase in heating consumption due to the efficient lighting.} \]
EXAMPLE

For example, for a 14W 500 lumen R20 reflector lamp is installed in an office and sign off form provided.

\[
\Delta kW = \frac{(45 - 14)}{1000} \times 1.0 \times 1.3 \times 0.66 \\
= 0.027 kW
\]

NATURAL GAS SAVINGS

Heating Penalty if fossil fuel heated building (or if heating fuel is unknown):

\[
\Delta \text{Therms} = \left(\frac{(\text{WattsBase} - \text{WattsEE})}{1000}\right) \times \text{ISR} \times \text{Hours} \times \text{IFTherms}
\]

Where:

\[
\text{IFTherms} = \text{Lighting-HVAC Interaction Factor for gas heating impacts; this factor represents the increased gas space heating requirements due to the reduction of waste heat rejected by the efficient lighting. Values are provided in the Reference Table in Section 4.5. If unknown, use the Miscellaneous value.}
\]

Other factors as defined above

EXAMPLE

For example, for a 14W 500 lumen R20 reflector lamp is installed in a gas heated office and sign off form provided.

\[
\Delta \text{Therms} = \left(\frac{(45 - 14)}{1000}\right) \times 1.0 \times 3088 \times -0.016 \\
= -1.5 \text{ Therms}
\]

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

The following O&M assumptions should be used: Life of the baseline bulb is assumed to be (1000/HOURS) year; baseline replacement cost is assumed to be $3.5 for those bulbs types exempt from EISA and $5 for non-exempt EISA bulb types defined above.

Measure Code: CI-LTG-SCFL-V01-150601

---

612 Negative value because this is an increase in heating consumption due to the efficient lighting.
613 NEEP Residential Lighting Survey, 2011
4.6 Refrigeration End Use

4.6.1 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.\(^{614}\)

**DEEMED MEASURE COST**

The deemed measure cost is $156.82 for a walk-in cooler or freezer.\(^{615}\)

**LOADSHAPE**

Loadshape C22 - Commercial Refrigeration

**COINCIDENCE FACTOR**

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

---

**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.\(^{616}\)

---

\(^{614}\) Source: DEER 2008

\(^{615}\) Ibid.

\(^{616}\) Measure savings from ComEd TRM developed by KEMA. June 1, 2010
### Illinois Statewide Technical Reference Manual - 4.6.1 Automatic Door Closer for Walk-In Coolers and Freezers

**Annual Savings kWh**

<table>
<thead>
<tr>
<th>Annual Savings</th>
<th>kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walk in Cooler</td>
<td>943</td>
</tr>
<tr>
<td>Walk in Freezer</td>
<td>2307</td>
</tr>
</tbody>
</table>

**Summer Coincident Peak Demand Savings**

<table>
<thead>
<tr>
<th>Annual Savings</th>
<th>kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walk in Cooler</td>
<td>0.137</td>
</tr>
<tr>
<td>Walk in Freezer</td>
<td>0.309</td>
</tr>
</tbody>
</table>

**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-V01-120601**
4.6.2 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 617.

DEEMED MEASURE COST

The actual measure installation cost should be used (including material and labor), but the following can be assumed for analysis purposes 618:

- Refrigerated Vending Machine and Glass Front Cooler: $180.00
- Non-Refrigerated Vending Machine: $80.00

LOADSHAPE

Loadshape C52 - Beverage and Snack Machine Controls

COINCIDENCE FACTOR

The summer peak coincidence factor for this measure is assumed to be 0 619.

---

618 ComEd workpapers, 8—15-11.pdf
619 Assumed that the peak period is coincident with periods of high traffic diminishing the demand reduction potential of occupancy based controls.
**Algorithm**

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

\[
\Delta \text{kWh} = \frac{\text{WATTs}_{\text{base}}}{1000} \times \text{HOURS} \times \text{ESF}
\]

Where:

- **WATTs\_base** = connected W of the controlled equipment; see table below for default values by connected equipment type:

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>WATTs_base</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refrigerated Beverage Vending Machines</td>
<td>400</td>
</tr>
<tr>
<td>Non-Refrigerated Snack Vending Machines</td>
<td>85</td>
</tr>
<tr>
<td>Glass Front Refrigerated Coolers</td>
<td>460</td>
</tr>
</tbody>
</table>

- 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:

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>Energy Savings Factor (ESF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refrigerated Beverage Vending Machines</td>
<td>46%</td>
</tr>
<tr>
<td>Non-Refrigerated Snack Vending Machines</td>
<td>46%</td>
</tr>
<tr>
<td>Glass Front Refrigerated Coolers</td>
<td>30%</td>
</tr>
</tbody>
</table>

**EXAMPLE**

For example, adding controls to a refrigerated beverage vending machine:

\[
\Delta \text{kWh} = \frac{\text{WATTs}_{\text{base}}}{1000} \times \text{HOURS} \times \text{ESF}
\]

\[
= \frac{400}{1000} \times 8766 \times 0.46
\]

\[= 1613 \text{kWh}\]

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

N/A

---


621 Ibid.
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-V02-150601
4.6.3 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 \(^{622}\).

**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 \(^{623}\).

**LOADSHAPE**

Loadshape C51 - Door Heater Control

**COINCIDENCE FACTOR** \(^{624}\)

The summer peak coincidence factor for this measure is assumed to be 0\% \(^{625}\).


\(^{624}\) Source partial list from DEER 2008

\(^{625}\) 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.
**Algorithm**

**Calculation of Savings**

**Electric Energy Savings**

\[ \Delta kWH = kWbase \times NUMdoors \times ESF \times BF \times 8766 \]

Where:

- **kWbase** = 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** = 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** = 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.

<table>
<thead>
<tr>
<th>Definition</th>
<th>Representative Evaporator Temperature Range, °F</th>
<th>Typical Uses</th>
<th>BF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>-35 to 0</td>
<td>Freezers for times such as frozen pizza, ice cream, etc.</td>
<td>1.36</td>
</tr>
<tr>
<td>Medium</td>
<td>0 – 20</td>
<td>Coolers for items such as meat, milk, dairy, etc</td>
<td>1.22</td>
</tr>
<tr>
<td>High</td>
<td>20 – 45</td>
<td>Coolers for items such as floral, produce and meat preparation rooms</td>
<td>1.15</td>
</tr>
</tbody>
</table>

8766 = annual hours of operation

---

626 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.

627 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.


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-V01-120601
4.6.4 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.630

DEEMED MEASURE COST

The measure cost is assumed to be $50 for a walk in cooler and walk in freezer.631

LOADSHAPE

Loadshape C22 - Commercial Refrigeration

COINCIDENCE FACTOR

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

Algorithm

CALCULATION OF SAVINGS632

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

630 DEER
following tables are values calculated within the SCE workpaper.

Table 156 SCE Restaurant Savings Walk-In

<table>
<thead>
<tr>
<th>SCE Workpaper Values</th>
<th>Northern California Climate Zones</th>
<th>kWh Savings Per Motor</th>
<th>Peak kW Savings Per Motor</th>
<th>kWh Savings Per Motor</th>
<th>Peak kW Savings Per Motor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Restaurant</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cooler</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freezeer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>318</td>
<td>0.0286</td>
<td>507</td>
<td>0.03</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>253</td>
<td>0.033</td>
<td>263</td>
<td>0.037</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>364</td>
<td>0.0315</td>
<td>649</td>
<td>0.034</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>365</td>
<td>0.0313</td>
<td>652</td>
<td>0.034</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>350</td>
<td>0.0305</td>
<td>605</td>
<td>0.033</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>410</td>
<td>0.0351</td>
<td>780</td>
<td>0.04</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>399</td>
<td>0.034</td>
<td>748</td>
<td>0.039</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>407</td>
<td>0.0342</td>
<td>771</td>
<td>0.039</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>354</td>
<td>0.0315</td>
<td>620</td>
<td>0.034</td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>358</td>
<td>0.0322</td>
<td>622</td>
<td>0.036</td>
<td></td>
</tr>
</tbody>
</table>

Table 157: SCE Grocery Savings Walk-In

<table>
<thead>
<tr>
<th>SCE Workpaper Values</th>
<th>Northern California Climate Zones</th>
<th>kWh Savings Per Motor</th>
<th>Peak kW Savings Per Motor</th>
<th>kWh Savings Per Motor</th>
<th>Peak kW Savings Per Motor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grocery</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cooler</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freezeer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>318</td>
<td>0.0284</td>
<td>438</td>
<td>0.03</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>252</td>
<td>0.0534</td>
<td>263</td>
<td>0.064</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>364</td>
<td>0.0486</td>
<td>552</td>
<td>0.056</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>365</td>
<td>0.048</td>
<td>553</td>
<td>0.055</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>349</td>
<td>0.0452</td>
<td>516</td>
<td>0.051</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>410</td>
<td>0.0601</td>
<td>656</td>
<td>0.074</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>398</td>
<td>0.0566</td>
<td>631</td>
<td>0.069</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>406</td>
<td>0.0574</td>
<td>649</td>
<td>0.07</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>354</td>
<td>0.0486</td>
<td>528</td>
<td>0.056</td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>357</td>
<td>0.0496</td>
<td>532</td>
<td>0.058</td>
<td></td>
</tr>
</tbody>
</table>
Electronically Commutated Motors (ECM) for Walk-in and Reach-in Coolers / Freezers

Table 158: SCE Grocery Savings Reach-In

<table>
<thead>
<tr>
<th>SCE Workpaper Values</th>
<th>Northern California Climate Zones</th>
<th>kWh Savings Per Motor</th>
<th>Peak kW Savings Per Motor</th>
<th>kWh Savings Per Motor</th>
<th>Peak kW Savings Per Motor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>306</td>
<td>0.031</td>
<td>362</td>
<td>0.031</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>269</td>
<td>0.033</td>
<td>273</td>
<td>0.035</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>331</td>
<td>0.032</td>
<td>421</td>
<td>0.034</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>332</td>
<td>0.032</td>
<td>422</td>
<td>0.034</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>323</td>
<td>0.032</td>
<td>402</td>
<td>0.033</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>357</td>
<td>0.034</td>
<td>476</td>
<td>0.037</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>350</td>
<td>0.034</td>
<td>462</td>
<td>0.036</td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>355</td>
<td>0.034</td>
<td>472</td>
<td>0.037</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>325</td>
<td>0.032</td>
<td>409</td>
<td>0.034</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>328</td>
<td>0.033</td>
<td>411</td>
<td>0.035</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Building type</th>
<th>kWh Savings/motor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Restaurant</td>
<td>411</td>
</tr>
<tr>
<td>Grocery</td>
<td>392</td>
</tr>
<tr>
<td>Average</td>
<td>401</td>
</tr>
</tbody>
</table>

**Summer Coincident Peak Demand Savings**

The following table provides the kW savings

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Peak kW Savings/motor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Restaurant</td>
<td>0.033</td>
</tr>
<tr>
<td>Grocery</td>
<td>0.051</td>
</tr>
<tr>
<td>Average</td>
<td>0.042</td>
</tr>
</tbody>
</table>

**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-V01-120601
4.6.5 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.

DEEMED MEASURE COST

The incremental cost of this measure is $500.

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

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 savings are calculated here.

ELECTRIC ENERGY SAVINGS

ENERGY STAR Vending Machine Savings

633 ENERGY STAR

634 ENERGY STAR

635 Savings from Vending Machine Calculator: http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=VMC
## 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-V02-150601

<table>
<thead>
<tr>
<th>Vending Machine Capacity (cans)</th>
<th>kWh Savings Per Machine w/o software</th>
<th>kWh Savings Per Machine w/ software</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;500</td>
<td>1,099</td>
<td>1,659</td>
</tr>
<tr>
<td>500 - 599</td>
<td>1,754</td>
<td>2,231</td>
</tr>
<tr>
<td>600 - 699</td>
<td>1,242</td>
<td>1,751</td>
</tr>
<tr>
<td>700 - 799</td>
<td>1,741</td>
<td>2,283</td>
</tr>
<tr>
<td>800+</td>
<td>713</td>
<td>1,288</td>
</tr>
<tr>
<td>Average</td>
<td>1,310</td>
<td>1,842</td>
</tr>
</tbody>
</table>
4.6.6 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.

**DEEMED MEASURE COST**

The measure cost is assumed to be $291.

**LOADSHAPE**

Loadshape C46 - Evaporator Fan Control

**COINCIDENCE FACTOR**

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

---

Algorithm

**CALCULATION OF SAVINGS**

Savings for this measure were obtained from the DEER database. 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

---

636 Source: DEER
637 Source: DEER
the fan is still assumed to operate even with the evaporator inactive.\textsuperscript{638}

**Electric Energy Savings**

DEER provides savings numbers for building vintages and grocery only. The numbers are averages of these vintages. We are assuming that this measure will be applicable for all building types. The DEER savings vary by climate zone between 476 and 483 kWh/motor. Climate zone most closely resembling IL are 1, 3, and 16. The simple average of the savings in those zones is given below.\textsuperscript{639}

\[ \Delta kWh = \text{Savings per motor} \times \text{motors} \]

Where:

- \( \text{Savings per motor} = 481 \text{ kWh} \)
- \( \text{motors} = \text{number of fan motors controlled} \)

**Summer Coincident Peak Demand Savings**

Using the same source and methodology as for \( \Delta kWh \):

\[ \Delta kW = 0.060 \text{ kW} \]

**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-EVPF-V02-140601

\textsuperscript{638} 2005 Database for Energy Efficiency Resources (DEER) Update Study Final Report

\textsuperscript{639} See “Ca Climate Zone Translation.docx” and “CDD Base 80 zone comparison.xlsx”
4.6.7 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\(^{640}\).

**Deemed Measure Cost**

The incremental capital cost for this measure is $286.16\(^{641}\).

**Loadshape**

Loadshape C22 - Commercial Refrigeration

**Coincidence Factor**

The summer peak coincidence factor for this measure is 100\%\(^{642}\).


\(^{641}\) Assume average walk in door size is 3.5 feet wide and 8 feet tall or 28 square feet. The reference for incremental cost is $10.22 per square foot of door opening (includes material and labor). 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, “Cost Values and Summary Documentation”, California Public Utilities Commission, December 16, 2008, Therefore incremental cost per door is $286.16

\(^{642}\) The summer coincident peak demand reduction is assumed as the total annual savings divided by the total number of hours per year, effectively assuming the average demand reduction is realized during the peak period. This is a reasonable assumption for refrigeration savings.
CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS\textsuperscript{643}

\[ \Delta \text{kWh} = 2,974 \text{ per freezer with curtains installed} \]
\[ = 422 \text{ per cooler with curtains installed} \]

SUMMER COINCIDENT PEAK DEMAND SAVINGS

\[ \Delta \text{kW} = \Delta \text{kWh} / 8766 \times \text{CF} \]
\[ = 0.34 \text{ for freezers} \]
\[ = 0.05 \text{ for coolers} \]

Where:
\[ 8766 = \text{hours per year} \]
\[ \text{CF} = \text{Summer Peak Coincidence Factor for the measure} \]
\[ = 1.0 \]

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-V03-150601

\textsuperscript{643} 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.
4.6.8 Refrigeration Economizers

**DESCRIPTION**
This measure applies to commercial walk in refrigeration systems and includes two components, outside air economizers and evaporator fan controllers. Economizers save energy by bringing in outside air when weather conditions allow, rather than operating the compressor. Walk-in refrigeration systems evaporator fans run almost all the time; 24 hrs/day, 365 days/yr. This is because they must run constantly to provide cooling when the compressor is running, and to provide air circulation when the compressor is not running. However, evaporator fans are a very inefficient method of providing air circulation. Installing an evaporator fan control system will turn off evaporator fans while the compressor is not running, and instead turn on an energy-efficient 35 watt fan to provide air circulation, resulting in significant energy savings. This measure allows for economizer systems with evaporator fan controls plus a circulation fan and without a circulation fan.

**DEFINITION OF EFFICIENT EQUIPMENT**
To qualify for this measure an economizer is installed on a walk in refrigeration system.

**DEFINITION OF BASELINE EQUIPMENT**
The baseline condition is a walk-in refrigeration system without an economizer

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**
The estimated life of this measure is 15 years.\(^{644}\)

**DEEMED MEASURE COST**
The installation cost for an economizer is $2,558.\(^{645}\)

**LOADSHAPE**
Loadshape C22 - Commercial Refrigeration

**COINCIDENCE FACTOR**
The summer peak coincidence factor for this measure is assumed to be 0%.\(^{646}\)

\(^{644}\) Estimated life from Efficiency Vermont TRM
\(^{645}\) Based on average of costs from Freeaire, Natural Cool, and Cooltrol economizer systems.
\(^{646}\) Based on the assumption that humidity levels will most likely be relatively high during the peak period, reducing the likelihood of demand savings.
Algorithm

**Calculation of Energy Savings**

**Electric Energy Savings**

Electric energy savings is calculated based on whether evaporator fans run all

- **With Fan Control Installed**

\[ \Delta \text{kWh} = \text{HP} \times \text{kWhCond} + [(kW_{\text{Evap}} \times n\text{Fans}) - kW_{\text{Circ}}] \times \text{Hours} \times \text{DCComp} \times BF - [kW_{\text{Econ}} \times DCE_{\text{Econ}} \times \text{Hours}] \]

- **Without Fan Control Installed**

\[ \Delta \text{kWh} = \text{HP} \times \text{kWhCond} - [kW_{\text{Econ}} \times DCE_{\text{Econ}} \times \text{Hours}] \]

Where:

- \( \text{HP} \) = Horsepower of Compressor. = actual installed

- \( \text{kWhCond} \) = Condensing unit savings, per hp. (value from savings table)

<table>
<thead>
<tr>
<th>Hermetic / Semi-Hermetic</th>
<th>Scroll</th>
<th>Discus</th>
</tr>
</thead>
<tbody>
<tr>
<td>kWh/HP</td>
<td>1,256</td>
<td>1,108</td>
</tr>
</tbody>
</table>

- \( \text{Hours} \) = Number of annual hours that economizer operates

<table>
<thead>
<tr>
<th>Region (city)</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Rockford)</td>
<td>2,376</td>
</tr>
<tr>
<td>2 (Chicago/O’Hare)</td>
<td>1,968</td>
</tr>
<tr>
<td>3 (Springfield)</td>
<td>1,728</td>
</tr>
<tr>
<td>4 (Bellevue)</td>
<td>1,488</td>
</tr>
<tr>
<td>5 (Marion)</td>
<td>1,224</td>
</tr>
</tbody>
</table>

- \( \text{DCComp} \) = Duty cycle of the compressor. = 50%

---

647 Savings table uses Economizer Calc.xls. Assume 5HP compressor size used to develop kWh/Hp value. No floating head pressure controls and compressor is located outdoors

648 In the source TRM (VT) this value was 2,996 hrs based on 38° F cooler setpoint, Burlington VT weather data, and 5 degree economizer deadband. The IL numbers were calculated by using weather bin data for each location (number of hours < 38F at each location is the Hours value).
kWEvap = Connected load kW of each evaporator fan,
= If known, actual installed. Otherwise assume 0.123 kW\(^{650}\)

kWCirc = Connected load kW of the circulating fan
= If known, actual installed. Otherwise assume 0.035 kW\(^{651}\)

nFans = Number of evaporator fans
= actual number of evaporator fans

DCEcon = Duty cycle of the economizer fan on days that are cool enough for the economizer to be working
= If known, actual installed. Otherwise assume 63%\(^{652}\)

BF = Bonus factor for reduced cooling load from running the evaporator fan less or (1.3)\(^{653}\)

kWEcon = Connected load kW of the economizer fan
= If known, actual installed. Otherwise assume 0.227 kW.\(^{654}\)

**EXAMPLE**

For example, adding an outdoor air economizer and fan controls in Rockford to a 5 hp walk in refrigeration unit with 3 evaporator fans would save:

\[
\Delta kW = \left[ \text{HP} \times \text{kWhCond} \right] + \left[ \left( (\text{kWEvap} \times n\text{Fans}) - \text{kWCirc} \right) \times \text{Hours} \times \text{DCComp} \times \text{BF} \right] - \left[ \text{kWEcon} \times \text{DCEcon} \times \text{Hours} \right]
\]

\[
= [5 \times 1256] + \left[ ((0.123 \times 3) - 0.035) \times 2376 \times 0.5 \times 1.3 \right] - \left[ 0.227 \times 0.63 \times 2376 \right]
\]

\[
= 6456 \text{ kWh}
\]

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

\[
\Delta kW = \Delta kWh / \text{Hours}
\]

**NATURAL GAS SAVINGS**

N/A

---

\(^{649}\) A 50% duty cycle is assumed based on examination of duty cycle assumptions from Richard Travers (35%-65%), Cooltrol (35%-65%), Natural Cool (70%), Pacific Gas & Electric (58%). Also, manufacturers typically size equipment with a built-in 67% duty factor and contractors typically add another 25% safety factor, which results in a 50% overall duty factor. (as referenced by the Efficiency Vermont, Technical Reference User Manual)

\(^{650}\) Wattage of fan used by Freeaire and Cooltrol. This fan is used to circulate air in the cooler when the evaporator fan is turned off. As such, it is not used when fan control is not present

\(^{651}\) Average of two manufacturer estimates of 50% and 75%.

\(^{652}\) Bonus factor (1+ 1/3.5) assumes COP of 3.5, based on the average of standard reciprocating and discus compressor efficiencies with a Saturated Suction Temperature of 20°F and a condensing temperature of 90°F

\(^{653}\) The 227 watts for an economizer is calculated from the average of three manufacturers: Freeaire (186 Watts), Cooltrol (285 Watts), and Natural Cool (218 Watts).
WATER IMPACT DESCRIPTIONS AND CALCULATION
N/A

DEEMED O&M COST ADJUSTMENT CALCULATION
N/A

MEASURE CODE: CI-RFG-ECON-V05-150601
4.6.9 Night Covers for Open Refrigerated Display Cases

**DESCRIPTION**

This measure is the installation of fitted covers on existing open-type refrigerated and freezer display cases that are deployed during the facility unoccupied hours. Night covers are designed to reduce refrigeration energy consumption by reducing the work done by the compressor. Night covers reduce the heat and moisture entry into the refrigerated space through various heat transfer mechanisms. By fully or partially covering the case opening, night covers reduce the convective heat transfer into the case through reduced air infiltration. Additionally, they provide a measure of insulation, reducing conduction into the case, and also decrease radiation into the case by blocking radiated heat from entering the refrigerated space.

**DEFINITION OF EFFICIENT EQUIPMENT**

Curtains or covers on top of open refrigerated or freezer display cases that are applied at least six hours (during off-hours) in a 24-hour period.

**DEFINITION OF BASELINE EQUIPMENT**

Refrigerated and freezer, open-type display case in vertical, semi-vertical, and horizontal displays, with no night cover.

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The measure life is 5 years, based on DEER 2014.\(^6\)

**DEEMED MEASURE COST**

The incremental capital cost for this measure is $42 per linear foot of cover installed including material and labor.\(^6\)

**LOADSHAPE**

Loadshape 22: Commercial Refrigeration

**COINCIDENCE FACTOR**

N/A – savings occur at night only.

---


Algorithm

**Calculation of Energy Savings**

**Electric Energy Savings**

\[ \Delta \text{kWh} = \text{ES} \times L \]

Where:

\[ \text{ES} \]

= the energy savings (\(\Delta\text{kWh}/\text{ft}\)) found in table below:

<table>
<thead>
<tr>
<th>Display Case Description</th>
<th>Case Temperature Range (°F)</th>
<th>Annual Electricity Use kWh/ft (^{657})</th>
<th>(\text{ES} \Delta\text{kWh}/\text{ft} \text{ reduction (}= 9% \text{ reduction of electricity use}^{658,659})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical Open, Remote Condensing, Medium Temperature</td>
<td>35°F to 55°F</td>
<td>1453</td>
<td>131</td>
</tr>
<tr>
<td>Vertical Open, Remote Condensing, Low Temperature</td>
<td>0°F to 30°F</td>
<td>3292</td>
<td>296</td>
</tr>
<tr>
<td>Vertical Open, Self-Contained Medium Temperature</td>
<td>35°F to 55°F</td>
<td>2800</td>
<td>252</td>
</tr>
<tr>
<td>Horizontal Open, Remote Condensing, Medium Temperature</td>
<td>35°F to 55°F</td>
<td>439</td>
<td>40</td>
</tr>
<tr>
<td>Horizontal Open, Remote Condensing, Low Temperature</td>
<td>0°F to 30°F</td>
<td>1007</td>
<td>91</td>
</tr>
<tr>
<td>Horizontal Open, Self-Contained, Medium Temperature</td>
<td>35°F to 55°F</td>
<td>1350</td>
<td>121</td>
</tr>
<tr>
<td>Horizontal Open, Self-Contained, Low Temperature</td>
<td>0°F to 30°F</td>
<td>2749</td>
<td>247</td>
</tr>
</tbody>
</table>

\[ L \]

= the length of the refrigerated case in linear feet

---

\(^{657}\) Energy Conservation Standards for Commercial Refrigeration Equipment: Technical Support Document, U.S. Department of Energy, September 2013. The information required to estimate annual energy savings for refrigerated display cases is taken from the 2013-2014 U.S. Department of Energy (DOE) energy conservation standard rulemaking for Commercial Refrigerated Equipment. During the rulemaking process, DOE estimates the energy savings specific to night covers through extensive simulation and energy models that are validated by both manufacturers of night covers and refrigerated cases. The information is also referenced from a study done by Southern California Edison and testing by Technischer Überwachungs-Verein Rheinland, which are used by DOE for the rulemaking process.


\(^{659}\) Technischer Überwachungs-Verein Rheinland E.V. Laboratory test results for energy savings on refrigerated dairy case, conducted for Econofrost.
= Actual

**Summer Coincident Peak Demand Savings**

Peak savings are null because savings occur at night only.

**Natural Gas Savings**

N/A

**Water Impact Descriptions and Calculation**

N/A

**Deemed O&M Cost Adjustment Calculation**

N/A

**Measure Code:** CI-RFG-NCOV-V01-150601
4.7 Miscellaneous End Use

4.7.1 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**

\[
\text{IncrementalCost (¢)} = (127 \times h_{\text{compressor}}) + 1446
\]

Where:

\[127\text{ and } 1446^{660}\] = compressor motor nominal hp to incremental cost conversion factor and offset

\[h_{\text{compressor}}\] = compressor motor nominal

**DEEMED O&M COST ADJUSTMENTS**

N/A

**LOADSHAPE**

Loadshape C35 - Industrial Process

**COINCIDENCE FACTOR**

The coincidence factor equals 0.95

---

\[660\text{ Conversion factor and offset based on a linear regression analysis of the relationship between air compressor motor nominal horsepower and incremental cost. Several Vermont vendors were surveyed to determine the cost of equipment. See “Compressed Air Analysis.xls” and “Compiled Data ReQuest Results.xls” for incremental cost details.}\]
Algorithm

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

\[ \Delta \text{kWh} = 0.9 \times \text{hp}_{\text{compressor}} \times \text{HOURS} \times (\text{CF}_b - \text{CF}_e) \]

Where:

- \( \Delta \text{kWh} \) = gross customer annual kWh savings for the measure
- \( \text{hp}_{\text{compressor}} \) = compressor motor nominal hp
- \( 0.9^{661} \) = compressor motor nominal hp to full load kW conversion factor
- \( \text{HOURS} \) = compressor total hours of operation below depending on shift

<table>
<thead>
<tr>
<th>Shift</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single shift (8/5)</td>
<td>1976 hours</td>
</tr>
<tr>
<td></td>
<td>7 AM – 3 PM, weekdays, minus some holidays and scheduled down time</td>
</tr>
<tr>
<td>2-shift (16/5)</td>
<td>3952 hours</td>
</tr>
<tr>
<td></td>
<td>7AM – 11 PM, weekdays, minus some holidays and scheduled down time</td>
</tr>
<tr>
<td>3-shift (24/5)</td>
<td>5928 hours</td>
</tr>
<tr>
<td></td>
<td>24 hours per day, weekdays, minus some holidays and scheduled down time</td>
</tr>
<tr>
<td>4-shift (24/7)</td>
<td>8320 hours</td>
</tr>
<tr>
<td></td>
<td>24 hours per day, 7 days a week minus some holidays and scheduled down time</td>
</tr>
</tbody>
</table>

- \( \text{CF}_b \) = baseline compressor factor\(^{662}\)
  - = 0.890
- \( \text{CF}_e \) = efficient compressor\(^{663}\)
  - = 0.705

\(^{661}\) 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”.

\(^{662}\) 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 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).

\(^{663}\) Ibid.
EXAMPLE
For example a VFD compressor with 10 HP operating in a 1 shift facility would save
\[ \Delta k\text{Wh} = 0.9 \times 10 \times 1976 \times (0.890 - 0.705) \]
\[ = 3290 \text{ kWh} \]

SUMMER COINCIDENT PEAK DEMAND SAVINGS
\[ \Delta \text{kW} = \frac{\Delta \text{kWh}}{\text{HOURS} \times \text{CF}} \]

EXAMPLE
For example a VFD compressor with 10 HP operating in a 1 shift facility would save
\[ \Delta \text{kW} = \frac{3290}{1976} \times 0.95 \]
\[ = 1.58 \text{ kW} \]

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-V01-120601
4.7.2 Compressed Air Low Pressure Drop Filters

**DESCRIPTION**

Low pressure drop filters remove solids and aerosols from compressed air systems with a longer life and lower pressure drop than standard coalescing filters, resulting in better efficiencies.

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 a low pressure drop filter with pressure drop not exceeding 1 psid when new and 3 psid at element change.

**DEFINITION OF BASELINE EQUIPMENT**

The baseline condition is a standard coalescing filter with a pressure drop of 3 psid when new and 5 or more at element change.

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

5 years

**DEEMED MEASURE COST**

The incremental cost for this measure is estimated to be $1000 Incremental cost per filter.

**LOADSHAPE**

Loadshape C35 - Industrial Process

**COINCIDENCE FACTOR**

The coincidence factor equals 0.95

---

**Algorithm**

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

\[
\Delta k\text{Wh} = (kW_{\text{typical}} \times \Delta P \times SF \times \text{Hours} / HP_{\text{typical}}) \times HP_{\text{real}}
\]

Where:

\[
kW_{\text{typical}} = \text{Adjusted compressor power (kW) based on typical compressor loading and operating profile. Use actual compressor control type if known:}
\]

---

664 Incremental cost research found in LPDF Costs.xlsx
### Compressor kW\textsubscript{typical}

<table>
<thead>
<tr>
<th>Control Type</th>
<th>kW\textsubscript{typical}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reciprocating - On/off Control</td>
<td>70.2</td>
</tr>
<tr>
<td>Reciprocating - Load/Unload</td>
<td>74.8</td>
</tr>
<tr>
<td>Screw - Load/Unload</td>
<td>82.3</td>
</tr>
<tr>
<td>Screw - Inlet Modulation</td>
<td>82.5</td>
</tr>
<tr>
<td>Screw - Inlet Modulation with Unloading</td>
<td>82.5</td>
</tr>
<tr>
<td>Screw - Variable Displacement</td>
<td>73.2</td>
</tr>
<tr>
<td>Screw - VFD</td>
<td>70.8</td>
</tr>
</tbody>
</table>

If the actual compressor control type is not known, then use a weighted average based on the following market assumptions:

<table>
<thead>
<tr>
<th>Control Type</th>
<th>Share %</th>
<th>kW\textsubscript{typical}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market share estimation for load/unload control compressors</td>
<td>40%</td>
<td>74.8</td>
</tr>
<tr>
<td>Market share estimation for modulation w/unloading control compressors</td>
<td>40%</td>
<td>82.5</td>
</tr>
<tr>
<td>Market share estimation for variable displacement control compressors</td>
<td>20%</td>
<td>73.2</td>
</tr>
</tbody>
</table>

Weighted Average 77.6

\[ \Delta P = \text{Reduced filter loss (psi)} \]
\[ \Delta P = 2 \text{ psi} \]

\[ SF = \text{% reduction in power per 2 psi reduction in system pressure is equal to 0.5\% reduction per 1 psi, or a Savings Factor of 0.005} \]

Hours = depending on shifts

Single shift (8/5) – 1976 hours (7 AM – 3 PM, weekdays, minus some holidays and scheduled down time) + 500 hrs maintenance = 2476 hrs

2-shift (16/5) – 3952 hours (7 AM – 11 PM, weekdays, minus some holidays and scheduled down time) + 500 hrs maintenance = 4452 hrs

---

665 See “Industrial System Standard Deemed Saving Analysis.xls”
666 See “Industrial System Standard Deemed Saving Analysis.xls”
667 Assumed pressure will be reduced from a roughly 3 psi pressure drop through a filter to less than 1 psi, for a 2 psi savings
3-shift (24/5) – 5928 hours (24 hours per day, weekdays, minus some holidays and scheduled down time) + 500 hrs maintenance = 6428 hrs

4-shift (24/7) – 8320 hours (24 hours per day, 7 days a week minus some holidays and scheduled down time)

\[
\begin{align*}
\text{HP}_{\text{typical}} & = \text{Nominal HP for typical compressor} = 100 \text{ hp}^{669} \\
\text{HP}_{\text{real}} & = \text{Total HP of real compressors distributing air through filter. This should include the total horsepower of the compressors that normally run through the filter, but not backup compressors}
\end{align*}
\]

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

\[\Delta kW = \Delta kWh / \text{HOURS} \times \text{CF}\]

**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-CALPDF-V01-140601**

---

669 Industrial System Standard Deemed Saving Analysis.xls
4.7.3 Compressed Air No-Loss Condensate Drains

**DESCRIPTION**

No-loss condensate drains remove condensate as needed without venting compressed air, resulting in less air demand and consequently better efficiency. Replacement or upgrades of existing no-loss drains are not eligible for the incentive.

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 installation of no-loss condensate drains.

**DEFINITION OF BASELINE EQUIPMENT**

The baseline condition is installation of standard condensate drains (open valve, timer, or both)

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

10 years

**DEEMED MEASURE COST**

$700 per drain

**LOADSHAPE**

Loadshape C35 - Industrial Process

**COINCIDENCE FACTOR**

The coincidence factor equals 0.95

---

**Algorithm**

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

\[
\Delta \text{kWh} = \text{CFM}_{\text{reduced}} \times \text{kW}_{\text{CFM}} \times \text{Hours}
\]

Where:

- \(\text{CFM}_{\text{reduced}}\) = Reduced air consumption (CFM) per drain
  
  \(\text{CFM}_{\text{reduced}} = 3 \text{ CFM}^{671}\)

- \(\text{kW}_{\text{CFM}}\) = System power reduction per reduced air demand (kw/CFM) depending on the type of

---

670 Based on empirical project data from ComEd Comprehensive Compressed Air Study program and VEIC review of pricing data found in CAS Cost Data.xls

671 Reduced CFM consumption is based on an a timer drain opening for 10 seconds every 300 seconds as the baseline. See “Industrial System Standard Deemed Saving Analysis.xls”
compressor control:

System Power Reduction per Reduced Air Demand\(^{672}\)

<table>
<thead>
<tr>
<th>Control Type</th>
<th>kW / CFM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reciprocating - On/off Control</td>
<td>0.184</td>
</tr>
<tr>
<td>Reciprocating - Load/Unload</td>
<td>0.136</td>
</tr>
<tr>
<td>Screw - Load/Unload</td>
<td>0.152</td>
</tr>
<tr>
<td>Screw - Inlet Modulation</td>
<td>0.055</td>
</tr>
<tr>
<td>Screw - Inlet Modulation w/ Unloading</td>
<td>0.055</td>
</tr>
<tr>
<td>Screw - Variable Displacement</td>
<td>0.153</td>
</tr>
<tr>
<td>Screw - VFD</td>
<td>0.178</td>
</tr>
</tbody>
</table>

Or if compressor control type is unknow, then a weighted average based on market share can be used:

<table>
<thead>
<tr>
<th>Control Type</th>
<th>Share %</th>
<th>kW / CFM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market share estimation for load/unload control compressors</td>
<td>40%</td>
<td>0.136</td>
</tr>
<tr>
<td>Market share estimation for modulation w/unloading control compressors</td>
<td>40%</td>
<td>0.055</td>
</tr>
<tr>
<td>Market share estimation for variable displacement control compressors</td>
<td>20%</td>
<td>0.153</td>
</tr>
<tr>
<td>Weighted Average</td>
<td></td>
<td>0.107</td>
</tr>
</tbody>
</table>

Hours = Compressed air system pressurized hours

=6136 hours\(^{673}\)

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

\[ \Delta kW = \Delta kWh / \text{HOURS} \times \text{CF} \]

**NATURAL GAS ENERGY SAVINGS**

N/A

\(^{672}\) Calculated based on the type of compressor control. This assumes the compressor will be between 40% and 100% capacity before and after the changes to the system demand. See “Industrial System Standard Deemed Saving Analysis.xls”

\(^{673}\) US DOE, Evaluation of the Compressed Air Challenge® Training Program, Page 19
WATER IMPACT DESCRIPTIONS AND CALCULATION
N/A

DEEMED O&M COST ADJUSTMENT CALCULATION
N/A

MEASURE CODE: CI-MSC-CANLCD-V01-140601
4.7.4 Pump Optimization

**DESCRIPTION**

Pump improvements can be done to optimize the design and control of centrifugal water pumping systems, including water solutions with freeze protection up to 15% concentration by volume. Other fluid and gas pumps cannot use this measure calculation. The measurement of energy and demand savings for commercial and industrial applications will vary with the type of pumping technology, operating hours, efficiency, and existing and proposed controls. Depending on the specific application slowing the pump, trimming or replacing the impeller may be suitable options for improving pumping efficiency. Pumps up to 40 HP are allowed to use this energy savings calculation. Larger motors should use a custom calculation (which may result in larger savings that this measure would claim).

**DEFINITION OF EFFICIENT EQUIPMENT**

In order for this characterization to apply, the efficient equipment is proven to be an optimized centrifugal pumping system meeting the applicable program efficiency requirements:

- Pump balancing valves no more than 15% throttled
- Balancing valves on at least one load 100% open.

**DEFINITION OF BASELINE EQUIPMENT**

In order for this characterization to apply, the baseline equipment is assumed to be the existing pumping system including existing controls and sequence of operations.

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The expected measure life is assumed to be 10 years.

**DEEMED MEASURE COST**

The incremental capital cost for this measure can vary considerably depending upon the strategy employed to achieve the required efficiency levels and should be determined on a site-specific basis.

**DEEMED O&M COST ADJUSTMENTS**

N/A

**COINCIDENCE FACTOR**

The summer peak coincidence factor for this measure is assumed to be 38%.

---


675 Summer Peak Coincidence Factor has been preserved from the “Technical Reference Manual” (TRM) for Ohio Senate Bill 221 Energy Efficiency and Conservation Program and 09-512-GE-UNC,” October 15, 2009. This is likely a conservative estimate, but is recommended for further study (as stated in the OH State TRM, page 269)
CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

\[ \Delta \text{kWh} = (\text{HP}_{\text{motor}} \times 0.746 \times \text{LF} / \eta_{\text{motor}}) \times \text{HOURS} \times \text{ESF} \]

Where:

- \( \text{HP}_{\text{motor}} \) = Installed nameplate motor horsepower
- \( \text{LF} / \eta_{\text{motor}} \) = Combined as a single factor since efficiency is a function of load
  - \( \eta_{\text{motor}} = 0.65 \) \(^{676}\)
  - LF = Load Factor; Ratio of the peak running load to the nameplate rating of the motor
- \( \text{HOURS} \) = Annual operating hours of the pump
- \( \text{ESF} \) = Energy Savings Factor; assume a value of 15% \(^{677}\).

---


\(^{677}\) Published estimates of typical pumping efficiency improvements range from 5 to 40%. For analysis purposes, assume 15%. United States Industrial Electric Motor Systems Market Opportunities Assessment December 2002, Table E-7, Page 18, [https://www1.eere.energy.gov/manufacturing/tech_assistance/pdfs/mtrmkt.pdf](https://www1.eere.energy.gov/manufacturing/tech_assistance/pdfs/mtrmkt.pdf)
**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

\[ \Delta kW = (HP_{motor} \times 0.746 \times (\frac{LF}{\eta_{motor}})) \times (ESF) \times CF \]

Where:

- \( CF \) = Summer Coincident Peak Factor for measure
- \( CF = 0.38 \) \(^{678}\)

**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-PMPO-V01-150601**

\(^{678}\) Summer Peak Coincidence Factor has been preserved from the “Technical Reference Manual” (TRM) for Ohio Senate Bill 221 Energy Efficiency and Conservation Program and 09-S12-GE-UNC,“ October 15, 2009. This is likely a conservative estimate, but is recommended for further study (as stated in the OH State TRM, page 269)
4.7.5 Efficient Compressed Air Nozzles

**DESCRIPTION**

This measure is for the replacement of standard air nozzle with high-efficiency air nozzle used in a compressed air system. High-efficiency air nozzles reduce the amount of air required to blow off parts or for drying. These nozzles utilize the Coandă effect to pull in free air to accomplish tasks with significantly less compressed air. High-efficiency nozzles often replace simple copper tubes. These nozzles have the added benefits of noise reduction and improved safety in systems with greater than 30 psig.

**DEFINITION OF EFFICIENT EQUIPMENT**

The high-efficiency air nozzle must meet the following specifications:

1. High-efficiency air nozzle must replace continuous open blow-offs
2. High-efficiency air nozzle must meet SCFM rating at 80psig less than or equal to: 1/8" 11 SCFM, 1/4" 29 SCFM, 5/16" 56 SCFM, 1/2" 140 SCFM.
3. Manufacturer’s specification sheet of the high-efficiency air nozzle must be provided along with the make and model

**DEFINITION OF BASELINE EQUIPMENT**

The baseline condition is a standard air nozzle

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The measure life is 15 years

**DEEMED MEASURE COST**

The estimated incremental measure costs are presented in the following table.

<table>
<thead>
<tr>
<th>Nozzle Diameter</th>
<th>1/8”</th>
<th>1/4”</th>
<th>5/16”</th>
<th>1/2”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average IMC</td>
<td>$42</td>
<td>$57</td>
<td>$87</td>
<td>$121</td>
</tr>
</tbody>
</table>

**LOADSHAPE**

Loadshape C35 - Industrial Process

**COINCIDENCE FACTOR**

The coincidence factor equals 0.95

---

Algorithm

Calculation of Energy Savings

Electric Energy Savings

\[ \Delta \text{kWh} = (\text{SCFM} \times \text{SCFM\%\,Reduced}) \times \text{kW/CFM} \times \%\text{USE} \times \text{HOURS} \]

Where:

- \( \text{SCFM} \) = Air flow through standard nozzle. Use actual rated flow at 80 psi if known. If unknown, the table below includes the CFM by orifice diameter.\(^{681, 682}\)

<table>
<thead>
<tr>
<th>Orifice Diameter</th>
<th>SCFM</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/8&quot;</td>
<td>21</td>
</tr>
<tr>
<td>1/4&quot;</td>
<td>58</td>
</tr>
<tr>
<td>5/16&quot;</td>
<td>113</td>
</tr>
<tr>
<td>1/2&quot;</td>
<td>280</td>
</tr>
</tbody>
</table>

- \( \text{SCFM\%\,Reduced} \) = Percent in reduction of air loss per nozzle. Estimated at 50\(^{683}\)

- \( \text{kW/CFM} \) = System power reduction per air demand (kW/CFM) depending on the type of air compressor found in table below.\(^{684}\)

<table>
<thead>
<tr>
<th>Air Compressor Type</th>
<th>( \Delta \text{kW/CFM} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reciprocating – On/off Control</td>
<td>0.18</td>
</tr>
<tr>
<td>Reciprocating – Load/Unload</td>
<td>0.14</td>
</tr>
<tr>
<td>Screw – Load/Unload</td>
<td>0.15</td>
</tr>
<tr>
<td>Screw – Inlet Modulation</td>
<td>0.06</td>
</tr>
<tr>
<td>Screw – Inlet Modulation w/ Unloading</td>
<td>0.06</td>
</tr>
<tr>
<td>Screw – Variable Displacement</td>
<td>0.15</td>
</tr>
<tr>
<td>Screw - VFD</td>
<td>0.18</td>
</tr>
</tbody>
</table>

- \( \%\text{USE} \) = percent of the compressor total operating hours that the nozzle is in use

---

\(^{681}\) Review of manufacturer’s information


\(^{683}\) Conservative estimate based on average values provided by the Compressed Air Challenge Training Program, Machinery’s Handbook 25th Edition, and manufacturers’ catalog.

\(^{684}\) Calculated based on the type of compressor control. This assumes the compressor will be between 40% and 100% capacity before and after the changes to the system demand. See “Industrial System Standard Deemed Saving Analysis.xls”
= Custom, if unknown assume 5% \(^{685}\)

Hours = Compressed air system pressurized hours.

= Use actual hours if known, otherwise assume values in table below:

<table>
<thead>
<tr>
<th>Shift</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Shift</td>
<td>1976</td>
</tr>
<tr>
<td>Two Shifts</td>
<td>3952</td>
</tr>
<tr>
<td>Three Shifts</td>
<td>5928</td>
</tr>
<tr>
<td>Four Shifts or Continual</td>
<td>8320</td>
</tr>
<tr>
<td>Operation</td>
<td></td>
</tr>
<tr>
<td>Unknown / Weighted average(^{686})</td>
<td>5702</td>
</tr>
</tbody>
</table>

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

\[ \Delta kW = \Delta kWh/\text{HOURS} \times CF \]

Where:

\[ \Delta kWh = \text{As calculated above} \]

\[ CF = 0.95 \]

**NATURAL GAS SAVINGS**

N/A

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-MSC-CNOZ-V01-150601**

\(^{685}\) Assumes 50% handheld air guns and 50% stationary air nozzles. Manual air guns tend to be used less than stationary air nozzles, and a conservative estimate of 1 second of blow-off per minute of compressor run time is assumed. Stationary air nozzles are commonly more wasteful as they are often mounted on machine tools and can be manually operated resulting in the possibility of a long term open blow situation. An assumption of 5 seconds of blow-off per minute of compressor run time is used.

\(^{686}\) Weighting of 16% single shift, 23% two shift, 25% three shift and 36% continual based on DOE evaluation of the Compressed Air Challenge, section 2.1.5 Facility Operating Schedules
4.7.6 Roof Insulation for C&I Facilities

**DESCRIPTION**

Energy and demand saving are realized through reductions in the building cooling and heating loads. This measure was developed to be applicable to the following program types: RF and NC.

If applied to other program types, the measure savings should be verified.

**DEFINITION OF EFFICIENT EQUIPMENT**

The efficient condition is above code and should be determined by the program. An example definition could be ASHRAE 90.1 – 2013 (see tables below):

<table>
<thead>
<tr>
<th></th>
<th>IL TRM Zones 1, 2, &amp; 3 [ASHRAE/IECC Climate Zone 5 (A, B, C)]</th>
<th></th>
<th>IL TRM Zones 4 &amp; 5 [ASHRAE/IECC Climate Zone 4 (A, B, C)]</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nonresidential</td>
<td>Semiheated</td>
<td>Nonresidential</td>
<td>Semiheated</td>
</tr>
<tr>
<td></td>
<td>Assembly Maximum</td>
<td>Insulation Min. R-Value</td>
<td>Assembly Maximum</td>
<td>Insulation Min. R-Value</td>
</tr>
<tr>
<td>Insulation Entirely Above Deck</td>
<td>0.032</td>
<td>R-30.0 c.i.</td>
<td>0.063</td>
<td>R-15 c.i.</td>
</tr>
<tr>
<td>Metal Building (Roof)</td>
<td>0.037</td>
<td>R-19 + R-11 Ls or R-25 + R-8 Ls</td>
<td>0.082</td>
<td>R-19</td>
</tr>
<tr>
<td>Attic and Other</td>
<td>0.021</td>
<td>R-49</td>
<td>0.034</td>
<td>R-30</td>
</tr>
</tbody>
</table>

**DEFINITION OF BASELINE EQUIPMENT**

The retrofit baseline condition is adopted from Ohio Energy Technical Reference Manual and expanded to cover all type of commercial buildings in the state of Illinois as follows.

For retrofits, the R-value for the entire assembly:

- Insulation Entirely Above Deck
  - IL TRM Zones 1, 2, & 3: 0.032 R-value
  - IL TRM Zones 4 & 5: 0.032 R-value

- Metal Building (Roof)
  - IL TRM Zones 1, 2, & 3: 0.037 R-value
  - IL TRM Zones 4 & 5: 0.037 R-value

- Attic and Other
  - IL TRM Zones 1, 2, & 3: 0.021 R-value
  - IL TRM Zones 4 & 5: 0.021 R-value

**Table Notes**

- c.i. = continuous insulation
- Ls = linear system, a continuous vapor barrier liner installed below the purlins and uninterrupted by framing members
<table>
<thead>
<tr>
<th>Building Type</th>
<th>Retrofit Assembly R-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assembly</td>
<td>13.5</td>
</tr>
<tr>
<td>Assisted Living</td>
<td>13.5</td>
</tr>
<tr>
<td>College</td>
<td>13.5</td>
</tr>
<tr>
<td>Convenience Store</td>
<td>13.5</td>
</tr>
<tr>
<td>Elementary School</td>
<td>13.5</td>
</tr>
<tr>
<td>Garage</td>
<td>13.5</td>
</tr>
<tr>
<td>Grocery</td>
<td>13.5</td>
</tr>
<tr>
<td>Healthcare Clinic</td>
<td>13.5</td>
</tr>
<tr>
<td>High School</td>
<td>13.5</td>
</tr>
<tr>
<td>Hospital</td>
<td>13.5</td>
</tr>
<tr>
<td>Hotel/Motel</td>
<td>13.5</td>
</tr>
<tr>
<td>Manufacturing Facility</td>
<td>12</td>
</tr>
<tr>
<td>MF - High Rise</td>
<td>13.5</td>
</tr>
<tr>
<td>MF - Mid Rise</td>
<td>13.5</td>
</tr>
<tr>
<td>Movie Theater</td>
<td>13.5</td>
</tr>
<tr>
<td>Office - High Rise</td>
<td>13.5</td>
</tr>
<tr>
<td>Office - Low Rise</td>
<td>13.5</td>
</tr>
<tr>
<td>Office - Mid Rise</td>
<td>13.5</td>
</tr>
<tr>
<td>Religious Building</td>
<td>13.5</td>
</tr>
<tr>
<td>Restaurant</td>
<td>13.5</td>
</tr>
<tr>
<td>Retail - Department Store</td>
<td>13.5</td>
</tr>
<tr>
<td>Retail - Strip Mall</td>
<td>13.5</td>
</tr>
<tr>
<td>Warehouse</td>
<td>12</td>
</tr>
<tr>
<td>Unknown</td>
<td>13.5</td>
</tr>
</tbody>
</table>
For new construction use IECC 2012 or ASHRAE – 90.1 – 2010 (listed below)

<table>
<thead>
<tr>
<th>IL TRM Zones 1, 2, &amp; 3 [ASHRAE/IECC Climate Zone 5 (A, B, C)]</th>
<th>Nonresidential</th>
<th>Semiheated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insulation Entirely Above Deck</td>
<td>Assembly Maximum</td>
<td>Assembly Maximum</td>
</tr>
<tr>
<td></td>
<td>0.048</td>
<td>R-20 c.i.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>U-0.119</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R-7.6 c.i.</td>
</tr>
<tr>
<td>Metal Building (Roof)</td>
<td>0.055</td>
<td>R-13.0 + R-13.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>U-0.083</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R-13.0</td>
</tr>
<tr>
<td>Attic and Other</td>
<td>0.027</td>
<td>R-38.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>U-0.053</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R-19.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>IL TRM Zones 4 &amp; 5 [ASHRAE/IECC Climate Zone 4 (A, B, C)]</th>
<th>Nonresidential</th>
<th>Semiheated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insulation Entirely Above Deck</td>
<td>Assembly Maximum</td>
<td>Assembly Max.</td>
</tr>
<tr>
<td></td>
<td>0.048</td>
<td>R-20.0 c.i.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.173</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R-5.0 c.i.</td>
</tr>
<tr>
<td>Metal Building (Roof)</td>
<td>0.055</td>
<td>R-13.0 + R-13.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.097</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R-10.0</td>
</tr>
<tr>
<td>Attic and Other</td>
<td>0.027</td>
<td>R-38.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.053</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R-19.0</td>
</tr>
</tbody>
</table>

**Table Notes**

- c.i. = continuous insulation
- Ls = linear system, a continuous vapor barrier liner installed below the purlins and uninterrupted by framing members

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The measure expected useful life (EUL) is assumed to be 20 years per DEER 2008. This is consistent with SDG&E’s 9th Year Measure Retrofit Study (1996 & 1997 Residential Weatherization Programs), CPUC’s Energy Efficiency Policy Manual v.2, and GDS’s Measure Life Report Residential and Commercial/Industrial Lighting and HVAC Measures (June 2007).

**DEEMED MEASURE COST**

Per the 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, “Cost Values and Summary Documentation”, the material cost for R-30 insulation is $0.75 per square foot. The installation cost is $0.61 per square foot. The total measure cost, therefore, is $1.36 per square foot of insulation installed. However, the actual cost should be used when available.

**LOADSHAPE**

Loadshape C03: Commercial Cooling
COINCIDENCE FACTOR

\[ CF_{SSP} = \text{Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)} \]
\[ = 91.3\% \]

\[ CF_{PJM} = \text{PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)} \]
\[ = 47.8\% \]

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS

Electric energy savings is calculated as the sum of energy saved when cooling the building and energy saved when heating the building

\[ \Delta kWh = \Delta kWh_{\text{cooling}} + \Delta kWh_{\text{heating}} \]

If central cooling, the electric energy saved in annual cooling due to the added insulation is

\[ \Delta kWh_{\text{cooling}} = \left(\frac{1}{R_{\text{existing}}} - \frac{1}{R_{\text{new}}}\right) \times \text{Area} \times EFLH_{\text{cooling}} \times \Delta T_{AVG,\text{cooling}} / 1,000 / \eta_{\text{cooling}} \]

Where:

\[ R_{\text{existing}} = \text{Roof heat loss coefficient with existing insulation [(hr-}^\circ\text{-F-}ft^2)/Btu]} \]

\[ R_{\text{new}} = \text{Roof heat loss coefficient with new insulation [(hr-}^\circ\text{-F-}ft^2)/Btu]} \]

\[ \text{Area} = \text{Area of the roof surface in square feet. Assume 1000 sq ft for planning.} \]

\[ EFLH_{\text{cooling}} = \text{Equivalent Full Load Hours for Cooling [hr] are provided in Section 4.4, HVAC end use} \]

\[ \Delta T_{AVG,\text{cooling}} = \text{Average temperature difference [}^\circ\text{F} \text{] during cooling season between outdoor air temperature and assumed 75}^\circ\text{F indoor air temperature} \]

---

\[ 687 \] 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.

\[ 688 \] 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.
### 4.7.6 Roof Insulation for C&I Facilities

<table>
<thead>
<tr>
<th>Climate Zone (City based upon)</th>
<th>OA$_{\text{AVG,cooling}}$ [°F]</th>
<th>ΔT$_{\text{AVG,cooling}}$ [°F]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Rockford)</td>
<td>81</td>
<td>6</td>
</tr>
<tr>
<td>2 (Chicago)</td>
<td>81</td>
<td>6</td>
</tr>
<tr>
<td>3 (Springfield)</td>
<td>81</td>
<td>6</td>
</tr>
<tr>
<td>4 (Belleville)</td>
<td>82</td>
<td>7</td>
</tr>
<tr>
<td>5 (Marion)</td>
<td>82</td>
<td>7</td>
</tr>
</tbody>
</table>

1,000 = Conversion from Btu to kBtu

η$_{\text{cooling}}$ = Seasonal energy efficiency ratio (SEER) of cooling system (kBtu/kWh). Use actual if possible, if unknown and for planning purposes assume the following:

<table>
<thead>
<tr>
<th>Year Equipment was Installed</th>
<th>SEER estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before 2006</td>
<td>10</td>
</tr>
<tr>
<td>After 2006</td>
<td>13</td>
</tr>
</tbody>
</table>

If the building is heated with electric heat (resistance or heat pump), the electric energy saved in annual heating due to the added insulation is

$$\Delta \text{kWh}_{\text{heating}} = \left[\frac{1}{R_{\text{existing}}} - \frac{1}{R_{\text{new}}}\right] \times \text{Area} \times \text{EFLH}_{\text{heating}} \times \Delta T_{\text{AVG,heating}} / 3,412 / \eta_{\text{heating}}$$

Where:

- EFLH$_{\text{heating}}$ = Equivalent Full Load Hours for Heating [hr] are provided in Section 4.4, HVAC end use
- ΔT$_{\text{AVG,heating}}$ = Average temperature difference [°F] during heating season between outdoor air temperature and assumed 55°F heating base temperature

<table>
<thead>
<tr>
<th>Climate Zone (City based upon)</th>
<th>OA$_{\text{AVG,heating}}$ [°F]</th>
<th>ΔT$_{\text{AVG,heating}}$ [°F]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Rockford)</td>
<td>32</td>
<td>23</td>
</tr>
<tr>
<td>2 (Chicago)</td>
<td>34</td>
<td>21</td>
</tr>
<tr>
<td>3 (Springfield)</td>
<td>35</td>
<td>20</td>
</tr>
</tbody>
</table>

---


Climate Zone (City based upon) | OA\textsubscript{AVG,heating} [°F] | ΔT\textsubscript{AVG,heating} [°F]  
--- | --- | ---  
4 (Belleville) | 36 | 19  
5 (Marion) | 39 | 16

3,142 = Conversion from Btu to kWh.  
η\textsubscript{heating} = Efficiency of heating system. Use actual efficiency. If not available refer to default table below.

| System Type | Age of Equipment | HSPF Estimate | η\textsubscript{Heat} (Effective COP Estimate) \((\text{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

If the building is heated with a gas furnace, there will be some electric savings in heating the building attributed to extra insulation since the furnace fans will run less.

$$\Delta \text{kWh}_\text{heating} = \Delta \text{Therms} \times \text{Fe} \times 29.3$$

Where:

\(\Delta \text{Therms}\) = Gas savings calculated with equation below.

\(\text{Fe}\) = Percentage of heating energy consumed by fans, assume 3.14%

29.3 = Conversion from therms to kWh

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

$$\Delta \text{kW} = (\Delta \text{kWh}_\text{cooling} / \text{EFLH}_\text{cooling}) \times \text{CF}_{SSP}$$

Where:

\(\text{EFLH}_\text{cooling}\) = Equivalent full load hours of air conditioning are provided in Section 4.4, HVAC end use

\(\text{CF}_{SSP}\) = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)
CF_{PJM} = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)

= 47.8% \(^{692}\)

**NATURAL GAS SAVINGS**

If building uses a gas furnace, the savings resulting from the insulation is calculated with the following formula.

\[
\Delta \text{Therms} = ((1/R_{\text{existing}}) - (1/R_{\text{new}})) \times \text{Area} \times \text{EFLH}_{\text{heating}} \times \Delta T_{AVG,heating} / 100,000 / \eta_{\text{heat}}
\]

Where:

- \(R_{\text{existing}}\) = Roof heat loss coefficient with existing insulation \([\text{hr}^{-1}\cdot°F^{-1}\cdot\text{ft}^2]/\text{Btu}\]
- \(R_{\text{new}}\) = Roof heat loss coefficient with new insulation \([\text{hr}^{-1}\cdot°F^{-1}\cdot\text{ft}^2]/\text{Btu}\]
- \(\text{Area}\) = Area of the roof surface in square feet. Assume 1000 sq ft for planning.
- \(\text{EFLH}_{\text{heating}}\) = Equivalent Full Load Hours for Heating are provided in Section 4.4, HVAC end use
- \(\Delta T_{AVG,heating}\) = Average temperature difference [°F] during heating season (see above)
- 100,000 = Conversion from BTUs to Therms
- \(\eta_{\text{heat}}\) = Efficiency of existing furnace. Assume 0.78 for planning purposes.

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-HVC-RINS-V01-150601**

---

\(^{691}\) 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.

\(^{692}\) 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.
4.7.7 Computer Power Management Software

**DESCRIPTION**

Computer power management software is installed on a network of computers. This is software which monitors and records computer and monitor usage, as well as allows centralized control of computer power management settings.

**DEFINITION OF EFFICIENT EQUIPMENT**

The efficient equipment is defined by the requirements listed below:

- Allow centralized control and override of computer power management settings of workstations which include both a computer monitor and CPU (i.e. a desktop or laptop computer on a distributed network)
- Be able to control on/off/sleep states on both the CPU and monitor according to the Network Administrator-defined schedules and apply power management policies to network groups
- Have capability to allow networked workstations to be remotely wakened from power-saving mode (e.g. for system maintenance or power/setting adjustments)
- Have capability to detect and monitor power management performance and generate energy savings reports
- Have capability to produce system reports to confirm the inventory and performance of equipment on which the software is installed.

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

**DEFINITION OF BASELINE EQUIPMENT**

Baseline is defined as a computer network without software enforcing the power management capabilities in existing computers and monitors.

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The expected measure life is five years.  

**DEEMED MEASURE COST**

The deemed measure cost is $29 per networked computer, including labor.

**LOADSHAPE**

Loadshape C21: Commercial Office Equipment.

---

693 The following reference uses 10 years, however, given the rapid changes in the technology industry, there is quite a lot of uncertainty about the measure life and a more conservative value was used (i.e. half the published measure life): Table VI.1: Dimetrosky, S., Luedtke, J. S., & Seiden, K. (2005). Surveyor Network Energy Manager: Market Progress Evaluation Report, No. 2 (Northwest Energy Efficiency Alliance report #E05-136). Portland, OR: Quantec LLC).

694 Work Paper WPSCNROE0003 Revision 1, Power Management Software for Networked Computers. Southern California Edison
**COINCIDENCE FACTOR**

NA

---

**Algorithm**

**CALCULATION OF ENERGY SAVINGS**

**ELECTRIC ENERGY SAVINGS**

\[ \Delta k\text{Wh} = W_{\text{savings}} \times W \]

Where:

- \( W_{\text{savings}} \) = annual energy savings per workstation
- \( W_{\text{savings}} = 200 \text{ kWh}^{695} \) for desktops, 50 kWh for laptops\(^{696}\)
- \( W_{\text{savings}} = \text{If unknown assume 161 kWh (based on 74% desktop and 26% laptop)}^{697}\)
- \( W \) = number of desktop or laptop workstations controlled by the power management software

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

NA

**NATURAL GAS SAVING**

NA

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

NA

**DEEMED O&M COST ADJUSTMENT CALCULATION**

Assumed to be $2/unit \(^{698}\)

---

\(^{695}\) Based on average energy savings/computer from the following sources:
- South California Edison, Work Paper WPSNROE0003 (200 kWh)
- Surveyor Network Energy Manager Evaluation Report, NEEA (68, 100, and 128kWh)
- Regional Technical Forum [http://rtf.nwcenter.org/measures/measure.asp?id=95](http://rtf.nwcenter.org/measures/measure.asp?id=95) (200 kWh)
- EnergySTAR Computer Power Management Savings Calculator (≈190 kWh for a mix of laptop/desktop and assuming 30% are already turned off at night)
- [http://www.energystar.gov/ia/products/power_mgt/LowCarbonIT SavingsCalc.xlsx?78c1-120e&78c1-120e](http://www.energystar.gov/ia/products/power_mgt/LowCarbonIT SavingsCalc.xlsx?78c1-120e&78c1-120e)


\(^{697}\) Based on PY6 ComEd Computer Software Program data showing a split of 74% desktop to 26% laptop.

MEASURE CODE: CI-MSC-CPMS-V01-150601

5 Residential Measures

5.1 Appliances End Use

5.1.1 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 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.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure life is assumed to be 9 years.

DEEMED MEASURE COST

The incremental cost for this measure is $70.

LOADSHAPE

Loadshape C53 - Flat

---

699 Measured according to the latest ANSI/AHAM AC-1 (AC-1) Standard
700 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.
702 Ibid
**COINCIDENCE FACTOR**

The summer peak coincidence factor for this measure is assumed to be 100% (the unit is assumed to be always on).

**Algorithm**

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

\[
\Delta k\text{Wh} = k\text{Wh}_{\text{base}} - k\text{Wh}_{\text{ESTAR}}
\]

Where:

- \(k\text{Wh}_{\text{BASE}}\) = Baseline kWh consumption per year\(^703\)
  - see table below
- \(k\text{Wh}_{\text{ESTAR}}\) = ENERGY STAR kWh consumption per year\(^704\)
  - see table below

<table>
<thead>
<tr>
<th>Clean Air Delivery Rate</th>
<th>Baseline Unit Energy Consumption (kWh/year)</th>
<th>ENERGY STAR Unit Energy Consumption (kWh/year)</th>
<th>(\Delta k\text{WH} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>CADR 51-100</td>
<td>596</td>
<td>329</td>
<td>268</td>
</tr>
<tr>
<td>CADR 101-150</td>
<td>1,072</td>
<td>548</td>
<td>525</td>
</tr>
<tr>
<td>CADR 151-200</td>
<td>1,480</td>
<td>767</td>
<td>714</td>
</tr>
<tr>
<td>CADR 201-250</td>
<td>1,887</td>
<td>986</td>
<td>902</td>
</tr>
<tr>
<td>CADR Over 250</td>
<td>1,641</td>
<td>1205</td>
<td>437</td>
</tr>
</tbody>
</table>

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

\[
\Delta kW = \Delta k\text{Wh}/\text{Hours} \times \text{CF}
\]

Where:

- \(\Delta k\text{Wh} \) = Gross customer annual kWh savings for the measure
- \(
\text{Hours}
\) = Average hours of use per year
  - 8766 hours\(^705\)

\(^703\) ENERGY STAR Qualified Room Air Cleaner Calculator, [http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorRoomAirCleaner.xls?8ed7-275b](http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorRoomAirCleaner.xls?8ed7-275b)

\(^704\) Ibid.

\(^705\) Consistent with ENERGY STAR Qualified Room Air Cleaner Calculator.
Illinois Statewide Technical Reference Manual - 5.1.1 ENERGY STAR Air Purifier/Cleaner

\[ \text{CF} = \text{Summer Peak Coincidence Factor for measure} \]
\[ = 1.0 \]

<table>
<thead>
<tr>
<th>Clean Air Delivery Rate</th>
<th>( \Delta kW )</th>
</tr>
</thead>
<tbody>
<tr>
<td>CADR 51-100</td>
<td>0.031</td>
</tr>
<tr>
<td>CADR 101-150</td>
<td>0.060</td>
</tr>
<tr>
<td>CADR 151-200</td>
<td>0.081</td>
</tr>
<tr>
<td>CADR 201-250</td>
<td>0.103</td>
</tr>
<tr>
<td>CADR Over 250</td>
<td>0.050</td>
</tr>
</tbody>
</table>

**NATURAL GAS SAVINGS**

N/A

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

There are no operation and maintenance cost adjustments for this measure.\(^{706}\)

**MEASURE CODE: RS-APL-ESAP-V01-120601**

\(^{706}\) 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.
5.1.2 ENERGY STAR and ENERGY STAR Most Efficient Clothes Washers

DESCRIPTION
This measure relates to the installation of a clothes washer meeting the ENERGY STAR, or ENERGY STAR Most Efficient 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 ENERGY STAR Most Efficient minimum qualifications, as required by the program.

DEFINITION OF BASELINE EQUIPMENT
The baseline condition is a standard sized clothes washer meeting the minimum federal baseline as of March 2015.

<table>
<thead>
<tr>
<th>Efficiency Level</th>
<th>Top loading &gt;2.5 Cu ft</th>
<th>Front loading &gt;2.5 Cu ft</th>
</tr>
</thead>
<tbody>
<tr>
<td>Federal Standard</td>
<td>1.29 IMEF, 8.4 IWF</td>
<td>1.84 IMEF, 4.7 IWF</td>
</tr>
<tr>
<td>ENERGY STAR</td>
<td>2.06 IMEF, 4.3 IWF</td>
<td>2.38 IMEF, 3.7 IWF</td>
</tr>
<tr>
<td>ENERGY STAR Most Efficient</td>
<td>2.76 IMEF, 3.5 IWF</td>
<td>2.74 IMEF, 3.2IWF</td>
</tr>
</tbody>
</table>

DEEMED LIFETIME OF EFFICIENT EQUIPMENT
The expected measure life is assumed to be 14 years.

DEEMED MEASURE COST
The incremental cost for an ENERGY STAR unit is assumed to be $65 and for an ENERGY STAR Most Efficient unit it is $210.

708 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
709 Cost estimates are based on Navigant analysis for the Department of Energy (see CW Analysis_09092014.xls). This analysis looked at incremental cost and shipment data from manufacturers and the Association of Home Appliance Manufacturers and
**DEEMED O&M COST ADJUSTMENTS**

N/A

**LOADSHAPE**

Loadshape R01 - Residential Clothes Washer

**COINCIDENCE FACTOR**

The coincidence factor for this measure is 3.8%\(^{710}\).

---

**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:

   \[ \text{MEF is the quotient of the capacity of the clothes container, } C, \text{ divided by the total clothes washer energy consumption per cycle, with such energy consumption expressed as the sum of the machine electrical energy consumption, } M, \text{ the hot water energy consumption, } E, \text{ and the energy required for removal of the remaining moisture in the wash load, } D. \]

   The hot water and dryer savings calculated here assumes electric DHW and Dryer (this will be separated in Step 2).

   \[ \text{IMEFsavings}^{712} = \text{Capacity} \times (1/\text{IMEFbase} - 1/\text{IMEFeff}) \times \text{Ncycles} \]

   Where

   - **Capacity** = Clothes Washer capacity (cubic feet)
     = Actual. If capacity is unknown assume 3.45 cubic feet \(^{713}\)
   - **IMEFbase** = Integrated Modified Energy Factor of baseline unit
     = 1.66\(^{714}\)

---

\(^{710}\)Calculated from Itron eShapes, 8760 hourly data by end use for Missouri, as provided by Ameren.

\(^{711}\)Definition provided on the Energy star website.

\(^{712}\)IMEFsavings represents total kWh only when water heating and drying are 100% electric.

\(^{713}\)Based on the average clothes washer volume of all units that pass the new Federal Standard on the California Energy Commission (CEC) database of Clothes Washer products accessed on 08/28/2014. 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.

\(^{714}\)Weighted average IMEF of Federal Standard rating for Front Loading and Top Loading units. Weighting is based upon the relative top v front loading percentage of available non-ENERGY STAR product in the CEC database.
IMEF_{eff} = \text{Integrated Modified Energy Factor of efficient unit}

\text{IMEF}_{base} = \text{Actual. If unknown assume average values provided below.}

N_{cycles} = \text{Number of Cycles per year}

\text{IMEF}_{eff} = 295^{715}

\text{IMEF}_{savings} \text{ is provided below based on deemed values}^{716}:

<table>
<thead>
<tr>
<th>Efficiency Level</th>
<th>IMEF</th>
<th>IMEF_{savings} (kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Federal Standard</td>
<td>1.66</td>
<td>0.0</td>
</tr>
<tr>
<td>Energy Star ENERGY STAR</td>
<td>2.26</td>
<td>163</td>
</tr>
<tr>
<td>ENERGY STAR Most Efficient</td>
<td>2.74</td>
<td>242</td>
</tr>
</tbody>
</table>

2. Break out savings calculated in Step 1 for electric DHW and electric dryer

\[ \Delta kWh = \left[ (\text{Capacity} \times \frac{1}{\text{IMEF}_{base}} \times N_{cycles}) \times (\%\text{CW}_{base} + (\%\text{DHW}_{base} \times \%\text{Electric_DHW}) + (\%\text{Dryer}_{base} \times \%\text{Electric_Dryer}) \right] - \left[ (\text{Capacity} \times \frac{1}{\text{IMEF}_{eff}} \times N_{cycles}) \times (\%\text{CW}_{eff} + (\%\text{DHW}_{eff} \times \%\text{Electric_DHW}) + (\%\text{Dryer}_{eff} \times \%\text{Electric_Dryer}) \right] \]

Where:

\%\text{CW} = \text{Percentage of total energy consumption for Clothes Washer operation (different for baseline and efficient unit – see table below)}

\%\text{DHW} = \text{Percentage of total energy consumption used for water heating (different for baseline and efficient unit – see table below)}

\%\text{Dryer} = \text{Percentage of total energy consumption for dryer operation (different for baseline and efficient unit – see table below)}

---

715 Weighted average of 295 clothes washer cycles per year (based on 2009 Residential Energy Consumption Survey (RECS) national sample survey of housing appliances section, state of IL: [http://www.eia.gov/consumption/residential/data/2009/](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.

716 IMEF values are the weighted average of the new ENERGY STAR specifications. Weighting is based upon the relative top v front loading percentage of available ENERGY STAR and ENERGY STAR Most Efficient product in the CEC database. See “CW Analysis_09092014.xls” for the calculation.

717 The percentage of total energy consumption that is used for the machine, heating the hot water or by the dryer is different.
Using the default assumptions provided above, the prescriptive savings for each configuration are presented below:

<table>
<thead>
<tr>
<th></th>
<th>ΔkWH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Electric DHW</td>
</tr>
<tr>
<td>Electric Dryer</td>
<td>162.7</td>
</tr>
<tr>
<td>Electric</td>
<td>162.7</td>
</tr>
<tr>
<td>Gas</td>
<td>77.0</td>
</tr>
<tr>
<td>Gas Dryer</td>
<td>96.0</td>
</tr>
<tr>
<td>Gas Dryer</td>
<td>10.2</td>
</tr>
<tr>
<td>ENERGY STAR</td>
<td>242.1</td>
</tr>
<tr>
<td>ENERGY STAR</td>
<td>242.1</td>
</tr>
<tr>
<td>Most Efficient</td>
<td>88.2</td>
</tr>
<tr>
<td>Electric</td>
<td>149.9</td>
</tr>
<tr>
<td>Gas Dryer</td>
<td>-4.0</td>
</tr>
</tbody>
</table>


**DHW fuel**

<table>
<thead>
<tr>
<th>Fuel</th>
<th>%Electric_DHWH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric</td>
<td>100%</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>0%</td>
</tr>
<tr>
<td>Unknown</td>
<td>16%</td>
</tr>
</tbody>
</table>

**Dryer fuel**

<table>
<thead>
<tr>
<th>Fuel</th>
<th>%Electric_DHWH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric</td>
<td>100%</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>0%</td>
</tr>
<tr>
<td>Unknown</td>
<td>27%</td>
</tr>
</tbody>
</table>

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.

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.
If the DHW and dryer fuel is unknown the prescriptive kWh savings based on defaults provided above should be:

<table>
<thead>
<tr>
<th></th>
<th>ΔkWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENERGY STAR</td>
<td>42.0</td>
</tr>
<tr>
<td>ENERGY STAR Most Efficient</td>
<td>45.5</td>
</tr>
</tbody>
</table>

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

\[ \Delta kW = \frac{\Delta kWh}{\text{Hours}} \times \text{CF} \]

Where:

- \( \Delta kWh \) = Energy Savings as calculated above
- \( \text{Hours} \) = Assumed Run hours of Clothes Washer
  
  = 295 hours\textsuperscript{720}
- \( \text{CF} \) = Summer Peak Coincidence Factor for measure.
  
  = 0.038\textsuperscript{721}

Using the default assumptions provided above, the prescriptive savings for each configuration are presented below:

<table>
<thead>
<tr>
<th></th>
<th>ΔkW</th>
<th>ΔkW</th>
<th>ΔkW</th>
<th>ΔkW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric DHW</td>
<td>0.021</td>
<td>0.010</td>
<td>0.012</td>
<td>0.0013</td>
</tr>
<tr>
<td>Electric Dryer</td>
<td>0.031</td>
<td>0.011</td>
<td>0.019</td>
<td>0.001</td>
</tr>
<tr>
<td>Gas DHW</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas Dryer</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENERGY STAR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENERGY STAR Most Efficient</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If the DHW and dryer fuel is unknown the prescriptive kW savings should be:

\[ \Delta kW \]

\textsuperscript{720} 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/)

\textsuperscript{721} Calculated from Itron eShapes, 8760 hourly data by end use for Missouri, as provided by Ameren.
### 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:

\[
\Delta \text{Therm} = \left( \text{Capacity} \times \frac{1}{\text{IMEFbase}} \times \text{Ncycles} \right) \times \left( \frac{\%\text{DHWbase} \times \%\text{Natural Gas\_DHW} \times \text{R\_eff}}{1} \right) + \left( \frac{\%\text{Dryerbase} \times \%\text{Gas\_Dryer}}{1} \right) - \left( \text{Capacity} \times \frac{1}{\text{IMEFeff}} \times \text{Ncycles} \right) \times \left( \frac{\%\text{DHWeff} \times \%\text{Natural Gas\_DHW} \times \text{R\_eff}}{1} \right) + \left( \frac{\%\text{Dryereff} \times \%\text{Gas\_Dryer}}{1} \right) \times \text{Therm\_convert}
\]

Where:

- \( \text{Therm\_convert} = \) Conversion factor from kWh to Therm
  \[= 0.03413 \]
- \( \text{R\_eff} = \) Recovery efficiency factor
  \[= 1.26^{722} \]
- \( \%\text{Natural Gas\_DHW} = \) Percentage of DHW savings assumed to be Natural Gas
  
<table>
<thead>
<tr>
<th>DHW fuel</th>
<th>%Natural Gas_DHW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric</td>
<td>0%</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>100%</td>
</tr>
<tr>
<td>Unknown</td>
<td>84%^{723}</td>
</tr>
</tbody>
</table>

- \( \%\text{Gas\_Dryer} = \) Percentage of dryer savings assumed to be Natural Gas

<table>
<thead>
<tr>
<th>Dryer fuel</th>
<th>%Gas_Dryer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric</td>
<td>100%</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>0%</td>
</tr>
</tbody>
</table>

^{722} 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](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.

^{723} 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.
Other factors as defined above

Using the default assumptions provided above, the prescriptive savings for each configuration are presented below:

<table>
<thead>
<tr>
<th>Dryer fuel</th>
<th>%Gas_Dryer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unknown</td>
<td>44%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ΔTherms</th>
<th>Electric DHW</th>
<th>Gas DHW</th>
<th>Electric DHW</th>
<th>Gas DHW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric Dryer</td>
<td>0.00</td>
<td>3.7</td>
<td>2.3</td>
<td>6.0</td>
</tr>
<tr>
<td>Gas DHW</td>
<td>6.6</td>
<td>3.1</td>
<td>9.8</td>
<td></td>
</tr>
</tbody>
</table>

If the DHW and dryer fuel is unknown the prescriptive Therm savings should be:

<table>
<thead>
<tr>
<th>ΔTherms</th>
<th>ENERGY STAR</th>
<th>ENERGY STAR Most Efficient</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4.10</td>
<td>6.94</td>
</tr>
</tbody>
</table>

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

\[ \Delta \text{Water (gallons)} = (\text{Capacity} \times (\text{IWFbase} - \text{IWFeff})) \times \text{Ncycles} \]

Where

\[ \text{IWFbase} = \text{Integrated Water Factor of baseline clothes washer} \]
\[ = 5.92^{725} \]

\[ \text{IWFeff} = \text{Water Factor of efficient clothes washer} \]
\[ = \text{Actual. If unknown assume average values provided below.} \]

Using the default assumptions provided above, the prescriptive water savings for each efficiency level are presented below:

---

724 Ibid.
725 Weighted average IWF of Federal Standard rating for Front Loading and Top Loading units. Weighting is based upon the relative top v front loading percentage of available non-ENERGY STAR product in the CEC database.
<table>
<thead>
<tr>
<th>Efficiency Level</th>
<th>IWF&lt;sup&gt;726&lt;/sup&gt;</th>
<th>ΔWater (gallons per year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Federal Standard</td>
<td>5.92</td>
<td>0.0</td>
</tr>
<tr>
<td>ENERGY STAR</td>
<td>3.93</td>
<td>2024</td>
</tr>
<tr>
<td>ENERGY STAR Most Efficient</td>
<td>3.21</td>
<td>2760</td>
</tr>
</tbody>
</table>

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: RS-APL-ESCL-V03-150601**

---

<sup>726</sup> IWF values are the weighted average of the new ENERGY STAR specifications. Weighting is based upon the relative top v front loading percentage of available ENERGY STAR and ENERGY STAR Most Efficient product in the CEC database. See “CW Analysis_09092014.xls” for the calculation.
5.1.3 ENERGY STAR Dehumidifier

**DESCRIPTION**

A dehumidifier meeting the minimum qualifying efficiency standard established by the current ENERGY STAR (Version 2.1 or 3.0)\(^727\) 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:

<table>
<thead>
<tr>
<th>Capacity (pints/day)</th>
<th>ENERGY STAR Criteria (L/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤25</td>
<td>≥1.20</td>
</tr>
<tr>
<td>&gt; 25 to ≤35</td>
<td>≥1.40</td>
</tr>
<tr>
<td>&gt; 35 to ≤45</td>
<td>≥1.50</td>
</tr>
<tr>
<td>&gt; 45 to ≤54</td>
<td>≥1.60</td>
</tr>
<tr>
<td>&gt; 54 to ≤75</td>
<td>≥1.80</td>
</tr>
<tr>
<td>&gt; 75 to ≤185</td>
<td>≥2.50</td>
</tr>
</tbody>
</table>

After 10/1/2012\(^728\):

<table>
<thead>
<tr>
<th>Capacity (pints/day)</th>
<th>ENERGY STAR Criteria (L/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;75</td>
<td>≥1.85</td>
</tr>
<tr>
<td>75 to ≤185</td>
<td>≥2.80</td>
</tr>
</tbody>
</table>

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. The Federal Standard for Dehumidifiers changed as of October 2012 as defined below:

---

\(^{727}\) Energy Star Version 3.0 will become effective 10/1/12

Until 9/30/2012:

<table>
<thead>
<tr>
<th>Capacity (pints/day)</th>
<th>Federal Standard Criteria (L/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤25</td>
<td>≥1.0</td>
</tr>
<tr>
<td>&gt; 25 to ≤35</td>
<td>≥1.20</td>
</tr>
<tr>
<td>&gt; 35 to ≤45</td>
<td>≥1.30</td>
</tr>
<tr>
<td>&gt; 45 to ≤54</td>
<td>≥1.30</td>
</tr>
<tr>
<td>&gt; 54 to ≤75</td>
<td>≥1.50</td>
</tr>
<tr>
<td>&gt; 75 to ≤185</td>
<td>≥2.25</td>
</tr>
</tbody>
</table>

Post 10/1/2013

<table>
<thead>
<tr>
<th>Capacity (pints/day)</th>
<th>Federal Standard Criteria (L/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 35</td>
<td>≥1.35</td>
</tr>
<tr>
<td>&gt; 35 to ≤45</td>
<td>≥1.50</td>
</tr>
<tr>
<td>&gt; 45 to ≤54</td>
<td>≥1.60</td>
</tr>
<tr>
<td>&gt; 54 to ≤75</td>
<td>≥1.70</td>
</tr>
<tr>
<td>&gt; 75 to ≤185</td>
<td>≥2.50</td>
</tr>
</tbody>
</table>

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The assumed lifetime of the measure is 12 years.\(^{730}\)

**DEEMED MEASURE COST**

The assumed incremental capital cost for this measure is $40 for units purchased prior to 10/1/2012 and $60 for units purchased after 10/1/2012\(^{731}\).


\(^{730}\) ENERGY STAR Dehumidifier Calculator http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDehumidifier.xls

LOADSHAPE

Loadshape R12 - Residential - Dehumidifier

COINCIDENCE FACTOR

The coincidence factor is assumed to be 37% \(^{732}\).

<table>
<thead>
<tr>
<th>Algorithm</th>
</tr>
</thead>
</table>

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

\[
\Delta \text{kWh} = \left( \frac{\text{Avg Capacity} \times 0.473}{24} \right) \times \text{Hours} \times \left( \frac{1}{\text{L/kWh\_Base}} - \frac{1}{\text{L/kWh\_Eff}} \right)
\]

Where:

- 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 \(^{733}\)

- 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):

<table>
<thead>
<tr>
<th>Capacity (pints/day) Range</th>
<th>Capacity Used</th>
<th>(≥ L/kWh)</th>
<th>(≥ L/kWh)</th>
<th>Federal Standard Criteria</th>
<th>ENERGY STAR Criteria</th>
<th>Federal Standard</th>
<th>ENERGY STAR</th>
<th>Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤25</td>
<td>20</td>
<td>1.0</td>
<td>1.2</td>
<td>643</td>
<td>536</td>
<td>1620</td>
<td>536</td>
<td>107</td>
</tr>
<tr>
<td>&gt; 25 to ≤35</td>
<td>30</td>
<td>1.2</td>
<td>1.4</td>
<td>804</td>
<td>689</td>
<td>1620</td>
<td>689</td>
<td>115</td>
</tr>
<tr>
<td>&gt; 35 to ≤45</td>
<td>40</td>
<td>1.3</td>
<td>1.5</td>
<td>990</td>
<td>858</td>
<td>1620</td>
<td>858</td>
<td>132</td>
</tr>
<tr>
<td>&gt; 45 to ≤54</td>
<td>50</td>
<td>1.3</td>
<td>1.6</td>
<td>1237</td>
<td>1005</td>
<td>1620</td>
<td>1005</td>
<td>232</td>
</tr>
<tr>
<td>&gt; 54 to ≤75</td>
<td>65</td>
<td>1.5</td>
<td>1.8</td>
<td>1394</td>
<td>1161</td>
<td>1620</td>
<td>1161</td>
<td>232</td>
</tr>
</tbody>
</table>

\(^{732}\) 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%

\(^{733}\) ENERGY STAR Dehumidifier Calculator

### Annual kWh

<table>
<thead>
<tr>
<th>Capacity Used (pints/day) Range</th>
<th>(≥ L/kWh)</th>
<th>(≥ L/kWh)</th>
<th>Federal Standard Criteria</th>
<th>ENERGY STAR Criteria</th>
<th>Federal Standard Annual kWh</th>
<th>ENERGY STAR Annual kWh</th>
<th>Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 75 to ≤ 185</td>
<td>130</td>
<td>2.25</td>
<td>2.5</td>
<td>1858</td>
<td>1673</td>
<td>186</td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>46</td>
<td>1.31</td>
<td>1.55</td>
<td>1129</td>
<td>953</td>
<td>176</td>
<td></td>
</tr>
</tbody>
</table>

### After 10/1/2012 (V 3.0):

<table>
<thead>
<tr>
<th>Capacity Used (pints/day) Range</th>
<th>(≥ L/kWh)</th>
<th>(≥ L/kWh)</th>
<th>Federal Standard Criteria</th>
<th>ENERGY STAR Criteria</th>
<th>Federal Standard Annual kWh</th>
<th>ENERGY STAR Annual kWh</th>
<th>Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤25</td>
<td>20</td>
<td>1.35</td>
<td>1.85</td>
<td>477</td>
<td>348</td>
<td>129</td>
<td></td>
</tr>
<tr>
<td>&gt; 25 to ≤35</td>
<td>30</td>
<td>1.35</td>
<td>1.85</td>
<td>715</td>
<td>522</td>
<td>193</td>
<td></td>
</tr>
<tr>
<td>&gt; 35 to ≤45</td>
<td>40</td>
<td>1.5</td>
<td>1.85</td>
<td>858</td>
<td>695</td>
<td>162</td>
<td></td>
</tr>
<tr>
<td>&gt; 45 to ≤54</td>
<td>50</td>
<td>1.6</td>
<td>1.85</td>
<td>1005</td>
<td>869</td>
<td>136</td>
<td></td>
</tr>
<tr>
<td>&gt; 54 to ≤75</td>
<td>65</td>
<td>1.7</td>
<td>1.85</td>
<td>1230</td>
<td>1130</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>&gt; 75 to ≤185</td>
<td>130</td>
<td>2.5</td>
<td>2.8</td>
<td>1673</td>
<td>1493</td>
<td>179</td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>46</td>
<td>1.51</td>
<td>1.85</td>
<td>983</td>
<td>800</td>
<td>183</td>
<td></td>
</tr>
</tbody>
</table>

### Summer Coincident Peak Demand Savings

\[ \Delta kW = \Delta kWh/\text{Hours} \times CF \]

Where:

- **Hours** = Annual operating hours
- **CF** = Summer Peak Coincidence Factor for measure

\[ \text{Hours} = 1632 \text{ hours} \]
\[ \text{CF} = 0.37 \]

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

---

734 Based on 68 days of 24 hour operation; ENERGY STAR Dehumidifier Calculator: [http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/appliance_calculator.xlsx?f3f7-6a8b&f3f7-6a8b](http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/appliance_calculator.xlsx?f3f7-6a8b&f3f7-6a8b)

735 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%
Until 9/30/2012 (V 2.1):

<table>
<thead>
<tr>
<th>Capacity (pints/day) Range</th>
<th>Annual Summer peak kW Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤25</td>
<td>0.024</td>
</tr>
<tr>
<td>&gt; 25 to ≤35</td>
<td>0.026</td>
</tr>
<tr>
<td>&gt; 35 to ≤45</td>
<td>0.030</td>
</tr>
<tr>
<td>&gt; 45 to ≤54</td>
<td>0.053</td>
</tr>
<tr>
<td>&gt; 54 to ≤75</td>
<td>0.053</td>
</tr>
<tr>
<td>&gt; 75 to ≤185</td>
<td>0.042</td>
</tr>
<tr>
<td>Average</td>
<td>0.040</td>
</tr>
</tbody>
</table>

After 10/1/2012 (V 3.0):

<table>
<thead>
<tr>
<th>Capacity (pints/day) Range</th>
<th>Annual Summer peak kW Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤25</td>
<td>0.029</td>
</tr>
<tr>
<td>&gt; 25 to ≤35</td>
<td>0.044</td>
</tr>
<tr>
<td>&gt; 35 to ≤45</td>
<td>0.037</td>
</tr>
<tr>
<td>&gt; 45 to ≤54</td>
<td>0.031</td>
</tr>
<tr>
<td>&gt; 54 to ≤75</td>
<td>0.023</td>
</tr>
<tr>
<td>&gt; 75 to ≤185</td>
<td>0.041</td>
</tr>
<tr>
<td>Average</td>
<td>0.042</td>
</tr>
</tbody>
</table>

**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-V02-130601
5.1.4 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 is only for standard dishwashers, not compact dishwashers. A compact dishwasher is a unit that holds less than eight place settings with six serving pieces.

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 dishwashers\(^\text{736}\)). The Energy Star standard is presented in the table below:

<table>
<thead>
<tr>
<th>Dishwasher Type</th>
<th>Maximum kWh/year</th>
<th>Maximum gallons/cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>295</td>
<td>4.25</td>
</tr>
</tbody>
</table>

**DEFINITION OF BASELINE EQUIPMENT**

The Baseline reflects the minimum federal efficiency standards for dishwashers effective May 30, 2013, as presented in the table below\(^\text{737}\).

<table>
<thead>
<tr>
<th>Dishwasher Type</th>
<th>Maximum kWh/year</th>
<th>Maximum gallons/cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>307</td>
<td>5.0</td>
</tr>
</tbody>
</table>

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The assumed lifetime of the measure is 13 years\(^\text{738}\).

**DEEMED MEASURE COST**

The incremental cost for this measure is $50\(^\text{739}\).

**LOADSHAPE**

Loadshape R02 - Residential Dish Washer

**COINCIDENCE FACTOR**

The coincidence factor is assumed to be 2.6%\(^\text{740}\).
CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

\[ \Delta k\text{Wh} = (((kWh_{base} - kWh_{ESTAR}) \times (%kWh_{op} + (%kWh_{heat} \times %Electric_{DHW}))) \]

Where:

- \( kWh_{base} \): Baseline kWh consumption per year
  - = 307 kWh
- \( kWh_{ESTAR} \): ENERGY STAR kWh annual consumption
  - = 295 kWh
- \( %kWh_{op} \): Percentage of dishwasher energy consumption used for unit operation
  - = 1 - 56% = 44%
- \( %kWh_{heat} \): Percentage of dishwasher energy consumption used for water heating
  - = 56%
- \( %Electric_{DHW} \): Percentage of DHW savings assumed to be electric

<table>
<thead>
<tr>
<th>DHW fuel</th>
<th>%Electric_{DHW}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric</td>
<td>100%</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>0%</td>
</tr>
<tr>
<td>Unknown</td>
<td>16%</td>
</tr>
</tbody>
</table>

An Energy Star standard dishwasher installed in place of a baseline unit with unknown DHW fuel:

\[ \Delta k\text{Wh} = (((307 - 295) \times (0.44 + (0.56 \times 0.16)))) \]

\[ = 6.4 \text{ kWh} \]

An Energy Star standard dishwasher installed in place of a baseline unit with electric DHW:

\[ \Delta k\text{Wh} = (((307 - 295) \times (0.44 + (0.56 \times 1.0)))) \]

\[ = 12 \text{ kWh} \]

740 Calculated from Itron eShapes, 8760 hourly data by end use for Missouri, as provided by Ameren.
741 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.
742 ENERGY STAR Dishwasher Calculator (http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDishwasher.xls)
743 Ibid.
744 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.
Summer Coincident Peak Demand Savings

$$\Delta kW = \Delta \text{kWh/Hours} \times \text{CF}$$

Where:

- **Hours** = Annual operating hours\(^{745}\)
  = 252 hours

- **CF** = Summer Peak Coincidence Factor
  = 2.6\(^{\%}\)\(^{746}\)

An Energy Star standard dishwasher installed in place of a baseline unit with unknown DHW fuel:

$$\Delta \text{kWh} = \frac{6.4}{252} \times 0.026$$

= 0.0007 kW

An Energy Star standard dishwasher installed in place of a baseline unit with electric DHW:

$$\Delta \text{kWh} = \frac{12}{252} \times 0.026$$

= 0.001 kWh

**NATURAL GAS SAVINGS**

$$\Delta \text{Therm} = (\text{kWh}_{\text{Base}} - \text{kWh}_{\text{ESTAR}}) \times \%\text{kWh}_\text{heat} \times \%\text{Natural Gas}_\text{DHW} \times R_{\text{eff}} \times 0.03413$$

Where

- **%kWh\_heat** = % of dishwasher energy used for water heating
  = 56\(^{\%}\)

- **%Natural Gas\_DHW** = Percentage of DHW savings assumed to be Natural Gas

<table>
<thead>
<tr>
<th>DHW fuel</th>
<th>%Natural Gas_DHW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric</td>
<td>0(^{%})</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>100(^{%})</td>
</tr>
<tr>
<td>Unknown</td>
<td>84(^{%})(^{747})</td>
</tr>
</tbody>
</table>

- **R\_eff** = Recovery efficiency factor
  = 1.26\(^{748}\)

\(^{745}\) 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/.

\(^{746}\) End use data from Ameren representing the average DW load during peak hours/peak load.

\(^{747}\) 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.

\(^{748}\) 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)).
An Energy Star standard dishwasher installed in place of a baseline unit with unknown DHW fuel:
\[ \Delta \text{Therm} = (307 - 295) \times 0.56 \times 0.84 \times 1.26 \times 0.03413 \]
\[ = 0.24 \text{ therm} \]

An Energy Star standard dishwasher installed in place of a baseline unit with gas DHW:
\[ \Delta \text{Therm} = (307 - 295) \times 0.56 \times 1.0 \times 1.26 \times 0.03413 \]
\[ = 0.29 \text{ Therm} \]

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

\[ \Delta \text{Water} = \text{Water}_{\text{Base}} - \text{Water}_{\text{EFF}} \]

Where

- \( \text{Water}_{\text{Base}} \) = water consumption of conventional unit
  = 840 gallons\(^{749}\)
- \( \text{Water}_{\text{EFF}} \) = annual water consumption of efficient unit:
  = 714 gallons\(^{750}\)

\[ \Delta \text{Water} = 840 - 714 = 126 \text{ gallons} \]

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: RS-APL-ESDI-V02-130601**

Therefore a factor of 0.98/0.78 (1.26) is applied.

\(^{749}\) Assuming 5 gallons/cycle (maximum allowed) 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/](http://205.254.135.7/consumption/residential/data/2009/)

\(^{750}\) Assuming 4.25gallons/cycle (maximum allowed) 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/](http://205.254.135.7/consumption/residential/data/2009/)
5.1.5 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):

<table>
<thead>
<tr>
<th>Product Category</th>
<th>Volume (cubic feet)</th>
<th>Assumptions up to September 2014</th>
<th>Assumptions after September 2014</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Usage in kWh/year(^{751})</td>
<td>Usage in kWh/year(^{752})</td>
</tr>
<tr>
<td>Upright Freezers with Manual Defrost</td>
<td>7.75 or greater</td>
<td>7.55*AV + 258.3</td>
<td>6.795*AV + 232.47</td>
</tr>
<tr>
<td>Upright Freezers with Automatic Defrost</td>
<td>7.75 or greater</td>
<td>12.43*AV + 326.1</td>
<td>11.187*AV + 293.49</td>
</tr>
<tr>
<td>Chest Freezers and all other Freezers except Compact Freezers</td>
<td>7.75 or greater</td>
<td>9.88*AV + 143.7</td>
<td>8.892*AV + 129.33</td>
</tr>
<tr>
<td>Compact Upright Freezers with Manual Defrost</td>
<td>&lt; 7.75 and 36 inches or less in height</td>
<td>9.78*AV + 250.8</td>
<td>7.824*AV + 200.64</td>
</tr>
<tr>
<td>Compact Upright Freezers with Automatic Defrost</td>
<td>&lt; 7.75 and 36 inches or less in height</td>
<td>11.40*AV + 391</td>
<td>9.12*AV + 312.8</td>
</tr>
<tr>
<td>Compact Chest Freezers</td>
<td>&lt; 7.75 and 36 inches or less in height</td>
<td>10.45*AV + 152</td>
<td>8.36*AV + 121.6</td>
</tr>
</tbody>
</table>

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:


<table>
<thead>
<tr>
<th>Equipment</th>
<th>Volume</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Size Freezer</td>
<td>7.75 cubic feet or greater</td>
<td>At least 10% more energy efficient than the minimum federal government standard (NAECA).</td>
</tr>
<tr>
<td>Compact Freezer</td>
<td>Less than 7.75 cubic feet and 36 inches or less in height</td>
<td>At least 20% more energy efficient than the minimum federal government standard (NAECA).</td>
</tr>
</tbody>
</table>

**DEFINITION OF BASELINE EQUIPMENT**

The baseline equipment is assumed to be a model that meets the federal minimum standard for energy efficiency. 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.\(^{755}\)

**DEEMED MEASURE COST**

The incremental cost for this measure is $35.\(^{756}\)

**LOADSHAPE**

Loadshape R04 - Residential Freezer

**COINCIDENCE FACTOR**

The summer peak coincidence factor for this measure is assumed to be 95%.\(^{757}\)

---

**Algorithm**

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS:**

\[
\Delta kWh = kWh_{Base} - kWh_{ESTAR}
\]

Where:

\[
kWh_{Base} = \text{Baseline kWh consumption per year as calculated in algorithm provided in table above.}
\]

\[
kWh_{ESTAR} = \text{ENERGY STAR kWh consumption per year as calculated in algorithm provided in table above.}
\]

\(^{755}\) Energy Star Freezer Calculator; http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Consumer_Residential_Freezer_Sav_Calc.xls?570a-f000


\(^{757}\) Based on eShapes Residential Freezer load data as provided by Ameren.
For example for a 7.75 cubic foot Upright Freezers with Manual Defrost purchased after September 2014:

\[
\Delta \text{kWh} = (5.57 \times (7.75 \times 1.73) + 193.7) - (5.01 \times (7.75 \times 1.73) + 174.3) \\
= 268.4 - 241.5 \\
= 26.9 \text{ kWh}
\]

If volume is unknown, use the following default values:

<table>
<thead>
<tr>
<th>Product Category</th>
<th>Volume Used</th>
<th>Assumptions up to September 2014</th>
<th>Assumptions after September 2014</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(\text{kWh}_{\text{BASE}})</td>
<td>(\text{kWh}_{\text{ESTAR}})</td>
</tr>
<tr>
<td>Upright Freezers with Manual Defrost</td>
<td>27.9</td>
<td>469.1</td>
<td>422.2</td>
</tr>
<tr>
<td>Upright Freezers with Automatic Defrost</td>
<td>27.9</td>
<td>673.2</td>
<td>605.9</td>
</tr>
<tr>
<td>Chest Freezers and all other Freezers except Compact Freezers</td>
<td>27.9</td>
<td>419.6</td>
<td>377.6</td>
</tr>
<tr>
<td>Compact Upright Freezers with Manual Defrost</td>
<td>10.4</td>
<td>352.3</td>
<td>281.9</td>
</tr>
<tr>
<td>Compact Upright Freezers with Automatic Defrost</td>
<td>10.4</td>
<td>509.3</td>
<td>407.5</td>
</tr>
<tr>
<td>Compact Chest Freezers</td>
<td>10.4</td>
<td>260.5</td>
<td>208.4</td>
</tr>
</tbody>
</table>

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

\[
\Delta \text{kW} = \Delta \text{kWh} / \text{Hours} \times \text{CF}
\]

Where:

- \(\Delta \text{kWh}\) = Gross customer annual kWh savings for the measure
- \(\text{Hours}\) = Full Load hours per year
- \(\text{CF}\) = Summer Peak Coincident Factor
- \(\text{CF} = 0.95\)  

---

758 Volume is based on ENERGY STAR Calculator assumption of 16.14 ft\(^3\) average volume, converted to Adjusted volume by multiplying by 1.73.

759 Calculated from eShapes Residential Freezer load data as provided by Ameren by dividing total annual load by the maximum kW in any one hour.

760 Based on eShapes Residential Freezer load data as provided by Ameren.
For example for a 7.75 cubic foot Upright Freezers with Manual Defrost:

$$\Delta kW = \frac{26.9}{5890} \times 0.95$$

$$= 0.0043 \text{ kW}$$

If volume is unknown, use the following default values:

<table>
<thead>
<tr>
<th>Product Category</th>
<th>Assumptions up to September 2014</th>
<th>Assumptions after September 2014</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kW Savings</td>
<td>kW Savings</td>
</tr>
<tr>
<td>Upright Freezers with Manual Defrost</td>
<td>0.0076</td>
<td>0.0057</td>
</tr>
<tr>
<td>Upright Freezers with Automatic Defrost</td>
<td>0.0109</td>
<td>0.0076</td>
</tr>
<tr>
<td>Chest Freezers and all other Freezers except Compact Freezers</td>
<td>0.0068</td>
<td>0.0050</td>
</tr>
<tr>
<td>Compact Upright Freezers with Manual Defrost</td>
<td>0.0114</td>
<td>0.0075</td>
</tr>
<tr>
<td>Compact Upright Freezers with Automatic Defrost</td>
<td>0.0164</td>
<td>0.0103</td>
</tr>
<tr>
<td>Compact Chest Freezers</td>
<td>0.0084</td>
<td>0.0064</td>
</tr>
</tbody>
</table>

**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-V02-140601**
5.1.6 ENERGY STAR and CEE Tier 2 Refrigerator

DESCRIPTION

This measure relates to:

a) Time of Sale: the purchase and installation of a new refrigerator meeting either ENERGY STAR or CEE TIER 2 specifications.

b) Early Replacement: the early removal of an existing residential inefficient Refrigerator from service, prior to its natural end of life, and replacement with a new ENERGY STAR or CEE Tier 2 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.

Energy usage specifications are defined in the table below (note, Adjusted Volume is calculated as the fresh volume + (1.63 * Freezer Volume):

<table>
<thead>
<tr>
<th>Product Category</th>
<th>Existing Unit Based on Refrigerator Recycling algorithm</th>
<th>Assumptions up to September 2014</th>
<th>Assumptions after September 2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Refrigerators and Refrigerator-freezers with manual defrost</td>
<td>Use Algorithm in 5.1.8</td>
<td>8.82*AV+248.4</td>
<td>7.056*AV+198.72</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6.11*AV+174.2</td>
<td></td>
</tr>
<tr>
<td>2. Refrigerator-Freezer--partial automatic defrost</td>
<td></td>
<td>8.82*AV+248.4</td>
<td>7.056*AV+198.72</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7.99AV + 225.0</td>
<td>7.19 * AV + 202.5</td>
</tr>
<tr>
<td>3. Refrigerator-Freezers--automatic defrost with top-mounted freezer without through-the-door ice service and all-refrigerators--automatic defrost</td>
<td>Refrigerator and Freezer Recycling measure to estimate existing unit consumption</td>
<td>9.80*AV+276</td>
<td>7.84*AV+220.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8.07AV + 233.7</td>
<td>7.26 * AV + 210.3</td>
</tr>
<tr>
<td>4. Refrigerator-Freezers--automatic defrost with side-</td>
<td></td>
<td>4.91*AV+507.5</td>
<td>3.928*AV+406</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8.51AV + 297.8</td>
<td>7.66 * AV + 268.0</td>
</tr>
</tbody>
</table>

761 http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/43
763 http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/43
5.1.6 ENERGY STAR and CEE Tier 2 Refrigerator

<table>
<thead>
<tr>
<th>Product Category</th>
<th>Existing Unit</th>
<th>Assumptions up to September 2014</th>
<th>Assumptions after September 2014</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Federal Baseline Maximum Energy Usage in kWh/year</td>
<td>ENERGY STAR Maximum Energy Usage in kWh/year</td>
</tr>
<tr>
<td>mounted freezer without through-the-door ice service</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Refrigerator-Freezers—automatic defrost with bottom-mounted freezer without through-the-door ice service</td>
<td></td>
<td>4.60*AV + 459</td>
<td>3.68*AV + 367.2</td>
</tr>
<tr>
<td>5A Refrigerator-freezer—automatic defrost with bottom-mounted freezer with through-the-door ice service</td>
<td></td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>6. Refrigerator-Freezers—automatic defrost with top-mounted freezer with through-the-door ice service</td>
<td></td>
<td>10.20*AV + 356</td>
<td>8.16*AV + 284.8</td>
</tr>
<tr>
<td>7. Refrigerator-Freezers—automatic defrost with side-mounted freezer with through-the-door ice service</td>
<td></td>
<td>10.10*AV + 406</td>
<td>8.08*AV + 324.8</td>
</tr>
</tbody>
</table>

Note CEE Tier 2 standard criteria is 25% less consumption than a new baseline unit. It is assumed that after September 2014 when the Federal Standard and ENERGY STAR specifications change, the CEE Tier 2 will remain set at 25% less that the new baseline assumption.

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**

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**

Time of Sale: baseline 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 September 1, 2014.

Early Replacement: the baseline is the existing refrigerator for the assumed remaining useful life of the unit and the new baseline as defined above for the remainder of the measure life.

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The measure life is assumed to be 12 years. Remaining life of existing equipment is assumed to be 4 years.

**DEEMED MEASURE COST**

Time of Sale: The incremental cost for this measure is assumed to be $40 for an ENERGY STAR unit and $140 for a CEE Tier 2 unit.

Early Replacement: The measure cost is the full cost of removing the existing unit and installing a new one. The actual program cost should be used. If unavailable assume $451 for ENERGY STAR unit and $551 for CEE Tier 2 unit.

The avoided replacement cost (after 4 years) of a baseline replacement refrigerator is $390.

**LOADSHAPE**

Loadshape R05 - Residential Refrigerator

**COINCIDENCE FACTOR**

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

---

766 Standard assumption of one third of effective useful life.
767 From ENERGY STAR calculator linked above.
769 ENERGY STAR full cost is based upon IL PHA Efficient Living Program data on sample size of 910 replaced units finding average cost of $430 plus an average recycling/removal cost of $21. The CEE Tier 2 estimate uses the delta from the Time of Sale estimate.
770 Calculated using incremental cost from Time of Sale measure.
Algorithm

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS:**

Time of Sale: \[ \Delta \text{kWh} = \text{UEC}_{\text{BASE}} - \text{UEC}_{\text{EE}} \]

Early Replacement:

\[ \Delta \text{kWh} \text{ for remaining life of existing unit (1st 4 years)} = \text{UEC}_{\text{EXIST}} - \text{UEC}_{\text{EE}} \]

\[ \Delta \text{kWh} \text{ for remaining measure life (next 8 years)} = \text{UEC}_{\text{BASE}} - \text{UEC}_{\text{EE}} \]

Where:

- \( \text{UEC}_{\text{EXIST}} \) = Annual Unit Energy Consumption of existing unit as calculated in algorithm from 5.1.8 Refrigerator and Freezer Recycling measure.
- \( \text{UEC}_{\text{BASE}} \) = Annual Unit Energy Consumption of baseline unit as calculated in algorithm provided in table above.
- \( \text{UEC}_{\text{EE}} \) = 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.

If volume is unknown, use the following defaults, based on an assumed Adjusted Volume of 25.8\(^{771}\):

**Assumptions prior to standard changes on September 1st, 2014:**

<table>
<thead>
<tr>
<th>Product Category</th>
<th>Existing Unit ( \text{UEC}_{\text{EXIST}} ) (^{772})</th>
<th>New Baseline ( \text{UEC}_{\text{BASE}} )</th>
<th>New Efficient ( \text{UEC}_{\text{EE}} )</th>
<th>Early Replacement (1st 4 years) ( \Delta \text{kWh} )</th>
<th>Time of Sale and Early Replacement (last 8 years) ( \Delta \text{kWh} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Refrigerators and Refrigerator-freezers with manual defrost</td>
<td>1027.7</td>
<td>475.7</td>
<td>380.5</td>
<td>356.8</td>
<td>647.2</td>
</tr>
<tr>
<td>2. Refrigerator-Freezer--partial automatic defrost</td>
<td>1027.7</td>
<td>475.7</td>
<td>380.5</td>
<td>356.8</td>
<td>647.2</td>
</tr>
<tr>
<td>3. Refrigerator-Freezers--automatic defrost with top-mounted freezer without through-the-door ice service and</td>
<td>814.5</td>
<td>528.5</td>
<td>422.8</td>
<td>396.4</td>
<td>391.7</td>
</tr>
</tbody>
</table>

\(^{771}\) Volume is based on the ENERGY STAR calculator average assumption of 14.75 ft\(^3\) fresh volume and 6.76 ft\(^3\) freezer volume.

\(^{772}\) Estimates of existing unit consumption are based on using the 5.1.8 Refrigerator and Freezer Recycling algorithm and the inputs described here: Age = 10 years, Pre-1990 = 0, Size = 21.5 ft\(^3\) (from ENERGY STAR calc and consistent with AV of 25.8), Single Door = 0, Side by side = 1 for classifications stating side by side, 0 for classifications stating top/bottom, and 0.5 for classifications that do not distinguish, Primary appliances = 1, unconditioned = 0, Part use factor = 0.
<table>
<thead>
<tr>
<th>Product Category</th>
<th>Existing Unit UEC&lt;sub&gt;EXIST&lt;/sub&gt; 772</th>
<th>New Baseline UEC&lt;sub&gt;BASE&lt;/sub&gt;</th>
<th>New Efficient UEC&lt;sub&gt;EE&lt;/sub&gt;</th>
<th>Early Replacement (1&lt;sup&gt;st&lt;/sup&gt; 4 years) ΔkWh</th>
<th>Time of Sale and Early Replacement (last 8 years) ΔkWh</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ENERGY STAR CEE T2</td>
<td>ENERGY STAR CEE T2</td>
</tr>
<tr>
<td>all-refrigerators--automatic defrost</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Refrigerator-Freezers--automatic defrost with side-mounted freezer without through-the-door ice service</td>
<td>1241.0</td>
<td>634.0</td>
<td>507.2</td>
<td>475.5</td>
<td>733.7</td>
</tr>
<tr>
<td>5. Refrigerator-Freezers--automatic defrost with bottom-mounted freezer without through-the-door ice service</td>
<td>814.5</td>
<td>577.5</td>
<td>462.0</td>
<td>433.2</td>
<td>352.5</td>
</tr>
<tr>
<td>6. Refrigerator-Freezers--automatic defrost with top-mounted freezer with through-the-door ice service</td>
<td>814.5</td>
<td>618.8</td>
<td>495.1</td>
<td>464.1</td>
<td>319.5</td>
</tr>
<tr>
<td>7. Refrigerator-Freezers--automatic defrost with side-mounted freezer with through-the-door ice service</td>
<td>1241.0</td>
<td>666.3</td>
<td>533.0</td>
<td>499.7</td>
<td>707.9</td>
</tr>
</tbody>
</table>

Assumptions after standard changes on September 1<sup>st</sup>, 2014:

<table>
<thead>
<tr>
<th>Product Category</th>
<th>Existing Unit UEC&lt;sub&gt;EXIST&lt;/sub&gt; 772</th>
<th>New Baseline UEC&lt;sub&gt;BASE&lt;/sub&gt;</th>
<th>New Efficient UEC&lt;sub&gt;EE&lt;/sub&gt;</th>
<th>Early Replacement (1&lt;sup&gt;st&lt;/sup&gt; 4 years) ΔkWh</th>
<th>Time of Sale and Early Replacement (last 8 years) ΔkWh</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ENERGY STAR CEE T2</td>
<td>ENERGY STAR CEE T2</td>
</tr>
<tr>
<td>1. Refrigerators and Refrigerator-freezers with manual defrost</td>
<td>1027.7</td>
<td>368.6</td>
<td>331.6</td>
<td>276.4</td>
<td>696.1</td>
</tr>
<tr>
<td>2. Refrigerator-Freezer--partial automatic defrost</td>
<td>1027.7</td>
<td>430.9</td>
<td>387.8</td>
<td>323.2</td>
<td>640.0</td>
</tr>
</tbody>
</table>

<sup>772</sup> Estimates of existing unit consumption are based on using the 5.1.8 Refrigerator and Freezer Recycling algorithm and the inputs described here: Age = 10 years, Pre-1990 = 0, Size = 21.5 ft<sup>3</sup> (from ENERGY STAR calc and consistent with AV of 25.8), Single Door = 0, Side by side = 1 for classifications stating side by side, 0 for classifications stating top/bottom, and 0.5 for classifications that do not distinguish, Primary appliances = 1, unconditioned = 0, Part use factor = 0.
### ENERGY STAR and CEE Tier 2 Refrigerator

#### Product Category

<table>
<thead>
<tr>
<th></th>
<th>Existing Unit UEC&lt;sub&gt;EXIST&lt;/sub&gt;</th>
<th>New Baseline UEC&lt;sub&gt;BASE&lt;/sub&gt;</th>
<th>New Efficient UEC&lt;sub&gt;EE&lt;/sub&gt;</th>
<th>Early Replacement (1&lt;sup&gt;st&lt;/sup&gt; 4 years) ΔkWh</th>
<th>Time of Sale and Early Replacement (last 8 years) ΔkWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. Refrigerator-Freezers--</td>
<td>814.5</td>
<td>441.7</td>
<td>397.4</td>
<td>417.2</td>
<td>483.3</td>
</tr>
<tr>
<td>automatic defrost with top-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mounted freezer without</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>through-the-door ice service and all-refrigerators--automatic defrost</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Refrigerator-Freezers--</td>
<td>1241.0</td>
<td>517.1</td>
<td>465.4</td>
<td>775.6</td>
<td>853.1</td>
</tr>
<tr>
<td>automatic defrost with side-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mounted freezer without</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>through-the-door ice service</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Refrigerator-Freezers--</td>
<td>814.5</td>
<td>545.1</td>
<td>490.7</td>
<td>323.9</td>
<td>405.8</td>
</tr>
<tr>
<td>automatic defrost with bottom-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mounted freezer without</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>through-the-door ice service</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5A Refrigerator-freezer—</td>
<td>814.5</td>
<td>713.8</td>
<td>651.0</td>
<td>163.6</td>
<td>279.2</td>
</tr>
<tr>
<td>automatic defrost with bottom-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mounted freezer with</td>
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<td></td>
</tr>
<tr>
<td>through-the-door ice service</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Refrigerator-Freezers--</td>
<td>814.5</td>
<td>601.9</td>
<td>550.1</td>
<td>264.4</td>
<td>363.2</td>
</tr>
<tr>
<td>automatic defrost with top-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mounted freezer with</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>through-the-door ice service</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Refrigerator-Freezers--</td>
<td>1241.0</td>
<td>652.9</td>
<td>596.1</td>
<td>489.6</td>
<td>751.3</td>
</tr>
<tr>
<td>automatic defrost with side-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mounted freezer with</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>through-the-door ice service</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

### SUMMER COINCIDENT PEAK DEMAND SAVINGS

\[
ΔkW = (\frac{ΔkWh}{8766}) \times TAF \times LSAF
\]

Where:

\[
TAF = \text{Temperature Adjustment Factor}
\]

\[
TAF = 1.25^{774}
\]

---

<sup>774</sup> 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 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...
LSAF = Load Shape Adjustment Factor

= 1.057

If volume is unknown, use the following defaults:
**Product Category** | **Assumptions prior to September 2014 standard change ΔkW** | **Assumptions after September 2014 standard change ΔkW**
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Early Replacement (1st 4 years)</td>
<td>Time of Sale and Early Replacement (last 8 years)</td>
<td>Early Replacement (1st 4 years)</td>
<td>Time of Sale and Early Replacement (last 8 years)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Refrigerators and Refrigerator-freezers with manual defrost</td>
<td>0.098 ENERGY STAR</td>
<td>0.101 CEE T2</td>
<td>0.014 ENERGY STAR</td>
<td>0.018 CEE T2</td>
<td>0.105 ENERGY STAR</td>
<td>0.113 CEE T2</td>
<td>0.006 ENERGY STAR</td>
<td>0.014 CEE T2</td>
</tr>
<tr>
<td>2. Refrigerator-Freezer--partial automatic defrost</td>
<td>0.098 ENERGY STAR</td>
<td>0.101 CEE T2</td>
<td>0.014 ENERGY STAR</td>
<td>0.018 CEE T2</td>
<td>0.096 ENERGY STAR</td>
<td>0.106 CEE T2</td>
<td>0.006 ENERGY STAR</td>
<td>0.016 CEE T2</td>
</tr>
<tr>
<td>3. Refrigerator-Freezers--automatic defrost with top-mounted freezer without through-the-door ice service and all-refrigerators--automatic defrost</td>
<td>0.059 ENERGY STAR</td>
<td>0.063 CEE T2</td>
<td>0.016 ENERGY STAR</td>
<td>0.020 CEE T2</td>
<td>0.063 ENERGY STAR</td>
<td>0.073 CEE T2</td>
<td>0.007 ENERGY STAR</td>
<td>0.017 CEE T2</td>
</tr>
<tr>
<td>4. Refrigerator-Freezers--automatic defrost with side-mounted freezer without through-the-door ice service</td>
<td>0.111 ENERGY STAR</td>
<td>0.115 CEE T2</td>
<td>0.019 ENERGY STAR</td>
<td>0.024 CEE T2</td>
<td>0.117 ENERGY STAR</td>
<td>0.129 CEE T2</td>
<td>0.008 ENERGY STAR</td>
<td>0.019 CEE T2</td>
</tr>
<tr>
<td>5. Refrigerator-Freezers--automatic defrost with bottom-mounted freezer without through-the-door ice service</td>
<td>0.053 ENERGY STAR</td>
<td>0.057 CEE T2</td>
<td>0.017 ENERGY STAR</td>
<td>0.022 CEE T2</td>
<td>0.049 ENERGY STAR</td>
<td>0.061 CEE T2</td>
<td>0.008 ENERGY STAR</td>
<td>0.021 CEE T2</td>
</tr>
<tr>
<td>5A Refrigerator-freezer—automatic defrost with bottom-mounted freezer with through-the-door ice service</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>0.025 ENERGY STAR</td>
<td>0.042 CEE T2</td>
<td>0.009 ENERGY Star</td>
<td>0.027 CEE T2</td>
</tr>
<tr>
<td>6. Refrigerator-Freezers--automatic defrost with top-mounted freezer with through-the-door ice service</td>
<td>0.048 ENERGY STAR</td>
<td>0.053 CEE T2</td>
<td>0.019 ENERGY STAR</td>
<td>0.023 CEE T2</td>
<td>0.040 ENERGY STAR</td>
<td>0.055 CEE T2</td>
<td>0.008 ENERGY STAR</td>
<td>0.023 CEE T2</td>
</tr>
<tr>
<td>7. Refrigerator-Freezers--automatic defrost with side-mounted freezer with through-the-door ice service</td>
<td>0.107 ENERGY STAR</td>
<td>0.112 CEE T2</td>
<td>0.020 ENERGY STAR</td>
<td>0.025 CEE T2</td>
<td>0.097 ENERGY STAR</td>
<td>0.113 CEE T2</td>
<td>0.009 ENERGY STAR</td>
<td>0.025 CEE T2</td>
</tr>
</tbody>
</table>

**Natural Gas Savings**

N/A

**Water Impact Descriptions and Calculation**

N/A

**Deemed O&M Cost Adjustment Calculation**

N/A

**Measure Code:** RS-APL-ESRE-V02-140601
5.1.7 ENERGY STAR and CEE Tier 1 Room Air Conditioner

DESCRIPTION

This measure relates to:

a) Time of Sale the purchase and installation of a room air conditioning unit that meets CEE TIER 1 (equivalent to ENERGY STAR version 3.0 which is effective October 1st, 2013) or CEE Tier 2 minimum qualifying efficiency specifications, in place of a baseline unit. The baseline is equivalent to ENERGY STAR Version 2.0 efficiency ratings presented below since according to ENERGY STAR Shipment Data the estimated market penetration of ENERGY STAR Room AC went from 33% in 2010 to 62% in 2011 and a 2012 Illinois program evaluation found a net-to-gross ratio of just 1% for a Version 2.0 ENERGY STAR unit.

<table>
<thead>
<tr>
<th>Product Type and Class (Btu/hr)</th>
<th>ENERGY STAR v2.0 with louvered sides (EER)</th>
<th>ENERGY STAR v2.0 without louvered sides (EER)</th>
<th>ENERGY STAR v3.0 / CEE Tier 1 with louvered sides (EER)</th>
<th>ENERGY STAR v3.0 / CEE Tier 1 without louvered sides (EER)</th>
<th>CEE TIER 2 (EER)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without Reverse Cycle</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 8,000</td>
<td>10.7</td>
<td>9.9</td>
<td>11.2</td>
<td>10.4</td>
<td>11.6</td>
</tr>
<tr>
<td>8,000 to 10,999</td>
<td>10.8</td>
<td>9.9</td>
<td>11.3</td>
<td>9.8</td>
<td>11.8</td>
</tr>
<tr>
<td>11,000 to 13,999</td>
<td>10.8</td>
<td>9.4</td>
<td>11.3</td>
<td>9.8</td>
<td>11.8</td>
</tr>
<tr>
<td>14,000 to 19,999</td>
<td>10.7</td>
<td>9.4</td>
<td>11.2</td>
<td>9.8</td>
<td>11.6</td>
</tr>
<tr>
<td>20,000 to 24,999</td>
<td>9.4</td>
<td>9.4</td>
<td>9.8</td>
<td>9.8</td>
<td>10.2</td>
</tr>
<tr>
<td>&gt;=25,000</td>
<td>9.4</td>
<td>9.4</td>
<td>9.8</td>
<td>9.8</td>
<td>10.2</td>
</tr>
<tr>
<td>With Reverse Cycle</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;14,000</td>
<td>9.9</td>
<td>9.4</td>
<td>10.4</td>
<td>9.8</td>
<td>11.8</td>
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<tr>
<td>14,000 to 19,999</td>
<td>9.9</td>
<td>8.8</td>
<td>10.4</td>
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<td>11.6</td>
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<tr>
<td>&gt;=20,000</td>
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<td>Casement only</td>
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<td>10.0</td>
</tr>
<tr>
<td>Casement-Slider</td>
<td>10.5</td>
<td></td>
<td></td>
<td></td>
<td>10.9</td>
</tr>
</tbody>
</table>

Side louvers 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.

---

779 http://www.energystar.gov/index.cfm?c=roomac.pr_crit_room_ac
Reverse cycle refers to the heating function found in certain room air conditioner models.

b) Early Replacement: the early removal of an existing residential inefficient Room AC unit from service, prior to its natural end of life, and replacement with a new ENERGY STAR or CEE Tier 1 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

To qualify for this measure the new room air conditioning unit must meet the CEE TIER 1 (equivalent to ENERGY STAR version 3.0 which is effective October 1st 2013) efficiency standards presented above.

DEFINITION OF BASELINE EQUIPMENT

Time of Sale: the baseline assumption is a new room air conditioning unit that meets the ENERGY STAR Version 2.0 efficiency standards as presented above.

Early Replacement: the baseline is the existing Room AC for the assumed remaining useful life of the unit and the new baseline as defined above for the remainder of the measure life.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure life is assumed to be 12 years. Remaining life of existing equipment is assumed to be 4 years.

DEEMED MEASURE COST

Time of Sale: The incremental cost for this measure is assumed to be $40 for a CEE TIER 1 unit and $100 for a CEE Tier 2 unit.

Early Replacement: The measure cost is the full cost of removing the existing unit and installing a new one. The actual program cost should be used. If unavailable assume $448 for CEE Tier 1 unit and $548 for CEE Tier 2 unit.

The avoided replacement cost (after 4 years) of a baseline replacement refrigerator is $376.

LOADSHAPE

Loadshape R08 - Residential Cooling

---

782 Standard assumption of one third of effective useful life.
783 CEE Tier 1 based on field study conducted by Efficiency Vermont and Tier 2 based on professional judgement.
784 Based on IL PHA Efficient Living Progroam Data for 810 replaced units showing $416 per unit plus $32 average recycling/removal cost.
785 Estimate based upon Time of Sale incremental costs.
**COINCIDENCE FACTOR**

The coincidence factor for this measure is assumed to be 0.3\(^{786}\).

---

**Algorithm**

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

\[
\Delta k\text{Wh} = (FLH_{\text{RoomAC}} \times \text{Btu/H} \times (1/\text{EER}_{\text{base}} - 1/\text{EER}_{\text{ee}}))/1000
\]

**Early Replacement:**

\[
\Delta k\text{Wh for remaining life of existing unit (1st 4 years)} = (FLH_{\text{RoomAC}} \times \text{Btu/H} \times (1/\text{EER}_{\text{exist}} - 1/\text{EER}_{\text{ee}}))/1000
\]

\[
\Delta k\text{Wh for remaining measure life (next 8 years)} = (FLH_{\text{RoomAC}} \times \text{Btu/H} \times (1/\text{EER}_{\text{base}} - 1/\text{EER}_{\text{ee}}))/1000
\]

Where:

\[FLH_{\text{RoomAC}}\] = Full Load Hours of room air conditioning unit

= dependent on location\(^{787}\):

<table>
<thead>
<tr>
<th>Climate Zone (City based upon)</th>
<th>(FLH_{\text{RoomAC}})</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Rockford)</td>
<td>220</td>
</tr>
<tr>
<td>2 (Chicago)</td>
<td>210</td>
</tr>
<tr>
<td>3 (Springfield)</td>
<td>319</td>
</tr>
<tr>
<td>4 (Belleville)</td>
<td>428</td>
</tr>
<tr>
<td>5 (Marion)</td>
<td>374</td>
</tr>
<tr>
<td>Weighted Average(^{788})</td>
<td>248</td>
</tr>
</tbody>
</table>

---


\(^{787}\) 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/bsavings_calc/CAC_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.

\(^{788}\) Weighted based on number of residential occupied housing units in each zone.
Btu/H = Size of rebated unit
= Actual. If unknown assume 8500 Btu/hr
EEReexist = Efficiency of existing unit
= Actual. If unknown assume 7.7
EERbase = Efficiency of baseline unit
= As provided in tables above
EERee = Efficiency of CEE Tier 1 (or ENERGY STAR Version 3.0) unit
= Actual. If unknown assume minimum qualifying standard as provided in tables above

**Time of Sale:**
For example for an 8,500 Btu/H capacity unit, with louvered sides, in an unknown location:

\[ \Delta kWH_{CEE\ TIER\ 1} = \frac{(248 \times 8500 \times (1/10.8 - 1/11.3))}{1000} \]
\[ = 8.6 \text{ kWh} \]

**Early Replacement:**
A 7.7EER, 9000Btu/h unit is removed from a home in Springfield and replaced with a CEE T1 unit with louvered sides:

\[ \Delta kWh \text{ for remaining life of existing unit (1st 4 years)} = \frac{(319 \times 9000 \times (1/7.7 - 1/11.3))}{1000} \]
\[ = 118.8 \text{ kWh} \]

\[ \Delta kWh \text{ for remaining measure life (next 8 years)} = \frac{(319 \times 9000 \times (1/10.8 - 1/11.3))}{1000} \]
\[ = 11.8 \text{ kWh} \]

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

\[ \Delta kW = \text{Btu/H} \times \left( \frac{1}{\text{EERee}} - \frac{1}{\text{EERee}} \right) / 1000 \times \text{CF} \]

Where:

\[ \text{CF} = \text{Summer Peak Coincidence Factor for measure} \]
\[ = 0.3 \]

Other variable as defined above

---

789 Based on maximum capacity average from the RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008
Time of Sale:
For example for an 8,500 Btu/H capacity unit, with louvered sides, for an unknown location:
\[
\Delta kW_{CEE\ Tier\ 1} = \frac{(8500 \times (1/10.8 - 1/11.3))}{1000} \times 0.3
\]
\[
= 0.010\ kW
\]

Early Replacement:
A 7.7EER, 9000Btu/h unit is removed from a home in Springfield and replaced with a CEE T1 unit with louvered sides:
\[
\Delta kW\ for\ remaining\ life\ of\ existing\ unit\ (1^{st}\ 4\ years) = \frac{(9000 \times (1/7.7 - 1/11.3))}{1000} \times 0.3
\]
\[
= 0.11\ kW
\]
\[
\Delta kW\ for\ remaining\ measure\ life\ (next\ 8\ years) = \frac{(9000 \times (1/10.8 - 1/11.3))}{1000} \times 0.3
\]
\[
= 0.011\ kW
\]

**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-V03-140601**
5.1.8 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 2013 workpaper provided by Cadmus that used data from a 2012 ComEd metering study and metering data from a Michigan study, to develop 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\(^{792}\).

**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\(^{793}\) per unit.

---

\(^{792}\) KEMA “Residential refrigerator recycling ninth year retention study”, 2004

\(^{793}\) Based on similar Efficiency Vermont program.
LOADSHAPE

Loadshape R05 - Residential Refrigerator

COINCIDENCE FACTOR

The coincidence factor is assumed to be 0.00012.

CALCULATION OF SAVINGS

ENERGY SAVINGS

Refrigerators:

Energy savings for refrigerators are based upon a linear regression model using the following coefficients:

<table>
<thead>
<tr>
<th>Independent Variable Description</th>
<th>Estimate Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>83.324</td>
</tr>
<tr>
<td>Age (years)</td>
<td>3.678</td>
</tr>
<tr>
<td>Pre-1990 (=1 if manufactured pre-1990)</td>
<td>485.037</td>
</tr>
<tr>
<td>Size (cubic feet)</td>
<td>27.149</td>
</tr>
<tr>
<td>Dummy: Side-by-Side (= 1 if side-by-side)</td>
<td>406.779</td>
</tr>
<tr>
<td>Dummy: Primary Usage Type (in absence of the program) (= 1 if primary unit)</td>
<td>161.857</td>
</tr>
<tr>
<td>Interaction: Located in Unconditioned Space x CDD/365.25</td>
<td>15.366</td>
</tr>
<tr>
<td>Interaction: Located in Unconditioned Space x HDD/365.25</td>
<td>-11.067</td>
</tr>
</tbody>
</table>

\[
\Delta \text{kWh} = [83.32 + (\text{Age} \times 3.68) + (\text{Pre-1990} \times 485.04) + (\text{Size} \times 27.15) + (\text{Side-by-side} \times 406.78) +
(\text{Proportion of Primary Appliances} \times 161.86) + (\text{CDD/365.25} \times \text{unconditioned} \times 15.37) +
(\text{HDD/365.25} \times \text{unconditioned} \times -11.07)] \times \text{Part Use Factor}
\]

Where:

\[\text{Age} = \text{Age of retired unit}\]

Based on the specified regression, a small number of units may have negative energy and demand consumption. These are a function of the unit size and age, and should comprise a very small fraction of the population. While on an individual basis this result is counterintuitive it is important that these negative results remain such that as a population the average savings is appropriate.

Energy savings are based on an average 30-year TMY temperature of 51.1 degrees. Coefficients provided in July 30, 2014 memo from Cadmus: “Appliance Recycling Update no single door July 30 2014”.

---

794 Based on the specified regression, a small number of units may have negative energy and demand consumption. These are a function of the unit size and age, and should comprise a very small fraction of the population. While on an individual basis this result is counterintuitive it is important that these negative results remain such that as a population the average savings is appropriate.

795 Energy savings are based on an average 30-year TMY temperature of 51.1 degrees. Coefficients provided in July 30, 2014 memo from Cadmus: “Appliance Recycling Update no single door July 30 2014”.

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5.1.8 Refrigerator and Freezer Recycling

Pre-1990 = Pre-1990 dummy (=1 if manufactured pre-1990, else 0)
Size = Capacity (cubic feet) of retired unit
Side-by-side = Side-by-side dummy (= 1 if side-by-side, else 0)
Single-Door = Single-Door dummy (= 1 if Single-Door, else 0)
Primary Usage = Primary Usage Type (in absence of the program) dummy

(= 1 if Primary, else 0)

Interaction: Located in Unconditioned Space x CDD/365.25

(=1 * CDD/365.25 if in unconditioned space)

CDD = Cooling Degree Days

= Dependent on location: ²⁷⁶

<table>
<thead>
<tr>
<th>Climate Zone (City based upon)</th>
<th>CDD 65</th>
<th>CDD/365.25</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Rockford)</td>
<td>820</td>
<td>2.25</td>
</tr>
<tr>
<td>2 (Chicago)</td>
<td>842</td>
<td>2.31</td>
</tr>
<tr>
<td>3 (Springfield)</td>
<td>1,108</td>
<td>3.03</td>
</tr>
<tr>
<td>4 (Belleville)</td>
<td>1,570</td>
<td>4.30</td>
</tr>
<tr>
<td>5 (Marion)</td>
<td>1,370</td>
<td>3.75</td>
</tr>
</tbody>
</table>

Interaction: Located in Unconditioned Space x HDD/365.25

(=1 * HDD/365.25 if in unconditioned space)

HDD = Heating Degree Days

= Dependent on location: ²⁷⁷

<table>
<thead>
<tr>
<th>Climate Zone (City based upon)</th>
<th>HDD 65</th>
<th>HDD/365.25</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Rockford)</td>
<td>6,569</td>
<td>17.98</td>
</tr>
<tr>
<td>2 (Chicago)</td>
<td>6,339</td>
<td>17.36</td>
</tr>
<tr>
<td>3 (Springfield)</td>
<td>5,497</td>
<td>15.05</td>
</tr>
<tr>
<td>4 (Belleville)</td>
<td>4,379</td>
<td>11.99</td>
</tr>
<tr>
<td>5 (Marion)</td>
<td>4,476</td>
<td>12.25</td>
</tr>
</tbody>
</table>

²⁷⁶ National Climatic Data Center, calculated from 1981-2010 climate normals with a base temp of 65°F.
²⁷⁷ National Climatic Data Center, calculated from 1981-2010 climate normals with a base temp of 65°F.
Part Use Factor = To account for those units that are not running throughout the entire year. The most recent part-use factor participant survey results available at the start of the current program year shall be used\(^798\). For illustration purposes, this example uses 0.93.\(^799\)

For example, the program averages for AIC’s ARP in PY4 produce the following equation:

\[
\Delta \text{kWh} = (83.32 + (22.81 \times 3.68) + (0.45 \times 485.04) + (18.82 \times 27.15) + (0.17 \times 406.78) + (0.34 \times 161.86) + (1.29 \times 15.37) + (6.49 \times -11.07)) \times 0.93
\]

\[
= 969 \times 0.93
\]

\[
= 900.9 \text{ kWh}
\]

Freezers:

Energy savings for freezers are based upon a linear regression model using the following coefficients\(^800\):

<table>
<thead>
<tr>
<th>Independent Variable Description</th>
<th>Estimate Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>132.122</td>
</tr>
<tr>
<td>Age (years)</td>
<td>12.130</td>
</tr>
<tr>
<td>Pre-1990 (=1 if manufactured pre-1990)</td>
<td>156.181</td>
</tr>
<tr>
<td>Size (cubic feet)</td>
<td>31.839</td>
</tr>
<tr>
<td>Chest Freezer Configuration (=1 if chest freezer)</td>
<td>-19.709</td>
</tr>
<tr>
<td>Interaction: Located in Unconditioned Space x CDD/365.25</td>
<td>9.778</td>
</tr>
<tr>
<td>Interaction: Located in Unconditioned Space x HDD/365.25</td>
<td>-12.755</td>
</tr>
</tbody>
</table>

\[
\Delta \text{kWh} = (132.12 + (\text{Age} \times 12.13) + (\text{Pre-1990} \times 156.18) + (\text{Size} \times 31.84) + (\text{Chest Freezer} \times -19.71) + (\text{CDDs} \times \text{unconditioned} \times 9.78) + (\text{HDDs} \times \text{unconditioned} \times -12.75)) \times \text{Part Use Factor}
\]

Where:

- Age = Age of retired unit
- Pre-1990 = Pre-1990 dummy (=1 if manufactured pre-1990, else 0)
- Size = Capacity (cubic feet) of retired unit
- Chest Freezer = Chest Freezer dummy (= 1 if chest freezer, else 0)

\(^798\) For example, the part-use factor that shall be applied to the current program year t (PYt) for savings verification purposes should be determined through the PYt-2 participant surveys conducted in the respective utility’s service territory, if available. If an evaluation was not performed in PYt-2 the latest available evaluation should be used.

\(^799\) Most recent refrigerator part-use factor from Ameren Illinois PY5 evaluation.

\(^800\) Energy savings are based on an average 30-year TMY temperature of 51.1 degrees. Coefficients provided in January 31, 2013 memo from Cadmus: “Appliance Recycling Update”.

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Interaction: Located in Unconditioned Space x CDD/365.25

\[(=1 \times \text{CDD/365.25 if in unconditioned space})\]

\[\text{CDD} = \text{Cooling Degree Days (see table above)}\]

Interaction: Located in Unconditioned Space x HDD/365.25

\[(=1 \times \text{HDD/365.25 if in unconditioned space})\]

\[\text{HDD} = \text{Heating Degree Days (see table above)}\]

Part Use Factor = To account for those units that are not running throughout the entire year. The most recent part-use factor participant survey results available at the start of the current program year shall be used. For illustration purposes, the example uses 0.85.

The program averages for AIC’s ARP PY4 program are used as an example.

\[\Delta \text{kWh} = [132.12 + (26.92 \times 12.13) + (0.6 \times 156.18) + (15.9 \times 31.84) + (0.48 \times -19.71) + (6.61 \times 9.78) + (1.3 \times -12.75)] \times 0.825\]

\[= 977 \times 0.825\]

\[= 905 \text{ kWh}\]

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

\[\Delta \text{kW} = \text{kWh}/8766 \times \text{CF}\]

Where:

\[\text{kWh} = \text{Savings provided in algorithm above}\]

\[\text{CF} = \text{Coincident factor defined as summer kW/average kW}\]

\[= 1.081 \text{ for Refrigerators}\]

\[= 1.028 \text{ for Freezers}\]

For example, the program averages for AIC’s ARP in PY4 produce the following equation:

\[\Delta \text{kW} = 806/8766 \times 1.081\]

\[= 0.099 \text{ kW}\]

---

801 For example, the part-use factor that shall be applied to the current program year t (PYt) for savings verification purposes should be determined through the PYt-2 participant surveys conducted in the respective utility’s service territory, if available. If an evaluation was not performed in PYt-2 the latest available evaluation should be used.

802 Most recent freezer part-use factor from Ameren Illinois Company PY5 evaluation.

803 Cadmus memo, February 12, 2013; “Appliance Recycling Update”
NATURAL GAS SAVINGS
N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION
N/A

DEEMED O&M COST ADJUSTMENT CALCULATION
N/A

M EASURE C ODE: RS-APL-RFRC-V05-150601
5.1.9 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.\textsuperscript{804}

DEEMED MEASURE COST

The actual implementation cost for recycling the existing unit should be used.

LOADSHAPE

Loadshape R08 - Residential Cooling

COINCIDENCE FACTOR

The coincidence factor for this measure is assumed to be 30\%.\textsuperscript{805}

\textsuperscript{804} A third of assumed measure life for Room AC.

\textsuperscript{805} Consistent with coincidence factors found in: RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008

Algorithm

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

\[ \Delta \text{kWh} = \frac{(\text{FLH}_{\text{RoomAC}} \times \text{Btu/hr} \times (1/\text{EERexist}))}{1000} \]

Where:

- \( \text{FLH}_{\text{RoomAC}} \) = Full Load Hours of room air conditioning unit
- \( \text{FLH}_{\text{RoomAC}} \) = dependent on location

<table>
<thead>
<tr>
<th>Climate Zone (City based upon)</th>
<th>FLH_{RoomAC}</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Rockford)</td>
<td>220</td>
</tr>
<tr>
<td>2 (Chicago)</td>
<td>210</td>
</tr>
<tr>
<td>3 (Springfield)</td>
<td>319</td>
</tr>
<tr>
<td>4 (Belleville)</td>
<td>428</td>
</tr>
<tr>
<td>5 (Marion)</td>
<td>374</td>
</tr>
<tr>
<td>Weighted Average</td>
<td>248</td>
</tr>
</tbody>
</table>

- \( \text{Btu/H} \) = Size of retired unit
- \( \text{Btu/H} \) = Actual. If unknown assume 8500 Btu/hr

- \( \text{EERexist} \) = Efficiency of existing unit
- \( \text{EERexist} \) = 7.7

---

806 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](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](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.

807 Weighted based on number of residential occupied housing units in each zone.

808 Based on maximum capacity average from the RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008

For example for an 8500 Btu/h unit in Springfield:
\[
\Delta kWh = \left(\frac{319 \times 8500 \times (1/7.7)}{1000}\right) = 352 \text{ kWh}
\]

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

\[
\Delta kW = \left(\frac{\text{Btu/hr} \times (1/EER\text{exist})}{1000}\right) \times CF
\]

Where:

\[
CF = \text{Summer Peak Coincidence Factor for measure}
\]

\[
CF = 0.3^{810}
\]

For example an 8500 Btu/h unit:

\[
\Delta kW = \left(\frac{8500 \times (1/7.7)}{1000}\right) \times 0.3 = 0.33 \text{ kW}
\]

**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-V01-120601**

---

\(^{810}\) Consistent with coincidence factors found in:
5.1.10 Residential ENERGY STAR Clothes Dryer

**DESCRIPTION**

This measure relates to the installation of a residential clothes dryer meeting the ENERGY STAR criteria. ENERGY STAR qualified clothes dryers save energy through a combination of more efficient drying and reduced runtime of the drying cycle. More efficient drying is achieved through increased insulation, modifying operating conditions such as air flow and/or heat input rate, improving air circulation through better drum design or booster fans, and improving efficiency of motors. Reducing the runtime of dryers through automatic termination by temperature and moisture sensors is believed to have the greatest potential for reducing energy use in clothes dryers. ENERGY STAR provides criteria for both gas and electric clothes dryers.

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 dryer must meet the ENERGY STAR criteria, as required by the program.

**DEFINITION OF BASELINE EQUIPMENT**

The baseline condition is a clothes dryer meeting the minimum federal requirements for units manufactured on or after January 1, 2015.

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The expected measure life is assumed to be 14 years.

**DEEMED MEASURE COST**

The incremental cost for an ENERGY STAR clothes dryer is assumed to be $152.

**LOADSHAPE**

N/A

**COINCIDENCE FACTOR**

The coincidence factor for this measure is 3.8%.

---


814 Based on coincidence factor of 3.8% for clothes washers
Algorithm

**CALCULATION OF ENERGY SAVINGS**

**ELECTRIC ENERGY SAVINGS**

\[ \Delta \text{kWh} = \left( \frac{\text{Load}}{\text{CEF}_{\text{base}}} - \frac{\text{Load}}{\text{CEF}_{\text{eff}}} \right) \times \text{Ncycles} \times \%\text{Electric} \]

Where:

- **Load** = The average total weight (lbs) of clothes per drying cycle. If dryer size is unknown, assume standard.

<table>
<thead>
<tr>
<th>Dryer Size</th>
<th>Load (lbs)(^815)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>8.45</td>
</tr>
<tr>
<td>Compact</td>
<td>3</td>
</tr>
</tbody>
</table>

- **CEF\(_{\text{base}}\)** = Combined energy factor (CEF) (lbs/kWh) of the baseline unit is based on existing federal standards energy factor and adjusted to CEF as performed in the ENERGY STAR analysis\(^816\). If product class unknown, assume electric, standard.

<table>
<thead>
<tr>
<th>Product Class</th>
<th>CEF (lbs/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vented Electric, Standard ((\geq 4.4 \text{ ft}^3))</td>
<td>3.11</td>
</tr>
<tr>
<td>Vented Electric, Compact (120V) (&lt; 4.4 ft(^3))</td>
<td>3.01</td>
</tr>
<tr>
<td>Vented Electric, Compact (240V) (&lt;4.4 ft(^3))</td>
<td>2.73</td>
</tr>
<tr>
<td>Ventless Electric, Compact (240V) (&lt;4.4 ft(^3))</td>
<td>2.13</td>
</tr>
<tr>
<td>Vented Gas</td>
<td>2.84(^817)</td>
</tr>
</tbody>
</table>

- **CEF\(_{\text{eff}}\)** = CEF (lbs/kWh) of the ENERGY STAR unit based on ENERGY STAR requirements.\(^818\) If product class unknown, assume electric, standard.

<table>
<thead>
<tr>
<th>Product Class</th>
<th>CEF (lbs/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vented or Ventless Electric, Standard ((\geq 4.4 \text{ ft}^3))</td>
<td>3.93</td>
</tr>
<tr>
<td>Vented or Ventless Electric, Compact (120V) (&lt; 4.4 ft(^3))</td>
<td>3.80</td>
</tr>
<tr>
<td>Vented Electric, Compact (240V) (&lt; 4.4 ft(^3))</td>
<td>3.45</td>
</tr>
<tr>
<td>Ventless Electric, Compact (240V) (&lt; 4.4 ft(^3))</td>
<td>2.68</td>
</tr>
<tr>
<td>Vented Gas</td>
<td>3.48(^819)</td>
</tr>
</tbody>
</table>

\(^815\) Based on ENERGY STAR test procedures. [https://www.energystar.gov/index.cfm?c=clothesdry.pr_crit_clothes_dryers](https://www.energystar.gov/index.cfm?c=clothesdry.pr_crit_clothes_dryers)

\(^816\) ENERGY STAR Draft 2 Version 1.0 Clothes Dryers Data and Analysis

\(^817\) Federal standards report CEF for gas clothes dryers in terms of lbs/kWh. To determine gas savings, this number is later converted to therms.

\(^818\) ENERGY STAR Clothes Dryers Key Product Criteria. [https://www.energystar.gov/index.cfm?c=clothesdry.pr_crit_clothes_dryers](https://www.energystar.gov/index.cfm?c=clothesdry.pr_crit_clothes_dryers)

\(^819\) Federal standards report CEF for gas clothes dryers in terms of lbs/kWh. To determine gas savings, this number is later converted to therms.
Ncycles = Number of dryer cycles per year. Use actual data if available. If unknown, use 283 cycles per year.

%Electric = The percent of overall savings coming from electricity

= 100% for electric dryers, 16% for gas dryers\textsuperscript{821}

\begin{example}
\textbf{Time of Sale:} For example, a standard, vented, electric clothes dryer:

\[ \Delta \text{kWh} = \left( \frac{8.45}{3.11} - \frac{8.45}{3.93} \right) \times 283 \times 100\% \]

\[ = 160 \text{kWh} \]
\end{example}

\textbf{SUMMER COINCIDENT PEAK DEMAND SAVINGS}

\[ \Delta \text{kW} = \Delta \text{kWh} / \text{Hours} \times CF \]

Where:

\[ \Delta \text{kWh} = \text{Energy Savings as calculated above} \]

\[ \text{Hours} = \text{Annual run hours of clothes dryer. Use actual data if available. If unknown, use 283 hours per year.}\textsuperscript{822} \]

\[ CF = \text{Summer Peak Coincidence Factor for measure} \]

\[ = 3.8\% \textsuperscript{823} \]

\begin{example}
\textbf{Time of Sale:} For example, a standard, vented, electric clothes dryer:

\[ \Delta \text{kW} = \frac{160}{283} \times 3.8\% \]

\[ = 0.0215 \text{kW} \]
\end{example}

\textbf{NATURAL GAS SAVINGS}

Natural gas savings only apply to ENERGY STAR vented gas clothes dryers.

\textsuperscript{820} Appendix D to Subpart B of Part 430 – Uniform Test Method for Measuring the Energy Consumption of Dryers.

\textsuperscript{821} %Electric accounts for the fact that some of the savings on gas dryers comes from electricity (motors, controls, etc). 16% was determined using a ratio of the electric to total savings from gas dryers given by ENERGY STAR Draft 2 Version 1.0 Clothes Dryers Data and Analysis.

\textsuperscript{822} ENERGY STAR qualified dryers have a maximum test cycle time of 80 minutes. Assume one hour per dryer cycle.

\textsuperscript{823} Based on coincidence factor of 3.8% for clothes washers.
\[ \Delta \text{Therm} = (\text{Load}/\text{EF}_{\text{base}} - \text{Load}/\text{CEF}_{\text{eff}}) \times N_{\text{cycles}} \times \text{Therm}_{\text{convert}} \times \%\text{Gas} \]

Where:

- \( \text{Therm}_{\text{convert}} \) = Conversion factor from kWh to Therm
  
  \[ = 0.03413 \]

- \( \%\text{Gas} \) = Percent of overall savings coming from gas
  
  \[ = 0\% \text{ for electric units and } 84\% \text{ for gas units}^{824} \]

**EXAMPLE**

Time of Sale: For example, a standard, vented, gas clothes dryer:

\[ \Delta \text{Therm} = (8.45/2.84 - 8.45/3.48) \times 283 \times 0.03413 \times 0.84 \]

\[ = 4.44 \text{ therms} \]

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: RS-APL-ESDR-V01-150601**

---

\(^{824}\) %Gas accounts for the fact that some of the savings on gas dryers comes from electricity (motors, controls, etc). 84% was determined using a ratio of the gas to total savings from gas dryers given by ENERGY STAR Draft 2 Version 1.0 Clothes Dryers Data and Analysis.
5.2 Consumer Electronics End Use

5.2.1 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 years825.

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-plug826.

LOADSHAPE
Loadshape R13 - Residential Standby Losses – Entertainment
Loadshape R14 - Residential Standby Losses - Home Office

COINCIDENCE FACTOR
The summer peak coincidence factor for this measure is assumed to be 80%827.

---

825  David Rogers, Power Smart Engineering, October 2008; “Smart Strip electrical savings and usability”, p22.
826  Price survey performed in NYSERDA Measure Characterization for Advanced Power Strips, p4
827  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.
Algorithm

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

\[
\begin{align*}
\Delta k\text{Wh}_{5-\text{Plug}} &= 56.5 \text{ kWh}^828 \\
\Delta k\text{Wh}_{7-\text{Plug}} &= 103 \text{ kWh}^829
\end{align*}
\]

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

\[
\Delta kW = \frac{\Delta k\text{Wh}}{\text{Hours}} \times \text{CF}
\]

Where:

- **Hours** = Annual number of hours during which the controlled standby loads are turned off by the Smart Strip.
  
  = 7,129^830

- **CF** = Summer Peak Coincidence Factor for measure
  
  = 0.8^831

\[
\begin{align*}
\Delta kW_{5-\text{Plug}} &= \frac{56.5}{7129} \times 0.8 \\
 &= 0.00634 \text{ kW}
\end{align*}
\]

\[
\begin{align*}
\Delta kW_{7-\text{Plug}} &= \frac{102.8}{7129} \times 0.8 \\
 &= 0.0115 \text{ kW}
\end{align*}
\]

**NATURAL GAS SAVINGS**

N/A

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

---

^828 NYSERDA Measure Characterization for Advanced Power Strips. Study based on review of:
Smart Strip Electrical Savings and Usability, Power Smart Engineering, October 27, 2008.

^829 Ibid.

^830 Average of hours for controlled TV and computer from; NYSERDA Measure Characterization for Advanced Power Strips

^831 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.
DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-CEL-SSTR-V01-120601
5.3 HVAC End Use

5.3.1 Air Source Heat Pump

**DESCRIPTION**

A heat pump provides heating or cooling by moving heat between indoor and outdoor air.

This measure characterizes:

a) **Time of Sale:**
   a. 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 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:**
   a. The early removal of functioning electric heating and cooling (SEER 10 or under if present) systems from service, prior to its natural end of life, and replacement with a new high efficiency air source heat pump 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.
   b. The assumption of the existing unit efficiency in the Early Replacement section of this TRM is based upon the average efficiency of units that were classified in Ameren’s PY3-PY4 as functioning and SEER <=10. Therefore it is only appropriate to use these Early Replacement assumptions where those conditions are met. The TAC defined “functioning” as the unit is fully operational – providing sufficient space conditioning (i.e. heat exchanger, compressors, pumps work effectively) and/or the cost of repair is under 20% of the new baseline replacement cost. Therefore in order to apply early replacement assumptions the programs should apply the following eligibility criteria: SEER <=10 and cost of any repairs <$249 per ton.
   c. A weighted average early replacement rate is provided for use when the actual baseline early replacement rates are unknown.

<table>
<thead>
<tr>
<th>Early Replacement Rate for ASHP participants</th>
<th>Deemed Early Replacement Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7%</td>
</tr>
</tbody>
</table>

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**

A new residential sized (<= 65,000 Btu/hr) air source heat pump with specifications to be determined by program.

---

832 Based upon research from “Home Energy Efficiency Rebate Program GPY2 Evaluation Report” which outlines early replacement rates for both primary and secondary central air cooling (CAC) and residential furnaces. This is used as a reasonable proxy for ASHP installations since ASHP specific data is not available. Report presented to Nicor Gas Company February 27, 2014, available at http://www.ilsag.info/evaluation-documents.html.
DEFINITION OF BASELINE EQUIPMENT

A new residential sized (<= 65,000 Btu/hr) air source heat pump meeting federal standards.

The baseline for the Time of Sale measure is based on the current Federal Standard efficiency level as of January 1st, 2015; 14 SEER and 8.2 HSPF.

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 for the remainder of the measure life.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 18 years. Remaining life of existing equipment is assumed to be 6 years.

DEEMED MEASURE COST

Time of sale: The incremental capital cost for this measure is dependent on the efficiency and capacity of the new unit. Note these costs are per ton of unit capacity:

<table>
<thead>
<tr>
<th>Efficiency (SEER)</th>
<th>Incremental Cost per Ton of Capacity ($/ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>$137</td>
</tr>
<tr>
<td>16</td>
<td>$274</td>
</tr>
<tr>
<td>17</td>
<td>$411</td>
</tr>
<tr>
<td>18</td>
<td>$548</td>
</tr>
</tbody>
</table>

Early replacement: The full install cost for this measure is the actual cost of removing the existing unit and installing the new one. If this is unknown, assume the following (note these costs are per ton of unit capacity):

<table>
<thead>
<tr>
<th>Efficiency (SEER)</th>
<th>Full Retrofit Cost (including labor) per Ton of Capacity ($/ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>$1,518</td>
</tr>
<tr>
<td>16</td>
<td>$1,655</td>
</tr>
<tr>
<td>17</td>
<td>$1,792</td>
</tr>
<tr>
<td>18</td>
<td>$1,929</td>
</tr>
</tbody>
</table>

---

834 Assumed to be one third of effective useful life
835 Based on costs derived from DEER 2008 Database Technology and Measure Cost Data (www.deeresources.com).
836 Ibid. See ‘ASHP_Revised DEER Measure Cost Summary.xls’ for calculation.
Assumed deferred cost (after 6 years) of replacing existing equipment with new baseline unit is assumed to be $1,381 per ton of capacity. This cost should be discounted to present value using the utilities’ discount rate.

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.

\[
\text{CF}_{\text{SSP}} = \text{Summer System Peak Coincidence Factor for Heat Pumps (during utility peak hour)} = 72\% \\
\text{CF}_{\text{PJM}} = \text{PJM Summer Peak Coincidence Factor for Heat Pumps (average during PJM peak period)} = 46.6\%
\]

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

Time of sale:

\[
\Delta \text{kWh} = \frac{((\text{FLH}_{\text{cooling}} \times \text{Capacity}_{\text{cooling}} \times (1/\text{SEER}_{\text{base}} - 1/\text{SEER}_{\text{ee}}))}{1000} + \frac{((\text{FLH}_{\text{heat}} \times \text{Capacity}_{\text{heating}} \times (1/\text{HSPF}_{\text{base}} - 1/\text{HSPF}_{\text{ee}}))}{1000}
\]

Early replacement:

\[
\Delta \text{kWh for remaining life of existing unit (1st 6 years)}
\]

\[
= \frac{((\text{FLH}_{\text{cooling}} \times \text{Capacity}_{\text{cooling}} \times (1/\text{SEER}_{\text{exist}} - 1/\text{SEER}_{\text{ee}}))}{1000} + \frac{((\text{FLH}_{\text{heat}} \times \text{Capacity}_{\text{heating}} \times (1/\text{HSPF}_{\text{exist}} - 1/\text{HSPF}_{\text{ee}}))}{1000}
\]

\[
\Delta \text{kWh for remaining measure life (next 12 years)}
\]

\[
= \frac{((\text{FLH}_{\text{cooling}} \times \text{Capacity}_{\text{cooling}} \times (1/\text{SEER}_{\text{base}} - 1/\text{SEER}_{\text{ee}}))}{1000} + \frac{((\text{FLH}_{\text{heat}} \times \text{Capacity}_{\text{heating}} \times (1/\text{HSPF}_{\text{base}} - 1/\text{HSPF}_{\text{ee}}))}{1000}
\]

\[837\] Ibid. 
\[838\] Based on analysis of metering results from 24 heat pumps in Ameren Illinois service territory in PY5 coincident with AIC’s 2010 system peak; ‘Impact and Process Evaluation of Ameren Illinois Company’s Residential HVAC Program (PY5)’. 
\[839\] 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. 
\[840\] 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).
Where:

\[ FLH_{\text{cooling}} = \text{Full load hours of air conditioning} \]
\[ = \text{dependent on location}^{841} \]

<table>
<thead>
<tr>
<th>Climate Zone (City based upon)</th>
<th>FLH(_{\text{cooling}}) (single family)</th>
<th>FLH(_{\text{cooling}}) (multi family)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Rockford)</td>
<td>512</td>
<td>467</td>
</tr>
<tr>
<td>2 (Chicago)</td>
<td>570</td>
<td>506</td>
</tr>
<tr>
<td>3 (Springfield)</td>
<td>730</td>
<td>663</td>
</tr>
<tr>
<td>4 (Belleville)</td>
<td>1,035</td>
<td>940</td>
</tr>
<tr>
<td>5 (Marion)</td>
<td>903</td>
<td>820</td>
</tr>
<tr>
<td>Weighted Average(^{842})</td>
<td>629</td>
<td>564</td>
</tr>
</tbody>
</table>

\[ \text{Capacity}_{\text{cooling}} = \text{Cooling Capacity of Air Source Heat Pump (Btu/hr)} \]
\[ = \text{Actual (1 ton = 12,000Btu/hr)} \]

\[ \text{SEER}_{\text{exist}} = \text{Seasonal Energy Efficiency Ratio of existing cooling system (kBtu/kWh)} \]
\[ = \text{Use actual SEER rating where it is possible to measure or reasonably estimate.} \]

<table>
<thead>
<tr>
<th>Existing Cooling System</th>
<th>SEER(_{\text{exist}})^{843}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Source Heat Pump</td>
<td>9.12</td>
</tr>
<tr>
<td>Central AC</td>
<td>8.60</td>
</tr>
<tr>
<td>No central cooling(^{844})</td>
<td>Make ‘1/SEER(_{\text{exist}})’ = 0</td>
</tr>
</tbody>
</table>

\[ \text{SEER}_{\text{base}} = \text{Seasonal Energy Efficiency Ratio of baseline Air Source Heat Pump (kBtu/kWh)} \]
\[ = 14^{845} \]

---

\(^{841}\) 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_299123020.pdf](http://ilsag.org/yahoo_site_admin/assets/docs/ComEd_PY2_CACES_Evaluation_Report_2010-10-18_299123020.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.

\(^{842}\) Weighted based on number of occupied residential housing units in each zone.

\(^{843}\) Average nameplate efficiencies of all Early Replacement qualifying equipment in Ameren PY3-PY4.

\(^{844}\) If there is no central cooling in place but the incentive encourages installation of a new ASHP with cooling, the added cooling load should be subtracted from any heating benefit.

\(^{845}\) Based on Minimum Federal Standard effective 1/1/2015;
SEER<sub>ee</sub> = Seasonal Energy Efficiency Ratio of efficient Air Source Heat Pump (kBtu/kWh)

= Actual

FLH<sub>heat</sub> = Full load hours of heating

= Dependent on location<sup>846</sup>: 

<table>
<thead>
<tr>
<th>Climate Zone (City based upon)</th>
<th>FLH&lt;sub&gt;heat&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Rockford)</td>
<td>1,969</td>
</tr>
<tr>
<td>2 (Chicago)</td>
<td>1,840</td>
</tr>
<tr>
<td>3 (Springfield)</td>
<td>1,754</td>
</tr>
<tr>
<td>4 (Belleville)</td>
<td>1,266</td>
</tr>
<tr>
<td>5 (Marion)</td>
<td>1,288</td>
</tr>
<tr>
<td>Weighted Average&lt;sup&gt;847&lt;/sup&gt;</td>
<td>1,821</td>
</tr>
</tbody>
</table>

Capacity<sub>heating</sub> = Heating Capacity of Air Source Heat Pump (Btu/hr)

= Actual (1 ton = 12,000Btu/hr)

HSPF<sub>exist</sub> = Heating System Performance Factor<sup>848</sup> of existing heating system (kBtu/kWh)

= Use actual HSPF rating where it is possible to measure or reasonably estimate. If not available use:

<table>
<thead>
<tr>
<th>Existing Heating System</th>
<th>HSPF&lt;sub&gt;exist&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Source Heat Pump</td>
<td>5.44&lt;sup&gt;849&lt;/sup&gt;</td>
</tr>
<tr>
<td>Electric Resistance</td>
<td>3.41&lt;sup&gt;850&lt;/sup&gt;</td>
</tr>
</tbody>
</table>


<sup>846</sup> 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](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/hr ASHP gives an estimate of average ASHP FLH<sub>heat</sub> 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.

<sup>847</sup> Weighted based on number of occupied residential housing units in each zone.

<sup>848</sup> HSPF ratings for Heat Pumps account for the seasonal average efficiency of the units and are based on testing within zone 4 which encompasses most of Illinois. Furthermore, a recent Cadmus/Opinion Dynamics metering study, “Impact and Process Evaluation of Ameren Illinois Company’s Residential HVAC Program (PY5)”, found no significant variance between metered performance and that presented in the TRM.

<sup>849</sup> This is estimated based on finding the average HSPF/SEER ratio from the AHRI directory data (using the least efficient models – SEER 12 and SEER 13) – 0.596, and applying to the average nameplate SEER rating of all Early Replacement qualifying equipment in Ameren PY3-PY4. This estimation methodology appears to provide a result within 10% of actual HSPF.

<sup>850</sup> Electric resistance has a COP of 1.0 which equals 1/0.293 = 3.41 HSPF.
HSPF_base = Heating System Performance Factor of baseline Air Source Heat Pump (kBtu/kWh) = 8.2

HSFP_ee = Heating System Performance Factor of efficient Air Source Heat Pump (kBtu/kWh) = Actual

### Time of Sale:

For example, a three ton, 15 SEER, 12EER, 9 HSPF Air Source Heat Pump installed in Marion:

\[ \Delta kW = ((903 \times 36,000 \times (1/14 - 1/15)) / 1000) + ((1288 \times 36,000 \times (1/8.2 - 1/9)) / 1000) \]

\[ = 657 \text{ kWh} \]

### Early Replacement:

For example, a three ton, 15 SEER, 12EER, 9 HSPF Air Source Heat Pump replaces an existing working Air Source Heat Pump with unknown efficiency ratings in Marion:

\[ \Delta kW \text{ for remaining life of existing unit (1st 6 years):} \]

\[ = ((903 \times 36,000 \times (1/9.12 - 1/15)) / 1000) + ((1288 \times 36,000 \times (1/5.44 - 1/9)) / 1000) \]

\[ = 4769 \text{ kWh} \]

\[ \Delta kW \text{ for remaining measure life (next 12 years):} \]

\[ = ((903 \times 36,000 \times (1/14 - 1/15)) / 1000) + ((1288 \times 36,000 \times (1/8.2 - 1/9)) / 1000) \]

\[ = 657 \text{ kWh} \]

### Summer Coincident Peak Demand Savings

**Time of sale:**

\[ \Delta kW = (\text{Capacity}_{\text{cooling}} \times (1/\text{EER}_{\text{base}} - 1/\text{EER}_{\text{ee}})) / 1000) \times \text{CF} \]

**Early replacement\textsuperscript{852}:**

\[ \Delta kW \text{ for remaining life of existing unit (1st 6 years):} \]

\[ = ((\text{Capacity}_{\text{cooling}} \times (1/\text{EER}_{\text{exist}} - 1/\text{EER}_{\text{ee}}))/1000 \times \text{CF}) \]

\[ \Delta kW \text{ for remaining measure life (next 12 years):} \]

\[ = ((\text{Capacity}_{\text{cooling}} \times (1/\text{EER}_{\text{base}} - 1/\text{EER}_{\text{ee}}))/1000 \times \text{CF}) \]


\textsuperscript{852} 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).
Where:

\[
\text{EER}_{\text{exist}} = \text{Energy Efficiency Ratio of existing cooling system} (\text{kBtu/hr} / \text{kW})
\]

= Use actual EER rating where it is possible to measure or reasonably estimate. If EER unknown but SEER available convert using the equation:

\[
\text{EER}_{\text{base}} = (-0.02 \times \text{SEER}^2) + (1.12 \times \text{SEER})
\]

If SEER rating unavailable use:

<table>
<thead>
<tr>
<th>Existing Cooling System</th>
<th>EER_{exist}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Source Heat Pump</td>
<td>8.55</td>
</tr>
<tr>
<td>Central AC</td>
<td>8.15</td>
</tr>
<tr>
<td>No central cooling</td>
<td>Make ‘1/EER_exist’ = 0</td>
</tr>
</tbody>
</table>

\[
\text{EER}_{\text{ee}} = \text{Energy Efficiency Ratio of baseline Air Source Heat Pump} (\text{kBtu/hr} / \text{kW})
\]

= Actual, if not provided convert SEER to EER using this formula:

\[
\text{EER}_{\text{ee}} = (-0.02 \times \text{SEER}^2) + (1.12 \times \text{SEER})
\]

\[
\text{CF}_{\text{SSP}} = \text{Summer System Peak Coincidence Factor for Heat Pumps} (\text{during system peak hour})
\]

= 72%\(^{858}\)

\[
\text{CF}_{\text{PJM}} = \text{PJM Summer Peak Coincidence Factor for Heat Pumps} (\text{average during peak period})
\]

= 46.6\(^{859}\)

---


\(^{854}\) Average nameplate efficiencies of all Early Replacement qualifying equipment in Ameren PY3-PY4.

\(^{855}\) If there is no central cooling in place but the incentive encourages installation of a new ASHP with cooling, the added cooling load should be subtracted from any heating benefit.

\(^{856}\) The Federal Standard does not include an EER requirement, so it is approximated with this formula: \((-0.02 \times \text{SEER}^2) + (1.12 \times \text{SEER})\)


\(^{858}\) Based on analysis of metering results from 24 heat pumps in Ameren Illinois service territory in PY5 coincident with AIC’s 2010 system peak; ‘Impact and Process Evaluation of Ameren Illinois Company’s Residential HVAC Program (PY5)’.

\(^{859}\) 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.
Time of Sale:
For example, a three ton, 15 SEER, 12EER, 9 HSPF Air Source Heat Pump installed in Marion:
\[
\Delta kW_{SSP} = \left( \frac{36,000 \times (1/11.8 - 1/12)}{1000} \right) \times 0.72 \\
= 0.037 \text{ kW}
\]
\[
\Delta kW_{PJM} = \left( \frac{36,000 \times (1/11.8 - 1/12)}{1000} \right) \times 0.466 \\
= 0.024 \text{ kW}
\]

Early Replacement:
For example, a three ton, 15 SEER, 12EER, 9 HSPF Air Source Heat Pump replaces an existing working Air Source Heat Pump with unknown efficiency ratings in Marion:
\[
\Delta kW_{SSP} \text{ for remaining life of existing unit (1st 6 years):} \\
= \left( \frac{36,000 \times (1/8.55 - 1/12)}{1000} \right) \times 0.72 \\
= 0.872 \text{ kW}
\]
\[
\Delta kW_{SSP} \text{ for remaining measure life (next 12 years):} \\
= \left( \frac{36,000 \times (1/11.8 - 1/12)}{1000} \right) \times 0.72 \\
= 0.037 \text{ kW}
\]

**Natural Gas Savings**
N/A

**Water Impact Descriptions and Calculation**
N/A

**Deemed O&M Cost Adjustment Calculation**
N/A

**Measure Code:** RS-HVC-ASHP-V04-150601
5.3.2 Boiler Pipe Insulation

**DESCRIPTION**

This measure describes adding insulation to un-insulated boiler pipes in un-conditioned basements or crawlspaces. This measure was developed to be applicable to the following program types: TOS, RNC, RF, DI. 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 boiler pipe.

**DEFINITION OF BASELINE EQUIPMENT**

The baseline is an un-insulated boiler pipe.

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The measure life is assumed to be 15 years\(^{860}\).

**DEEMED MEASURE COST**

The measure cost including material and installation is assumed to be $3 per linear foot\(^{861}\).

**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**

\[
\Delta\text{Therm} = \left(\left(\frac{1}{R_{\text{exist}}} \cdot C_{\text{exist}}\right) - \left(\frac{1}{R_{\text{new}}} \cdot C_{\text{new}}\right)\right) \cdot \text{FLH}_{\text{heat}} \cdot L \cdot \Delta T / \eta_{\text{Boiler}} / 100,000
\]


\(^{861}\) Consistent with DEER 2008 Database Technology and Measure Cost Data (www.deeresources.com).
Where:

\[ R_{\text{exist}} = \text{Pipe heat loss coefficient of uninsulated pipe (existing)} \left( \text{hr} \cdot \text{°F} \cdot \text{ft}^2 \right) / \text{Btu} \]

\[ R_{\text{new}} = \text{Actual (0.5 + R value of insulation)} \]

\[ FLH_{\text{heat}} = \text{Full load hours of heating} \]

\[ L = \text{Length of boiler pipe in unconditioned space covered by pipe wrap (ft)} \]

\[ C_{\text{exist}} = \text{Circumference of bare pipe (ft)} \left( \text{Diameter (in)} \times \pi / 12 \right) \]

\[ C_{\text{new}} = \text{Circumference of pipe with insulation (ft)} \left( \text{Diameter (in)} \times \pi / 12 \right) \]

\[ \Delta T = \text{Average temperature difference between circulated heated water and unconditioned space air temperature (°F)} \]

---

862 Assumption based on data obtained from the 3E Plus heat loss calculation software provided by the NAIMA (North American Insulation Manufacturer Association) and derived from Table 15 and Table 16 of 2009 ASHRAE Fundamentals Handbook, Chapter 23 Insulation for Mechanical Systems, page 23.17.

863 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/agc/consumereducation.aspx](http://www.icc.illinois.gov/agc/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/hr ASHP gives an estimate of average ASHP FLH\text{\textsubscript{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.

864 Weighted based on number of occupied residential housing units in each zone.

865 Assumes 160°F water temp for a boiler without reset control, 120°F for a boiler with reset control, and 50°F air temperature...
Pipes in unconditioned basement:

<table>
<thead>
<tr>
<th>Outdoor reset controls</th>
<th>ΔT (°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boiler without reset control</td>
<td>110</td>
</tr>
<tr>
<td>Boiler with reset control</td>
<td>70</td>
</tr>
</tbody>
</table>

Pipes in crawl space:

<table>
<thead>
<tr>
<th>Climate Zone (City based upon)</th>
<th>ΔT (°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Boiler without reset control</td>
</tr>
<tr>
<td>1 (Rockford)</td>
<td>127</td>
</tr>
<tr>
<td>2 (Chicago)</td>
<td>126</td>
</tr>
<tr>
<td>3 (Springfield)</td>
<td>122</td>
</tr>
<tr>
<td>4 (Belleville)</td>
<td>120</td>
</tr>
<tr>
<td>5 (Marion)</td>
<td>120</td>
</tr>
<tr>
<td>Weighted Average(^{866})</td>
<td>125</td>
</tr>
</tbody>
</table>

\( η_{\text{Boiler}} = \text{Efficiency of boiler} \)

\( = 0.819^{867} \)

For example, insulating 10 feet of 0.75” pipe with R-3 wrap (0.75” thickness) in a crawl space of a Marion home with a boiler without reset control:

\[
Δ\text{Therm} = \frac{(((1/0.5 * 0.196) - (1/3.5 * 0.589)) * 10 * 120 * 1288)}{0.819 / 100,000}
= 4.2 \text{ therms}
\]

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

for pipes in unconditioned basements and the following average heating season outdoor temperatures as the air temperature in crawl spaces: Zone 1 – 33.1, Zone 2 – 34.4, Zone 3 – 37.7, Zone 4 – 40.0, Zone 5 – 39.8, Weighted Average – 35.3 (NCDC 1881-2010 Normals, average of monthly averages Nov – Apr for zones 1-3 and Nov-March for zones 4 and 5).\(^{866}\)

\(^{866}\)Weighted based on number of occupied residential housing units in each zone.

\(^{867}\)Average efficiency of boiler units found in Ameren PY3-PY4 data.
MEASURE CODE: RS-HVC-PINS-V01-130601
5.3.3 Central Air Conditioning > 14.5 SEER

**DESCRIPTION**

This measure characterizes:

a) **Time of Sale:**
   a. 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:**
   a. 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.
   b. The assumption of the existing unit efficiency in the Early Replacement section of this TRM is based upon the average efficiency of units that were classified in Ameren’s PY3-PY4 as functioning and SEER <=10. Therefore it is only appropriate to use these Early Replacement assumptions where those conditions are met. The TAC defined “functioning” as the unit is fully operational – providing sufficient space conditioning (i.e. heat exchanger, compressors, pumps work effectively) and/or the cost of repair is under 20% of the new baseline replacement cost. Therefore in order to apply early replacement assumptions the programs should apply the following eligibility criteria: SEER <=10 and cost of any repairs <$190 per ton.

   c. A weighted average early replacement rate is provided for use when the actual baseline early replacement rate is unknown.

**Deemed Early Replacement Rates For CAC Units in Combined System Replacement (CSR) Projects**

<table>
<thead>
<tr>
<th>Replacement Scenario for the CAC Unit</th>
<th>Deemed Early Replacement Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early Replacement Rate for a CAC unit when the CAC unit is the Primary unit in a CSR project</td>
<td>14%</td>
</tr>
<tr>
<td>Early Replacement Rate for a CAC unit when the CAC unit is the Secondary unit in a CSR project</td>
<td>40%</td>
</tr>
</tbody>
</table>

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.

---

Based upon research from “Home Energy Efficiency Rebate Program GPY2 Evaluation Report” which outlines early replacement rates for both primary and secondary central air cooling (CAC) and residential furnaces. The unit (furnace or CAC unit) that initially caused the customer to contact a trade ally is defined as the “primary unit”. The furnace or CAC unit that was also replaced but did not initially prompt the customer to contact a trade ally is defined as the “secondary unit”. This evaluation used different criteria for early replacement due to the availability of data after the fact; cost of any repairs <$550 and age of unit < 20 years. Report presented to Nicor Gas Company February 27, 2014, available at http://www.ilsag.info/evaluation-documents.html.
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 for the remainder of the measure life.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 18 years.

Remaining life of existing equipment is assumed to be 6 years.

DEEMED MEASURE COST

Time of sale: The incremental capital cost for this measure is dependent on equipment size and efficiency. Assumed costs per ton of cooling capacity are provided below:

<table>
<thead>
<tr>
<th>Efficiency Level</th>
<th>Cost per Ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEER 14</td>
<td>$119</td>
</tr>
<tr>
<td>SEER 15</td>
<td>$238</td>
</tr>
<tr>
<td>SEER 16</td>
<td>$357</td>
</tr>
<tr>
<td>SEER 17</td>
<td>$476</td>
</tr>
<tr>
<td>SEER 18</td>
<td>$596</td>
</tr>
<tr>
<td>SEER 19</td>
<td>$715</td>
</tr>
<tr>
<td>SEER 20</td>
<td>$834</td>
</tr>
<tr>
<td>SEER 21</td>
<td>$908</td>
</tr>
<tr>
<td>Average</td>
<td>$530</td>
</tr>
</tbody>
</table>

Early replacement: The full install cost for this measure is the actual cost of removing the existing unit and installing the new equipment.

---

869 Baseline SEER and EER should be updated when new minimum federal standards become effective.  
The "lifespan" of a central air conditioner is about 15 to 20 years (US DOE:  
871 Assumed to be one third of effective useful life  
872 DEER 2008 Database Technology and Measure Cost Data (www.deeresources.com)
installing the new one. If this is unknown, assume $3,413\textsuperscript{873}.

Assumed deferred cost (after 6 years) of replacing existing equipment with new baseline unit is assumed to be $2,857\textsuperscript{874}. This cost should be discounted to present value using the utilities’ discount rate.

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.

\[
\begin{align*}
\text{CF}_{\text{SSP}} &= \text{Summer System Peak Coincidence Factor for Central A/C (during system peak hour)} \\
&= 68\% \textsuperscript{875} \\
\text{CF}_{\text{PJM}} &= \text{PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)} \\
&= 46.6\% \textsuperscript{876}
\end{align*}
\]

\textsuperscript{873} 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).

\textsuperscript{874} 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.

\textsuperscript{875} Based on metering of 24 homes with central AC during PY4 and PYS in Ameren Illinois service territory.

\textsuperscript{876} 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.
Algorithm

Calculation of Savings

Electric Energy Savings

Time of sale:

\[ \Delta kWH = \frac{(FLH_{cool} \times Btu/hr \times (1/SEER_{base} - 1/SEER_{ee}))}{1000} \]

Early replacement\(^{877}\):

\[ \Delta kWH \text{ for remaining life of existing unit (1st 6 years)}: \]

\[ = \frac{(FLH_{cool} \times \text{Capacity} \times (1/SEER_{exist} - 1/SEER_{ee}))}{1000}; \]

\[ \Delta kWH \text{ for remaining measure life (next 12 years)}: \]

\[ = \frac{(FLH_{cool} \times \text{Capacity} \times (1/SEER_{base} - 1/SEER_{ee}))}{1000} \]

Where:

FLH\(_{cool}\) = Full load cooling hours

= dependent on location and building type\(^{878}\):

<table>
<thead>
<tr>
<th>Climate Zone (City based upon)</th>
<th>FLH(_{cool}) (single family)</th>
<th>FLH(_{cool}) (multi family)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Rockford)</td>
<td>512</td>
<td>467</td>
</tr>
<tr>
<td>2 (Chicago)</td>
<td>570</td>
<td>506</td>
</tr>
<tr>
<td>3 (Springfield)</td>
<td>730</td>
<td>663</td>
</tr>
<tr>
<td>4 (Belleville)</td>
<td>1035</td>
<td>940</td>
</tr>
<tr>
<td>5 (Marion)</td>
<td>903</td>
<td>820</td>
</tr>
<tr>
<td>Weighted Average(^{879})</td>
<td>629</td>
<td>564</td>
</tr>
</tbody>
</table>

\(^{877}\) 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).

\(^{878}\) 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](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.
Capacity = Size of new equipment in Btu/hr (note 1 ton = 12,000 Btu/hr)
= Actual installed, or if actual size unknown 33,600 Btu/hr for single-family buildings

SEERbase = Seasonal Energy Efficiency Ratio of baseline unit (kBtu/kWh)
= 13

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.

SEERee = Seasonal Energy Efficiency Ratio of ENERGY STAR unit (kBtu/kWh)
= Actual installed or 14.5 if unknown

---

Time of sale example: a 3 ton unit with SEER rating of 14.5, in unknown location:
\[ \Delta \text{kWh} = \frac{(629 \times 36,000 \times (1/13 - 1/14.5))}{1000} \]
= 180 kWh

---

Early replacement example: a 3 ton unit, with SEER rating of 14.5 replaces an existing unit in unknown location:

\[ \Delta \text{kWh (for first 6 years)} = \frac{(629 \times 36,000 \times (1/10 - 1/14.5))}{1000} \]
= 702 kWh

\[ \Delta \text{kWh (for next 12 years)} = \frac{(629 \times 36,000 \times (1/13 - 1/14.5))}{1000} \]
= 180 kWh

Therefore savings adjustment of 26% (180/702) after 6 years.

---

879 Weighted based on number of residential occupied housing units in each zone.
880 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.
882 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.
**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

Time of sale:

\[
\Delta k\text{W} = (\text{Capacity} \times (1/\text{EER}_{\text{base}} - 1/\text{EER}_{\text{ee}}))/1000 \times \text{CF}
\]

Early replacement\(^{883}\):

\[
\Delta k\text{W} \text{ for remaining life of existing unit (1st 6 years)}:
\]

\[
= (\text{(Capacity} \times (1/\text{EER}_{\text{exist}} - 1/\text{EER}_{\text{ee}}))/1000 \times \text{CF})
\]

\[
\Delta k\text{W} \text{ for remaining measure life (next 12 years)}:
\]

\[
= (\text{(Capacity} \times (1/\text{EER}_{\text{base}} - 1/\text{EER}_{\text{ee}}))/1000 \times \text{CF})
\]

Where:

- \(\text{EER}_{\text{base}}\) = EER Efficiency of baseline unit
  
  = 11.2\(^{884}\)

- \(\text{EER}_{\text{exist}}\) = EER Efficiency of existing unit
  
  = Actual EER of unit should be used, if EER is unknown, use 9.2\(^{885}\)

- \(\text{EER}_{\text{ee}}\) = EER Efficiency of ENERGY STAR unit
  
  = Actual installed or 12 if unknown

- \(\text{CF}_{\text{SSP}}\) = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)
  
  = 68\%\(^{886}\)

- \(\text{CF}_{\text{PJM}}\) = PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)
  
  = 46.6\%\(^{887}\)

---

\(^{883}\) 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).

\(^{884}\) 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 * SEER\(^2\)) + (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).

\(^{885}\) Based on SEER of 10,0, using formula above to give 9.2 EER.

\(^{886}\) Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.

\(^{887}\) 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.
Time of sale example: a 3 ton unit with EER rating of 12:

\[
\Delta kW_{SSP} = \frac{(36,000 \times (1/11.2 - 1/12))}{1000} \times 0.68
\]

\[= 0.146 \text{ kW}\]

\[
\Delta kW_{PJM} = \frac{(36,000 \times (1/11.2 - 1/12))}{1000} \times 0.466
\]

\[= 0.100 \text{ kW}\]

Early replacement example: a 3 ton unit with EER rating of 12 replaces an existing unit:

\[
\Delta kW_{SSP} \text{ (for first 6 years)} = \frac{(36,000 \times (1/9.2 - 1/12))}{1000} \times 0.68
\]

\[= 0.621 \text{ kW}\]

\[
\Delta kW_{SSP} \text{ (for next 12 years)} = \frac{(36,000 \times (1/11.2 - 1/12))}{1000} \times 0.68
\]

\[= 0.146 \text{ kW}\]

\[
\Delta kW_{PJM} \text{ (for first 6 years)} = \frac{(36,000 \times (1/9.2 - 1/12))}{1000} \times 0.466
\]

\[= 0.425 \text{ kW}\]

\[
\Delta kW_{PJM} \text{ (for next 12 years)} = \frac{(36,000 \times (1/11.2 - 1/12))}{1000} \times 0.466
\]

\[= 0.100 \text{ kW}\]

**NATURAL GAS SAVINGS**

N/A

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: RS-HVC-CAC1-V04-150601**
5.3.4 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.


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’;

   
   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.

DEEMED MEASURE COST
The actual duct sealing measure cost should be used.

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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.

\[ CF_{SSP} = \text{Summer System Peak Coincidence Factor for Central A/C (during utility peak hour)} \]
\[ = 68\% \]

\[ CF_{PJM} = \text{PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)} \]
\[ = 46.6\% \]

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

Methodology 1: Modified Blower Door Subtraction

a) Determine Duct Leakage rate before and after performing duct sealing:

\[ \text{Duct Leakage (CFM50_{DL})} = (\text{CFM50}_{\text{Whole House}} - \text{CFM50}_{\text{Envelope Only}}) \times SCF \]

Where:

\[ \text{CFM50}_{\text{Whole House}} = \text{Standard Blower Door test result finding Cubic Feet per Minute at 50 Pascal pressure differential} \]

\[ \text{CFM50}_{\text{Envelope Only}} = \text{Blower Door test result finding Cubic Feet per Minute at 50 Pascal pressure differential with all supply and return registers sealed.} \]

\[ SCF = \text{Subtraction Correction Factor to account for underestimation of duct leakage due to connections between the duct system and the home. Determined by measuring pressure in duct system with registers sealed and using look up table provided by Energy Conservatory.} \]

\[ 889\] Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.

\[ 890\] 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.
b) Calculate duct leakage reduction, convert to CFM25<sub>DL</sub> and factor in Supply and Return Loss Factors

Duct Leakage Reduction (ΔCFM25<sub>DL</sub>) = (Pre CFM50<sub>DL</sub> – Post CFM50<sub>DL</sub>) * 0.64 * (SLF + RLF)

Where:

0.64 = Converts CFM50 to CFM25<sup>891</sup>

SLF = Supply Loss Factor

= % leaks sealed located in Supply ducts * 1<sup>892</sup>

Default = 0.5<sup>893</sup>

RLF = Return Loss Factor

= % leaks sealed located in Return ducts * 0.5<sup>894</sup>

Default = 0.25<sup>895</sup>

c) Calculate Electric Energy Savings:

ΔkWh = ΔkWh<sub>cooling</sub> + ΔkWh<sub>Fan</sub>

ΔkWh<sub>cooling</sub> = ((ΔCFM25<sub>DL</sub>) / ((CapacityCool/12,000) * 400)) * FLHcool * CapacityCool / 1000 / ηCool

ΔkWh<sub>Fan</sub> = (ΔTherms * F<sub>e</sub> * 29.3)

Where:

ΔCFM25<sub>DL</sub> = Duct leakage reduction in CFM25

= calculated above

---

<sup>891</sup> 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).

<sup>892</sup> 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

<sup>893</sup> Assumes 50% of leaks are in supply ducts.

<sup>894</sup> 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

<sup>895</sup> Assumes 50% of leaks are in return ducts.
CapacityCool = Capacity of Air Cooling system (Btu/hr)

=Actual

12,000 = Converts Btu/H capacity to tons

400 = Converts capacity in tons to CFM (400CFM / ton)<sup>896</sup>

FLHcool = Full load cooling hours

= Dependent on location as below<sup>897</sup>:

<table>
<thead>
<tr>
<th>Climate Zone (City based upon)</th>
<th>FLHcool Single Family</th>
<th>FLHcool Multifamily</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Rockford)</td>
<td>512</td>
<td>467</td>
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<td>730</td>
<td>663</td>
</tr>
<tr>
<td>4 (Belleville)</td>
<td>1,035</td>
<td>940</td>
</tr>
<tr>
<td>5 (Marion)</td>
<td>903</td>
<td>820</td>
</tr>
<tr>
<td>Weighted Average&lt;sup&gt;898&lt;/sup&gt;</td>
<td>629</td>
<td>564</td>
</tr>
</tbody>
</table>

1000 = Converts Btu to kBtu

ηCool = Efficiency (SEER) of Air Conditioning equipment (kBtu/kWh)

= Actual. If unknown assume the following<sup>899</sup>:

<table>
<thead>
<tr>
<th>Age of Equipment</th>
<th>SEER Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before 2006</td>
<td>10</td>
</tr>
<tr>
<td>After 2006 - 2014</td>
<td>13</td>
</tr>
<tr>
<td>Central AC After 1/1/2015</td>
<td>13</td>
</tr>
<tr>
<td>Heat Pump After 1/1/2015</td>
<td>14</td>
</tr>
</tbody>
</table>

<sup>896</sup> This conversion is an industry rule of thumb; e.g. see http://www.hvacsalesandsupply.com/Linked%20Documents/Tech%20Tips/61-Why%20400%20CFM%20per%20ton.pdf

<sup>897</sup> 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.

<sup>898</sup> Weighted based on number of occupied residential housing units in each zone.

<sup>899</sup> 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.
\[ \Delta \text{Therms} = \text{Therm savings as calculated in Natural Gas Savings} \]

\[ F_e = \text{Furnace Fan energy consumption as a percentage of annual fuel consumption} \]

\[ = 3.14\% \]

\[ 29.3 = \text{kWh per therm} \]

For example, duct sealing in a single family house in Springfield with a 36,000 Btu/H, SEER 11 central air conditioning, an 80% AFUE, 105,000 Btu/H natural gas furnace and the following blower door test results:

**Before:**
- CFM50\(_{\text{Whole House}}\) = 4800 CFM50
- CFM50\(_{\text{Envelope Only}}\) = 4500 CFM50
- House to duct pressure of 45 Pascals = 1.29 SCF (Energy Conservatory look up table)

**After:**
- CFM50\(_{\text{Whole House}}\) = 4600 CFM50
- CFM50\(_{\text{Envelope Only}}\) = 4500 CFM50
- House to duct pressure of 43 Pascals = 1.39 SCF (Energy Conservatory look up table)

**Duct Leakage:**
- CFM50\(_{DL, \text{before}}\) = \((4800 - 4500) \times 1.29\)
  = 387 CFM
- CFM50\(_{DL, \text{after}}\) = \((4600 - 4500) \times 1.39\)
  = 139 CFM

**Duct Leakage reduction at CFM25:**
- \[ \Delta \text{CFM25}_{DL} = (387 - 139) \times 0.64 \times (0.5 + 0.25) \]
  = 119 CFM25

**Energy Savings:**
- \[ \Delta \text{kWh}_{\text{cooling}} = \frac{\left[\frac{119}{\left(\frac{(36,000/12,000) \times 400)} \times 730 \times 36,000\right)} / 1000 / 11\right] + (212 \times 0.0314 \times 29.3)}{}}\]
  = 237 + 195
  = 432 kWh

---

\(^{900}F_e\) 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.
Heating savings for homes with electric heat (Heat Pump):

\[ \Delta \text{kWh}_{\text{heating}} = \frac{((\Delta CFM_{25DL} / ((\text{OutputCapacityHeat}/12,000) \times 400)) \times \text{FLH}_{\text{heat}} \times \text{OutputCapacityHeat}} {\eta_{\text{Heat}} / 3412} \]

Where:

- OutputCapacityHeat = Heating output capacity (Btu/hr) of electric heat
- FLH_{\text{heat}} = Full load heating hours
- \eta_{\text{Heat}} = Efficiency in COP of Heating equipment

### Climate Zone

<table>
<thead>
<tr>
<th>Climate Zone (City based upon)</th>
<th>FLH_{\text{heat}}</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Rockford)</td>
<td>1,969</td>
</tr>
<tr>
<td>2 (Chicago)</td>
<td>1,840</td>
</tr>
<tr>
<td>3 (Springfield)</td>
<td>1,754</td>
</tr>
<tr>
<td>4 (Belleville)</td>
<td>1,266</td>
</tr>
<tr>
<td>5 (Marion)</td>
<td>1,288</td>
</tr>
<tr>
<td>Weighted Average</td>
<td>1,821</td>
</tr>
</tbody>
</table>

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.

Weighted based on number of occupied residential housing units in each zone.

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.
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”

\[
\Delta \text{kWh}_{\text{heating}} = \frac{((\text{DE}_{\text{after}} - \text{DE}_{\text{before}})/ \text{DE}_{\text{after}})) \times \text{FLH}_{\text{cool}} \times \text{Capacity}_{\text{Cool}}/1000 / \eta_{\text{Cool}} + (\Delta \text{Therms} \times F_e \times 29.3)}{3412}
\]

Where:

- \(\text{DE}_{\text{after}}\) = Distribution Efficiency after duct sealing
- \(\text{DE}_{\text{before}}\) = Distribution Efficiency before duct sealing
- \(\text{FLH}_{\text{cool}}\) = Full load cooling hours
- \(\eta_{\text{Cool}}\) = Efficiency of air cooling system
- \(\text{Capacity}_{\text{Cool}}\) = Capacity of air cooling system (Btu/hr)
- \(\Delta \text{Therms}\) = Additional thermal energy required
- \(F_e\) = Energy factor
- \(29.3\) = Conversion factor

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:

\[
\begin{align*}
\Delta \text{kWh}_{\text{heating}} &= \frac{((119 / (36,000/12,000) \times 400)) \times 1,754 \times 36,000}{2.5 / 3412} \\
&= 734 \text{ kWh}
\end{align*}
\]

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</tr>
<tr>
<td>Weighted Average(^{905})</td>
<td>629</td>
<td>564</td>
</tr>
</tbody>
</table>

\(^{904}\) 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.

\(^{905}\) Weighted based on number of occupied residential housing units in each zone.
=Actual
1000 = Converts Btu to kBtu
\( \eta_{\text{Cool}} \) = Efficiency (SEER) of Air Conditioning equipment (kBtu/kWh)

= Actual. If unknown assume\(^{906}\):

<table>
<thead>
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<th>Age of Equipment</th>
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<tr>
<td>Heat Pump After 1/1/2015</td>
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</tbody>
</table>

For example, duct sealing in a single family house in Springfield, with 36,000 Btu/H SEER 11 central air conditioning, an 80% AFUE, 105,000 Btu/H natural gas furnace and the following duct evaluation results:

\( DE_{\text{before}} = 0.85 \)
\( DE_{\text{after}} = 0.92 \)

Energy Savings:

\[ \Delta kWh_{\text{cooling}} = \left( \frac{(0.92 - 0.85) / 0.92 \times 730 \times 36,000}{1000 / 11} + (212 \times 0.0314 \times 29.3) \right) \]

\[ = 182 + 195 \]

\[ = 377 \text{ kWh} \]

Heating savings for homes with electric heat (Heat Pump):

\[ \Delta kWh_{\text{heating}} = \left( \frac{(DE_{\text{after}} - DE_{\text{before}})}{DE_{\text{after}}} \right) \times \text{FLHheat} \times \text{OutputCapacityHeat} / \eta_{\text{Heat}} / 3412 \]

Where:

\( \text{OutputCapacityHeat} = \) Heating output capacity (Btu/hr) of the electric heat

\( \text{FLHheat} = \) Full load heating hours

\( \text{=Actual} \)

\( \text{= Dependent on location as below}^{907} \):

\(^{906}\) 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.

\(^{907}\) Heating EFLH based on ENERGY Star EFLH for Rockford, Chicago, and Springfield and on NCDC/NOAA HDD for the other two
### Climate Zone (City based upon) and FLH_heat

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<tr>
<td>5 (Marion)</td>
<td>1,288</td>
</tr>
<tr>
<td>Weighted Average (908)</td>
<td>1,821</td>
</tr>
</tbody>
</table>

COP = Coefficient of Performance of electric heating system (909) = Actual. If not available use (910):

<table>
<thead>
<tr>
<th>System Type</th>
<th>Age of Equipment</th>
<th>HSPF Estimate</th>
<th>COP Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat Pump</td>
<td>Before 2006</td>
<td>6.8</td>
<td>2.00</td>
</tr>
<tr>
<td></td>
<td>After 2006 - 2014</td>
<td>7.7</td>
<td>2.26</td>
</tr>
<tr>
<td></td>
<td>2015 on</td>
<td>8.2</td>
<td>2.40</td>
</tr>
<tr>
<td>Resistance</td>
<td>N/A</td>
<td>N/A</td>
<td>1.00</td>
</tr>
</tbody>
</table>

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:

\[
\begin{align*}
DE_{after} &= 0.92 \\
DE_{before} &= 0.85
\end{align*}
\]

Energy Savings:

\[
\Delta kWh_{heating} = \frac{(0.92 - 0.85)/0.92 \times 1,967 \times 36,000}{2.5} / 3412
\]

\[= 632 \text{ kWh}\]

cities. In all cases, the hours were adjusted based on average natural gas heating consumption in IL.

908 Weighted based on number of occupied residential housing units in each zone.

909 Note that the HSPF of a heat pump is equal to the COP * 3.413.

910 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

\[ \Delta kW = \Delta kW_{cooling}/FLH_{cool} \times CF \]

Where:

\[ FLH_{cool} = \text{Full load cooling hours:} \]

= Dependent on location as below:

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<td>820</td>
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<tr>
<td>Weighted Average</td>
<td>629</td>
<td>564</td>
</tr>
</tbody>
</table>

\[ CF_{SSP} = \text{Summer System Peak Coincidence Factor for Central A/C (during system peak hour)} \]

= 68%\(^{913}\)

\[ CF_{PJM} = \text{PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)} \]

= 46.6%\(^{914}\)

NATURAL GAS SAVINGS

For homes with Natural Gas Heating:

Methodology 1: Modified Blower Door Subtraction

\[ \Delta \text{Therm} = \frac{(((\Delta CFM_{25,DL} / (InputCapacityHeat \times 0.0123)) \times FLH_{heat} \times InputCapacityHeat \times (\eta_{Equipment} / \eta_{System}))}{100,000} \]

Where:

\(^{911}\) 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.

\(^{912}\) Weighted based on number of occupied residential housing units in each zone.

\(^{913}\) Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.

\(^{914}\) 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.
\( \Delta \text{CFM}_{25}^{\text{DL}} \) = Duct leakage reduction in CFM25

\( \text{InputCapacityHeat} \) = Heating input capacity (Btu/hr)

\( = \text{Actual} \)

0.0123 = Conversion of Capacity to CFM \((0.0123 \text{CFM} / \text{Btu/hr})\)

FLH_{\text{heat}} = Full load heating hours

\( = \text{Dependent on location as below}^{916} \):

<table>
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<td>1,266</td>
</tr>
<tr>
<td>5 (Marion)</td>
<td>1,288</td>
</tr>
<tr>
<td>Weighted Average(^{917})</td>
<td>1,821</td>
</tr>
</tbody>
</table>

100,000 = Converts Btu to therms

\( \eta_{\text{Equipment}} \) = Heating Equipment Efficiency

\( = \text{Actual}^{918} \). If not available use 83\(^{919}\)

---

\(^{915}\) Based on Natural Draft Furnaces requiring 100 CFM per 10,000 Btu, Induced Draft Furnaces requiring 130 CFM per 10,000 Btu and Condensing Furnaces requiring 150 CFM per 10,000 Btu (rule of thumb from [http://contractingbusiness.com/enewletters/cb_imp_43580/](http://contractingbusiness.com/enewletters/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 vs induced draft non-condensing furnaces, as 123 per 10,000 Btu or 0.0123/Btu.

\(^{916}\) 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.

\(^{917}\) Weighted based on number of occupied residential housing units in each zone.

\(^{918}\) The Equipment Efficiency can be obtained either by recording the AFUE of the unit, or performing a steady state efficiency test. 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.

\(^{919}\) 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]](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
ηSystem = Pre duct sealing Heating System Efficiency (Equipment Efficiency * Pre Distribution Efficiency)

= Actual. If not available use 70%.

For example, duct sealing in a house in Springfield with an 80% AFUE, 105,000 Btu/H (input capacity) natural gas furnace 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

= 119 CFM

Duct Leakage reduction at CFM25:

ΔCFM25 DL = (387 – 139) * 0.64 * (0.5 + 0.25)

= 119 CFM25

Energy Savings:

Pre Distribution Efficiency = 1 – (387/4800) = 92%

ηSystem = 80% * 92% = 74%

ΔTherm = ((119/ (105,000 * 0.0123)) * 1,754 * 105,000 * (0.8/0.74)) / 100,000

= 183 therms

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) = 0.829

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.

Estimated as follows: 0.829 * (1-0.15) = 0.70
**Methodology 2: Evaluation of Distribution Efficiency**

\[
\Delta \text{Therm} = \left( \frac{\text{DE}_{\text{after}} - \text{DE}_{\text{before}}}{\text{DE}_{\text{after}}} \right) \times \text{FLHheat} \times \text{InputCapacityHeat} \times \left( \frac{\eta_{\text{Equipment}}}{\eta_{\text{System}}} \right) / 100,000
\]

Where:

- \( \text{DE}_{\text{after}} \) = Distribution Efficiency after duct sealing
- \( \text{DE}_{\text{before}} \) = 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 (input capacity) natural gas furnace and the following duct evaluation results:

- \( \text{DE}_{\text{after}} = 0.92 \)
- \( \text{DE}_{\text{before}} = 0.85 \)

Energy Savings:

\[
\eta_{\text{System}} = 80\% \times 85\% = 68\%
\]

\[
\Delta \text{Therm} = \left( \frac{(0.92 - 0.85)}{0.92} \right) \times 1,754 \times 105,000 \times \left( \frac{0.8}{0.68} \right) / 100,000
\]

\[
= 164 \text{ therm}
\]

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: RS-HVC-DINS-V05-150601**
5.3.5 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\(^{922}\).

DEEMED MEASURE COST

The capital cost for this measure is assumed to be $97\(^{923}\).

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.

\[
\begin{align*}
CF_{SSP} & = \text{Summer System Peak Coincidence Factor for Central A/C (during utility peak hour)} \\
& = 68\%_9^{24} \\
CF_{PJM} & = \text{PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)} \\
& = 46.6\%_9^{25}
\end{align*}
\]

Algorithm

**Calculation of Savings**

**Electric Energy Savings**

\[
\Delta \text{kWh} = \text{Heating Savings + Cooling Savings + Shoulder Season Savings}
\]

Where:

- **Heating Savings** = Blower motor savings during heating season
  - 418 kWh\(^9_26\)
- **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\(^9_27\)
- **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:

\[
\Delta \text{kWh} = \text{Heating Savings + Cooling Savings + Shoulder Season Savings} \\
= 418 + 263 + 51 \\
= 732 \text{ kWh}
\]

\(^9_24\) Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.  
\(^9_25\) 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.  
\(^9_26\) 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.  
\(^9_27\) 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).
**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

\[
\Delta kW = \text{Cooling Savings} / \text{FLH}_{\text{cooling}} \times CF
\]

Where:

- \( \text{FLH}_{\text{cooling}} \) = Full load hours of air conditioning
- \( \text{FLH}_{\text{cooling}} \) = Dependent on location[^928]:

<table>
<thead>
<tr>
<th>Climate Zone (City based upon)</th>
<th>FLH_{cooling}</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Rockford)</td>
<td>512</td>
</tr>
<tr>
<td>2 (Chicago)</td>
<td>570</td>
</tr>
<tr>
<td>3 (Springfield)</td>
<td>730</td>
</tr>
<tr>
<td>4 (Belleville)</td>
<td>1,035</td>
</tr>
<tr>
<td>5 (Marion)</td>
<td>903</td>
</tr>
<tr>
<td>Weighted Average[^929]</td>
<td>629</td>
</tr>
</tbody>
</table>

- \( \text{CF}_{\text{SSP}} \) = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)
- \( \text{CF}_{\text{SSP}} \) = 68%[^930]

- \( \text{CF}_{\text{PJM}} \) = PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)
- \( \text{CF}_{\text{PJM}} \) = 46.6%[^931]

For example, a blower motor in a home of unknown location where Central AC prevalence is unknown:

\[
\Delta kW_{\text{SSP}} = 251 / 629 \times 0.68
\]

\[
= 0.271 \text{kW}
\]

\[
\Delta kW_{\text{SSP}} = 251 / 629 \times 0.466
\]

\[
= 0.186 \text{kW}
\]

[^928]: 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](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.

[^929]: Weighted based on number of occupied residential housing units in each zone.

[^930]: Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.

[^931]: 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.

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**NATURAL GAS SAVINGS**

\[ \Delta \text{therms} = - \text{Heating Savings} \times 0.03412 / \text{AFUE} \]

Where:

- \(0.03412\) = Converts kWh to therms
- \(\text{AFUE}\) = Efficiency of the Furnace
  - Actual. If unknown assume 95\% \(933\) if in new furnace or 64.4 AFUE\% \(934\) if in existing furnace

Using defaults:

For new Furnace

\[ = - (418 \times 0.03412) / 0.95 \]
\[ = - 15.0 \text{ therms} \]

For existing Furnace

\[ = - (418 \times 0.03412) / 0.644 \]
\[ = - 22.1 \text{ therms} \]

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: RS-HVC-FBMT-V03-150601**

---

932 The blower fan is in the heating duct so all, or very nearly all, of its waste heat is delivered to the conditioned space. Negative value since this measure will increase the heating load due to reduced waste heat.

933 Minimum ENERGY STAR efficiency after 2.1.2012.

934 Average nameplate efficiencies of all Early Replacement qualifying equipment in Ameren PY3-PY4.
5.3.6 Gas High Efficiency Boiler

**DESCRIPTION**

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 characterizes:

a) **Time of Sale:**
   a. The installation of a new high efficiency, gas-fired hot water boiler in a residential location. 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:**
   a. The early removal of an existing functional AFUE 75% or less boiler from service, prior to its natural end of life, and replacement with a new high efficiency 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.

b. The assumption of the existing unit efficiency in the Early Replacement section of this TRM is based upon the average efficiency of units that were classified in Ameren’s PY3-PY4 as functioning and AFUE <=75%. Therefore it is only appropriate to use these Early Replacement assumptions where those conditions are met. The TAC defined “functioning” as the unit is fully operational – providing sufficient space conditioning (i.e. heat exchanger, compressors, pumps work effectively) and/or the cost of repair is under 20% of the new baseline replacement cost. Therefore in order to apply early replacement assumptions the programs should apply the following eligibility criteria: AFUE <=75% and cost of any repairs <$709.

b. A weighted average early replacement rate is provided for use when the actual baseline early replacement rates are unknown.

<table>
<thead>
<tr>
<th>Deemed Early Replacement Rates For Boilers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early Replacement Rate for Boiler participants</td>
</tr>
</tbody>
</table>

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**

To qualify for this measure the installed Boiler must be ENERGY STAR qualified (AFUE rated at or greater than 85%)

935 Based upon research from “Home Energy Efficiency Rebate Program GPY2 Evaluation Report” which outlines early replacement rates for both primary and secondary central air cooling (CAC) and residential furnaces. This is used as a reasonable proxy for boiler installations since boiler specific data is not available. Report presented to Nicor Gas Company February 27, 2014, available at http://www.ilsag.info/evaluation-documents.html.
and input capacity less than 300,000 Btu/hr).

**DEFINITION OF BASELINE EQUIPMENT**

Time of sale: 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:

<table>
<thead>
<tr>
<th>Program Year</th>
<th>AFUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>June 2012 – May 2013</td>
<td>80%</td>
</tr>
<tr>
<td>June 2013 on</td>
<td>82%</td>
</tr>
</tbody>
</table>

Early replacement: The baseline for this measure is the efficiency of the existing equipment for the assumed remaining useful life of the unit and the new baseline as defined above for the remainder of the measure life.

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The expected measure life is assumed to be 25 years.

Early replacement: Remaining life of existing equipment is assumed to be 8 years.

**DEEMED MEASURE COST**

Time of sale: The incremental install cost for this measure is dependent on tier:

<table>
<thead>
<tr>
<th>Measure Type</th>
<th>Installation Cost (June 2012 – May 2013)</th>
<th>Incremental Install Cost (June 2013)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFUE 80%</td>
<td>$3334</td>
<td>n/a</td>
</tr>
<tr>
<td>AFUE 82%</td>
<td>$3543</td>
<td></td>
</tr>
<tr>
<td>AFUE 85% (Energy Star Minimum)</td>
<td>$4268</td>
<td>$934</td>
</tr>
<tr>
<td>AFUE 90%</td>
<td>$4815</td>
<td>$1,481</td>
</tr>
<tr>
<td>AFUE 95%</td>
<td>$5328</td>
<td>$1,994</td>
</tr>
</tbody>
</table>

936 There will be some delay to the baseline shift while existing stocks of lower efficiency equipment is sold.

937 Table 8.3.3 The Technical support documents for federal residential appliance standards:

938 Assumed to be one third of effective useful life

939 Based on data provided in Appendix E of the Appliance Standards Technical Support Documents including equipment cost and installation labor (http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/fb_fr_tsd/appendix_e.pdf). Where efficiency ratings are not provided, the values are interpolated from those that are.
Early Replacement: The full installation cost is provided in the table above. The assumed deferred cost (after 8 years) of replacing existing equipment with a new baseline unit is assumed to be $3543. This cost should be discounted to present value using the utilities’ discount rate.

**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**

**Time of Sale:**

\[ \Delta \text{Therms} = \text{Gas}_\text{Boiler}_\text{Load} \times (\frac{1}{\text{AFUE(base)}} - \frac{1}{\text{AFUE(eff)}}) \]

Early replacement\(^{940}\):

- \( \Delta \text{Therms} \) for remaining life of existing unit (1st 8 years):
  \[ = \text{Gas}_\text{Boiler}_\text{Load} \times (\frac{1}{\text{AFUE(exist)}} - \frac{1}{\text{AFUE(eff)}}) \]
- \( \Delta \text{Therms} \) for remaining measure life (next 17 years):
  \[ = \text{Gas}_\text{Boiler}_\text{Load} \times (\frac{1}{\text{AFUE(base)}} - \frac{1}{\text{AFUE(eff)}}) \]

Where:

\[ \text{Gas}_\text{Boiler}_\text{Load}^{941} = \text{Estimate of annual household Load for gas boiler heated single-family homes.} \]

---

\(^{940}\) 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).

\(^{941}\) 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)
If location is unknown, assume the average below\textsuperscript{942}.

$= \text{or Actual if informed by site-specific load calculations, ACCA Manual J or equivalent}\textsuperscript{943}$.

<table>
<thead>
<tr>
<th>Climate Zone (City based upon)</th>
<th>Gas_Boiler Load (therms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Rockford)</td>
<td>1275</td>
</tr>
<tr>
<td>2 (Chicago)</td>
<td>1218</td>
</tr>
<tr>
<td>3 (Springfield)</td>
<td>1043</td>
</tr>
<tr>
<td>4 (Belleville)</td>
<td>805</td>
</tr>
<tr>
<td>5 (Marion)</td>
<td>819</td>
</tr>
<tr>
<td>Average</td>
<td>1158</td>
</tr>
</tbody>
</table>

$\text{AFUE(exist)} = \text{Existing Boiler Annual Fuel Utilization Efficiency Rating}$

$= \text{Use actual AFUE rating where it is possible to measure or reasonably estimate.}$

If unknown, assume 61.6 AFUE\%\textsuperscript{944}.

$\text{AFUE(base)} = \text{Baseline Boiler Annual Fuel Utilization Efficiency Rating}$

$= \text{Dependent on year as listed below:}$

<table>
<thead>
<tr>
<th>Program Year</th>
<th>AFUE(base)</th>
</tr>
</thead>
<tbody>
<tr>
<td>June 2012 – May 2013</td>
<td>80%</td>
</tr>
<tr>
<td>June 2013 on</td>
<td>82%</td>
</tr>
</tbody>
</table>

$\text{AFUE(eff)} = \text{Efficient Boiler Annual Fuel Utilization Efficiency Rating}$

$= \text{Actual. If unknown, use defaults dependent\textsuperscript{945} on tier as listed below:}$

<table>
<thead>
<tr>
<th>Measure Type</th>
<th>AFUE(eff)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENERGY STAR*</td>
<td>87.5%</td>
</tr>
<tr>
<td>AFUE 90%</td>
<td>92.5%</td>
</tr>
</tbody>
</table>

\textsuperscript{942} 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.

\textsuperscript{943} The Air Conditioning Contractors of America Manual J, Residential Load Calculation 8\textsuperscript{th} 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 be completed by contractors during the selection process and may be readily available for program data purposes.

\textsuperscript{944} Average nameplate efficiencies of all Early Replacement qualifying equipment in Ameren PY3-PY4.

\textsuperscript{945} 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.
<table>
<thead>
<tr>
<th>Measure Type</th>
<th>AFUE(\text{eff})</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFUE 95%</td>
<td>95%</td>
</tr>
</tbody>
</table>

**Time of Sale:**
For example, a default sized ENERGY STAR boiler purchased and installed near Springfield in the year 2012

\[
\Delta\text{Therms} = (1043) \times (1/0.8) - 1/0.875 \\
= 112 \text{ Therms}
\]

**Early Replacement:**
For example, an existing function boiler with unknown efficiency is replaced with an ENERGY STAR boiler purchased and installed in Springfield in 2013.

\[
\Delta\text{Therms for remaining life of existing unit (1st 8 years):} \\
= 1043 \times (1/0.616 - 1/0.875) \\
= 501 \text{ Therms}
\]

\[
\Delta\text{Therms for remaining measure life (next 17 years):} \\
= (1043) \times (1/0.82 - 1/0.875) \\
= 80.0 \text{ Therms}
\]

**WATER IMPACT DESCRIPTIONS AND CALCULATION**
N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**
N/A

**MEASURE CODE:** RS-HVC-GHEB-V03-150601
5.3.7 Gas High Efficiency Furnace

DESCRIPTION

High efficiency furnace features may include improved heat exchangers and modulating multi-stage burners. This measure characterizes:

a) Time of sale:
   a. The installation of a new high efficiency, gas-fired condensing furnace in a residential location. 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:
   a. The early removal of an existing functioning AFUE 75% or less furnace from service, prior to its natural end of life, and replacement with a new high efficiency 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. At time of writing, the DOE had rescinded the next Federal Standard change for furnaces, however it is likely that a new standard will be in effect after the assumed remaining useful life of the existing unit. For the purposes of this measure - the new baseline is assumed to be 90%.
   b. The assumption of the existing unit efficiency in the Early Replacement section of this TRM is based upon the average efficiency of units that were classified in Ameren’s PY3-PY4 as functioning and AFUE <=75%. Therefore it is only appropriate to use these Early Replacement assumptions where those conditions are met. The TAC defined “functioning” as the unit is fully operational – providing sufficient space conditioning (i.e. heat exchanger, compressors, pumps work effectively) and/or the cost of repair is under 20% of the new baseline replacement cost. Therefore in order to apply early replacement assumptions the programs should apply the following eligibility criteria: AFUE <=75% and cost of any repairs <$528.
   c. A weighted average early replacement rate is provided for use when the actual baseline early replacement rate is unknown.

Deemed Early Replacement Rates For Furnaces

<table>
<thead>
<tr>
<th>Replacement Scenario for the Furnace</th>
<th>Deemed Early Replacement Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early Replacement Rate for Furnace-only participants</td>
<td>7%</td>
</tr>
<tr>
<td>Early Replacement Rate for a furnace when the furnace is the Primary unit in a Combined System Replacement (CSR) project</td>
<td>14%</td>
</tr>
<tr>
<td>Early Replacement Rate for a furnace when the furnace is the</td>
<td>46%</td>
</tr>
</tbody>
</table>

946 Based upon research from “Home Energy Efficiency Rebate Program GPY2 Evaluation Report” which outlines early replacement rates for both primary and secondary central air cooling (CAC) and residential furnaces. The unit (furnace or CAC unit) that initially caused the customer to contact a trade ally is defined as the “primary unit”. The furnace or CAC unit that was also replaced but did not initially prompt the customer to contact a trade ally is defined as the “secondary unit”. This evaluation used different criteria for early replacement due to the availability of data after the fact; cost of any repairs < $550 and age of unit < 20 years. Report presented to Nicor Gas Company February 27, 2014, available at http://www.ilsag.info/evaluation-documents.html.
Replacement Scenario for the Furnace | Deemed Early Replacement Rate
--- | ---
Secondary unit in a CSR project |  

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**

To qualify for this measure the installed equipment must be a residential sized (input energy less than 225,000 Btu/hr) natural gas fired furnace with an Annual Fuel Utilization Efficiency (AFUE) rating exceeding the program requirements.

**Definition of Baseline Equipment**

Time of Sale: 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%. The baseline will be adjusted when the Federal Standard is updated.

Early replacement: The baseline for this measure is the efficiency of the existing equipment for the assumed remaining useful life of the unit and a new baseline unit for the remainder of the measure life. As discussed above we estimate that the new baseline unit that could be purchased in the year the existing unit would have needed replacing is 90%.

**Deemed Lifetime of Efficient Equipment**

The expected measure life is assumed to be 20 years. For early replacement: Remaining life of existing equipment is assumed to be 6 years.

**Deemed Measure Cost**

Time of sale: The incremental installed cost (retail equipment cost plus installation cost) for this measure depends on efficiency as listed below:

<table>
<thead>
<tr>
<th>AFUE</th>
<th>Installed Cost</th>
<th>Incremental Installed Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>80%</td>
<td>$2011</td>
<td>n/a</td>
</tr>
<tr>
<td>90%</td>
<td>$2641</td>
<td>$630</td>
</tr>
<tr>
<td>91%</td>
<td>$2727</td>
<td>$716</td>
</tr>
<tr>
<td>92%</td>
<td>$2813</td>
<td>$802</td>
</tr>
</tbody>
</table>

---

947 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  
948 Assumed to be one third of effective useful life  
949 Based on data from Table E.1.1 of Appendix E of the Appliance Standards Technical Support Documents including equipment cost and installation labor. (http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/fb_fr_tsd/appendix_e.pdf). Where efficiency ratings are not provided, the values are interpolated from those that are. Note that ECM furnace fan cost (refer to other measure in TRM) has been deducted from the 93%-96% AFUE values to avoid double counting.
<table>
<thead>
<tr>
<th>AFUE</th>
<th>Installed Cost</th>
<th>Incremental Installed Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>93%</td>
<td>$3025</td>
<td>$1014</td>
</tr>
<tr>
<td>94%</td>
<td>$3237</td>
<td>$1226</td>
</tr>
<tr>
<td>95%</td>
<td>$3449</td>
<td>$1438</td>
</tr>
<tr>
<td>96%</td>
<td>$3661</td>
<td>$1650</td>
</tr>
</tbody>
</table>

Early Replacement: The full installed cost is provided in the table above. The assumed deferred cost (after 6 years) of replacing existing equipment with a new baseline unit is assumed to be $2641. This cost should be discounted to present value using the utility’s discount rate.

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

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

Time of Sale:

$$\Delta\text{Therms} = \text{Gas\_Furnace\_Heating\_Load} \times (1/\text{AFUE(base)} - 1/\text{AFUE(eff)})$$

Early replacement$^{950}$:

$$\Delta\text{Therms for remaining life of existing unit (1st 6 years)}:$$

$$= \text{Gas\_Furnace\_Heating\_Load} \times (1/\text{AFUE(exist)} - 1/\text{AFUE(eff)})$$

$$\Delta\text{Therms for remaining measure life (next 14 years)}:$$

$^{950}$ 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).
= Gas_Furnace_Heating_Load * (1/AFUE(base) - 1/AFUE(eff))

Where:

Gas_Furnace_Heating_Load

- Estimate of annual household heating load\(^{951}\) for gas furnace heated single-family homes. If location is unknown, assume the average below\(^{952}\).
- Actual if informed by site-specific load calculations, ACCA Manual J or equivalent\(^{953}\).

<table>
<thead>
<tr>
<th>Climate Zone (City based upon)</th>
<th>Gas_Furnace_Heating_Load (therms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Rockford)</td>
<td>873</td>
</tr>
<tr>
<td>2 (Chicago)</td>
<td>834</td>
</tr>
<tr>
<td>3 (Springfield)</td>
<td>714</td>
</tr>
<tr>
<td>4 (Belleville)</td>
<td>551</td>
</tr>
<tr>
<td>5 (Marion)</td>
<td>561</td>
</tr>
<tr>
<td>Average</td>
<td>793</td>
</tr>
</tbody>
</table>

HF

- Household factor, to adjust heating consumption for non-single-family households.

<table>
<thead>
<tr>
<th>Household Type</th>
<th>HF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-Family</td>
<td>100%</td>
</tr>
<tr>
<td>Multi-Family</td>
<td>65%(^{954})</td>
</tr>
<tr>
<td>Actual</td>
<td>Custom(^{955})</td>
</tr>
</tbody>
</table>

AFUE(exist)

- Existing Furnace Annual Fuel Utilization Efficiency Rating
- Use actual AFUE rating where it is possible to measure or reasonably estimate.

\(^{951}\) Heating load is used to describe the household heating need, which is equal to (gas consumption * AFUE).

\(^{952}\) Values are based on household heating consumption values and inferred average AFUE results from Table 2-1, Energy Efficiency / Demand Response Nicor Gas Plan Year 1 (6/1/2011-5/31/2012) Research Report: Furnace Metering Study (August 1, 2013) (prepared by Navigant Consulting, Inc.) and 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.

\(^{953}\) The Air Conditioning Contractors of America Manual J, Residential Load Calculation 8\(^{th}\) 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 are commonly completed by contractors during the selection process and may be readily available for program data purposes.

\(^{954}\) 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.

\(^{955}\) Program-specific household factors may be utilized on the basis of sufficiently validated program evaluations.
If unknown, assume 64.4 AFUE%\(^{956}\).

$\text{AFUE(base)} = \text{Baseline Furnace Annual Fuel Utilization Efficiency Rating}$

$= \text{Dependent on program type as listed below}\(^{957}\).$

<table>
<thead>
<tr>
<th>Program Year</th>
<th>AFUE(base)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time of Sale</td>
<td>80%</td>
</tr>
<tr>
<td>Early Replacement</td>
<td>90%</td>
</tr>
</tbody>
</table>

$\text{AFUE(eff)} = \text{Efficient Furnace Annual Fuel Utilization Efficiency Rating}$

$= \text{Actual. If unknown, assume 95%}\(^{958}\)$

**Time of Sale:**
For example, a 95% AFUE furnace near Rockford and purchased in the year 2014

$$\Delta \text{Therms} = 873 \times (1/0.8 - 1/0.95)$$

$$= 172 \text{ therms}$$

**Early Replacement:**
For example, an existing functioning furnace with unknown efficiency is replaced with an 95% furnace purchased and installed in Rockford in 2014.

- $\Delta \text{Therms for remaining life of existing unit (1st 6 years):}$
  $$= 873 \times (1/0.644 - 1/0.95)$$
  $$= 437 \text{ therms}$$

- $\Delta \text{Therms for remaining measure life (next 14 years):}$
  $$= 873 \times (1/0.9 - 1/0.95)$$
  $$= 51.1 \text{ therms}$$

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: RS-HVC-GHEF-V04-150601**

---

\(^{956}\) Average nameplate efficiencies of all Early Replacement qualifying equipment in Ameren PY3-PY4.

\(^{957}\) 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.

\(^{958}\) Minimum ENERGY STAR efficiency after 2.1.2012.
5.3.8 Ground Source Heat Pump

**DESCRIPTION**

This measure characterizes the installation of a Ground Source Heat Pump under the following scenarios:

a) New Construction:
   a. The installation of a new residential sized Ground Source Heat Pump system meeting ENERGY STAR efficiency standards presented below in a new home.
   b. Note the baseline in this case should be determined via EM&V and the algorithms are provided to allow savings to be calculated from any baseline condition.

b) Time of Sale:
   a. The planned installation of a new residential sized Ground Source Heat Pump system meeting ENERGY STAR efficiency standards presented below to replace an existing system(s) that does not meet the criteria for early replacement described in section c below.
   b. Note the baseline in this case is an equivalent replacement system to that which exists currently in the home. The calculation of savings is dependent on whether an incentive for the installation has been provided by both a gas and electric utility, just an electric utility or just a gas utility.
   c. Additional DHW savings are calculated based upon the fuel and efficiency of the existing unit.

c) Early Replacement/Retrofit:
   a. The early removal of functioning either electric or gas space heating and/or cooling systems from service, prior to the natural end of life, and replacement with a new high efficiency Ground Source Heat Pump system.
   b. Note the baseline in this case is the existing equipment being replaced. The calculation of savings is dependent on whether an incentive for the installation has been provided by both a gas and electric utility, just an electric utility or just a gas utility.
   c. Additional DHW savings are calculated based upon the fuel and efficiency of the existing unit.
   d. The definitions for when an installation can be claimed as an early replacement are provided below. Note if one system (heating or cooling) has failed or does not meet the criteria below but the other system does, then the appropriate new baseline replacement should be used for the unit not meeting early replacement criteria and the existing system efficiency for the unit that does should be used in the algorithm:

<table>
<thead>
<tr>
<th>Existing System</th>
<th>Early Replacement Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Source Heat Pump</td>
<td>SEER &lt;=10 and cost of any repairs &lt;$249 per ton</td>
</tr>
<tr>
<td>Central Air Conditioner</td>
<td>SEER &lt;=10 and cost of any repairs &lt;$190 per ton</td>
</tr>
<tr>
<td>Boiler</td>
<td>AFUE &lt;= 75% and cost of any repairs &lt;$709</td>
</tr>
<tr>
<td>Furnace</td>
<td>AFUE &lt;= 75% and cost of any repairs &lt;$528</td>
</tr>
<tr>
<td>Ground Source Heat Pump</td>
<td>SEER &lt;=10 and cost of any repairs &lt;$249 per ton</td>
</tr>
</tbody>
</table>
The ENERGY STAR efficiency standards are presented below.

<table>
<thead>
<tr>
<th>Product Type</th>
<th>Cooling EER</th>
<th>Heating COP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water-to-air</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Closed Loop</td>
<td>17.1</td>
<td>3.6</td>
</tr>
<tr>
<td>Open Loop</td>
<td>21.1</td>
<td>4.1</td>
</tr>
<tr>
<td>Water-to-Water</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Closed Loop</td>
<td>16.1</td>
<td>3.1</td>
</tr>
<tr>
<td>Open Loop</td>
<td>20.1</td>
<td>3.5</td>
</tr>
<tr>
<td>DGX</td>
<td>16</td>
<td>3.6</td>
</tr>
</tbody>
</table>

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 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**

For these products, baseline equipment includes Air Conditioning, Space Heating and Water Heating.

New Construction:

To calculate savings with an electric baseline, the baseline equipment is assumed to be an Air Source Heat Pump meeting the Federal Standard efficiency level; 14 SEER, 8.2 HSPF and 11.8 EER and a Federal Standard electric hot water heater.

To calculate savings with a furnace/central AC baseline, the baseline equipment is assumed to be an 80% AFUE Furnace and central AC meeting the Federal Standard efficiency level; 13 SEER, 11 EER. If a gas water heater, the Federal Standard baseline is calculated as follows:\(\text{EF} = 0.8012 - (0.00078 \times \text{storage size in gallons})\) for storage tanks >55 gallon, or \(\text{EF} = 0.615\) for a 40-gallon storage water heater.

---

959 The Federal Standard does not include an EER requirement, so it is approximated with this formula: \((-0.02 \times \text{SEER}^2) + (1.12 \times \text{SEER})\) Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder.

Time of Sale: The baseline for this measure is a new replacement unit of the same system type as the existing unit, meeting the baselines provided below.

<table>
<thead>
<tr>
<th>Unit Type</th>
<th>Efficiency Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASHP</td>
<td>14 SEER, 11.8 EER, 8.2 HSPF</td>
</tr>
<tr>
<td>Gas Furnace</td>
<td>80% AFUE</td>
</tr>
<tr>
<td>Gas Boiler</td>
<td>82% AFUE</td>
</tr>
<tr>
<td>Central AC</td>
<td>13 SEER, 11 EER</td>
</tr>
</tbody>
</table>

Early replacement / Retrofit: The baseline for this measure is the efficiency of the *existing* heating, cooling and hot water equipment for the assumed remaining useful life of the existing unit and a new baseline heating and cooling system for the remainder of the measure life (as provided in table above except for Gas Furnace where new baseline assumption is 90% due to pending standard change).

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The expected measure life is assumed to be 25 years\(^{961}\). For early replacement, the remaining life of existing equipment is assumed to be 8 years\(^{962}\).

**DEEMED COST**

New Construction and Time of Sale: The actual installed cost of the Ground Source Heat Pump should be used (default of $3957 per ton\(^{963}\)), minus the assumed installation cost of the baseline equipment ($1936 per ton for ASHP\(^{964}\), or $2011 for a new baseline 80% AFUE furnace or $3543 for a new 82% AFUE boiler\(^{965}\) and $2,857\(^{966}\) for new baseline Central AC replacement).

Early Replacement: The full installation cost of the Ground Source Heat Pump should be used (default provided above). The assumed deferred cost (after 8 years) of replacing existing equipment with a new baseline unit is assumed to be $1936 per ton for a new baseline Air Source Heat Pump, or $2641\(^{967}\) for a new baseline 90% AFUE furnace or $3543 for a new 82% AFUE boiler and $2,857 for new baseline Central AC replacement. This future cost

---

961 System life of indoor components as per DOE estimate http://energy.gov/energysaver/articles/geothermal-heat-pumps. The ground loop has a much longer life, but the compressor and other mechanical components are the same as an ASHP. [http://neep.org/uploads/EMV%20Forum/EMV%20Studies/measure_life_GDS%5B1%5D.pdf](http://neep.org/uploads/EMV%20Forum/EMV%20Studies/measure_life_GDS%5B1%5D.pdf)

962 Assumed to be one third of effective useful life


964 Based on data provided on Home Advisor website, providing national average ASHP cost based on 2465 cost submittals. [http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/fb_fr_tsd/appendix_e.pdf](http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/fb_fr_tsd/appendix_e.pdf)

965 Furnace and boiler costs are based on data provided in Appendix E of the Appliance Standards Technical Support Documents including equipment cost and installation labor (http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/fb_fr_tsd/appendix_e.pdf). Where efficiency ratings are not provided, the values are interpolated from those that are.

966 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.

967 Based on data from Table E.1.1 of Appendix E of the Appliance Standards Technical Support Documents including equipment cost and installation labor (http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/fb_fr_tsd/appendix_e.pdf).
should be discounted to present value using the utilities’ discount rate.

**LOADSHAPE**

Loadshape R08 - Residential Cooling  
(if replacing gas heat and central AC)

Loadshape R09 - Residential Electric Space Heat  
(if replacing electric heat with no cooling)

Loadshape R10 - Residential Electric Heating and Cooling  
(if replacing ASHP)

**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.

\[
\begin{align*}
\text{CF}_{\text{SSP}} &= \text{Summer System Peak Coincidence Factor for Heat Pumps (during utility peak hour)} \\
&= 72\% \quad ^{968} \\
\text{CF}_{\text{PJM}} &= \text{PJM Summer Peak Coincidence Factor for Heat Pumps (average during PJM peak period)} \\
&= 46.6\% \quad ^{969}
\end{align*}
\]

**Algorithm**

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

New Construction and Time of Sale (non-fuel switch only):

\[
\Delta \text{kWh} = \text{[Cooling savings]} + \text{[Heating savings]} + \text{[DHW savings]}
\]

\[
\begin{align*}
&= (\text{FLHcool} \times \text{Capacity_{cooling}} \times (1/\text{SEER}_{\text{base}} - (1/\text{EER}_{\text{PL}})/1000) + \text{Elecheat} \times \text{FLHheat} \times \text{Capacity_{heating}} \times (1/\text{HSPF}_{\text{base}} - (1/\text{COP}_{\text{PL}} \times 3.412))/1000 + \text{ElecDHW} \times \%\text{DHWDisplaced} \times (((1/\text{EF}_{\text{ELEC}}) \times \text{GPD} \times \text{Household} \times 365.25 \times \gamma_{\text{Water}} \times (T_{\text{OUT}} - T_{\text{IN}}) \times 1.0) / 3412)
\end{align*}
\]

New Construction and Time of Sale (fuel switch only):

If measure is supported by gas utility only, \(\Delta \text{kWh} = 0\)

If measure is supported by gas and electric utility or electric utility only, electric utility claim savings calculated below:

\[
\Delta \text{kWh} = \text{[Cooling savings]} + \text{[Heating savings from base ASHP to GSHP]} + \text{[DHW savings]}
\]

\[
\begin{align*}
&= (\text{FLHcool} \times \text{Capacity_{cooling}} \times (1/\text{SEER}_{\text{base}} - (1/\text{EER}_{\text{PL}})/1000) + \text{FLHheat} \times \\
&
\end{align*}
\]

---

\(^{968}\) Based on analysis of metering results from 24 heat pumps in Ameren Illinois service territory in PY5 coincident with AIC’s 2010 system peak; ‘Impact and Process Evaluation of Ameren Illinois Company’s Residential HVAC Program (PY5)’.  

\(^{969}\) 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.
FFHcool = Full load cooling hours

Dependent on location as below

970 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).

971 Based on Full Load Hours from ENERGY STAR with adjustments made in a Navigant Evaluation, other cities were scaled using
### Climate Zone (City based upon) FLHcool Single Family FLHcool Multifamily

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Rockford)</td>
<td>512</td>
<td>467</td>
</tr>
<tr>
<td>2 (Chicago)</td>
<td>570</td>
<td>506</td>
</tr>
<tr>
<td>3 (Springfield)</td>
<td>730</td>
<td>663</td>
</tr>
<tr>
<td>4 (Belleville)</td>
<td>1,035</td>
<td>940</td>
</tr>
<tr>
<td>5 (Marion)</td>
<td>903</td>
<td>820</td>
</tr>
<tr>
<td><strong>Weighted Average</strong></td>
<td><strong>629</strong></td>
<td><strong>564</strong></td>
</tr>
</tbody>
</table>

**Capacity\_cooling** = Cooling Capacity of Ground Source Heat Pump (Btu/hr)

= Actual (1 ton = 12,000Btu/hr)

**SEERbase** = SEER Efficiency of new replacement baseline unit

<table>
<thead>
<tr>
<th>Existing Cooling System</th>
<th>SEERbase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Source Heat Pump</td>
<td>14&lt;sup&gt;973&lt;/sup&gt;</td>
</tr>
<tr>
<td>Central AC</td>
<td>13&lt;sup&gt;974&lt;/sup&gt;</td>
</tr>
<tr>
<td>No central cooling</td>
<td>13&lt;sup&gt;975&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

**SEERexist** = SEER Efficiency of existing cooling unit

= Use actual SEER rating where it is possible to measure or reasonably estimate, if unknown assume default provided below:

<table>
<thead>
<tr>
<th>Existing Cooling System</th>
<th>SEER exist</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Source Heat Pump</td>
<td>9.12&lt;sup&gt;976&lt;/sup&gt;</td>
</tr>
<tr>
<td>Central AC</td>
<td>8.60&lt;sup&gt;977&lt;/sup&gt;</td>
</tr>
<tr>
<td>No central cooling</td>
<td>13 &lt;sup&gt;978&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

**SEER\_ASHP** = SEER Efficiency of new baseline Air Source Heat Pump unit (for fuel switch)

---

those results and CDD. There is a county mapping table in the Section 3.7 of the TRM providing the appropriate city to use for each county of Illinois.

<sup>972</sup> Weighted based on number of occupied residential housing units in each zone.


<sup>975</sup> Assumes that the decision to replace existing systems includes desire to add cooling.

<sup>976</sup> Average nameplate efficiencies of all Early Replacement qualifying equipment in Ameren PY3-PY4.

<sup>977</sup> Ibid.

<sup>978</sup> Assumes that the decision to replace existing systems includes desire to add cooling.
EER_{PL} = Part Load EER Efficiency of efficient GSHP unit

ElecHeat = 1 if existing building is electrically heated
= 0 if existing building is not electrically heated

FLHheat = Full load heating hours

Dependent on location as below:

<table>
<thead>
<tr>
<th>Climate Zone (City based upon)</th>
<th>FLH_heat</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Rockford)</td>
<td>1,969</td>
</tr>
<tr>
<td>2 (Chicago)</td>
<td>1,840</td>
</tr>
<tr>
<td>3 (Springfield)</td>
<td>1,754</td>
</tr>
<tr>
<td>4 (Belleville)</td>
<td>1,266</td>
</tr>
<tr>
<td>5 (Marion)</td>
<td>1,288</td>
</tr>
<tr>
<td>Weighted Average</td>
<td>1,821</td>
</tr>
</tbody>
</table>

Capacity_heating = Heating Capacity of Ground Source Heat Pump (Btu/hr)

= Actual (1 ton = 12,000Btu/hr)

HSPF_{base} = Heating System Performance Factor of new replacement baseline heating system (kBtu/kWh)

<table>
<thead>
<tr>
<th>Existing Heating System</th>
<th>HSPF_{base}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Source Heat Pump</td>
<td>8.2</td>
</tr>
<tr>
<td>Electric Resistance</td>
<td>3.41</td>
</tr>
</tbody>
</table>

HSPF_{exist} = Heating System Performance Factor of existing heating system (kBtu/kWh)

= Use actual HSPF rating where it is possible to measure or reasonably estimate. If unknown assume default:

Minimum Federal Standard as of 1/1/2015:

As per conversations with David Buss territory manager for Connor Co, the SEER and COP ratings of an ASHP equate most appropriately with the part load EER and COP of a GSHP.

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 Section 3.7 of the TRM providing the appropriate city to use for each county of Illinois.

Weighted based on number of occupied residential housing units in each zone.

Electric resistance has a COP of 1.0 which equals 1/0.293 = 3.41 HSPF.
<table>
<thead>
<tr>
<th>Existing Heating System</th>
<th>HSPF_exist</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Source Heat Pump</td>
<td>5.44</td>
</tr>
<tr>
<td>Electric Resistance</td>
<td>3.41</td>
</tr>
</tbody>
</table>

HSPF\textsubscript{ASHP} = Heating Season Performance Factor for new ASHP baseline unit (for fuel switch)

HSPF\textsubscript{ASHP} = 8.2 \textsuperscript{984}

COP\textsubscript{PL} = Part Load Coefficient of Performance of efficient unit \textsuperscript{985}

COP\textsubscript{PL} = Actual Installed

3.412 = Constant to convert the COP of the unit to the Heating Season Performance Factor (HSPF).

ElecDHW = 1 if existing DHW is electrically heated

ElecDHW = 0 if existing DHW is not electrically heated

%DHWDISplaced = Percentage of total DHW load that the GSHP will provide

%DHWDISplaced = Actual if known

%DHWDISplaced = If unknown and if desuperheater installed assume 44% \textsuperscript{986}

%DHWDISplaced = 0% if no desuperheater installed

EF\textsubscript{ELEC} = Energy Factor (efficiency) of electric water heater

EF\textsubscript{ELEC} = Actual. If unknown or for new construction assume federal standard \textsuperscript{987}:

For <=55 gallons: \(0.96 - (0.0003 \times \text{rated volume in gallons})\)

For >55 gallons: \(2.057 - (0.00113 \times \text{rated volume in gallons})\)

GPD = Gallons Per Day of hot water use per person

GPD = 45.5 gallons hot water per day per household/2.59 people per household \textsuperscript{988}

Household = Average number of people per household


\textsuperscript{985} As per conversations with David Buss territory manager for Connor Co, the SEER and COP ratings of an ASHP equate most appropriately with the part load EER and COP of a GSHP.

\textsuperscript{986} Assumes that the desuperheater can provide two thirds of hot water needs for eight months of the year (2/3 * 2/3 = 44%). Based on input from Doug Dougherty, Geothermal Exchange Organization.


\textsuperscript{988} Email message from Maureen Hodgins, Research Manager for Water Research Foundation, to TAC/SAG, August 26, 2014
### Household Unit Type

<table>
<thead>
<tr>
<th>Household Unit Type</th>
<th>Household</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-Family - Deemed</td>
<td>2.56&lt;sup&gt;989&lt;/sup&gt;</td>
</tr>
<tr>
<td>Custom</td>
<td>Actual Occupancy or Number of Bedrooms&lt;sup&gt;990&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

- **365.25** = Days per year
- **γ<sub>Water</sub>** = Specific weight of water
  - = 8.33 pounds per gallon
- **T<sub>OUT</sub>** = Tank temperature
  - = 125°F
- **T<sub>IN</sub>** = Incoming water temperature from well or municipal system
  - = 54°F<sup>991</sup>
- **1.0** = Heat Capacity of water (1 Btu/lb°F)
- **3412** = Conversion from Btu to kWh

---


<sup>990</sup> 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.

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

**New Construction and Time of Sale:**

\[
\Delta kW = \text{(Capacity\_cooling} \times \frac{1}{\text{EERbase} - \frac{1}{\text{EERPL}}})/1000\] * CF

**Early replacement:**

\[
\Delta kW \text{ for remaining life of existing unit (1st 8 years):} = \left(\text{Capacity\_cooling} \times \frac{1}{\text{EERexist} - \frac{1}{\text{COPPL} \times 3.412}}\right)/1000 + \text{(ElecDHW} \times \%\text{DHW\_displaced}) \times \left(\frac{1}{\text{EF} \times \text{GPD} \times \text{Household}} \times \text{γWater} \times \left(\frac{\text{T\_OUT} - \text{T\_IN}}{3412}\right)\right)
\]

**NEW CONSTRUCTION USING ASHP BASELINE:**

For example, a 3 ton unit with Part Load EER rating of 19 and Part Load COP of 4.4 with desuperheater is installed with a 50 gallon electric water heater in single family house in Springfield:

\[
\Delta kWh = \left(\frac{\text{FLH\_cool} \times \text{Capacity\_cooling} \times \left(1/\text{SEERbase} - \frac{1}{\text{EERPL}}\right)}{1000}\right) + \left(\frac{\text{FLH\_heat} \times \text{Capacity\_heating} \times \left(1/\text{HSPFbase} - \frac{1}{\text{COPPL} \times 3.412}\right)}{1000}\right) + \left(\text{ElecDHW} \times \%\text{DHW\_displaced} \times \left(\frac{1}{\text{EF\_EXIST}} \times \text{GPD} \times \text{Household} \times \text{γWater} \times \left(\frac{\text{T\_OUT} - \text{T\_IN}}{3412}\right)\right)\right)
\]

\[
\Delta kWh = \left(\frac{730 \times 36,000 \times (1/14 - 1/19)}{1000}\right) + \left(\frac{1754 \times 36,000 \times (1/8.2 - 1/ (4.4 \times 3.412))}{1000}\right) + \left(0.44 \times 1 \times \left(\frac{(1/0.945) \times 17.6 \times 2.56 \times 365.25 \times 8.33 \times (125 - 54) \times 1}{3412}\right)\right)
\]

\[
\Delta kWh = 494 + 3494 + 1328 = 5316 kWh
\]

**EARLY REPLACEMENT – NON-FAIR SWITCH (SEE EXAMPLE AFTER NATURAL GAS SECTION FOR FUEL SWITCH):**

For example, a 3 ton unit with Part Load EER rating of 19 and Part Load COP of 4.4 with desuperheater is installed in single family house in Springfield with a 50 gallon electric water heater replacing an existing working Air Source Heat Pump with unknown efficiency ratings:

\[
\Delta kWh \text{ for remaining life of existing unit (1st 8 years):} = \left(\frac{730 \times 36,000 \times (1/9.12 - 1/19)}{1000}\right) + \left(\frac{1754 \times 36,000 \times (1/5.44 - 1/ (4.4 \times 3.412))}{1000}\right) + \left(0.44 \times 1 \times \left(\frac{(1/0.945) \times 17.6 \times 2.56 \times 365.25 \times 8.33 \times (125 - 54) \times 1}{3412}\right)\right)
\]

\[
\Delta kWh = 1498 + 7401 + 1328 = 10,227 kWh
\]

\[
\Delta kWh \text{ for remaining measure life (next 17 years):} = \left(\frac{730 \times 36,000 \times (1/14 - 1/28)}{1000}\right) + \left(\frac{1967 \times 36,000 \times (1/8.2 - 1/ (4.4 \times 3.412))}{1000}\right) + \left(0.44 \times 1 \times \left(\frac{(1/0.945) \times 17.6 \times 2.56 \times 365.25 \times 8.33 \times (125 - 54) \times 1}{3412}\right)\right)
\]

\[
\Delta kWh = 494 + 3494 + 1328 = 5316 kWh
\]
EER\textsubscript{base} = EER Efficiency of new replacement unit

<table>
<thead>
<tr>
<th>Existing Cooling System</th>
<th>EER_base</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Source Heat Pump</td>
<td>11.8\textsuperscript{992}</td>
</tr>
<tr>
<td>Central AC</td>
<td>11\textsuperscript{993}</td>
</tr>
<tr>
<td>No central cooling</td>
<td>11\textsuperscript{994}</td>
</tr>
</tbody>
</table>

EER\textsubscript{exist} = Energy Efficiency Ratio of existing cooling unit (kBtu/hr / kW)

- Use actual EER rating where it is possible to measure or reasonably estimate. If EER unknown but SEER available convert using the equation:

\[ EER\textsubscript{exist} = (-0.02 \times \text{SEER}\textsubscript{exist}^2) + (1.12 \times \text{SEER}\textsubscript{exist}) \]

- If SEER rating unavailable use:

<table>
<thead>
<tr>
<th>Existing Cooling System</th>
<th>EER_exist</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Source Heat Pump</td>
<td>8.55</td>
</tr>
<tr>
<td>Central AC</td>
<td>8.15\textsuperscript{997}</td>
</tr>
<tr>
<td>No central cooling</td>
<td>11\textsuperscript{998}</td>
</tr>
</tbody>
</table>

EER\textsubscript{FL} = Full Load EER Efficiency of ENERGY STAR GSHP unit

CF\textsubscript{SSP} = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)

- 72\%\textsuperscript{1000}

CF\textsubscript{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)

- 46.6\%\textsuperscript{1001}

---

\textsuperscript{992} The Federal Standard does not include an EER requirement, so it is approximated with the conversion formula from Wassmer, M. 2003 thesis referenced below.


\textsuperscript{994} Assumes that the decision to replace existing systems includes desire to add cooling.


\textsuperscript{996} Average nameplate efficiencies of all Early Replacement qualifying equipment in Ameren PY3-PY4.

\textsuperscript{997} Ibid.

\textsuperscript{998} Assumes that the decision to replace existing systems includes desire to add cooling.

\textsuperscript{999} As per conversations with David Buss territory manager for Connor Co, the EER rating of an ASHP equate most appropriately with the full load EER of a GSHP.

\textsuperscript{1000} Based on analysis of metering results from 24 heat pumps in Ameren Illinois service territory in PY5 coincident with AIC's 2010 system peak; 'Impact and Process Evaluation of Ameren Illinois Company's Residential HVAC Program (PYS)'.

\textsuperscript{1001} 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.
New Construction or Time of Sale:
For example, a 3 ton unit with Full Load EER rating of 19:
\[
\Delta kW_{SSP} = \frac{(36,000 \times (1/11.8 - 1/19))}{1000} \times 0.72
\]
\[= 0.83 \text{ kW}\]
\[
\Delta kW_{PJM} = \frac{(36,000 \times (1/11 - 1/19))}{1000} \times 0.466
\]
\[= 0.54 \text{ kW}\]

Early Replacement:
For example, a 3 ton Full Load 19 EER replaces an existing working Air Source Heat Pump with unknown efficiency ratings in Marion:
\[
\Delta kW_{SSP} \text{ for remaining life of existing unit (1st 8 years):}
\]
\[= \frac{(36,000 \times (1/8.55 - 1/19))}{1000} \times 0.72
\]
\[= 1.67 \text{ kW}\]
\[
\Delta kW_{SSP} \text{ for remaining measure life (next 17 years):}
\]
\[= \frac{(36,000 \times (1/11.8 - 1/19))}{1000} \times 0.72
\]
\[= 0.83 \text{ kW}\]
\[
\Delta kW_{PJM} \text{ for remaining life of existing unit (1st 8 years):}
\]
\[= \frac{(36,000 \times (1/8.55 - 1/19))}{1000} \times 0.466
\]
\[= 1.08 \text{ kW}\]
\[
\Delta kW_{PJM} \text{ for remaining measure life (next 17 years):}
\]
\[= \frac{(36,000 \times (1/11.8 - 1/19))}{1000} \times 0.466
\]
\[= 0.54 \text{ kW}\]
**NATURAL GAS SAVINGS**

New Construction and Time of Sale with baseline gas heat and/or hot water:

If measure is supported by gas utility only, gas utility claim savings calculated below:

\[
\Delta \text{Therms} = [\text{Heating Savings}] + [\text{DHW Savings}]
\]

\[
= [\text{Replaced gas consumption} – \text{therm equivalent of GSHP source kWh}] + [\text{DHW Savings}]
\]

\[
= [(1 – \text{ElecHeat}) \times ((\text{Gas}_\text{Heating}_\text{Load}/\text{AFUEbase}) – (\text{kWhToTherm} \times \text{FLHheat} \times \text{Capacity}_\text{heating} \times 1/(\text{COP}_\text{PL}/10000)) + [(1 – \text{ElecDHW}) \times \%\text{DHWDisplaced} \times (1/\text{EF}\text{GAS EXIST} \times \text{GPD} \times \text{Household} \times 365.25 \times \gamma\text{Water} \times (T_{\text{OUT}} – T_{\text{IN}}) \times 1.0) / 100,000]]
\]

If measure is supported by electric utility only, \(\Delta \text{Therms} = 0\)

If measure is supported by gas and electric utility, gas utility claim savings calculated below, (electric savings is provided in Electric Energy Savings section):

\[
\Delta \text{Therms} = [\text{Heating Savings}] + [\text{DHW Savings}]
\]

\[
= [\text{Replaced gas consumption} – \text{therm equivalent of base ASHP source kWh}] + [\text{DHW Savings}]
\]

\[
= [(1 – \text{ElecHeat}) \times ((\text{Gas}_\text{Heating}_\text{Load}/\text{AFUEbase}) – (\text{kWhToTherm} \times \text{FLHheat} \times \text{Capacity}_\text{heating} \times 1/(\text{HSPF}_{\text{ASHP}}/3.412))/1000]) + [(1 – \text{ElecDHW}) \times \%\text{DHWDisplaced} \times (1/\text{EF}\text{GAS EXIST} \times \text{GPD} \times \text{Household} \times 365.25 \times \gamma\text{Water} \times (T_{\text{OUT}} – T_{\text{IN}}) \times 1.0) / 100,000]]
\]

Early replacement for homes with existing gas heat and/or hot water:

If measure is supported by gas utility only, gas utility claim savings calculated below:

\[
\Delta \text{Therms for remaining life of existing unit (1st 8 years)}:
\]

\[
= [\text{Heating Savings}] + [\text{DHW Savings}]
\]

\[
= [\text{Replaced gas consumption} – \text{therm equivalent of GSHP source kWh}] + [\text{DHW Savings}]
\]

\[
= [(1 – \text{ElecHeat}) \times ((\text{Gas}_\text{Heating}_\text{Load}/\text{AFUEexist}) – (\text{kWhToTherm} \times \text{FLHheat} \times \text{Capacity}_\text{heating} \times 1/(\text{COP}_\text{PL} \times 3.412))/1000)]) + [(1 – \text{ElecDHW}) \times \%\text{DHWDisplaced} \times (1/\text{EF}\text{GAS EXIST} \times \text{GPD} \times \text{Household} \times 365.25 \times \gamma\text{Water} \times (T_{\text{OUT}} – T_{\text{IN}}) \times 1.0) / 100,000])]
\]

\[
\Delta \text{Therms for remaining measure life (next 17 years)}:
\]

\[
= [(1 – \text{ElecHeat}) \times ((\text{Gas}_\text{Heating}_\text{Load}/\text{AFUEexist}) – (\text{kWhToTherm} \times \text{FLHheat} \times \text{Capacity}_\text{heating} \times 1/(\text{HSPF}_{\text{ASHP}}/3.412))/1000)]) + [(1 – \text{ElecDHW}) \times \%\text{DHWDisplaced} \times (1/\text{EF}\text{GAS EXIST} \times \text{GPD} \times \text{Household} \times 365.25 \times \gamma\text{Water} \times (T_{\text{OUT}} – T_{\text{IN}}) \times 1.0) / 100,000])]
\]

If measure is supported by electric utility only, \(\Delta \text{Therms} = 0\)

If measure is supported by gas and electric utility, gas utility claim savings calculated below:

\[
\Delta \text{Therms for remaining life of existing unit (1st 8 years)}:
\]

\[
= [\text{Heating Savings}] + [\text{DHW Savings}]
\]

\[
= [\text{Replaced gas consumption} – \text{therm equivalent of base ASHP source kWh}] + [\text{DHW Savings}]
\]

\[
= [(1 – \text{ElecHeat}) \times ((\text{Gas}_\text{Heating}_\text{Load}/\text{AFUEexist}) – (\text{kWhToTherm} \times \text{FLHheat} \times \text{Capacity}_\text{heating} \times 1/(\text{HSPF}_{\text{ASHP}})/3.412))/1000)]) + [(1 – \text{ElecDHW}) \times \%\text{DHWDisplaced} \times (1/\text{EF}\text{GAS EXIST} \times \text{GPD} \times \text{Household} \times 365.25 \times \gamma\text{Water} \times (T_{\text{OUT}} – T_{\text{IN}}) \times 1.0) / 100,000])]
\]
ΔTherms for remaining measure life (next 17 years):

\[
\Delta \text{Therms} = \left\{ \begin{array}{l}
(1 - \text{ElecHeat}) \times \left( \frac{\text{Gas}_\text{Heating}_\text{Load}}{\text{AFUEbaseER}} - (\text{kWhtoTherm} \times \text{FLHheat} \times \text{Capacity}_\text{heating} \times \frac{1}{\text{HSPF}_{\text{ASHP}}/1000}) + \left(1 - \text{ElecDHW}\right) \times \frac{\%\text{DHWDisplaced} \times (1/ \text{EF}_{\text{GAS}_{\text{EXIST}}} \times \text{GPD} \times \text{Household} \times 365.25 \times \gamma_{\text{Water}} \times (T_{\text{OUT}} - T_{\text{IN}}) \times 1.0}{100,000}\right)\right)
\end{array} \right.
\]

Where:

- ElecHeat = 1 if existing building is electrically heated
- ElecHeat = 0 if existing building is not electrically heated

- Gas_Heating_Load
  = Estimate of annual household heating load for gas furnace heated single-family homes. If location is unknown, assume the average below.
  = Actual if informed by site-specific load calculations, ACCA Manual J or equivalent.

<table>
<thead>
<tr>
<th>Climate Zone (City based upon)</th>
<th>Gas_Heating_Load if Furnace (therms)</th>
<th>Gas_Heating_Load if Boiler (therms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Rockford)</td>
<td>873</td>
<td>1275</td>
</tr>
<tr>
<td>2 (Chicago)</td>
<td>834</td>
<td>1218</td>
</tr>
<tr>
<td>3 (Springfield)</td>
<td>714</td>
<td>1043</td>
</tr>
<tr>
<td>4 (Belleville)</td>
<td>551</td>
<td>805</td>
</tr>
<tr>
<td>5 (Marion)</td>
<td>561</td>
<td>819</td>
</tr>
<tr>
<td>Average</td>
<td>793</td>
<td>1158</td>
</tr>
</tbody>
</table>

AFUEbase = Baseline Annual Fuel Utilization Efficiency Rating
= 80% if furnace and 82% if boiler.

AFUEexist = Existing Annual Fuel Utilization Efficiency Rating

---

1002 Heating load is used to describe the household heating need, which is equal to (gas consumption * AFUE).

1003 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 are commonly completed by contractors during the selection process and may be readily available for program data purposes.

1004 Values are based on household heating consumption values and inferred average AFUE results from Table 2-1, Energy Efficiency / Demand Response Nicor Gas Plan Year 1 (6/1/2011-5/31/2012) Research Report: Furnace Metering Study (August 1, 2013) (prepared by Navigant Consulting, Inc.) and 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.

1005 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. 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.
= Use actual AFUE rating where it is possible to measure or reasonably estimate. If unknown, assume 64.4% if furnace and 61.6% if boiler.

AFUEbaseER = Baseline Annual Fuel Utilization Efficiency Rating for early replacement measure = 90% if furnace and 82% if boiler.

kWtoTherm = Converts source kWh to Therms
= \frac{H_{grid}}{100000}

H_{grid} = Heat rate of the grid in btu/kWh based on the average fossil heat rate for the EPA eGRID subregion and includes a factor that takes into account T&D losses.

For systems operating less than 6,500 hrs per year:

Use the Non-baseload heat rate provided by EPA eGRID for RFC West region for ComEd territory (including independent providers connected to RFC West), and SERC Midwest region for Ameren territory (including independent providers connected to SERC Midwest). Also include any line losses.

For systems operating more than 6,500 hrs per year:

Use the All Fossil Average heat rate provided by EPA eGRID for RFC West region for ComEd territory, and SERC Midwest region for Ameren territory. Also include any line losses.

3.412 = Converts HSPF to COP

EF_{GAS\ EXIST} = Energy Factor (efficiency) of existing gas water heater
= Actual. If unknown assume federal standard:

For \leq 55 gallons: \quad 0.675 - (0.0015 \times \text{tank size})
For > 55 gallons \quad 0.8012 - (0.00078 \times \text{tank size})

= If tank size unknown assume 40 gallons and EF_Baseline of 0.615

All other variables provided above

---

1006 Average nameplate efficiencies of all Early Replacement qualifying equipment in Ameren PY3-PY4.
1007 Assumes that Federal Standard will have been increased to 90% by the time the existing unit would have to have been replaced.
- Non-baseload RFC West: 9,811 Btu/kWh \times (1 + \text{Line Losses})
- Non-baseload SERC Midwest: 10,511 Btu/kWh \times (1 + \text{Line Losses})
- All Fossil Average RFC West: 10,038 Btu/kWh \times (1 + \text{Line Losses})
- All Fossil Average SERC Midwest: 10,364 Btu/kWh \times (1 + \text{Line Losses})
Illustrative Examples [for illustrative purposes a Heat Rate of 10,000 Btu/kWh is used]

New construction using gas furnace and central AC baseline, supported by gas utility only:

For example, a 3 ton unit with Part Load EER rating of 19 and Part Load COP of 4.4 in single family house in Springfield with a 40 gallon gas water heater is installed in place of a natural gas furnace and 3 ton Central AC unit:

\[
\Delta \text{kWh} = 0
\]

\[
\Delta \text{Therms} = [\text{Heating Savings}] + [\text{DHW Savings}]
\]

\[
= [\text{Replaced gas consumption - therm equivalent of GSHP source kWh}] + [\text{DHW Savings}]
\]

\[
= [(1 - \text{ElecHeat}) \times (\text{Gas\_Heating\_Load/AFUEbase}) - (\text{kWh\_to\_Therm} \times \text{FLH\_Heat} \times \text{Capacity\_heating} / (1/(\text{COP}\_PL \times 3.412) / 1000))] + [(1 - \text{ElecDHW}) \times \%\text{DHW\_Displaced} \times (1 / \text{EF\_GAS\_EXIST} \times \text{GPD} \times \text{Household} \times 365.25 \times \gammaWater \times (T_{OUT} - T_{IN}) \times 1.0) / 100,000)]
\]

\[
= [(1-0) \times ((714/0.80) - (10000/100000 \times 1754 \times 36,000 \times 1/(4.4 \times 3.412))/1000)] + [(1 - 0) \times 0.44 \times (1/0.615 \times 17.6 \times 2.56 \times 365.25 \times 8.33 \times (125-54) / 100,000)]
\]

\[
= 472 + 70
\]

\[
= 542 \text{ therms}
\]

Early Replacement fuel switch, supported by gas and electric utility:

For example, a 3 ton unit with Part Load EER rating of 19 and Part Load COP of 4.4 in single family house in Springfield with a 40 gallon gas water heater replaces an existing working natural gas furnace and 3 ton Central AC unit with unknown efficiency ratings:

\[
\Delta \text{kWh for remaining life of existing unit (1st 8 years)}:
\]

\[
= [\text{Cooling savings}] + [\text{Heating savings from base ASHP to GSHP}] + [\text{DHW savings}]
\]

\[
= [(\text{FLH\_cool} \times \text{Capacity\_cooling} \times (1/\text{SEER\_exist} - 1/\text{EER\_PL}/1000)] + [(\text{FLH\_heat} \times \text{Capacity\_heating} \times (1/\text{HSPF\_ASHP} - 1/(1/COP\_PL \times 3.412))/1000) + [\text{Elec\_DHW} \times \%\text{DHW\_Displaced} \times ((1/\text{EF\_ELEC}) \times \text{GPD} \times \text{Household} \times 365.25 \times \gammaWater \times (T_{OUT} - T_{IN}) \times 1.0) / 3412)]
\]

\[
= [(730 \times 36,000 \times (1/8.6 - 1/19)) / 1000] + [(1754 \times 36,000 \times (1/8.2 - 1/(4.4 \times 3.412))) / 1000] + [0 \times 0.44 \times (((1/0.904) \times 17.6 \times 2.56 \times 365.25 \times 8.33 \times (125-54) / 1)/3412)]
\]

\[
= 1673 + 3494 + 0
\]

\[
= 5167 \text{ kWh}
\]

Continued on next page.
Illustrative Example continued

ΔkWh for remaining measure life (next 17 years):
= [Cooling savings] + [Heating savings] + [DHW savings]
= [[FLHcool * Capacity_cooling * (1/SEERbase - (1/EERPL)/1000)] + [[FLHheat * Capacity_heating * (1/HSPFASHP - (1/COPPL * 3.412))/1000] + [ElecDHW * %DHWDisplaced * (((1/ EFEL) * GPD * Household * 365.25 * γWater * (TOUT - TIN) * 1.0) /3412)]
= [(730 * 36,000 * (1/13 - 1/19)) / 1000] + [1754 * 36,000 * (1/8.2 - 1/ (4.4 *3.412)) / 1000] + [0 * 0.44 * (((1/0.904) * 17.6 * 2.56 *365.25 * 8.33 * (125-54) *1)/3412)]
= 638 + 3494 + 0
= 4132 kWh

ΔTherms for remaining life of existing unit (1st 8 years):
= [Heating Savings] + [DHW Savings]
= [Replaced gas consumption – therm equivalent of base ASHP source kWh] + [DHW Savings]
= [(1 – ElecHeat) * ((Gas_Heating_Load/AFUEexist) – (kWhtoTherm * FLHheat * Capacity_heating * 1/HSPFASHP)/1000)] + [(1 – ElecDHW) * %DHWDisplaced * (1/ EF GAS EXIST) * GPD * Household * 365.25 * γWater * (TOUT − TIN) * 1.0) / 100,000]
= [(1-0) * ((714/0.644) – (10000/100000 * 1754 * 36,000 * 1/8.2)/1000)] + [(1 – 0) * (0.44 * (1/ 0.615 * 17.6 * 2.56 *365.25 * 8.33 * (125-54) * 1) / 100,000)]
= 339 + 70
= 408 therms

ΔTherms for remaining measure life (next 17 years):
= [(1 – ElecHeat) * ((Gas_Heating_Load/AFUEbaseER) – (kWhtoTherm * FLHheat * Capacity_heating * 1/HSPFASHP)/1000)] + [(1 – ElecDHW) * %DHWDisplaced * (1/ EF GAS EXIST) * GPD * Household * 365.25 * γWater * (TOUT − TIN) * 1.0) / 100,000]
= [(1-0) * ((714/0.9) – (10000/100000 * 1754 * 36,000 * 1/8.2)/1000)] + [(1 – 0) * (0.44 * (1/ 0.615 * 17.6 * 2.56 *365.25 * 8.33 * (125-54) * 1) / 100,000)]
= 23 + 70
= 93 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION
N/A

DEEMED O&M COST ADJUSTMENT CALCULATION
N/A
COST EFFECTIVENESS SCREENING AND LOAD REDUCTION FORECASTING WHEN FUEL SWITCHING

This measure can involve fuel switching from gas to electric.

For the purposes of forecasting load reductions due to fuel switch GSHP projects per Section 16-111.5B, changes in site energy use at the customer’s meter (using ΔkWh algorithm below) adjusted for utility line losses (at-the-busbar savings), customer switching estimates, NTG, and any other adjustment factors deemed appropriate, should be used.

The inputs to cost effectiveness screening should reflect the actual impacts on the electric and fuel consumption at the customer meter and, for fuel switching measures, this will not match the output of the calculation/ allocation methodology presented in the “Electric Energy Savings” and “Natural Gas Savings” sections above. Therefore in addition to the calculation of savings claimed, the following values should be used to assess the cost effectiveness of the measure.

\[
\Delta \text{Therms} = [\text{Heating Consumption Replaced}^{1010}] + [\text{DHW Savings if gas}]
= [(1 - \text{ElecHeat}) \times ((\text{Gas Heating Load}/\text{AFUEbase}]) + [(1 - \text{ElecDHW}) \times \%\text{DHWDisplaced}
\times (1/\text{EF}_\text{GAS EXIST} \times \text{GPD} \times \text{Household} \times 365.25 \times \gamma \text{Water} \times (T_{\text{OUT}} - T_{\text{IN}}) \times 1.0) / 100,000)]
\]

\[
\Delta \text{kWh} = -[\text{GSHP heating consumption}] + [\text{Cooling savings}^{1011}] + [\text{DHW savings if electric}]
= -[(\text{FLHheat} \times \text{Capacity_heating} \times (1/COP_{PL} \times 3.412))/1000] + [(\text{FLHcool} \times \text{Capacity_cooling} \times (1/\text{SEERbase} - 1/\text{EER}_{PL}))/1000] + [(\text{ElecDHW} \times \%\text{DHWDisplaced}
\times (1/\text{EF}_\text{ELEC} \times \text{GPD} \times \text{Household} \times 365.25 \times \gamma \text{Water} \times (T_{\text{OUT}} - T_{\text{IN}}) \times 1.0) / 3412)]
\]

\[^{1010}\] Note AFUEbase in the algorithm should be replaced with AFUEexist for early replacement measures.

\[^{1011}\] Note SEERbase in the algorithm should be replaced with SEERexist for early replacement measures.
Illustrative Example of Cost Effectiveness Inputs for Fuel Switching

For example, a 3 ton unit with Part Load EER rating of 19 and Part Load COP of 4.4 in single family house in Springfield with a 40 gallon gas water heater replaces an existing working natural gas furnace and 3 ton Central AC unit with unknown efficiency ratings. [Note the calculation provides the annual savings for the first 8 years of the measure life, an additional calculation (not shown) would be required to calculated the annual savings for the remaining life (years 9-25)]:

\[ \Delta \text{Therms} = [(1 - \text{ElecHeat}) \times ((\text{Gas Heating Load}/\text{AFUEexist})] + [(1 - \text{ElecDHW}) \times \%\text{DHWDisplaced} \times (1/ \text{EFGAS EXIST}) \times \text{GPD} \times \text{Household} \times 365.25 \times \gamma \text{Water} \times (T_{\text{OUT}} - T_{\text{IN}}) \times 1.0) / 100,000]\]

= [(1-0) \times (714/0.644)] + [((1-0) \times 0.44 \times 17.6 \times 2.56 \times 365.25 \times 8.33 \times (125-54) \times 1) / 100,000]]

= 1109 + 70

= 1179 therms

\[ \Delta \text{kWh} = - [(\text{FLHheat} \times \text{Capacity heating} \times (1/\text{COP}_{\text{PL}} \times 3.412))/1000] + [(\text{FLHcool} \times \text{Capacity cooling} \times (1/\text{SEER}_{\text{exist}} - 1/\text{EER}_{\text{PL}}))/1000] + [\text{ElecDHW} \times \%\text{DHWDisplaced} \times ((1/\text{EF}_{\text{ELEC}}) \times \text{GPD} \times \text{Household} \times 365.25 \times \gamma \text{Water} \times (T_{\text{OUT}} - T_{\text{IN}}) \times 1.0) / 3412)]

= -[(1754 \times 36,000 \times (1/(4.4 \times 3.412)))/ 1000] + [(730 \times 36,000 \times (1/8.6 - 1/19))/ 1000] + [0 \times 0.44 \times ((1/0.904) \times 17.6 \times 2.56 \times 365.25 \times 8.33 \times (125-54) \times 1)/3412])

= -4206 + 1673 + 0

= -2533 kWh

**Measure Code:** RS-HVC-GSHP-V04-150601
5.3.9 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) exhaust-only ventilation fan, quiet (< 2.0 sones) Continuous operation in accordance with recommended ventilation rate indicated by ASHRAE 62.2.

DEFINITION OF BASELINE EQUIPMENT

New standard efficiency (average CFM/Watt of 3.1) exhaust-only ventilation fan, quiet (< 2.0 sones) operating in accordance with recommended ventilation rate indicated by ASHRAE 62.2.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 19 years.

DEEMED MEASURE COST

Incremental cost per installed fan is $43.50 for quiet, efficient fans.

LOADSHAPE

Loadshape R11 - Residential Ventilation

COINCIDENCE FACTOR

The summer Peak Coincidence Factor is assumed to be 100% because the fan runs continuously.

---

1012 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.
1013 Bi-level controls may be used by efficient fans larger than 50 CFM
1014 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.
1015 On/off cycling controls may be required of baseline fans larger than 50 CFM.
1016 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.
1017 VEIC analysis using cost data collected from wholesale vendor; http://www.westsidewholesale.com/.
Algorithm

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

\[
\Delta \text{kWh} = (\text{CFM} \times \frac{1}{\eta_{\text{BASELINE}}} - \frac{1}{\eta_{\text{EFFICIENT}}})/1000 \times \text{Hours}
\]

Where:

- **CFM** = Nominal Capacity of the exhaust fan
  - = 50 CFM

- **\( \eta_{\text{BASELINE}} \)** = Average efficacy for baseline fan
  - = 3.1 CFM/Watt

- **\( \eta_{\text{EFFICIENT}} \)** = Average efficacy for efficient fan
  - = 8.3 CFM/Watt

- **Hours** = assumed annual run hours,
  - = 8766 for continuous ventilation.

\[
\Delta \text{kWh} = (50 \times \frac{1}{3.1} - \frac{1}{8.3})/1000 \times 8766 \\
= 88.6 \text{kWh}
\]

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

\[
\Delta \text{kW} = (\text{CFM} \times \frac{1}{\eta_{\text{BASELINE}}} - \frac{1}{\eta_{\text{EFFICIENT}}})/1000 \times \text{CF}
\]

Where:

- **CF** = Summer Peak Coincidence Factor
  - = 1.0 (continuous operation)

Other variables as defined above

\[
\Delta \text{kW} = (50 \times \frac{1}{3.1} - \frac{1}{8.3})/1000 \times 1.0 \\
= 0.0101 \text{kW}
\]

**NATURAL GAS SAVINGS**

N/A

---

1018 50 CFM is the closest available fan size to ASHRAE 62.2 Section 4.1 Whole House Ventilation rates based upon typical square footage and bedrooms.

1019 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.

1020 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.
WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HVC-BAFA-V01-120601
5.3.10 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\(^{1021}\).

**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\(^{1022}\).

**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.

\[
CF_{SSP} = \text{Summer System Peak Coincidence Factor for Central A/C (during utility peak hour)}
\]

= 68\(^{1023}\)\%

\[
CF_{SSP} = \text{Summer System Peak Coincidence Factor for Heat Pumps (during system peak hour)}
\]

\(^{1021}\) Based on VEIC professional judgment.

\(^{1022}\) 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.

\(^{1023}\) Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.
CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

\[
\Delta kWh_{\text{Central AC}} = (FLH_{\text{cool}} \times \text{Capacity}_{\text{cooling}} \times (1/\text{SEER}_{\text{CAC}}))/1000 \times \text{MFe}
\]

\[
\Delta kWh_{\text{Air Source Heat Pump}} = ((FLH_{\text{cool}} \times \text{Capacity}_{\text{cooling}} \times (1/\text{SEER}_{\text{ASHP}}))/1000 \times \text{MFe}) + (\text{FLH}_{\text{heat}} \times \text{Capacity}_{\text{heating}} \times (1/\text{HSPF}_{\text{ASHP}}))/1000 \times \text{MFe})
\]

Where:

- FLH_{\text{cool}} = Full load cooling hours
- \text{Dependent on location as below:}^{1026}

<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>FLHcool Single Family</th>
<th>FLHcool Multifamily</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Rockford)</td>
<td>512</td>
<td>467</td>
</tr>
<tr>
<td>2 (Chicago)</td>
<td>570</td>
<td>506</td>
</tr>
<tr>
<td>3 (Springfield)</td>
<td>730</td>
<td>663</td>
</tr>
<tr>
<td>4 (Belleville)</td>
<td>1,035</td>
<td>940</td>
</tr>
<tr>
<td>5 (Marion)</td>
<td>903</td>
<td>820</td>
</tr>
<tr>
<td>Weighted Average [1027]</td>
<td>629</td>
<td>564</td>
</tr>
</tbody>
</table>

\text{Capacity}_{\text{cooling}} = \text{Cooling capacity of equipment in Btu/hr (note 1 ton = 12,000 Btu/hr)}

= \text{Actual}

\text{SEER}_{\text{CAC}} = \text{SEER Efficiency of existing central air conditioning unit receiving maintenance}

---

1024 Based on analysis of metering results from 24 heat pumps in Ameren Illinois service territory in PY5 coincident with AIC’s 2010 system peak; ‘Impact and Process Evaluation of Ameren Illinois Company’s Residential HVAC Program (PY5)’.

1025 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.

1026 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.

1027 Weighted based on number of occupied residential housing units in each zone.
= Actual. If unknown assume 10 SEER\textsuperscript{1028}  

MFe = Maintenance energy savings factor  
= 0.05\textsuperscript{1029}  

SEER\textsubscript{ASHP} = SEER Efficiency of existing air source heat pump unit receiving maintenance  
= Actual. If unknown assume 10 SEER\textsuperscript{1030}  

FLHheat = Full load heating hours  
Dependent on location:\textsuperscript{1031}  

<table>
<thead>
<tr>
<th>Climate Zone (City based upon)</th>
<th>FLHheat</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Rockford)</td>
<td>2208</td>
</tr>
<tr>
<td>2 (Chicago)</td>
<td>2064</td>
</tr>
<tr>
<td>3 (Springfield)</td>
<td>1967</td>
</tr>
<tr>
<td>4 (Belleville)</td>
<td>1420</td>
</tr>
<tr>
<td>5 (Marion)</td>
<td>1445</td>
</tr>
<tr>
<td>Weighted Average\textsuperscript{1032}</td>
<td>1821</td>
</tr>
</tbody>
</table>

Capacity\textsubscript{heating} = Heating capacity of equipment in Btu/hr (note 1 ton = 12,000 Btu/hr)  
= Actual  

HSPF\textsubscript{base} = Heating Season Performance Factor of existing air source heat pump unit receiving maintenance  
= Actual. If unknown assume 6.8 HSPF\textsuperscript{1033}  

\textsuperscript{1028} 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.  
\textsuperscript{1029} Energy Center of Wisconsin, May 2008; “Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research.”  
\textsuperscript{1030} 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.  
\textsuperscript{1031} 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/hr 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.  
\textsuperscript{1032} Weighted based on number of occupied residential housing units in each zone.  
\textsuperscript{1033} 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.
For example, maintenance of a 3-ton, SEER 10 air conditioning unit in a single family house in Springfield:

\[ \Delta \text{kWh}_{\text{CAC}} = \left( 730 \times 36,000 \times \left( \frac{1}{10} \right) \right) / 1000 \times 0.05 \]
\[ = 131 \text{ kWh} \]

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

\[ \Delta \text{kWh}_{\text{ASHP}} = \left( 730 \times 36,000 \times \left( \frac{1}{10} \right) \right) / 1000 \times 0.05 + \left( 1967 \times 36,000 \times \left( \frac{1}{6.8} \right) \right) / 1000 \times 0.05 \]
\[ = 652 \text{ kWh} \]

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

\[ \Delta \text{kW} = \text{Capacity}_{\text{cooling}} \times \left( \frac{1}{\text{EER}} \right) / 1000 \times \text{MFd} \times \text{CF} \]

Where:

- **EER** = EER Efficiency of existing unit receiving maintenance in Btu/H/Watts
  - Calculate using Actual SEER
  - \[ = 0.02 \times \text{SEER}^3 + 1.12 \times \text{SEER} \]

- **MFd** = Maintenance demand savings factor
  - 0.02

- **CF_{SSP}** = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)
  - 68%

- **CF_{SSP}** = Summer System Peak Coincidence Factor for Heat Pumps (during system peak hour)
  - 72%

- **CF_{PJM}** = PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)
  - 46.6%

---

1035 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.
1036 Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.
1037 Based on analysis of metering results from 24 heat pumps in Ameren Illinois service territory in PY5 coincident with AIC’s 2010 system peak; ‘Impact and Process Evaluation of Ameren Illinois Company’s Residential HVAC Program (PYS)’.
1038 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, maintenance of 3-ton, SEER 10 (equals EER 9.2) CAC unit:

\[
\Delta kW_{SSP} = 36,000 \times \frac{1}{9.2} \times \frac{1}{1000} \times 0.02 \times 0.68 \\
= 0.0532 \text{ kW}
\]

\[
\Delta kW_{PJM} = 36,000 \times \frac{1}{9.2} \times \frac{1}{1000} \times 0.02 \times 0.466 \\
= 0.0365 \text{ kW}
\]

**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-V02-140601**
5.3.11 Programmable Thermostats

DESCRIPTION

This measure characterizes the household energy savings from the installation of a new or reprogramming of an existing 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. Energy savings are applicable at the household level; all thermostats controlling household heat should be programmable and installation of multiple programmable thermostats per home does not accrue additional savings.

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

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.

For the thermostat reprogramming measure, the auditor consults with the homeowner to determine an appropriate set back schedule, reprograms the thermostat and educates the homeowner on its appropriate use.

DEFINITION OF BASELINE EQUIPMENT

For new thermostats the baseline is a non-programmable thermostat requiring manual intervention to change temperature setpoint.

For the purpose of thermostat reprogramming, an existing programmable thermostat that an auditor determines is being used in override mode or otherwise effectively being operated like a manual thermostat.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life of a programmable thermostat is assumed to be 10 years based upon equipment life only. For the purposes of claiming savings for a new programmable thermostat, this is reduced by a 50% persistence factor to give final measures life of 5 years. For reprogramming, this is reduced further to give a measure life of 2 years.

---

1039 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’.
1040 Table 1, HVAC Controls, Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007
1041 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.
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 the new installation measure is assumed to be $36. The cost for reprogramming is assumed to be $10 to account for the auditors time to reprogram and educate the homeowner.

LOADSHAPE

Loadshape R09 - Residential Electric Space Heat

COINCIDENCE FACTOR

N/A due to no savings attributable to cooling during the summer peak period.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

\[ \Delta \text{kWh} = \% \text{ElectricHeat} \times \text{Elec\_Heating\_Consumption} \times \text{Heating\_Reduction} \times \text{HF} \times \text{Eff\_ISR} + (\Delta \text{Therms} \times F_e \times 29.3) \]

Where:

\%ElectricHeat = Percentage of heating savings assumed to be electric

<table>
<thead>
<tr>
<th>Heating fuel</th>
<th>%ElectricHeat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric</td>
<td>100%</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>0%</td>
</tr>
<tr>
<td>Unknown</td>
<td>13%</td>
</tr>
</tbody>
</table>

\text{Elec\_Heating\_Consumption} = Estimate of annual household heating consumption for electrically heated single-family homes. If location and heating type is unknown, assume 15,678 kWh. 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.

Note the second part of the algorithm relates to furnace fan savings if the heating system is Natural Gas.

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.

Values in table are based on converting an average household heating load (834 therms) for Chicago based on Table E-1, Energy Efficiency/Demand Response Nicor Gas Plan Year 1: Research Report: Furnace Metering Study, Draft, Navigant, August 1 2013 to an electric heat load (divide by 0.03413) to electric resistance and ASHP heat load (resistance load reduced by 15% to account for distribution losses that occur in furnace heating but not in electric resistance while ASHP heat is assumed to suffer.
### Climate Zone (City based upon)

<table>
<thead>
<tr>
<th></th>
<th>Electric Resistance</th>
<th>Electric Heat Pump</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Elec_Heating_Consumption (kWh)</td>
<td>Elec_Heating_Consumption (kWh)</td>
</tr>
<tr>
<td>1 (Rockford)</td>
<td>21,741</td>
<td>12,789</td>
</tr>
<tr>
<td>2 (Chicago)</td>
<td>20,771</td>
<td>12,218</td>
</tr>
<tr>
<td>3 (Springfield)</td>
<td>17,789</td>
<td>10,464</td>
</tr>
<tr>
<td>4 (Belleville)</td>
<td>13,722</td>
<td>8,072</td>
</tr>
<tr>
<td>5 (Marion)</td>
<td>13,966</td>
<td>8,215</td>
</tr>
<tr>
<td>Average</td>
<td>19,743</td>
<td>11,613</td>
</tr>
</tbody>
</table>

**Heating Reduction**
- Assumed percentage reduction in total household heating energy consumption due to programmable thermostat
  - $= 6.2\%^{1047}$

**HF**
- Household factor, to adjust heating consumption for non-single-family households.

<table>
<thead>
<tr>
<th>Household Type</th>
<th>HF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-Family</td>
<td>100%</td>
</tr>
<tr>
<td>Multi-Family</td>
<td>65% $^{1048}$</td>
</tr>
<tr>
<td>Actual</td>
<td>Custom $^{1049}$</td>
</tr>
</tbody>
</table>

**Eff_ISR**
- Effective In-Service Rate, the percentage of thermostats installed and programmed effectively.

from similar distribution losses) and then to electric consumption assuming efficiencies of 100% for resistance and 200% for HP (see 'Household Heating Load Summary Calculations_11062013.xls'). Finally these values were adjusted 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.

$^{1046}$ 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.

$^{1047}$ 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.

$^{1048}$ 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 based on professional judgment that average household size, and heat loads of MF households are smaller than single-family homes.

$^{1049}$ Program-specific household factors may be utilized on the basis of sufficiently validated program evaluations.
Program Delivery | Eff_ISR
---|---
Direct Install | 100%
Other, or unknown | 56%

\[ \Delta \text{Therms} = \text{Therm savings if Natural Gas heating system} \]

\[ = \text{See calculation in Natural Gas section below} \]

\[ F_e = \text{Furnace Fan energy consumption as a percentage of annual fuel consumption} \]

\[ = 3.14\%^{1051} \]

\[ 29.3 = \text{kWh per therm} \]

For example, a programmable thermostat directly installed in an electric resistance heated, single-family home in Springfield:

\[ \Delta \text{kWH} = 1 \times 17,789 \times 0.062 \times 100\% \times 100\% + (0 \times 0.0314 \times 29.3) \]

\[ = 1,103 \text{ kWh} \]

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

N/A due to no savings from cooling during the summer peak period.

**NATURAL GAS ENERGY SAVINGS**

\[ \Delta \text{Therms} = \%\text{FossilHeat} \times \text{Gas\_Heating\_Consumption} \times \text{Heating\_Reduction} \times HF \times \text{Eff\_ISR} \]

Where:

\[ \%\text{FossilHeat} = \text{Percentage of heating savings assumed to be Natural Gas} \]

<table>
<thead>
<tr>
<th>Heating fuel</th>
<th>%FossilHeat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric</td>
<td>0%</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>100%</td>
</tr>
<tr>
<td>Unknown</td>
<td>87%^{1052}</td>
</tr>
</tbody>
</table>

\[ \text{Gas\_Heating\_Consumption} = \text{Estimate of annual household heating consumption for gas heated single-family} \]

---


1051 \( F_e \) 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.

1052 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.
homes. If location is unknown, assume the average below\textsuperscript{1053}.

<table>
<thead>
<tr>
<th>Climate Zone (City based upon)</th>
<th>Gas_Heating_Consumption (therms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Rockford)</td>
<td>1,052</td>
</tr>
<tr>
<td>2 (Chicago)</td>
<td>1,005</td>
</tr>
<tr>
<td>3 (Springfield)</td>
<td>861</td>
</tr>
<tr>
<td>4 (Belleville)</td>
<td>664</td>
</tr>
<tr>
<td>5 (Marion)</td>
<td>676</td>
</tr>
<tr>
<td>Average</td>
<td>955</td>
</tr>
</tbody>
</table>

For example, a programmable thermostat directly-installed in a gas heated single-family home in Chicago:

\[
\Delta\text{Therms} = 1.0 \times 1005 \times 0.062 \times 100\% \times 100\%
\]

\[
= 62.3\text{ therms}
\]

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: RS-HVC-PROG-V03-140601**

\textsuperscript{1053} Values are based on adjusting the average household heating load (834 therms) for Chicago based on 'Table E-1, Energy Efficiency / Demand Response Nicor Gas Plan Year 1, Research Report: Furnace Metering Study', divided by standard assumption of existing unit efficiency of 83% (estimate based on 24% of furnaces purchased in Illinois were condensing in 2000 (based on data from GAMA, provided to Department of Energy), assuming typical efficiencies: \(0.24\times0.92 + (0.76\times0.8) = 0.83\)) to give 1005 therms. This Chicago value was then adjusted 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.
5.3.12 Ductless Heat Pumps

**DESCRIPTION**

This measure is designed to calculate electric savings for supplementing existing electric HVAC systems with ductless heat pumps. Existing systems can include: electric resistance heating or ducted air-source heat pumps. For ducted air source heat pumps, cooling savings are also possible if there is an existing air conditioning system.

Savings are achieved by displacing some of the heating or cooling load currently provided by the existing system and meeting that load with the more efficient ductless heat pump instead. The offset of the home’s heating load is likely for the milder heating periods. The limitations on heating offset increase as the outdoor temperature drops, because the DHP capacity decreases, and the point-source nature of the heater is less able to satisfy heating loads in remote rooms.

For cooling, the proposed savings calculations are aligned with those of typical replacement systems. In most cases, the DHP is expected to replace (rather than offset) a comparable amount of cooling in homes with electric resistance heat—at a much higher efficiency than the previously used cooling.

In order for this measure to apply, the control strategy for the heat pump is assumed to be chosen to maximize savings per installer recommendation.\(^{1054}\)

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 new equipment must be a high-efficiency, variable-capacity (typically “inverter-driven” DC motor) ductless heat pump system that exceeds the current Federal Standard. This means the unit must meet or exceed 8.2 HSPF (heating mode) and 14 SEER (cooling mode)\(^{1055}\).

This measure only applies to the *first* ductless heat pump installed in a residence.\(^{1056}\)

**DEFINITION OF BASELINE EQUIPMENT**

In order for this characterization to apply, baseline equipment must include a permanent electric resistance heating source or a ducted air-source heat pump. For multifamily buildings, each residence must have existing individual heating equipment. Multifamily residences with central heating do not qualify for this characterization. Existing cooling equipment is assumed to be standard efficiency. Note that in order to claim cooling savings, there must be an existing air conditioning system.

---

\(^{1054}\) The whole purpose of installing ductless heat pumps is to conserve energy, so the installer can be assumed to be capable of recommending an appropriate controls strategy. For most applications, the heating setpoint for the ductless heat pump should be at least 2 F higher than any remaining existing system and the cooling setpoint for the ductless heat pump should be at least 2 F cooler than the existing system (this should apply to all periods of a programmable schedule, if applicable). This helps ensure that the ductless heat pump will be used to meet as much of the load as possible before the existing system operates to meet the remaining load. Ideally, the new ductless heat pump controls should be set to the current comfort settings, while the existing system setpoints should be adjusted down (heating) and up (cooling) to capture savings.


\(^{1056}\) Additional heat pumps will achieve additional savings, but not as much as the first one.
DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 18 years\textsuperscript{1057}.

DEEMED MEASURE COST

The incremental cost for this measure is provided below:

<table>
<thead>
<tr>
<th>Unit Size</th>
<th>Incremental Cost\textsuperscript{1058}</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-Ton</td>
<td>$3,000</td>
</tr>
<tr>
<td>1.5-Ton</td>
<td>$3750</td>
</tr>
<tr>
<td>2-Ton</td>
<td>$4,500</td>
</tr>
</tbody>
</table>

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.

\[ CF_{SSP} = \text{Summer System Peak Coincidence Factor for ASHP (during utility peak hour)} \]

\[ CF_{SSP} = 72\% \text{\textsuperscript{1059}} \]

\[ CF_{PJM} = \text{PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)} \]

\[ CF_{PJM} = 46.6\% \text{\textsuperscript{1060}} \]


\textsuperscript{1059} Based on analysis of metering results from 24 heat pumps in Ameren Illinois service territory in PY5 coincident with AIC’s 2010 system peak; ‘Impact and Process Evaluation of Ameren Illinois Company’s Residential HVAC Program (PYS)’.

\textsuperscript{1060} 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.
**Calculation of Savings**

**Electric Energy Savings**

Electric savings

\[ \Delta \text{kWh} = \Delta \text{kWh}_{\text{heat}} + \Delta \text{kWh}_{\text{cool}} \]

\[ \Delta \text{kWh}_{\text{heat}} = \text{PLD}\times\text{AHHL}\times\text{HF}\times(1/\text{HSPF}_{\text{exist}}-1/\text{HSPF}_{\text{new}})\times3.413 \]

\[ \Delta \text{kWh}_{\text{cool}} = \text{Capacity}_{\text{cool}}\times\text{HF}\times(1/\text{SEER}_{\text{exist}}-1/\text{SEER}_{\text{new}})\times\text{EFLH}_{\text{cool}} \]

Where:

\[ \text{PLD} = \text{Percent Load Displaced}. \text{ The average total annual heating load displaced from the existing heating system and now provided by the ductless heat pump}\]

For a first DHP installed in a given home.

<table>
<thead>
<tr>
<th>Climate zone</th>
<th>1-ton unit</th>
<th>1.5-ton unit</th>
<th>2-ton unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rockford</td>
<td>26%</td>
<td>39%</td>
<td>39%</td>
</tr>
<tr>
<td>Chicago</td>
<td>27%</td>
<td>40%</td>
<td>42%</td>
</tr>
<tr>
<td>Springfield</td>
<td>31%</td>
<td>47%</td>
<td>48%</td>
</tr>
<tr>
<td>Belleville</td>
<td>30%</td>
<td>45%</td>
<td>48%</td>
</tr>
<tr>
<td>Marion</td>
<td>31%</td>
<td>46%</td>
<td>50%</td>
</tr>
</tbody>
</table>

\[ \text{AHHL} = \text{Annual Household Heating Load in kWh} \]

---

1061 PLD values calculated in “DHP Savings Model 12-31-13.xls”. To verify that the proposed algorithm generates reasonable savings, we compared the results to metering studies done to measure ductless heat pump savings.


1062 Values in table are based on converting an average household heating load (834 therms) for Chicago based on ‘Table E-1, Energy Efficiency/Demand Response Nicor Gas Plan Year 1: Research Report: Furnace Metering Study, Draft, Navigant, August 1 2013 to an electric heat load (divide by 0.03413) to electric resistance and ASHP heat load (resistance load reduced by 15% to account for distribution losses that occur in furnace heating but not in electric resistance while ASHP heat is assumed to suffer from similar distribution losses) [see ‘Household Heating Load Summary Calculations_11062013.xls‘]. Finally these values were adjusted to a statewide average using relative HDD assumptions to adjust for the evaluation results focus on northern region.
Climate Zone | Annual Household Heating Load Resistance (kWh) | Annual Household Heating Load ASHP (kWh)
--- | --- | ---
1 (Rockford) | 21,741 | 25,578
2 (Chicago) | 20,771 | 24,436
3 (Springfield) | 17,789 | 20,928
4 (Belleville) | 13,722 | 16,144
5 (Marion) | 13,966 | 16,431
Average | 19,743 | 23,227

HF = Household factor, to adjust heating consumption for non-single-family households.

| Household Type | HF |
--- | --- |
Single-Family | 100% |
Multi-Family | 65% |
Actual | Custom |

Capacity_{cool} = the cooling capacity of the ductless heat pump unit in kBtu/hr.  
= Actual installed

HSPF_{ee} = HSPF rating of new equipment  
= Actual installed

HSPF_{exist} = HSPF rating of existing equipment

| Existing Equipment Type | HSPFbase |
--- | --- |
Electric resistance heating | 3.41 |
Air Source Heat Pump | 5.44 |

Values for individual cities are then calculated by comparing average HDD to the individual city’s HDD.

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. Program-specific household factors may be utilized on the basis of sufficiently validated program evaluations.

1 Ton = 12 kBtu/hr

Electric resistance has a COP of 1.0 which equals 1/0.293 = 3.41 HSPF.
SEER_{new} = SEER rating of new equipment

= Actual installed \(^\text{1068}\)

SEER_{exist} = SEER rating of existing equipment

= Use actual value. If unknown, see table below

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>SEER(^{\text{exist}})</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTAC</td>
<td>7.4 SEER</td>
</tr>
<tr>
<td>PTHP</td>
<td>7.4 SEER</td>
</tr>
<tr>
<td>SPVAC &lt; 65kBtu/hr</td>
<td>9.0 SEER</td>
</tr>
<tr>
<td>SPVHP &lt; 65 kBtu/hr</td>
<td>9.0 SEER</td>
</tr>
<tr>
<td>Room AC</td>
<td>7.0 SEER</td>
</tr>
<tr>
<td>Ducted ASHP</td>
<td>13.0 SEER</td>
</tr>
<tr>
<td>No existing system</td>
<td>No cooling savings.</td>
</tr>
</tbody>
</table>

\(\text{EFLH}_{\text{cool}}\) = Equivalent Full Load Hours for cooling. Depends on location. See table below \(^\text{1070}\).

<table>
<thead>
<tr>
<th>Climate Zone (City based upon)</th>
<th>FLHRoomAC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Rockford)</td>
<td>220</td>
</tr>
<tr>
<td>2 (Chicago)</td>
<td>210</td>
</tr>
<tr>
<td>3 (Springfield)</td>
<td>319</td>
</tr>
<tr>
<td>4 (Belleville)</td>
<td>428</td>
</tr>
<tr>
<td>5 (Marion)</td>
<td>374</td>
</tr>
<tr>
<td>Weighted Average (^\text{1071})</td>
<td>248</td>
</tr>
</tbody>
</table>

\(^{1067}\) This is from the ASHP measure which estimated HSPF based on finding the average HSPF/SEER ratio from the AHRI directory data (using the least efficient models – SEER 12 and SEER 13) – 0.596, and applying to the average nameplate SEER rating of all Early Replacement qualifying equipment in Ameren PY3-PY4. This estimation methodology appears to provide a result within 10% of actual HSPF.

\(^{1068}\) Note that if only an EER rating is available, a conversion factor of SEER=1.1*EER can be used

\(^{1069}\) Converted from EER using formula EER = 1.1 SEER

\(^{1070}\) Residential EFLH for room AC

\(^{1071}\) Weighted based on number of residential occupied housing units in each zone.
For example, installing a 1.5-ton (heating and cooling capacity) ductless heat pump unit rated at 8 HSPF and 14 SEER in a single-family home in Chicago to displace electric baseboard heat and replace a window air conditioner, savings are:

\[
\begin{align*}
\Delta \text{kWh}_{\text{heat}} &= 40\% \times 20,771 \text{kWh} \times 100\% \times (1/3.41 - 1/8) \times 3.413 = 4,771 \text{kWh} \\
\Delta \text{kWh}_{\text{cool}} &= 18 \times 100\% \times (1/7 - 1/14) \times 210 = 270 \text{kWh} \\
\Delta \text{kWh} &= 4,771 + 270 = 5,041 \text{kWh}
\end{align*}
\]

### SUMMER COINCIDENT PEAK DEMAND SAVINGS

\[
\Delta \text{kW} = (\text{Capacity} \times \text{HF} \times (1/\text{EER}_{\text{exist}} - 1/\text{EER}_{\text{ee}})) / 1000 \times \text{CF}
\]

Where:

- \(\text{EER}_{\text{exist}}\) = Energy Efficiency Ratio of existing cooling system (kBtu/hr / kW)
- \(\text{EER}_{\text{ee}}\) = Energy Efficiency Ratio of new ductless Air Source Heat Pump (kBtu/hr / kW)

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>EERexist</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTAC</td>
<td>8.1 EER</td>
</tr>
<tr>
<td>PTHP</td>
<td>8.1 EER</td>
</tr>
<tr>
<td>SPVAC &lt; 65kBtu/hr</td>
<td>9.9 EER</td>
</tr>
<tr>
<td>SPVHP &lt; 65 kBtu/hr</td>
<td>9.9 EER</td>
</tr>
<tr>
<td>Room AC</td>
<td>7.7 EER</td>
</tr>
<tr>
<td>Ducted ASHP</td>
<td>11.2 EER</td>
</tr>
</tbody>
</table>

EER_{ee} = Energy Efficiency Ratio of new ductless Air Source Heat Pump (kBtu/hr / kW)

= Actual, if not provided convert SEER to EER using this formula:

\[
\text{SEER} = \frac{1.1 \times \text{EER}}{1.1} - 0.02 \times \text{SEER}^2 + 1.12 \times \text{SEER}
\]

where SEER is the energy efficiency rating of a residential air conditioner or heat pump. The formula is based on the Federal Standard for Residential Air Conditioners and Heat Pumps, which requires an energy efficiency ratio of at least 11.2. The table above shows the EER values for different types of equipment, including PTAC, PTHP, SPVAC, SPVHP, Room AC, and Ducted ASHP.
\[ \text{CF}_{SSP} = \text{Summer System Peak Coincidence Factor for Central A/C (during system peak hour)} \]
\[ = 72\%^{1078} \]
\[ \text{CF}_{PJM} = \text{PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)} \]
\[ = 46.6\%^{1079} \]

**Natural Gas Savings**

N/A

**Water Impact Descriptions and Calculation**

N/A

**Deemed O&M Cost Adjustment Calculation**

N/A

**Measure Code:** RS-HVC-DHP-V02-150601

---

\(^{1078}\) Based on analysis of metering results from 24 heat pumps in Ameren Illinois service territory in PY5 coincident with AIC’s 2010 system peak; ‘Impact and Process Evaluation of Ameren Illinois Company’s Residential HVAC Program (PY5)’.

\(^{1079}\) 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.
5.3.13 Residential Furnace Tune-Up

DESCRIPTION

This measure is for a natural gas Residential furnace that provides space heating. The tune-up will improve furnace performance by inspecting, cleaning and adjusting the furnace and appurtenances for correct and efficient operation. Additional savings maybe realized through a complete system tune-up.

This measure was developed to be applicable to the following program types: Residential.

If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure an approved technician must complete the tune-up requirements listed below:

- Measure combustion efficiency using an electronic flue gas analyzer
- Check and clean blower assembly and components per manufacturer’s recommendations
- Where applicable Lubricate motor and inspect and replace fan belt if required
- Inspect for gas leaks
- Clean burner per manufacturer’s recommendations and adjust as needed
- Check ignition system and safety systems and clean and adjust as needed
- Check and clean heat exchanger per manufacturer’s recommendations
- Inspect exhaust/flue for proper attachment and operation
- Inspect control box, wiring and controls for proper connections and performance
- Check air filter and clean or replace per manufacturer’s
- Inspect duct work connected to furnace for leaks or blockages
- Measure temperature rise and adjust flow as needed
- Check for correct line and load volts/amps
- Check thermostat operation is per manufacturer’s recommendations (if adjustments made, refer to ‘Residential Programmable Thermostat’ measure for savings estimate)
- Perform Carbon Monoxide test and adjust heating system until results are within standard industry acceptable limits

DEFINITION OF BASELINE EQUIPMENT

The baseline is furnace assumed not to have had a tune-up in the past 2 years.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure life for the tune up is 2 years.

DEEMED MEASURE COST

The incremental cost for this measure should be the actual cost of tune up.

DEEMED O&M COST ADJUSTMENTS

There are no expected O&M savings associated with this measure.

LOADSHAPE

Loadshape R09 - Residential Electric Space Heat

COINCIDENCE FACTOR

N/A

Algorithms

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = \Delta \text{Therms} \times F_e \times 29.3$$

Where:

$\Delta \text{Therms} = \text{as calculated below}$

$F_e = \text{Furnace Fan energy consumption as a percentage of annual fuel consumption}$

$= 3.14\%^{1082}$

$29.3 = \text{kWh per therm}$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

---

$^{1082} F_e$ 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.
### Natural Gas Savings

\[
\Delta \text{therms} = (\text{Gas}_\text{Furnace}_\text{Heating_Load} \times HF \times \left(1 - \frac{1}{\text{Eff}_{before} + \text{Ei}}\right))
\]

Where:
- \(\text{Gas}_\text{Furnace}_\text{Heating_Load}\) = Estimate of annual household heating load\(^{1083}\) for gas furnace heated single-family homes. If location is unknown, assume the average below\(^{1084}\).
- \(\text{Actual}\) if informed by site-specific load calculations, ACCA Manual J or equivalent\(^{1085}\).

<table>
<thead>
<tr>
<th>Climate Zone (City based upon)</th>
<th>Gas_Furnace_Heating_Load (therms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Rockford)</td>
<td>873</td>
</tr>
<tr>
<td>2 (Chicago)</td>
<td>834</td>
</tr>
<tr>
<td>3 (Springfield)</td>
<td>714</td>
</tr>
<tr>
<td>4 (Belleville)</td>
<td>551</td>
</tr>
<tr>
<td>5 (Marion)</td>
<td>561</td>
</tr>
<tr>
<td>Average</td>
<td>793</td>
</tr>
</tbody>
</table>

- \(HF\) = Household factor, to adjust heating consumption for non-single-family households.

<table>
<thead>
<tr>
<th>Household Type</th>
<th>HF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-Family</td>
<td>100%</td>
</tr>
<tr>
<td>Multi-Family</td>
<td>65%(^{1086})</td>
</tr>
<tr>
<td>Actual</td>
<td>Custom(^{1087})</td>
</tr>
</tbody>
</table>

- \(\text{Eff}_{before}\) = Efficiency of the furnace before the tune-up

---

\(^{1083}\) Heating load is used to describe the household heating need, which is equal to (gas consumption * AFUE).

\(^{1084}\) Values are based on household heating consumption values and inferred average AFUE results from Table 2-1, Energy Efficiency / Demand Response Nicor Gas Plan Year 1 (6/1/2011-5/31/2012) Research Report: Furnace Metering Study (August 1, 2013) (prepared by Navigant Consulting, Inc.) and 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.


\(^{1086}\) 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.

\(^{1087}\) Program-specific household factors may be utilized on the basis of sufficiently validated program evaluations.
\[ \text{EI} = \text{Actual} \]

\[ \text{EI} = \text{Efficiency Improvement of the furnace tune-up measure} \]

\[ \text{EI} = \text{Actual} \]

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: RS-HVC-FTUN-V01-150601**
5.3.14 Boiler Reset Controls

**DESCRIPTION**

This measure relates to improving system efficiency by adding controls to residential heating boilers to vary the boiler entering water temperature relative to heating load as a function of the outdoor air temperature to save energy. The water can be run a little cooler during fall and spring, and a little hotter during the coldest parts of the winter. A boiler reset control has two temperature sensors - one outside the house and one in the boiler water. As the outdoor temperature goes up and down, the control adjusts the water temperature setting to the lowest setting that is meeting the house heating demand. There are also limits in the controls to keep a boiler from operating outside of its safe performance range.\(^\text{1088}\)

This measure was developed to be applicable to the following program types: RF.

**DEFINITION OF EFFICIENT EQUIPMENT**

Natural gas single family residential customer adding boiler reset controls capable of resetting the boiler supply water temperature in an inverse fashion with outdoor air temperature. The system must be set so that the minimum temperature is not more than 10 degrees above manufacturer’s recommended minimum return temperature. This boiler reset measure is limited to existing condensing boilers serving a single family residence. Boiler reset controls for non-condensing boilers in single family residences should be implemented as a custom measure, and the cost-effectiveness should be confirmed.

**DEFINITION OF BASELINE EQUIPMENT**

Existing condensing boiler in a single family residential setting without boiler reset controls.

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The life of this measure is 20 years.\(^\text{1089}\)

**DEEMED MEASURE COST**

The cost of this measure is $612.\(^\text{1090}\)

**LOADSHAPE**

NA

**COINCIDENCE FACTOR**

NA

---

\(^{1088}\) Energy Solutions Center, a consortium of natural gas utilities, equipment manufacturers and vendors. Boiler Reset Control, accessed at http://naturalgasefficiency.org/residential/Boiler_Reset_Control.htm

\(^{1089}\) CLEAResult references the Brooklyn Union Gas Company, High Efficiency Heating and Water and Controls, Gas Energy Efficiency Program Implementation Plan.

Algorithm

**Calculation of Energy Savings**

**Electric Energy Savings**

NA

**Summer Coincident Peak Demand Savings**

NA

**Natural Gas Savings**

\[ \Delta \text{Therms} = \text{Gas}_{\text{Boiler Load}} \times \left( \frac{1}{\text{AFUE}} \right) \times \text{Savings Factor} \]

Where:

\[ \text{Gas}_{\text{Boiler Load}} \]

1. Estimate of annual household load for gas boiler heated single-family homes. If location is unknown, assume the average below\(^{1092}\).
2. or actual if informed by site-specific load calculations, ACCA Manual J or equivalent\(^{1093}\).

<table>
<thead>
<tr>
<th>Climate Zone (City based upon)</th>
<th>Gas Boiler Load (therms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Rockford)</td>
<td>1275</td>
</tr>
<tr>
<td>2 (Chicago)</td>
<td>1218</td>
</tr>
<tr>
<td>3 (Springfield)</td>
<td>1043</td>
</tr>
<tr>
<td>4 (Belleville)</td>
<td>805</td>
</tr>
</tbody>
</table>

\(^{1091}\) 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 \(\times\) AFUE).

\(^{1092}\) 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.

\(^{1093}\) 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 be completed by contractors during the selection process and may be readily available for program data purposes.
Climate Zone | Gas_Boiler Load (therms)
--- | ---
5 (Marion) | 819
Average | 1158

AFUE = Existing Condensing Boiler Annual Fuel Utilization Efficiency Rating

= Actual.

SF = Savings Factor, 5%^{1094}

**EXAMPLE**

For example, boiler reset controls on a 92.5 AFUE boiler at a household in Rockford, IL

\[ \Delta \text{Therms} = 1275 \times (1/0.925) \times 0.05 \]

\[ = 69 \text{ Therms} \]

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

NA

**DEEMED O&M COST ADJUSTMENT CALCULATION**

NA

**MEASURE CODE:** RS-HVC-BREC-V01-150601

^{1094} Energy Solutions Center, a consortium of natural gas utilities, equipment manufacturers and vendors. Boiler Reset Control, accessed at http://naturalgasefficiency.org/residential/Boiler_Reset_Control.htm
5.3.15 ENERGY STAR Ceiling Fan

DESCRIPTION

A ceiling fan/light unit meeting the efficiency specifications of ENERGY STAR is installed in place of a model meeting the federal standard. ENERGY STAR qualified ceiling fan/light combination units are over 60% more efficient than conventional fan/light units, and use improved motors and blade designs.\footnote{http://www.energystar.gov/products/certified-products/detail/ceiling-fans}

Due to the savings from this measure being derived from more efficient ventilation and more efficient lighting, and the loadshape and measure life for each component being very different, the savings are split in to the component parts and should be claimed together. Lighting savings should be estimated utilizing the 5.5.1 ENERGY STAR Compact Fluorescent Lamp measure.

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 defined as an ENERGY STAR certified ceiling fan with integral CFL bulbs.

DEFINITION OF BASELINE EQUIPMENT

The baseline equipment is assumed to be a standard fan with efficient incandescent or halogen light bulbs. Production of 100W, standard efficacy incandescent lamps ended in 2012 followed by restrictions on 75W in 2013 and 60W and 40W in 2014, due to the Energy Independence and Security Act of 2007 (EISA). 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) for the lighting portion of the savings 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.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The fan savings measure life is assumed to be 10 years.\footnote{http://www.energystar.gov/buildings/sites/default/uploads/files/light_fixture_ceiling_fan_calculator.xlsx?8178-e52c}

The lighting savings measure life is assumed to be 5 years for lighting savings, see 5.5.1 ENERGY STAR Compact Fluorescent Lamp measure.

DEEMED MEASURE COST


LOADSHAPE

R06 - Residential Indoor Lighting
R11 - Residential Ventilation

\footnote{http://www.energystar.gov/products/certified-products/detail/ceiling-fans}
COINCIDENCE FACTOR

The summer peak coincidence factor for the ventilation savings is assumed to be 30%. For lighting savings, see 5.5.1 ENERGY STAR Compact Fluorescent Lamp measure.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

\[ \Delta \text{kWh} = \Delta \text{kWh}_{\text{fan}} + \Delta \text{kWh}_{\text{light}} \]

\[ \Delta \text{kWh}_{\text{fan}} = \left[ \text{Days} \times \text{FanHours} \times \left( \frac{\% \text{Low}_{\text{base}} \times \text{WattsLow}_{\text{base}} + \% \text{Med}_{\text{base}} \times \text{WattsMed}_{\text{base}} + \% \text{High}_{\text{base}} \times \text{WattsHigh}_{\text{base}}}{1000} \right) \right] - \left[ \text{Days} \times \text{FanHours} \times \left( \frac{\% \text{Low}_{\text{ES}} \times \text{WattsLow}_{\text{ES}} + \% \text{Med}_{\text{ES}} \times \text{WattsMed}_{\text{ES}} + \% \text{High}_{\text{ES}} \times \text{WattsHigh}_{\text{ES}}}{1000} \right) \right] \]

\[ \Delta \text{kWh}_{\text{light}} = \text{see 5.5.1 ENERGY STAR Compact Fluorescent Lamp measure.} \]

Where:

- Days = Days used per year
  = Actual. If unknown use 365.25 days/year
- FanHours = Daily Fan “On Hours”
  = Actual. If unknown use 3 hours
- \%Low_{\text{base}} = Percent of time spent at Low speed of baseline
  = 40%
- WattsLow_{\text{base}} = Fan wattage at Low speed of baseline
  = Actual. If unknown use 15 watts
- \%Med_{\text{base}} = Percent of time spent at Medium speed of baseline
  = 40%
- WattsMed_{\text{base}} = Fan wattage at Medium speed of baseline
  = Actual. If unknown use 34 watts


All fan default assumptions are based upon assumptions provided in the ENERGY STAR Ceiling Fan Savings Calculator; http://www.energystar.gov/buildings/sites/default/uploads/files/light_fixture_ceiling_fan_calculator.xlsx?8178-e52c
\%_{\text{High base}} = \text{Percent of time spent at High speed of baseline} \\
= 20\% \\
Watts_{\text{High base}} = \text{Fan wattage at High speed of baseline} \\
= \text{Actual. If unknown use 67 watts} \\
\%_{\text{Low ES}} = \text{Percent of time spent at Low speed of ENERGY STAR} \\
= 40\% \\
Watts_{\text{Low ES}} = \text{Fan wattage at Low speed of ENERGY STAR} \\
= \text{Actual. If unknown use 6 watts} \\
\%_{\text{Med ES}} = \text{Percent of time spent at Medium speed of ENERGY STAR} \\
= 40\% \\
Watts_{\text{Med ES}} = \text{Fan wattage at Medium speed of ENERGY STAR} \\
= \text{Actual. If unknown use 23 watts} \\
\%_{\text{High ES}} = \text{Percent of time spent at High speed of ENERGY STAR} \\
= 20\% \\
Watts_{\text{High ES}} = \text{Fan wattage at High speed of ENERGY STAR} \\
= \text{Actual. If unknown use 56 watts} \\

For ease of reference, the fan assumptions are provided below in table form:

<table>
<thead>
<tr>
<th>Percent of Time at Given Speed</th>
<th>Low Speed</th>
<th>Medium Speed</th>
<th>High Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional Unit Wattage</td>
<td>40%</td>
<td>40%</td>
<td>20%</td>
</tr>
<tr>
<td>ENERGY STAR Unit Wattage</td>
<td>6</td>
<td>23</td>
<td>56</td>
</tr>
<tr>
<td>(\Delta W)</td>
<td>9</td>
<td>11</td>
<td>11</td>
</tr>
</tbody>
</table>

If the lighting WattsBase and WattsEE is unknown, assume the following

WattsBase = 3 \times 43 = 129 W \\
WattsEE = 1 \times 42 = 42 W
Using the default assumptions provided above, the deemed savings is 81.2 kWh.

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

\[
\Delta kW = \Delta kW_{\text{fan}} + \Delta kW_{\text{light}}
\]

\[
\Delta kW_{\text{fan}} = \frac{(\text{WattsHigh}_{\text{base}} - \text{WattsHigh}_{\text{ES}})}{1000} \times CF_{\text{fan}}
\]

\[
\Delta kW_{\text{light}} = \text{see 5.5.1 ENERGY STAR Compact Fluorescent Lamp measure.}
\]

Where:

\[
CF_{\text{fan}} = \text{Summer Peak coincidence factor for ventilation savings} = 30\%^{1099}
\]

\[
CF_{\text{light}} = \text{Summer Peak coincidence factor for lighting savings} = 7.1\%^{1100}
\]

---


1100 Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.
EXAMPLE

For example a ceiling fan with three 43W bulb light fixtures, replaced with an ES ceiling fan with one 42W bulb light fixture, the savings are:

\[ \Delta kW_{\text{fan}} = \frac{(67-56)}{1000} \times 0.3 \]
\[ = 0.0033 \text{ kW} \]

\[ \Delta kW_{\text{light}} = \frac{(129-42)}{1000} \times 1.11 \times 0.071 \]
\[ = 0.0068 \text{ kW} \]

\[ \Delta kW = 0.0033 + 0.0068 \]
\[ = 0.010 \text{ kW} \]

Using the default assumptions provided above, the deemed savings is 0.010kW.

**NATURAL GAS SAVINGS**

N/A

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

See 5.5.1 ENERGY STAR Compact Fluorescent Lamp measure for bulb replacement costs.

**MEASURE CODE: RS-HVC-CFAN-V01-150601**
5.4 Hot Water End Use

5.4.1 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\(^{1101}\).

**DEEMED MEASURE COST**

The measure cost including material and installation is assumed to be $3 per linear foot\(^{1102}\).

**LOADSHAPE**

Loadshape CS3 - Flat

**COINCIDENCE FACTOR**

This measure assumes a flat loadshape since savings relate to reducing standby losses and as such the coincidence factor is 1.


\(^{1102}\) Consistent with DEER 2008 Database Technology and Measure Cost Data (www.deeresources.com).
Algorithm

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

For electric DHW systems:

\[ \Delta \text{kWh} = \frac{(1/R_{\text{exist}} - 1/R_{\text{new}}) \times (L \times C) \times \Delta T \times 8766}{\eta_{\text{DHW}} / 3412} \]

Where:

- \( R_{\text{exist}} \): Pipe heat loss coefficient of uninsulated pipe (existing) \([(\text{hr}-\text{°F}-\text{ft})/\text{Btu}]\)
  - \( R_{\text{exist}} = 1.0^{1103} \)
- \( R_{\text{new}} \): Pipe heat loss coefficient of insulated pipe (new) \([(\text{hr}-\text{°F}-\text{ft})/\text{Btu}]\)
  - \( R_{\text{new}} = \text{Actual} \times (1.0 + \text{R value of insulation}) \)
- \( L \): Length of pipe from water heating source covered by pipe wrap (ft)
  - \( L = \text{Actual} \)
- \( C \): Circumference of pipe (ft) \((\text{Diameter (in)} \times \pi/12)\)
  - \( C = \text{Actual} \) (0.5” pipe = 0.131ft, 0.75” pipe = 0.196ft)
- \( \Delta T \): Average temperature difference between supplied water and outside air temperature (°F)
  - \( \Delta T = 60^\circ \text{F}^{1104} \)
- \( 8,766 \): Hours per year
- \( \eta_{\text{DHW}} \): Recovery efficiency of electric hot water heater
  - \( \eta_{\text{DHW}} = 0.98^{1105} \)
- \( 3412 \): Conversion from Btu to kWh

For example, insulating 5 feet of 0.75” pipe with R-5 wrap:

\[
\Delta \text{kWh} = \frac{(1/R_{\text{exist}} - 1/R_{\text{new}}) \times (L \times C) \times \Delta T \times 8766}{\eta_{\text{DHW}} / 3412} \\
= \frac{((1/1 - 1/(1+5)) \times (5 \times 0.196) \times 60 \times 8766)}{0.98 / 3412} \\
= 128 \text{kWh}
\]

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.

\[
\Delta \text{kWh} = \frac{(1/R_{\text{exist}} - 1/R_{\text{new}}) \times (L \times C) \times \Delta T \times 8766}{\eta_{\text{DHW}} / 3412} \\
= \frac{((1/1 - 1/(1+5)) \times (3 \times 0.196) \times 60 \times 8766)}{0.98 / 3412} \\
\]

---

1103 Navigant Consulting Inc., April 2009; “Measures and Assumptions for Demand Side Management (DSM) Planning; Appendix C Substantiation Sheets”, p77.

1104 Assumes 125°F water leaving the hot water tank and average temperature of basement of 65°F.

1105 Electric water heaters have recovery efficiency of 98%: [http://www.ahridirectory.org/ahridirectory/pages/home.aspx](http://www.ahridirectory.org/ahridirectory/pages/home.aspx)
= 77.1 kWh per 3ft length

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

\[ \Delta kW = \Delta kWh / 8766 \]

Where:

- \( \Delta kWh \) = 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:

\[ \Delta kW = 128/8766 \]
\[ = 0.015 kW \]

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.

\[ \Delta kW = 77.1/8766 \]
\[ = 0.0088 kW \]

**NATURAL GAS SAVINGS**

For Natural Gas DHW systems:

\[ \Delta \text{Therm} = \frac{((1/R_{exist} - 1/R_{new}) * (L * C) * \Delta T * 8766)}{\eta_{DHW}/100,000} \]

Where:

- \( \eta_{DHW} \) = Recovery efficiency of gas hot water heater
  \[ = 0.78 \]

Other variables as defined above

For example, insulating 5 feet of 0.75" pipe with R-5 wrap:

\[ \Delta \text{Therm} = \frac{((1/1- 1/(1+5)) * (5 * 0.196) * 60 * 8766)}{0.78 / 100,000} \]
\[ = 5.51 \text{ therms} \]

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.

\[ \Delta \text{Therm} = \frac{((1/R_{exist} - 1/R_{new}) * (L * C) * \Delta T * 8766)}{\eta_{DHW} / 100,000} \]
\[ = \frac{((1/1- 1/(1+5)) * (3 * 0.196) * 60 * 8766)}{0.78 /100,000} \]
\[ = 3.30 \text{ therms per 3ft length} \]

\[ ^{1106} \text{Review of AHRI Directory suggests range of recovery efficiency ratings for new Gas DHW units of 70-87%. Average of existing units is estimated at 78%} \]
WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HWE-PINS-V02-150601
5.4.2 Gas Water Heater

DESCRIPTION
This measure characterizes:

a) Time of sale or new construction:
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.

b) Early replacement:
The early removal of an existing functioning natural gas water heater from service, prior to its natural end of life, and replacement with a new high efficiency 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
To qualify for this measure the efficient equipment must be a water heater rated with the following minimum efficiency ratings:

<table>
<thead>
<tr>
<th>Water Heater Type</th>
<th>Minimum Energy Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas Storage</td>
<td>0.67</td>
</tr>
<tr>
<td>Condensing gas storage</td>
<td>0.80</td>
</tr>
<tr>
<td>Tankless whole-house unit</td>
<td>0.82</td>
</tr>
</tbody>
</table>

DEFINITION OF BASELINE EQUIPMENT
Time of Sale or New Construction: 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. For 20 to 55 gallon tanks the Federal Standard is calculated as $0.675 - (0.0015 \times \text{storage size in gallons})$ and for tanks 55 - 100 gallon $0.8012 - (0.00078 \times \text{storage size in gallons})$\(^{107}\). For a 40-gallon storage water heater this would be 0.615 EF.

Early replacement: The baseline for this measure is the efficiency of the existing equipment for the assumed remaining useful life of the unit and a new baseline unit for the remainder of the measure life.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT
The expected measure life is assumed to be 13 years.\(^ {108}\)

\(^{108}\) 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
For early replacement: Remaining life of existing equipment is assumed to be 4 years\textsuperscript{1109}.

**DEEMED MEASURE COST**

Time of Sale or New Construction:

The incremental capital cost for this measure is dependent on the type of water heater as listed below\textsuperscript{1110}.

Early Replacement: The full installed cost is provided in the table below. The assumed deferred cost (after 4 years) of replacing existing equipment with a new baseline unit is assumed to be $614\textsuperscript{1111}. This cost should be discounted to present value using the utility's discount rate.

<table>
<thead>
<tr>
<th>Water heater Type</th>
<th>Incremental Cost</th>
<th>Full Install Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas Storage</td>
<td>$400</td>
<td>$1014</td>
</tr>
<tr>
<td>Condensing gas storage</td>
<td>$685</td>
<td>$1299</td>
</tr>
<tr>
<td>Tankless whole-house unit</td>
<td>$605</td>
<td>$1219</td>
</tr>
</tbody>
</table>

**LOADSHAPE**

N/A

**COINCIDENCE FACTOR**

N/A

**Algorithm**

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

N/A

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

N/A


\textsuperscript{1110} Assumed to be one third of effective useful life

\textsuperscript{1111} The deemed install cost of a Gas Storage heater is based upon DCEO Efficient Living Program Data for a sample size of 157 gas water heaters.
NATURAL GAS ENERGY SAVINGS

Time of Sale or New Construction:

\[ \Delta \text{Therms} = \frac{(1/ \text{EF}_{\text{BASE}} - 1/ \text{EF}_{\text{EFFICIENT}}) \times (\text{GPD} \times \text{Household} \times 365.25 \times \gamma_{\text{Water}} \times (T_{\text{OUT}} - T_{\text{IN}}) \times 1.0)}{100,000} \]

Early replacement\(^{1112}\):

\[ \Delta \text{Therms for remaining life of existing unit (1st 4 years)}: \]

\[ = \frac{(1/ \text{EF}_{\text{EXISTING}} - 1/ \text{EF}_{\text{EFFICIENT}}) \times (\text{GPD} \times \text{Household} \times 365.25 \times \gamma_{\text{Water}} \times (T_{\text{OUT}} - T_{\text{IN}}) \times 1.0)}{100,000} \]

\[ \Delta \text{Therms for remaining measure life (next 9 years)}: \]

\[ = \frac{(1/ \text{EF}_{\text{BASE}} - 1/ \text{EF}_{\text{EFFICIENT}}) \times (\text{GPD} \times \text{Household} \times 365.25 \times \gamma_{\text{Water}} \times (T_{\text{OUT}} - T_{\text{IN}}) \times 1.0)}{100,000} \]

Where:

\( \text{EF}_{\text{Baseline}} \) = Energy Factor rating for baseline equipment

For <= 55 gallons: \[0.675 - (0.0015 \times \text{tank size})\]

For > 55 gallons: \[0.8012 - (0.00078 \times \text{tank size})\]

\[ = \text{if tank size unknown assume 40 gallons and } \text{EF}_{\text{Baseline}} \text{ of 0.615} \]

\( \text{EF}_{\text{Efficient}} \) = Energy Factor Rating for efficient equipment

\[ = \text{Actual. If Tankless whole-house multiply rated efficiency by 0.91}^{1113}. \text{If unknown assume values in look up in table below} \]

<table>
<thead>
<tr>
<th>Water Heater Type</th>
<th>EF_Efficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condensing Gas Storage</td>
<td>0.80</td>
</tr>
<tr>
<td>Gas Storage</td>
<td>0.67</td>
</tr>
<tr>
<td>Tankless whole-house</td>
<td>0.82 * 0.91 = 0.75</td>
</tr>
</tbody>
</table>

\( \text{EF}_{\text{Existing}} \) = Energy Factor rating for existing equipment

\[ = \text{Use actual EF rating where it is possible to measure or reasonably estimate.} \]

\[ = \text{if unknown assume 0.52}^{1114} \]

\( \text{GPD} \) = Gallons Per Day of hot water use per person

---

\(^{1112}\) 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).

\(^{1113}\) 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.

\(^{1114}\) Based on DCEO Efficient Living Program Data for a sample size of 157 gas water heaters.
= 45.5 gallons hot water per day per household/2.59 people per household

= 17.6

Household = Average number of people per household

<table>
<thead>
<tr>
<th>Household Unit Type</th>
<th>Household</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-Family - Deemed</td>
<td>2.56</td>
</tr>
<tr>
<td>Multi-Family - Deemed</td>
<td>2.1</td>
</tr>
<tr>
<td>Custom</td>
<td>Actual Occupancy or Number of Bedrooms</td>
</tr>
</tbody>
</table>

365.25 = Days per year, on average

\( \gamma_{\text{Water}} = \text{Specific Weight of water} \)
= 8.33 pounds per gallon

\( T_{\text{OUT}} = \text{Tank temperature} \)
= 125°F

\( T_{\text{IN}} = \text{Incoming water temperature from well or municipal system} \)
= 54°F

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 in a single family house:

\[
\Delta \text{Therms} = (1/0.615 - 1/0.8) \times (17.6 \times 2.56 \times 365.25 \times 8.33 \times (125 - 54) \times 1) / 100,000
\]

= 36.6 therms

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: RS-HWE-GWHT-V04-150601**

---

1115 Email message from Maureen Hodgins, Research Manager for Water Research Foundation, to TAC/SAG, August 26, 2014
1118 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.
1119 US DOE Building America Program. Building America Analysis Spreadsheet. For Chicago, IL  
http://www1.eere.energy.gov/buildings/building_america/analysis_spreadsheets.html
5.4.3 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 standards1120:

For <=55 gallons: 0.96 – (0.0003 * rated volume in gallons)
For >55 gallons: 2.057 – (0.00113 * rated volume in gallons)

DEEMED LIFETIME OF EFFICIENT EQUIPMENT
The expected measure life is assumed to be 13 years.1121

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.1122

LOADSHAPE
Loadshape R03 - Residential Electric DHW

COINCIDENCE FACTOR
The summer Peak Coincidence Factor is assumed to be 12%.1123

---

1123 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 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
Algorithm

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

\[ \Delta \text{kWh} = \left( \frac{1}{EF_{\text{BASE}}} - \frac{1}{EF_{\text{EFFICIENT}}} \right) \times \text{GPD} \times \text{Household} \times 365.25 \times \gamma_{\text{Water}} \times (T_{\text{OUT}} - T_{\text{IN}}) \times 1.0 / 3412 \] 

\[ \text{+ kWh_{cooling} - kWh_{heating}} \]

Where:

- \( EF_{\text{BASE}} \) = Energy Factor (efficiency) of standard electric water heater according to federal standards\textsuperscript{1124}:
  - For \( \leq 55 \) gallons: \( 0.96 - (0.0003 \times \text{rated volume in gallons}) \)
  - For \( > 55 \) gallons: \( 2.057 - (0.00113 \times \text{rated volume in gallons}) \)
  - \( = 0.945 \) for a 50 gallon tank, the most common size for HPWH

- \( EF_{\text{EFFICIENT}} \) = Energy Factor (efficiency) of Heat Pump water heater
  - Actual

- \( GPD \) = Gallons Per Day of hot water use per person
  - \( = 45.5 \) gallons hot water per day per household/2.59 people per household\textsuperscript{1125}
  - \( = 17.6 \)

- \( \text{Household} \) = Average number of people per household

<table>
<thead>
<tr>
<th>Household Unit Type</th>
<th>Household</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-Family - Deemed</td>
<td>2.56\textsuperscript{1126}</td>
</tr>
<tr>
<td>Multi-Family - Deemed</td>
<td>2.1\textsuperscript{1127}</td>
</tr>
<tr>
<td>Custom</td>
<td>Actual Occupancy or Number of Bedrooms\textsuperscript{1128}</td>
</tr>
</tbody>
</table>

- \( 365.25 \) = Days per year


\textsuperscript{1125} Email message from Maureen Hodgins, Research Manager for Water Research Foundation, to TAC/SAG, August 26, 2014


\textsuperscript{1128} 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.
γWater = Specific weight of water
= 8.33 pounds per gallon

T_{OUT} = Tank temperature
= 125°F

T_{IN} = Incoming water temperature from well or municipal system
= 54°F

1.0 = Heat Capacity of water (1 Btu/lb*°F)

3412 = Conversion from Btu to kWh

kWh\textsubscript{cooling} = Cooling savings from conversion of heat in home to water heat

=(((GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0) / 3412) – ((1/ EF_{NEW} * GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0) / 3412)) * LF * 27% / COP\textsubscript{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

COP\textsubscript{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

\textsuperscript{1129} US DOE Building America Program. Building America Analysis Spreadsheet. For Chicago, IL http://www1.eere.energy.gov/buildings/building_america/analysis_spreadsheets.html

\textsuperscript{1130} 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.

\textsuperscript{1131} 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).
kWh\textsubscript{heating} = Heating cost from conversion of heat in home to water heat (dependent on heating fuel)

For Natural Gas heating, kWh\textsubscript{heating} = 0

For electric heating:

\[ \text{kWh\textsubscript{heating}} = \left(\frac{(\text{GPD} \times \text{Household} \times 365.25 \times \gamma_{\text{Water}} \times (T_{\text{OUT}} - T_{\text{IN}}) \times 1.0)}{3412}\right) - \left(\frac{(1/ \text{EF}\textsubscript{NEW} \times \text{GPD} \times \text{Household} \times 365.25 \times \gamma_{\text{Water}} \times (T_{\text{OUT}} - T_{\text{IN}}) \times 1.0)}{3412}\right) \times \text{LF} \times 49\% \times \frac{1}{\text{COP}_{\text{HEAT}}}
\]

Where:

- 49\% = Portion of reduced waste heat that results in increased heating load\textsuperscript{1133}
- COP\textsubscript{HEAT} = COP of electric heating system

\[ \text{COP}_{\text{HEAT}} = \text{actual. If not available use}\textsuperscript{1134}; \]

<table>
<thead>
<tr>
<th>System Type</th>
<th>Age of Equipment</th>
<th>HSPF Estimate</th>
<th>COP\textsubscript{HEAT} (COP Estimate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat Pump</td>
<td>Before 2006</td>
<td>6.8</td>
<td>2.00</td>
</tr>
<tr>
<td></td>
<td>After 2006 - 2014</td>
<td>7.7</td>
<td>2.26</td>
</tr>
<tr>
<td></td>
<td>2015 on</td>
<td>8.2</td>
<td>2.40</td>
</tr>
<tr>
<td>Resistance</td>
<td>N/A</td>
<td>N/A</td>
<td>1.00</td>
</tr>
</tbody>
</table>

For example, a 2.0 EF heat pump water heater, in a conditioned space in a single family home with gas space heat and central air conditioning (SEER 10.5) in Belleville:

\[ \Delta \text{kWh} = \left(\frac{1 / 0.945 - 1 / 2.0}{17.6 \times 2.56 \times 365.25 \times 8.33 \times (125 - 54)}}{3412} + 166.3 - 0 \right)
\]

\[ \Delta \text{kWh} = 1759 \text{ kWh} \]

\textsuperscript{1132} 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

\textsuperscript{1133} 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).

\textsuperscript{1134} 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

\[ \Delta kW = \Delta kWh / \text{Hours} \times \text{CF} \]

Where:

- **Hours** = Full load hours of water heater
  
  = 2533

- **CF** = Summer Peak Coincidence Factor for measure
  
  = 0.12

For example, a 2.0 COP heat pump water heater, in a conditioned space in a single family home with gas space heat and central air conditioning in Belleville:

\[ kW = \frac{1759}{2533} \times 0.12 \]

= 0.083 kW

### NATURAL GAS SAVINGS

\[ \Delta \text{Therms} = \frac{-((\text{GPD} \times \text{Household} \times 365.25 \times \gamma_{\text{Water}} \times (T_{\text{OUT}} - T_{\text{IN}}) \times 1.0) / 3412) - ((\text{GPD} \times \text{Household} \times 365.25 \times \gamma_{\text{Water}} \times (T_{\text{OUT}} - T_{\text{IN}}) \times 1.0) / 3412) / \text{EF}_{\text{EFFICIENT}}) \times \text{LF} \times 49\% \times 0.03412}{\eta_{\text{Heat}} \times \% \text{Natural Gas}} \]

Where:

- **\Delta \text{Therms}** = Heating cost from conversion of heat in home to water heat for homes with Natural Gas heat.

- 0.03412 = conversion factor (therms per kWh)

- \(\eta_{\text{Heat}}\) = Efficiency of heating system

- **Actual.** If not available use 70%. 

---

1135 Full load hours assumption based on Efficiency Vermont analysis of Itron eShapes.

1136 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](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

1137 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. kW\text{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.

1138 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](http://www.bpi.org/files/pdf/DistributionEfficiencyTable-BlueSheet.pdf) or by performing duct blaster testing.
% Natural Gas = Factor dependent on heating fuel:

<table>
<thead>
<tr>
<th>Heating System</th>
<th>% Natural Gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric resistance or heat pump</td>
<td>0%</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>100%</td>
</tr>
<tr>
<td>Unknown heating fuel</td>
<td>87%</td>
</tr>
</tbody>
</table>

Other factors as defined above

For example, a 2.0 COP heat pump water heater in conditioned space, in a single family home with gas space heat (70% system efficiency):

\[
\Delta \text{Therms} = -\left(\frac{(17.6 \times 2.56 \times 365.25 \times 8.33 \times (125 - 54) \times 1.0)}{3412} - \frac{(17.6 \times 2.56 \times 365.25 \times 8.33 \times (125 - 54) \times 1.0)}{3412 \times 2.0} \right) \times 0.49 \times 0.03412 / (0.7 \times 1)
\]

\[
= -34.1 \text{ therms}
\]

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE**: RS-HWE-HPWH-V04-150601

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1139 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:

\[(0.24 \times 0.92) + (0.76 \times 0.8) \times (1-0.15) = 0.70\]

1140 2010 American Community Survey.
5.4.4 Low Flow Faucet Aerators

This measure relates to the installation of a low flow faucet aerator in a household kitchen or bath faucet fixture. This measure may be used for units provided through Efficiency Kit’s however the in service rate for such measures should be derived through evaluation results specifically for this implementation methodology. This measure was developed to be applicable to the following program types: TOS, NC, RF, DI, KITS.

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 low flow 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 greater, or a standard kitchen faucet aerator rated at 2.75 GPM or greater. Average measured flow rates are used in the algorithm and are lower, reflecting the penetration of previously installed low flow fixtures (and therefore the freerider rate for this measure should be 0), use of the faucet at less than full flow, debris buildup, and lower water system pressure than fixtures are rated at.

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The expected measure life is assumed to be 9 years.\(^{1141}\)

**DEEMED MEASURE COST**

The incremental cost for this measure is $8\(^{1142}\) or program actual. For faucet aerators provided in Efficiency Kits, the actual program delivery costs should be utilized.

**LOADSHAPE**

Loadshape R03 - Residential Electric DHW

**COINCIDENCE FACTOR**

The coincidence factor for this measure is assumed to be 2.2%.\(^{1143}\)

---


\(^{1142}\) 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)

\(^{1143}\) 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
Algorithm

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

Note these savings are per faucet retrofitted\(^{1144}\) (unless faucet type is unknown, then it is per household).

\[
\Delta \text{KWh} = \% \text{ElectricDHW} \times ((\text{GPM}_{\text{base}} \times \text{L}_{\text{base}} - \text{GPM}_{\text{low}} \times \text{L}_{\text{low}}) \times \text{Household} \times 365.25 \times \text{DF} / \text{FPH}) \times \text{EPG}_{\text{electric}} \times \text{ISR}
\]

Where:

\[
\% \text{ElectricDHW} = \text{proportion of water heating supplied by electric resistance heating}
\]

<table>
<thead>
<tr>
<th>DHW fuel</th>
<th>%ElectricDHW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric</td>
<td>100%</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>0%</td>
</tr>
<tr>
<td>Unknown</td>
<td>16%(^{1145})</td>
</tr>
</tbody>
</table>

\(\text{GPM}_{\text{base}}\) = Average flow rate, in gallons per minute, of the baseline faucet “as-used.” This includes the effect of existing low flow fixtures and therefore the freerider rate for this measure should be 0.

\[= 1.39\(^{1146}\) \text{ or custom based on metering studies}\(^{1147}\) \text{ or if measured during DI:}

\[= \text{Measured full throttle flow} \times 0.83 \text{ throttling factor}\(^{1148}\)

\(\text{GPM}_{\text{low}}\) = Average flow rate, in gallons per minute, of the low-flow faucet aerator “as-used”

\[= 0.94\(^{1149}\) \text{ or custom based on metering studies}\(^{1150}\) \text{ or if measured during DI:}

---

\(^{1144}\) This algorithm calculates the amount of energy saved per aerator by determining the fraction of water consumption savings for the upgraded fixture.

\(^{1145}\) 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.

\(^{1146}\) Email message from Maureen Hodgins, Research Manager for Water Research Foundation, to TAC/SAG, August 26, 2014

\(^{1147}\) 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.


\(^{1149}\) 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 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.

\(^{1150}\) 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
Low Flow Faucet Aerators

\[ L_{\text{base}} = \text{Rated full throttle flow} \times 0.95 \text{ throttling factor} \]

- \( L_{\text{base}} \) = Average baseline daily length faucet use per capita for faucet of interest in minutes
- If available custom based on metering studies, if not use:

<table>
<thead>
<tr>
<th>Faucet Type</th>
<th>( L_{\text{base}} ) (min/person/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kitchen</td>
<td>4.5\textsuperscript{1152}</td>
</tr>
<tr>
<td>Bathroom</td>
<td>1.6\textsuperscript{1153}</td>
</tr>
<tr>
<td>If location unknown (total for household): Single-Family</td>
<td>9.0\textsuperscript{1154}</td>
</tr>
<tr>
<td>If location unknown (total for household): Multi-Family</td>
<td>6.9\textsuperscript{1155}</td>
</tr>
</tbody>
</table>

\[ L_{\text{low}} = \text{Average retrofit daily length faucet use per capita for faucet of interest in minutes} \]

- If available custom based on metering studies, if not use:

<table>
<thead>
<tr>
<th>Faucet Type</th>
<th>( L_{\text{low}} ) (min/person/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kitchen</td>
<td>4.5\textsuperscript{1156}</td>
</tr>
<tr>
<td>Bathroom</td>
<td>1.6\textsuperscript{1157}</td>
</tr>
<tr>
<td>If location unknown (total for household): Single-Family</td>
<td>9.0\textsuperscript{1158}</td>
</tr>
<tr>
<td>If location unknown (total for household): Multi-Family</td>
<td>6.9\textsuperscript{1159}</td>
</tr>
</tbody>
</table>

Household = Average number of people per household

occupant behavior which does not always use maximum flow.


\textsuperscript{1152} Cadmus and Opinion Dynamics Showerhead and Faucet Aerator Meter Study Memorandum dated June 2013, directed to Michigan Evaluation Working Group. This study of 135 single and multi-family homes in Michigan metered energy parameters for efficient showerhead and faucet aerators.

\textsuperscript{1153} Ibid.

\textsuperscript{1154} One kitchen faucet plus 2.83 bathroom faucets. Based on findings from a 2009 ComEd residential survey of 140 sites, provided by Cadmus.

\textsuperscript{1155} One kitchen faucet plus 1.5 bathroom faucets. Based on findings from a 2009 ComEd residential survey of 140 sites, provided by Cadmus.

\textsuperscript{1156} Cadmus and Opinion Dynamics Showerhead and Faucet Aerator Meter Study Memorandum dated June 2013, directed to Michigan Evaluation Working Group.

\textsuperscript{1157} Ibid.

\textsuperscript{1158} One kitchen faucet plus 2.83 bathroom faucets. Based on findings from a 2009 ComEd residential survey of 140 sites, provided by Cadmus.

\textsuperscript{1159} One kitchen faucet plus 1.5 bathroom faucets. Based on findings from a 2009 ComEd residential survey of 140 sites, provided by Cadmus.
### 5.4.4 Low Flow Faucet Aerators

<table>
<thead>
<tr>
<th>Household Unit Type</th>
<th>Household</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-Family - Deemed</td>
<td>2.56&lt;sup&gt;1160&lt;/sup&gt;</td>
</tr>
<tr>
<td>Multi-Family - Deemed</td>
<td>2.1&lt;sup&gt;1161&lt;/sup&gt;</td>
</tr>
<tr>
<td>Custom</td>
<td>Actual Occupancy or Number of Bedrooms&lt;sup&gt;1162&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

| 365.25                | = Days in a year, on average.          |
| DF                    | = Drain Factor                         |

<table>
<thead>
<tr>
<th>Faucet Type</th>
<th>Drain Factor&lt;sup&gt;1163&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kitchen</td>
<td>75%</td>
</tr>
<tr>
<td>Bath</td>
<td>90%</td>
</tr>
<tr>
<td>Unknown</td>
<td>79.5%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Faucet Type</th>
<th>FPH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kitchen Faucets Per Home (KFPH)</td>
<td>1</td>
</tr>
<tr>
<td>Bathroom Faucets Per Home (BFPH): Single-Family</td>
<td>2.83&lt;sup&gt;1164&lt;/sup&gt;</td>
</tr>
<tr>
<td>Bathroom Faucets Per Home (BFPH): Multi-Family</td>
<td>1.5&lt;sup&gt;1165&lt;/sup&gt;</td>
</tr>
<tr>
<td>If location unknown (total for household): Single-Family</td>
<td>3.83</td>
</tr>
<tr>
<td>If location unknown (total for household): Multi-Family</td>
<td>2.5</td>
</tr>
</tbody>
</table>

---


<sup>1162</sup> 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.

<sup>1163</sup> 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.

<sup>1164</sup> Based on findings from a 2009 ComEd residential survey of 140 sites, provided by Cadmus.

<sup>1165</sup> Ibid.
EPG\textsubscript{electric} = Energy per gallon of water used by faucet supplied by electric water heater

\[
\text{EPG\textsubscript{electric}} = \frac{(8.33 \times 1.0 \times (\text{WaterTemp} - \text{SupplyTemp}))}{(\text{RE\textsubscript{electric}} \times 3412)}
\]

\[
= \frac{(8.33 \times 1.0 \times (86 - 54.1))}{(0.98 \times 3412)}
\]

= 0.0795 kWh/gal (Bath), 0.0969 kWh/gal (Kitchen), 0.0919 kWh/gal (Unknown)

8.33 = Specific weight of water (lbs/gallon)

1.0 = Heat Capacity of water (btu/lb\textdegree\text{F})

WaterTemp = Assumed temperature of mixed water

= 86\textdegree F for Bath, 93\textdegree F for Kitchen 91\textdegree F for Unknown \textsuperscript{1166}

SupplyTemp = Assumed temperature of water entering house

= 54.1\textdegree \textsuperscript{1167}

RE\textsubscript{electric} = Recovery efficiency of electric water heater

= 98\% \textsuperscript{1168}

3412 = Converts Btu to kWh (btu/kWh)

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

<table>
<thead>
<tr>
<th>Selection</th>
<th>ISR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct Install - Single Family</td>
<td>0.95  \textsuperscript{1169}</td>
</tr>
<tr>
<td>Direct Install – Multi Family Kitchen</td>
<td>0.91 \textsuperscript{1170}</td>
</tr>
<tr>
<td>Direct Install – Multi Family Bathroom</td>
<td>0.95 \textsuperscript{1171}</td>
</tr>
<tr>
<td>Efficiency Kits</td>
<td>To be determined through evaluation</td>
</tr>
</tbody>
</table>

\textsuperscript{1166} Cadmus and Opinion Dynamics Showerhead and Faucet Aerator Meter Study Memorandum dated June 2013, directed to Michigan Evaluation Working Group. If the aerator location is unknown an average of 91\% should be used which is based on the assumption that 70\% of household water runs through the kitchen faucet and 30\% through the bathroom \((0.7\times93)+(0.3\times86)=0.91\).


\textsuperscript{1168} Electric water heaters have recovery efficiency of 98\%: http://www.ahridirectory.org/ahridirectory/pages/home.aspx


\textsuperscript{1171} Ibid.
For example, a direct installed kitchen low flow faucet aerator in a single-family electric DHW home:

\[ \Delta \text{kWh} = 1.0 \* \left( \frac{((1.39 \times 4.5 - 0.94 \times 4.5) \times 2.56 \times 365.25 \times 0.75)}{1} \right) \times 0.0969 \times 0.95 \]

\[ = 131 \text{kWh} \]

For example, a direct installed bath low flow faucet aerator in a multi-family electric DHW home:

\[ \Delta \text{kWh} = 1.0 \* \left( \frac{((1.39 \times 1.6 - 0.94 \times 1.6) \times 2.1 \times 365.25 \times 0.90)}{1.5} \right) \times 0.0795 \times 0.95 \]

\[ = 25.0 \text{kWh} \]

For example, a direct installed low flow faucet aerator in unknown faucet in a single-family electric DHW home:

\[ \Delta \text{kWh} = 1.0 \* \left( \frac{((1.39 \times 9.0 - 0.94 \times 9.0) \times 2.56 \times 365.25 \times 0.795)}{3.83} \right) \times 0.0919 \times 0.95 \]

\[ = 68.6 \text{kWh} \]

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

\[ \Delta \text{kW} = \Delta \text{kWh} / \text{Hours} \times \text{CF} \]

Where:

- \( \Delta \text{kWh} \) = calculated value above
- \( \text{Hours} \) = Annual electric DHW recovery hours for faucet use per faucet

\[ = \left( \frac{\text{GPM}\_\text{base} \times \text{L}\_\text{base} \times \text{Household}/\text{FPH} \times 365.25 \times \text{DF} \times 0.545}{\text{GPH}} \right) / \text{GPH} \]

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Faucet Location</th>
<th>Calculation</th>
<th>Hours per Faucet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Family</td>
<td>Kitchen</td>
<td>\left( \frac{((1.39 \times 4.5) \times 2.56/1 \times 365.25 \times 0.75)}{25.5} \right) \times 0.545 / 25.5</td>
<td>94</td>
</tr>
<tr>
<td></td>
<td>Bathroom</td>
<td>\left( \frac{((1.39 \times 1.6) \times 2.56/2.83 \times 365.25 \times 0.9)}{25.5} \right) \times 0.545 / 25.5</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Unknown</td>
<td>\left( \frac{((1.39 \times 9.0) \times 2.56/3.83 \times 365.25 \times 0.795)}{3.83} \right) \times 0.545 / 25.5</td>
<td>52</td>
</tr>
<tr>
<td>Multi Family</td>
<td>Kitchen</td>
<td>\left( \frac{((1.39 \times 4.5) \times 2.1/1 \times 365.25 \times 0.75)}{25.5} \right) \times 0.545 / 25.5</td>
<td>77</td>
</tr>
<tr>
<td></td>
<td>Bathroom</td>
<td>\left( \frac{((1.39 \times 1.6) \times 2.1/1.5 \times 365.25 \times 0.9)}{25.5} \right) \times 0.545 / 25.5</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>Unknown</td>
<td>\left( \frac{((1.39 \times 6.9) \times 2.1/2.5 \times 365.25 \times 0.795)}{25.5} \right) \times 0.545 / 25.5</td>
<td>50</td>
</tr>
</tbody>
</table>

GPH = Gallons per hour recovery of electric water heater calculated for 70.9F temp rise (125-54.1), 98% recovery efficiency, and typical 4.5kW electric resistance storage tank.

\[ = 25.5 \]

CF = Coincidence Factor for electric load reduction

\(^{1172} 54.5\% \text{ is the proportion of hot 120F water mixed with 54.1F supply water to give 90F mixed faucet water.}\)
\[ = 0.022^{1173} \]

For example, a direct installed kitchen low flow faucet aerator in a single family electric DHW home:
\[ \Delta kW = 131/94 \times 0.022 \]
\[ = 0.0306 \text{ kW} \]

**NATURAL GAS SAVINGS**

\[ \Delta \text{Therms} = \%\text{FossilDHW} \times \left( (\text{GPM}_{\text{base}} \times \text{L}_{\text{base}} - \text{GPM}_{\text{low}} \times \text{L}_{\text{low}}) \times \text{Household} \times 365.25 \times \text{DF} / \text{FPH} \right) \times \text{EPG}_{\text{gas}} \times \text{ISR} \]

Where:

\[ \%\text{FossilDHW} = \text{proportion of water heating supplied by Natural Gas heating} \]

<table>
<thead>
<tr>
<th>DHW fuel</th>
<th>%Fossil_DHW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric</td>
<td>0%</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>100%</td>
</tr>
<tr>
<td>Unknown</td>
<td>84%^{1174}</td>
</tr>
</tbody>
</table>

\[ \text{EPG}_{\text{gas}} = \text{Energy per gallon of Hot water supplied by gas} \]
\[ = (8.33 \times 1.0 \times (\text{WaterTemp} - \text{SupplyTemp})) / (\text{RE}_{\text{gas}} \times 100,000) \]
\[ = 0.00341 \text{ Therm/gal for SF homes (Bath), 0.00415 Therm/gal for SF homes (Kitchen), 0.00394 Therm/gal for SF homes (Unknown)} \]
\[ = 0.00397 \text{ Therm/gal for MF homes (Bath), 0.00484 Therm/gal for MF homes (Kitchen), 0.00459 Therm/gal for MF homes (Unknown)} \]
\[ \text{RE}_{\text{gas}} = \text{Recovery efficiency of gas water heater} \]
\[ = 78\% \text{ For SF homes}^{1175} \]
\[ = 67\% \text{ For MF homes}^{1176} \]

---

^{1173} 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 \times 65 / 365 = 3.21\%. The number of hours of recovery during peak periods is therefore assumed to be 3.21\% \times 180 = 5.8 \text{ 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 \]

^{1174} 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.

^{1175} 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\%. 

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

Other variables as defined above.

For example, a direct-installed kitchen low flow faucet aerator in a fuel DHW single-family home:

\[
\Delta \text{Therms} = 1.0 \times \left( (1.39 \times 4.5 - 0.94 \times 4.5) \times 2.56 \times 365.25 \times 0.75 \right) / 1 \times 0.00415 \times 0.95
\]
\[
= 5.60 \text{ Therms}
\]

For example, a direct installed bath low flow faucet aerator in a fuel DHW multi-family home:

\[
\Delta \text{Therms} = 1.0 \times \left( (1.39 \times 1.6 - 0.94 \times 1.6) \times 2.1 \times 365.25 \times 0.90 \right) / 1.5 \times 0.003974 \times 0.95
\]
\[
= 1.25 \text{ Therms}
\]

For example, a direct installed low flow faucet aerator in unknown faucet in a fuel DHW single-family home:

\[
\Delta \text{Therms} = 1.0 \times \left( (1.39 \times 9.0 - 0.94 \times 9.0) \times 2.56 \times 365.25 \times 0.795 \right) / 3.83 \times 0.00394 \times 0.95
\]
\[
= 2.94 \text{ Therms}
\]

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

\[
\Delta \text{gallons} = ((\text{GPM}_{\text{base}} \times \text{L}_{\text{base}} - \text{GPM}_{\text{low}} \times \text{L}_{\text{low}}) \times \text{Household} \times 365.25 \times \text{DF} / \text{FPH}) \times \text{ISR}
\]

Variables as defined above

For example, a direct-installed kitchen low flow faucet aerator in a single family home

\[
\Delta \text{gallons} = (((1.39 \times 4.5 - 0.94 \times 4.5) \times 2.56 \times 365.25 \times 0.75) / 1) \times 0.95
\]
\[
= 1350 \text{ gallons}
\]

For example, a direct installed bath low flow faucet aerator in a multi-family home:

\[
\Delta \text{gallons} = (((1.39 \times 1.6 - 0.94 \times 1.6) \times 2.1 \times 365.25 \times 0.90) / 1.5) \times 0.95
\]
\[
= 314 \text{ gallons}
\]

For example, a direct installed low flow faucet aerator in unknown faucet in a single-family home:

\[
\Delta \text{gallons} = (((1.39 \times 9.0 - 0.94 \times 9.0) \times 2.56 \times 365.25 \times 0.795) / 3.83) \times 0.95
\]
\[
= 747 \text{ gallons}
\]

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

---

107 Water heating in multi-family buildings 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 efficiency of 0.67 is used for this analysis as a default for multi-family buildings.
**Sources**

<table>
<thead>
<tr>
<th>Source ID</th>
<th>Reference</th>
</tr>
</thead>
</table>

**Measure Code:** RS-HWE-LFFA-V04-150601
5.4.5 Low Flow Showerheads

DESCRIPTION

This measure relates to the installation of a low flow showerhead in a single or multi-family household. This measure may be used for units provided through Efficiency Kit’s however the in service rate for such measures should be derived through evaluation results specifically for this implementation methodology. This measure was developed to be applicable to the following program types: TOS, RF, NC, DI, KITS. 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 low flow 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.\footnote{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, \textcolor{red}{"http://neep.org/uploads/EMV%20Forum/EMV%20Studies/measure_life_GDS%5B1%5D.pdf"}}

DEEMED MEASURE COST

The incremental cost for this measure is $12\footnote{Direct-install price per showerhead assumes cost of showerhead (Market research average of $7 and assess and install time of $5 (20min @ $15/hr)} or program actual.

For low flow showerheads provided in Efficiency Kits, the actual program delivery costs should be utilized.

LOADSHAPE

Loadshape R03 - Residential Electric DHW

COINCIDENCE FACTOR

The coincidence factor for this measure is assumed to be 2.78%.\footnote{Calculated as follows: Assume 11% showers take place during peak hours (based on: \textcolor{red}{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}
Algorithm

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

Note these savings are per showerhead fixture

\[ \Delta \text{kWh} = \% \text{ElectricDHW} \times ((\text{GPM}_{\text{base}} \times \text{L}_{\text{base}} - \text{GPM}_{\text{low}} \times \text{L}_{\text{low}}) \times \text{Household} \times \text{SPCD} \times 365.25 \div \text{SPH}) \times \text{EPG}_{\text{electric}} \times \text{ISR} \]

Where:

- \( \% \text{ElectricDHW} \) = proportion of water heating supplied by electric resistance heating

<table>
<thead>
<tr>
<th>DHW fuel</th>
<th>% ElectricDHW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric</td>
<td>100%</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>0%</td>
</tr>
<tr>
<td>Unknown</td>
<td>16%</td>
</tr>
</tbody>
</table>

- \( \text{GPM}_{\text{base}} \) = Flow rate of the baseline showerhead

<table>
<thead>
<tr>
<th>Program</th>
<th>GPM_{base}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct-install</td>
<td>2.67</td>
</tr>
<tr>
<td>Retrofit, Efficiency Kits, NC or TOS</td>
<td>2.35</td>
</tr>
</tbody>
</table>

- \( \text{GPM}_{\text{low}} \) = As-used flow rate of the low-flow showerhead, which may, as a result of measurements of program evaluations deviate from rated flows, see table below:

<table>
<thead>
<tr>
<th>Rated Flow</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0 GPM</td>
<td></td>
</tr>
<tr>
<td>1.75 GPM</td>
<td></td>
</tr>
<tr>
<td>1.5 GPM</td>
<td></td>
</tr>
</tbody>
</table>

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

1180 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

1181 Based on measured data from Ameren IL EM&V of Direct-Install program. Program targets showers that are rated 2.5 GPM or above.

1182 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.
Low Flow Showerheads

<table>
<thead>
<tr>
<th>Rated Flow</th>
<th>Custom or Actual&lt;sup&gt;1183&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>L&lt;sub&gt;base&lt;/sub&gt;</td>
<td>Shower length in minutes with baseline showerhead</td>
</tr>
<tr>
<td>= 7.8 min&lt;sup&gt;1184&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>L&lt;sub&gt;low&lt;/sub&gt;</td>
<td>Shower length in minutes with low-flow showerhead</td>
</tr>
<tr>
<td>= 7.8 min&lt;sup&gt;1185&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Household</td>
<td>Average number of people per household</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Household Unit Type&lt;sup&gt;1186&lt;/sup&gt;</th>
<th>Household</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-Family - Deemed</td>
<td>2.56&lt;sup&gt;1187&lt;/sup&gt;</td>
</tr>
<tr>
<td>Multi-Family - Deemed</td>
<td>2.1&lt;sup&gt;1188&lt;/sup&gt;</td>
</tr>
<tr>
<td>Custom</td>
<td>Actual Occupancy or Number of Bedrooms&lt;sup&gt;1189&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

| SPCD | Showers Per Capita Per Day |
| = 0.6<sup>1190</sup> |
| 365.25 | Days per year, on average. |
| SPH | Showerheads Per Household so that per-showerhead savings fractions can be determined |

<table>
<thead>
<tr>
<th>Household Type</th>
<th>SPH&lt;sup&gt;1191&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-Family</td>
<td>1.79</td>
</tr>
</tbody>
</table>

<sup>1183</sup> 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.

<sup>1184</sup> Cadmus and Opinion Dynamics Showerhead and Faucet Aerator Meter Study Memorandum dated June 2013, directed to Michigan Evaluation Working Group. This study of 135 single and multi-family homes in Michigan metered energy parameters for efficient showerhead and faucet aerators.

<sup>1185</sup> Ibid.

<sup>1186</sup> If household type is unknown, as may be the case for time of sale measures, then single family deemed value shall be used.


<sup>1188</sup> ComEd PY3 Multi-Family Evaluation Report REVISED DRAFT v5 2011-12-08.docx

<sup>1189</sup> 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.

<sup>1190</sup> Ibid.

<sup>1191</sup> Based on findings from a 2009 ComEd residential survey of 140 sites, provided by Cadmus.
### 5.4.5 Low Flow Showerheads

#### Household Type

<table>
<thead>
<tr>
<th>Household Type</th>
<th>SPH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multi-Family</td>
<td>1.3&lt;sup&gt;1192&lt;/sup&gt;</td>
</tr>
<tr>
<td>Custom</td>
<td>Actual</td>
</tr>
</tbody>
</table>

**EPG<sub>electric</sub>** = Energy per gallon of hot water supplied by electric

\[
\text{EPG}_{\text{electric}} = \frac{(8.33 \times 1.0 \times (\text{ShowerTemp} - \text{SupplyTemp}))}{\text{RE}_{\text{electric}} \times 3412} \\
= \frac{(8.33 \times 1.0 \times (101 - 54.1))}{0.98 \times 3412} \\
= 0.117 \text{ kWh/gal}
\]

8.33 = Specific weight of water (lbs/gallon)
1.0 = Heat Capacity of water (btu/°lb-

\*ShowerTemp = Assumed temperature of water\*

\*SupplyTemp = Assumed temperature of water entering house\*

\*RE<sub>electric</sub> = Recovery efficiency of electric water heater\*

\*3412 = Converts Btu to kWh (btu/kWh)\*

\*ISR = In service rate of showerhead\*

\*ISR = Dependant on program delivery method as listed in table below\*

<table>
<thead>
<tr>
<th>Selection</th>
<th>ISR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct Install - Single Family</td>
<td>0.98&lt;sup&gt;1196&lt;/sup&gt;</td>
</tr>
<tr>
<td>Direct Install – Multi Family</td>
<td>0.95&lt;sup&gt;1197&lt;/sup&gt;</td>
</tr>
<tr>
<td>Efficiency Kits</td>
<td>To be determined through evaluation</td>
</tr>
</tbody>
</table>

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<sup>1192</sup> Ibid.
<sup>1195</sup> Electric water heaters have recovery efficiency of 98%: [http://www.ahridirectory.org/ahridirectory/pages/home.aspx](http://www.ahridirectory.org/ahridirectory/pages/home.aspx)
For example, a direct-installed 1.5 GPM low flow showerhead in a single family home with electric DHW where the number of showers is not known:

$$\Delta \text{kWh} = 1.0 \times ((2.67 \times 7.8 - 1.5 \times 7.8) \times 2.56 \times 0.6 \times 365.25 / 1.79) \times 0.117 \times 0.98$$

$$= 328 \text{ kWh}$$

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

$$\Delta \text{kW} = \Delta \text{kWh} / \text{Hours} \times \text{CF}$$

Where:

- $\Delta \text{kWh}$ = calculated value above
- Hours = Annual electric DHW recovery hours for showerhead use
  $$= ((\text{GPM} \_\text{base} \times \text{L} \_\text{base}) \times \text{Household} \times \text{SPCD} \times 365.25) \times 0.712^{1198} / \text{GPH}$$
  - 302 for SF Direct Install; 248 for MF Direct Install
  - 266 for SF Retrofit, Efficiency Kits, NC and TOS; 218 for MF Retrofit, Efficiency Kits, NC and TOS
- GPH = Gallons per hour recovery of electric water heater calculated for 65.9°F 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
  $$= 0.0278^{1199}$$

For example, a direct installed 1.5 GPM low flow showerhead in a single family home with electric DHW where the number of showers is not known:

$$\Delta \text{kW} = 328/302 \times 0.0278$$

$$= 0.0302 \text{ kW}$$

**NATURAL GAS SAVINGS**

$$\Delta \text{Therms} = \%\text{FossilDHW} \times ((\text{GPM} \_\text{base} \times \text{L} \_\text{base} - \text{GPM} \_\text{low} \times \text{L} \_\text{low}) \times \text{Household} \times \text{SPCD} \times 365.25 / \text{SPH}) \times \text{EPG} \_\text{gas} \times \text{ISR}$$

Where:

- $\%\text{FossilDHW}$ = proportion of water heating supplied by Natural Gas heating

---

1198 71.2% is the proportion of hot 120F water mixed with 54.1F supply water to give 101F shower water.

1199 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](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
### Low Flow Showerheads

#### DHW fuel

<table>
<thead>
<tr>
<th>DHW fuel</th>
<th>%Fossil_DHW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric</td>
<td>0%</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>100%</td>
</tr>
<tr>
<td>Unknown</td>
<td>84%</td>
</tr>
</tbody>
</table>

#### EPG_gas

- Energy per gallon of Hot water supplied by gas
- $\text{EPG}_{\text{gas}} = (8.33 \times 1.0 \times (\text{ShowerTemp} - \text{SupplyTemp})) / (\text{RE}_{\text{gas}} \times 100,000)$
- $0.00501$ Therm/gal for SF homes
- $0.00583$ Therm/gal for MF homes

#### RE_gas

- Recovery efficiency of gas water heater
- $78\%$ for SF homes
- $67\%$ for MF homes

#### 100,000

- Converts Btus to Therms (btu/Therm)
- Other variables as defined above

For example, a direct installed 1.5 GPM low flow showerhead in a gas fired DHW single family home where the number of showers is not known:

\[
\Delta \text{Therms} = 1.0 \times ((2.67 \times 7.8 - 1.5 \times 7.8) \times 2.56 \times 0.6 \times 365.25 / 1.79) \times 0.00501 \times 0.98 = 14.0 \text{ therms}
\]

### WATER IMPACT DESCRIPTIONS AND CALCULATION

\[
\Delta \text{gallons} = ((\text{GPM}_{\text{base}} \times \text{L}_{\text{base}} - \text{GPM}_{\text{low}} \times \text{L}_{\text{low}}) \times \text{Household} \times \text{SPCD} \times 365.25 / \text{SPH}) \times \text{ISR}
\]

Variables as defined above

---

1200 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.

1201 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%.

1202 Water heating in multi-family buildings 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 efficiency of 0.67 is used for this analysis as a default for multi-family buildings.
For example, a direct installed 1.5 GPM low flow showerhead in a single family home where the number of showers is not known:

$$\Delta \text{gallons} = ((2.67 \times 7.8 - 1.5 \times 7.8) \times 2.56 \times 0.6 \times 365.25 / 1.79) \times 0.98$$

$$= 2803 \text{ gallons}$$

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**SOURCES**

<table>
<thead>
<tr>
<th>Source ID</th>
<th>Reference</th>
</tr>
</thead>
</table>

**MEASURE CODE:** RS-HWE-LFSH-V03-140601
5.4.6 Water Heater Temperature Setback

**DESCRIPTION**
This measure was developed to be applicable to the following program types: NC, RF, DI, KITS.

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 reduced to no lower than 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. Note if there are more than one DHW tanks in the home at or higher than 130 degrees and they are all turned down, then the savings per tank can be multiplied by the number of tanks.

**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, or no cost if the measure is self-installed.

**LOADSHAPE**
Loadshape R03 - Residential Electric DHW

**COINCIDENCE FACTOR**
The summer peak coincidence factor for this measure is assumed to be 1.
Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

For homes with electric DHW tanks:

\[ \Delta \text{kWh} = \frac{(UA \times (T_{pre} - T_{post}) \times \text{Hours})}{(3412 \times \text{RE}_{\text{electric}})} \]

Where:

- \( U \) = Overall heat transfer coefficient of tank (Btu/HR-°F-ft\(^2\)).
  - = Actual if known. If unknown assume R-12, \( U = 0.083 \)
- \( A \) = Surface area of storage tank (square feet)
  - = Actual if known. If unknown use table below based on capacity of tank. If capacity unknown assume 50 gal tank; \( A = 24.99\text{ft}^2 \)

<table>
<thead>
<tr>
<th>Capacity (gal)</th>
<th>A (\text{ft}^2) (^{1204})</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>19.16</td>
</tr>
<tr>
<td>40</td>
<td>23.18</td>
</tr>
<tr>
<td>50</td>
<td>24.99</td>
</tr>
<tr>
<td>80</td>
<td>31.84</td>
</tr>
</tbody>
</table>

- \( T_{pre} \) = Actual hot water setpoint prior to adjustment
- \( T_{post} \) = Actual new hot water setpoint, which may not be lower than 120 degrees

Default Hot Water Temperature Inputs

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>( T_{pre} )</td>
<td>135</td>
</tr>
<tr>
<td>( T_{post} )</td>
<td>120</td>
</tr>
</tbody>
</table>

\(^{1203}\) Note this algorithm provides savings only from reduction in standby losses. The TAC considered avoided energy from not heating the water to the higher temperature but determined that dishwashers are likely to boost the temperature within the unit (roughly canceling out any savings), faucet and shower use is likely to be at the same temperature so there would need to be more lower temperature hot water being used (cancelling any savings) and clothes washers will only see savings if the water from the tank is taken without any temperature control. It was felt the potential impact was too small to be characterized.

\(^{1204}\) 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.
Hours = Number of hours in a year (since savings are assumed to be constant over year).
= 8766

3412 = Conversion from Btu to kWh

RE\_electric = Recovery efficiency of electric hot water heater
= 0.98 \textsuperscript{1205}

A deemed savings assumption, where site specific assumptions are not available would be as follows:

\[
\Delta k\text{Wh} = \frac{(UA \times (T_{pre} - T_{post}) \times \text{Hours})}{(3412 \times \text{RE\_electric})}
\]

\[
= \frac{(0.083 \times 24.99 \times (135 - 120) \times 8766)}{(3412 \times 0.98)}
\]

\[
= 81.6 \text{ kWh}
\]

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

\[
\Delta kW = \frac{\Delta k\text{Wh}}{\text{Hours}} \times CF
\]

Where:

\[
\text{Hours} = 8766
\]

\[
\text{CF} = \text{Summer Peak Coincidence Factor for measure}
\]

\[
= 1
\]

A deemed savings assumption, where site specific assumptions are not available would be as follows:

\[
\Delta kW = \frac{(81.6}{8766}) \times 1
\]

\[
\Delta kW \text{ default} = 0.00931 \text{ kW}
\]

**NATURAL GAS SAVINGS**

For homes with gas water heaters:

\textsuperscript{1205} Electric water heaters have recovery efficiency of 98%: http://www.ahridirectory.org/ahridirectory/pages/home.aspx
\[ \Delta \text{Therms} = \frac{(UA \times (T_{\text{pre}} - T_{\text{post}}) \times \text{Hours})}{(100,000 \times \text{RE}_{\text{gas}})} \]

Where

- 100,000 = Converts Btus to Therms (btu/Therm)
- \( \text{RE}_{\text{gas}} \) = Recovery efficiency of gas water heater
  - 78% for SF homes\(^{1206}\)
  - 67% for MF homes\(^{1207}\)

A deemed savings assumption, where site specific assumptions are not available would be as follows:

For Single Family homes:

\[ \Delta \text{Therms} = \frac{(UA \times (T_{\text{pre}} - T_{\text{post}}) \times \text{Hours})}{(\text{RE}_{\text{gas}})} = \frac{(((0.083 \times 24.99) \times (135 - 120) \times 8766)}{(100,000 \times 0.78)} = 3.5 \text{ Therms} \]

For Multi Family homes:

\[ \Delta \text{Therms} = \frac{(UA \times (T_{\text{pre}} - T_{\text{post}}) \times \text{Hours})}{(\text{RE}_{\text{gas}})} = \frac{(((0.083 \times 24.99) \times (135 - 120) \times 8766)}{(100,000 \times 0.67)} = 4.1 \text{ Therms} \]

**WATER IMPACT DESCRIPTIONS ANDCALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: RS-HWE-TMPS-V04-150601**

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\(^{1206}\) 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%.

\(^{1207}\) Water heating in multi-family buildings 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 efficiency of 0.67 is used for this analysis as a default for multi-family buildings.
5.4.7 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.\(^\text{1208}\)

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\(^\text{1209}\).

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.

LOADSHAPE
Loadshape R03 - Residential Electric DHW

COINCIDENCE FACTOR
This measure assumes a flat loadshape and as such the coincidence factor is 1.

\(^{1208}\) Visually determine whether it is insulated by foam (newer, rigid, and more effective) or fiberglass (older, gives to gently pressure, and not as effective)

\(^{1209}\) 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:

\[
\Delta \text{kWh} = \left( \frac{A_{\text{base}}}{R_{\text{base}}} - \frac{A_{\text{insul}}}{R_{\text{insul}}} \right) \times \Delta T \times \text{Hours} \div (3412 \times \eta_{\text{DHW}})
\]

Where:

- \( R_{\text{base}} \): Overall thermal resistance coefficient prior to adding tank wrap (Hr°F-ft²/BTU).  
- \( R_{\text{insul}} \): Overall thermal resistance coefficient after addition of tank wrap (Hr°F-ft²/BTU).  
- \( A_{\text{base}} \): Surface area of storage tank prior to adding tank wrap (square feet).  
- \( A_{\text{insul}} \): Surface area of storage tank after addition of tank wrap (square feet).  
- \( \Delta T \): Average temperature difference between tank water and outside air temperature (°F).  
- \( \text{Hours} \): Number of hours in a year (since savings are assumed to be constant over year).  
- 3412: Conversion from Btu to kWh.  
- \( \eta_{\text{DHW}} \): Recovery efficiency of electric hot water heater.  
- 0.98: Electric water heaters have recovery efficiency of 98%.  

Area includes tank sides and top to account for typical wrap coverage.  
Ibid.  
Assumes 125°F water leaving the hot water tank and average temperature of basement of 65°F.  
Electric water heaters have recovery efficiency of 98%: http://www.ahridirectory.org/ahridirectory/pages/home.aspx
The following table has default savings for various tank capacity and pre and post R-VALUES.

<table>
<thead>
<tr>
<th>Capacity (gal)</th>
<th>Rbase</th>
<th>Rinsul</th>
<th>Abase (ft²)</th>
<th>Ainsul (ft²)</th>
<th>ΔkWh</th>
<th>ΔkW</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>8</td>
<td>16</td>
<td>19.16</td>
<td>20.94</td>
<td>171</td>
<td>0.0195</td>
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<tr>
<td>30</td>
<td>10</td>
<td>18</td>
<td>19.16</td>
<td>20.94</td>
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<td>30</td>
<td>12</td>
<td>20</td>
<td>19.16</td>
<td>20.94</td>
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<td>18</td>
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<td>20.94</td>
<td>194</td>
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</tr>
<tr>
<td>30</td>
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<td>20</td>
<td>19.16</td>
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<td>30</td>
<td>12</td>
<td>22</td>
<td>19.16</td>
<td>20.94</td>
<td>101</td>
<td>0.0116</td>
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<tr>
<td>40</td>
<td>8</td>
<td>16</td>
<td>23.18</td>
<td>25.31</td>
<td>207</td>
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<td>10</td>
<td>20</td>
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<td>22</td>
<td>31.84</td>
<td>34.14</td>
<td>173</td>
<td>0.0198</td>
</tr>
</tbody>
</table>

1214 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.

1215 Assumptions from PA TRM. Ainsul was calculated by assuming that the water heater wrap is a 2” thick fiberglass material.
**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

\[ \Delta kW = \Delta kWh / 8766 \times CF \]

Where:
- \( \Delta kWh \) = 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.

**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-V02-150601**
5.4.8 Thermostatic Restrictor Shower Valve

**DESCRIPTION**

The measure is the installation of a thermostatic restrictor shower valve in a single or multi-family household. This is a valve attached to a residential showerhead which restricts hot water flow through the showerhead once the water reaches a set point (generally 95°F or lower).

This measure was developed to be applicable to the following program types: 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 a thermostatic restrictor shower valve installed on a residential showerhead.

**DEFINITION OF BASELINE EQUIPMENT**

The baseline equipment is the residential showerhead without the restrictor valve installed.

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The expected measure life is assumed to be 10 years. 1216

**DEEMED MEASURE COST**

The incremental cost of the measure should be the actual program cost or $301217 if not available.

**LOADSHAPE**

Loadshape R03 - Residential Electric DHW

**COINCIDENCE FACTOR**

The coincidence factor for this measure is assumed to be 0.22%. 1218

---

1217 Based on actual cost of the SS-1002CP-SB Ladybug Water-Saving Shower-Head adapter from Evolve showerheads.
1218 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](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 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% * 29.5 = 0.577 hours of recovery during peak period, where 29.5 equals the average annual electric DHW recovery hours for showerhead use prevented by the device 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 0.577/260 = 0.0022
Algorithm

**Calculation of Energy Savings**

**Electric Energy Savings**

\[
\Delta \text{kWh} = \%\text{ElectricDHW} \times ((\text{GPM}_\text{base}_S \times \text{L}_\text{showerdevice}) \times \text{Household} \times \text{SPCD} \times 365.25 / \text{SPH}) \times \text{ISR}
\]

Where:

\%\text{ElectricDHW} = \text{proportion of water heating supplied by electric resistance heating}

<table>
<thead>
<tr>
<th>DHW fuel</th>
<th>%\text{ElectricDHW}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric</td>
<td>100%</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>0%</td>
</tr>
<tr>
<td>Unknown</td>
<td>16% \textsuperscript{1219}</td>
</tr>
</tbody>
</table>

\text{GPM}_\text{base}_S = \text{Flow rate of the basecase showerhead, or actual if available}

<table>
<thead>
<tr>
<th>Program</th>
<th>GPM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct-install, device only</td>
<td>2.67 \textsuperscript{1220}</td>
</tr>
<tr>
<td>New Construction or direct install of device and low flow showerhead</td>
<td>Rated or actual flow of program-installed showerhead</td>
</tr>
<tr>
<td>Retrofit or TOS</td>
<td>2.35 \textsuperscript{1221}</td>
</tr>
</tbody>
</table>

\text{L}_\text{showerdevice} = \text{Hot water waste time avoided due to thermostatic restrictor valve}

\text{L}_\text{showerdevice} = 0.89 \text{ minutes} \textsuperscript{1222}

\text{Household} = \text{Average number of people per household}

\textsuperscript{1219} 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

\textsuperscript{1220} Based on measured data from Ameren IL EM&V of Direct-Install program. Program targets showers that are rated 2.5 GPM or above. Assumes low flow showerhead not included in direct installation.

\textsuperscript{1221} 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.

<table>
<thead>
<tr>
<th>Household Unit Type</th>
<th>SPCD = Showers Per Capita Per Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-Family - Deemed</td>
<td>2.56</td>
</tr>
<tr>
<td>Multi-Family - Deemed</td>
<td>2.1</td>
</tr>
<tr>
<td>Custom</td>
<td>Actual Occupancy or Number of Bedrooms</td>
</tr>
</tbody>
</table>

SPCD = Showers Per Capita Per Day

= 0.6

365.25 = Days per year, on average.

SPH = Showerheads Per Household so that per-showerhead savings fractions can be determined

<table>
<thead>
<tr>
<th>Household Type</th>
<th>SPH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-Family</td>
<td>1.79</td>
</tr>
<tr>
<td>Multi-Family</td>
<td>1.3</td>
</tr>
<tr>
<td>Custom</td>
<td>Actual</td>
</tr>
</tbody>
</table>

SPH = Showerheads Per Household

EPG\_electric = Energy per gallon of hot water supplied by electric

= (8.33 * 1.0 * (ShowerTemp - SupplyTemp)) / (RE\_electric * 3412)

= (8.33 * 1.0 * (101 – 54.1)) / (0.98 * 3412)

= 0.117 kWh/gal

8.33 = Specific weight of water (lbs/gallon)

1.0 = Heat Capacity of water (btu/lb\(^\circ\))

ShowerTemp = Assumed temperature of water

---

1223 If household type is unknown, as may be the case for time of sale measures, then single family deemed value shall be used.


1225 ComEd PY3 Multi-Family Evaluation Report REVISED DRAFT v5 2011-12-08.docx

1226 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.


1228 Based on findings from a 2009 ComEd residential survey of 140 sites, provided by Cadmus.

1229 Ibid.
= 101F

SupplyTemp = Assumed temperature of water entering house

= 54.1F

RE_electric = Recovery efficiency of electric water heater

= 98%

3412 = Converts Btu to kWh (btu/kWh)

ISR = In service rate of showerhead

= Dependent on program delivery method as listed in table below

<table>
<thead>
<tr>
<th>Selection</th>
<th>ISR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct Install - Single Family</td>
<td>0.98</td>
</tr>
<tr>
<td>Direct Install – Multi Family</td>
<td>0.95</td>
</tr>
<tr>
<td>Efficiency Kits</td>
<td>To be determined through evaluation</td>
</tr>
</tbody>
</table>

**EXAMPLE**

For example, a direct installed valve in a single-family home with electric DHW:

\[
\Delta kWh = 1.0 \times (2.67 \times 0.89 \times 2.56 \times 0.6 \times 365.25 / 1.79) \times 0.117 \times 0.98
\]

= 85 kWh

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

\[
\Delta kW = \Delta kWh / Hours \times CF
\]

Where:

\[
\Delta kWh = \text{calculated value above}
\]

---


**5.4.8 Thermostatic Restrictor Shower Valve**

**Hours**

\[
\text{Hours} = \text{Annual electric DHW recovery hours for wasted showerhead use prevented by device} \\
= \left( \left( \text{GPM}_\text{base}_S \times \text{L}_{\text{showerdevice}} \right) \times \text{Household} \times \text{SPCD} \times 365.25 \right) \times 0.712 \div \text{GPH} \\
\text{GPH} = \text{Gallons per hour recovery of electric water heater calculated for 65.9F temp rise (120-54.1), 98% recovery efficiency, and typical 4.5kW electric resistance storage tank.} \\
= 27.51 \\
= 34.4 \text{ for SF Direct Install; 28.3 for MF Direct Install} \\
= 30.3 \text{ for SF Retrofit and TOS; 24.8 for MF Retrofit and TOS} \\
\text{CF} = \text{Coincidence Factor for electric load reduction} \\
= 0.0022 \tag{1236}
\]

**Example**

For example, a direct installed thermostatic restrictor device in a single family home with electric DHW where the number of showers is not known.

\[
\Delta kW = \frac{85.3}{34.4} \times 0.0022 \\
= 0.0055 \text{ kW}
\]

**Natural Gas Savings**

\[
\Delta \text{Therms} = \%\text{FossilDHW} \times \left( \left( \text{GPM}_\text{base}_S \times \text{L}_{\text{showerdevice}} \right) \times \text{Household} \times \text{SPCD} \times 365.25 \div \text{SPH} \right) \times \text{EPG}_{\text{gas}} \times \text{ISR}
\]

Where:

\[
\%\text{FossilDHW} = \text{proportion of water heating supplied by Natural Gas heating}
\]

<table>
<thead>
<tr>
<th>DHW fuel</th>
<th>%Fossil_DHW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric</td>
<td>0%</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>100%</td>
</tr>
</tbody>
</table>

\(^{1235}\) 71.2\% is the proportion of hot 120F water mixed with 54.1F supply water to give 101F shower water.

\(^{1236}\) 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](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 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\% * 29.5 = 0.577 hours of recovery during peak period, where 29.5 equals the average annual electric DHW recovery hours for showerhead use prevented by the device 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 0.577/260 = 0.0022
### Table 5.4.8

<table>
<thead>
<tr>
<th>DHW fuel</th>
<th>%Fossil_DHW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unknown</td>
<td>84%</td>
</tr>
</tbody>
</table>

**EPG_gas**

= Energy per gallon of Hot water supplied by gas

= \((8.33 \times 1.0 \times (\text{ShowerTemp} - \text{SupplyTemp})) / (\text{RE}_{\text{gas}} \times 100,000)\)

= 0.00501 Therm/gal for SF homes

= 0.00583 Therm/gal for MF homes

**RE_gas**

= Recovery efficiency of gas water heater

= 78% for SF homes

= 67% for MF homes

100,000

= Converts Btus to Therms (btu/Therm)

Other variables as defined above.

**Example**

For example, a direct installed thermostatic restrictor device in a gas fired DHW single family home where the number of showers is not known:

\[
\Delta \text{Therms} = 1.0 \times (2.67 \times 0.89) \times 2.56 \times 0.6 \times 365.25 / 1.79 \times 0.00501 \times 0.98
\]

\[
= 3.7 \text{ therms}
\]

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

\[
\Delta \text{gallons} = ((\text{GPM\_base\_S} \times \text{L\_showerdevice}) \times \text{Household} \times \text{SPCD} \times 365.25 / \text{SPH}) \times \text{ISR}
\]

Variables as defined above

---

1237 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

1238 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%.

1239 Water heating in multi-family buildings 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 efficiency of 0.67 is used for this analysis as a default for multi-family buildings.
EXAMPLE

For example, a direct installed thermostatic restrictor device in a single family home where the number of showers is not known:

\[
\Delta \text{gallons} = \left( (2.67 \times 0.89) \times 2.56 \times 0.6 \times 365.25 / 1.79 \right) \times 0.98
\]

\[= 730 \text{ gallons}\]

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

SOURCES

<table>
<thead>
<tr>
<th>Source ID</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>2014, New York State Record of Revision to the TRM, Case 07-M-0548, June 19, 2014.</td>
</tr>
</tbody>
</table>
MEASURE CODE: RS-HWE-TRVA-V01-150601
5.5 Lighting End Use

5.5.1 ENERGY STAR Compact Fluorescent Lamp (CFL)

**DESCRIPTION**

A low wattage ENERGY STAR qualified compact fluorescent screw-in bulb (CFL) is installed in place of a baseline 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), a deemed split of 96% Residential and 4% Commercial assumptions should be used\(^{1240}\).

Federal legislation stemming from the Energy Independence and Security Act of 2007 (EISA) required all general-purpose light bulbs between 40W and 100W to be approximately 30% more energy efficient than current incandescent bulbs. Production of 100W, standard efficacy incandescent lamps ended in 2012, followed by restrictions on 75W in 2013 and 60W and 40W in 2014. The baseline for this measure has therefore become bulbs (improved incandescent or halogen) that meet the new standard.

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, KITS. 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 an EISA qualified incandescent or halogen as provided in the table provided in the Electric Energy Savings section.

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

Residential, Multi Family In unit bulbs and Unknown: The expected measure life (number of years that savings should be claimed) for bulbs installed June 2012 – May 2015 is assumed to be 5.2 years\(^{1241}\). 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\(^{1242}\).

---

\(^{1240}\) RES v C&I split is based on a weighted (by sales volume) average of ComEd PY4, PY5 and PY6 and Ameren PY5 and PY6 in store intercept survey results. See ‘RESvCI Split_122014.xls’.

\(^{1241}\) 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.

\(^{1242}\) 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.
Exterior bulbs: The expected measure life is 3.2 years\textsuperscript{1243} for bulbs installed June 2012 – May 2016. For bulbs installed June 2017-May 2018 this would be reduced to 3 years.

\textbf{DEEMED MEASURE COST}

For the Retail (Time of Sale) measure, the incremental capital cost is $1.25 from June 2014 – May 2015, $1.6 from June 2015 to May 2016 and $1.70 from June 2017 to May 2018\textsuperscript{1244}.

For the Direct Install measure, the full cost of $2.50 per bulb should be used, plus $5 labor cost\textsuperscript{1245} for a total of $7.50 per bulb. However actual program delivery costs should be utilized if available.

For bulbs provided in Efficiency Kits, the actual program delivery costs should be utilized.

\textbf{LOADSHAPE}

Loadshape R06 - Residential Indoor Lighting

Loadshape R07 - Residential Outdoor Lighting

\textbf{COINCIDENCE FACTOR}

The summer peak coincidence factor is assumed to be 7.1\% for Time of Sale Residential and in-unit Multi Family bulbs, 27.3\% for exterior bulbs and 8.1\% for unknown\textsuperscript{1246} and 7.4\% for Residential Direct Install\textsuperscript{1247}.

\begin{center}
\textbf{Algorithm}
\end{center}

\textbf{CALCULATION OF SAVINGS}

\textbf{ELECTRIC ENERGY SAVINGS}

\[
\Delta k\text{Wh} = \frac{(WattsBase - WattsEE)}{1000} \times ISR \times (1 - \text{Leakage}) \times \text{Hours} \times WHFe
\]

Where:

- \text{WattsBase} = Based on lumens of CFL bulb and program year installed:

\begin{center}
\begin{tabular}{|c|c|c|}
\hline
Minimum Lumens & Maximum Lumens & Incandescent Equivalent Post-EISA 2007 (WattsBase) \\
\hline
5280 & 6209 & 300 \\
3000 & 5279 & 200 \\
\hline
\end{tabular}
\end{center}

\textsuperscript{1243} Based on using 8,000 hour rated life assumption since more switching and use outdoors. 8,000/2475 = 3.2 years
\textsuperscript{1244} Based upon pricing forecast developed by Applied Proactive Technologies Inc (APT) based on industry input and provided to Ameren.
\textsuperscript{1245} Based on 15 minutes at $20 an hour. Includes some portion of travel time to site.
\textsuperscript{1246} Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.
\textsuperscript{1247} Based on lighting logger study conducted as part of the PY5/PY6 ComEd Residential Lighting Program evaluation and excluding all logged bulbs installed in closets.
### 5.5.1 ENERGY STAR Compact Fluorescent Lamp (CFL)

<table>
<thead>
<tr>
<th>Minimum Lumens</th>
<th>Maximum Lumens</th>
<th>Incandescent Equivalent Post-EISA 2007 (WattsBase)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2601</td>
<td>2999</td>
<td>150</td>
</tr>
<tr>
<td>1490</td>
<td>2600</td>
<td>72</td>
</tr>
<tr>
<td>1050</td>
<td>1489</td>
<td>53</td>
</tr>
<tr>
<td>750</td>
<td>1049</td>
<td>43</td>
</tr>
<tr>
<td>310</td>
<td>749</td>
<td>29</td>
</tr>
<tr>
<td>250</td>
<td>309</td>
<td>25</td>
</tr>
</tbody>
</table>

**WattsEE** = Actual wattage of CFL purchased / installed

**ISR** = In Service Rate, the percentage of units rebated that are actually in service.

<table>
<thead>
<tr>
<th>Program</th>
<th>Weighted Average 1st Year In Service Rate (ISR)</th>
<th>2nd year Installations</th>
<th>3rd year Installations</th>
<th>Final Lifetime In Service Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retail (Time of Sale)</td>
<td>73.2%</td>
<td>13.4%</td>
<td>11.4%</td>
<td>98.0%</td>
</tr>
<tr>
<td>Direct Install</td>
<td>96.9%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Efficiency Kits</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CFL Distribution</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Efficiency Kits</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>School Kits</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Notes:

**ISR**

- 1st year in service rate is based upon review of PY4-6 evaluations from ComEd and PY5-6 for Ameren (see ‘IL RES Lighting ISR_122014.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.

**Final Lifetime ISR**

- The 98% Lifetime ISR assumption is based upon review of two evaluations: ‘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.

**In Service Rates**


- In Service Rates provided are for the CFL bulb within a kit only. Given the significant differences in program design and the level of education provided through Efficiency Kits programs, the evaluators should apply the ISR estimated through evaluations (either past evaluations or the current program year evaluation) of the specific Efficiency Kits program. In cases where program-specific evaluation results for an ISR are unavailable, the default ISR values for Efficiency Kits provided may be used.

- Free bulbs provided without request, with little or no education. Based on ‘Impact and Process Evaluation of 2013 (PY6) Ameren Illinois Company Residential CFL Distribution Program’, Report Table 11 and Appendix B.

- Kits provided free to students through school, with education program. Based on ‘Impact and Process Evaluation of 2013 Ameren Illinois Company Residential CFL Distribution Program’.
<table>
<thead>
<tr>
<th>Program</th>
<th>Weighted Average 1st Year In Service Rate (ISR)</th>
<th>2nd year Installations</th>
<th>3rd year Installations</th>
<th>Final Lifetime In Service Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct Mail Kits</td>
<td>66%</td>
<td>14%</td>
<td>12%</td>
<td>93%</td>
</tr>
</tbody>
</table>

Leakage = Adjustment to account for the percentage of bulbs purchased that move out (and in if deemed appropriate) of the Utility Jurisdiction.

Upstream (TOS) Lighting programs = Determined through evaluation. All other programs = 0

Hours = Average hours of use per year

<table>
<thead>
<tr>
<th>Program Delivery</th>
<th>Installation Location</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retail (Time of Sale) and Efficiency Kits</td>
<td>Residential Interior and in-unit Multi Family</td>
<td>759</td>
</tr>
<tr>
<td></td>
<td>Exterior</td>
<td>2,475</td>
</tr>
<tr>
<td></td>
<td>Unknown</td>
<td>847</td>
</tr>
<tr>
<td>Direct Install</td>
<td>Residential Interior and in-unit Multi Family</td>
<td>793</td>
</tr>
<tr>
<td></td>
<td>Exterior</td>
<td>2,475</td>
</tr>
</tbody>
</table>

WHFe = Waste heat factor for energy to account for cooling energy savings from efficient lighting

<table>
<thead>
<tr>
<th>Bulb Location</th>
<th>WHFe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interior single family or unknown location</td>
<td>1.06</td>
</tr>
</tbody>
</table>

(PY6) Ameren Illinois Company Residential Efficiency Kits Program’, table 10. Final ISR assumptions are based upon comparing with CFL Distribution First year ISR and multiplying by the CFL Distribution Final ISR value, and second and third year estimates based on same proportion of future installs.

1254 Opt-in program to receive kits via mail, with little or no education. Based on ‘Impact and Process Evaluation of 2013 (PY6) Ameren Illinois Company Residential Efficiency Kits Program’, table 10, as above.

1255 Using a leakage estimate from the current program year evaluation, from past evaluation results, or a rolling average of leakage estimates from previous years.

1256 Except where noted, based on lighting logger study conducted as part of the PY5/PY6 ComEd Residential Lighting Program evaluation. Direct Install value excludes all logged bulbs installed in closets.

1257 Based on secondary research conducted as part of the PY5/PY6 ComEd Residential Lighting Program evaluation.

1258 Assumes 5% exterior lighting, based on PYPY5/PY6 ComEd Residential Lighting Program evaluation.

1259 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...
### Bulb Location

<table>
<thead>
<tr>
<th>Bulb Location</th>
<th>WHFe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multi family in unit</td>
<td>1.04</td>
</tr>
<tr>
<td>Exterior or uncooled location</td>
<td>1.0</td>
</tr>
</tbody>
</table>

#### Deferred Installs

As presented above, the characterization assumes that a percentage of bulbs purchased are not installed until Year 2 and Year 3 (see ISR assumption above). The Illinois Technical Advisory Committee has determined the following methodology for calculating the savings of these future installs.

- **Year 1 (Purchase Year) installs:** Characterized using assumptions provided above or evaluated assumptions if available.
- **Year 2 and 3 installs:** Characterized using delta watts assumption and hours of use from the Install Year i.e. the actual deemed (or evaluated if available) assumptions active in Year 2 and 3 should be applied.
  
  The NTG factor for the Purchase Year should be applied.

### Heating Penalty

If electric heated home (if heating fuel is unknown assume gas, see Natural Gas section):

\[
\Delta \text{kWh}_{1\text{st year installs}} = \frac{(43 - 14)}{1000} \times 0.722 \times 847 \times 1.06
\]

\[
= 18.8 \text{ kWh}
\]

\[
\Delta \text{kWh}_{2\text{nd year installs}} = \frac{(43 - 14)}{1000} \times 0.139 \times 847 \times 1.06
\]

\[
= 3.6 \text{ kWh}
\]

\[
\Delta \text{kWh}_{3\text{rd year installs}} = \frac{(43 - 14)}{1000} \times 0.119 \times 847 \times 1.06
\]

\[
= 3.1 \text{ kWh}
\]

Note: Here we assume no change in hours assumption. NTG value from Purchase year applied.

### Heating Penalty

If electric heated home (if heating fuel is unknown assume gas, see Natural Gas section):

\[
\Delta \text{kWh}^{\text{1261}} = - \frac{((\text{WattsBase} - \text{WattsEE})}{1000} \times \text{ISR} \times \text{Hours} \times \text{HF}}{\eta_{\text{Heat}}}
\]

### Notes

- 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%20 Conditioning%20by%20Housing%20Unit%20Type.xls](http://205.254.135.7/consumption/residential/data/2009/xls/HC7.1%20Air%20 Conditioning%20by%20Housing%20Unit%20Type.xls))
- Negative value because this is an increase in heating consumption due to the efficient lighting.
Where:

- HF = Heating Factor or percentage of light savings that must be heated
  - 49%\textsuperscript{1262} for interior or unknown location
  - 0% for exterior or unheated location

- ηHeat = Efficiency in COP of Heating equipment
  - actual. If not available use\textsuperscript{1263}:

<table>
<thead>
<tr>
<th>System Type</th>
<th>Age of Equipment</th>
<th>HSPF Estimate</th>
<th>ηHeat (COP Estimate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat Pump</td>
<td>Before 2006</td>
<td>6.8</td>
<td>2.00</td>
</tr>
<tr>
<td></td>
<td>2006 - 2014</td>
<td>7.7</td>
<td>2.26</td>
</tr>
<tr>
<td></td>
<td>2015 on</td>
<td>8.2</td>
<td>2.40</td>
</tr>
<tr>
<td>Resistance</td>
<td>N/A</td>
<td>N/A</td>
<td>1.00</td>
</tr>
</tbody>
</table>

For example, a 14W standard CFL is purchased in 2014 and installed in home with 2.0 COP Heat Pump:

\[
\Delta k\text{Wh}_{1\text{st year}} = - \left( \left( \frac{43 - 14}{1000} \right) \times 0.722 \times 759 \times 0.49 \right) / 2.0
\]

\[
= - 3.9 \text{ kWh}
\]

Second and third year install savings should be calculated using the appropriate ISR and the delta watts and hours from the install year.

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

\[
\Delta kW = \left( \frac{(Watts\text{Base} - Watts\text{EE})}{1000} \right) \times ISR \times WHFd \times CF
\]

Where:

- WHFd = Waste heat factor for demand to account for cooling savings from efficient lighting.

<table>
<thead>
<tr>
<th>Bulb Location</th>
<th>WHFd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interior single family or unknown location</td>
<td>1.11\textsuperscript{1264}</td>
</tr>
<tr>
<td>Multi family in unit</td>
<td>1.07\textsuperscript{1265}</td>
</tr>
</tbody>
</table>

\textsuperscript{1262} 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.

\textsuperscript{1263} 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.

\textsuperscript{1264} 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.

\textsuperscript{1265} As above but using estimate of 45% of multi family buildings in Illinois having central cooling (based on data from "Table
### Natural Gas Savings

Heating Penalty if Natural Gas heated home (or if heating fuel is unknown):

\[
\Delta \text{Therms} = -(((Watts_{Base} - Watts_{EE}) / 1000) * \text{ISR} * \text{Hours} * \text{HF} * 0.03412) / \eta_{\text{Heat}}
\]

Where:

- \( \text{HF} \) = Heating Factor or percentage of light savings that must be heated
- \( \text{HF} = 49\% \)\(^{1268}\) for interior or unknown location
- \( \text{HF} = 0\% \) for exterior or unheated location
- 0.03412 = Converts kWh to Therms
- \( \eta_{\text{Heat}} \) = Efficiency of heating system

---

<table>
<thead>
<tr>
<th>Bulb Location</th>
<th>WHFd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exterior or uncooled location</td>
<td>1.0</td>
</tr>
</tbody>
</table>

\( CF \) = Summer Peak Coincidence Factor for measure.

<table>
<thead>
<tr>
<th>Program Delivery</th>
<th>Bulb Location</th>
<th>( CF^{1266} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retail (Time of Sale)</td>
<td>Interior single family or Multi Family in unit</td>
<td>7.1%</td>
</tr>
<tr>
<td></td>
<td>Exterior</td>
<td>27.3%</td>
</tr>
<tr>
<td></td>
<td>Unknown location</td>
<td>8.1%</td>
</tr>
<tr>
<td>Direct Install</td>
<td>Residential</td>
<td>7.4%</td>
</tr>
</tbody>
</table>

Other factors as defined above

For example, a 14W standard CFL is purchased and installed in a single family interior location in 2014:

\[
\Delta kW = ((43 - 14) / 1000) * 0.722 * 1.11 * 0.071
\]

\[
= 0.0017 \text{ kW}
\]

Second and third year install savings should be calculated using the appropriate ISR and the delta watts and hours from the install year.

---

\(^{1266}\) Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation. Direct Install value is based on result excluding all logged bulbs installed in closets.

\(^{1267}\) Negative value because this is an increase in heating consumption due to the efficient lighting.

\(^{1268}\) 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.
For example, an standard CFL is purchased and installed in a home in 2014:

\[ \Delta \text{Therms} = - \frac{((43 - 14) / 1000) \times 0.722 \times 759 \times 0.49 \times 0.03412}{0.7} \]

\[ = - 0.38 \text{ Therms} \]

Second and third year install savings should be calculated using the appropriate ISR and the delta watts and hours from the install year.

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

Bulb replacement costs assumed in the O&M calculations are provided below.

<table>
<thead>
<tr>
<th>Year</th>
<th>Std Inc</th>
<th>EISA Compliant Halogen</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>$0.34</td>
<td>$1.25</td>
</tr>
<tr>
<td>2015</td>
<td>$0.34</td>
<td>$0.90</td>
</tr>
<tr>
<td>2016</td>
<td>$0.34</td>
<td>$0.80</td>
</tr>
<tr>
<td>2017</td>
<td>$0.34</td>
<td>$0.70</td>
</tr>
<tr>
<td>2018</td>
<td>$0.34</td>
<td>$0.60</td>
</tr>
<tr>
<td>2019</td>
<td>$0.34</td>
<td>$0.60</td>
</tr>
<tr>
<td>2020 &amp; after</td>
<td>$0.34</td>
<td>N/A</td>
</tr>
</tbody>
</table>

In order to account for the falling EISA Qualified bulb replacement cost provided above, an equivalent annual levelized baseline replacement cost over the lifetime of the CFL bulb is calculated. Note that the measure life for these measures is capped to the number of years remaining until 2020.

The NPV for replacement lamps and annual levelized replacement costs using the statewide real discount rate of 5.23% are presented below:

---

1269 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/H6.9%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:

\[ (0.24 \times 0.92) + (0.76 \times 0.8) \times (1 - 0.15) = 0.70 \]

1270 Based upon pricing forecast developed by Applied Proactive Technologies Inc (APT) based on industry input and provided to Ameren.
Note incandescent lamps in lumen range <310 and >2600 are exempt from EISA. For halogen bulbs, we assume the same replacement cycle as incandescent bulbs. The replacement cycle is based on the location of the lamp and varies based on the hours of use for that location. Both incandescent and halogen lamps are assumed to last for 1,000 hours before needing replacement.

**MEASURE CODE:** RS-LTG-ESCF-V04-150601

---

1271 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.
5.5.2 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.

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) a deemed split of 96% Residential and 4% Commercial assumptions should be used\textsuperscript{1272}.

This measure was developed to be applicable to the following program types: TOS, NC, DI, KITS.

If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT


DEFINITION OF BASELINE EQUIPMENT

The baseline is a specialty incandescent light bulb including those exempt of the EISA 2007 standard: three-way, plant light, daylight bulb, bug light, post light, globes G40 (<40W), candelabra base (<60W), vibration service bulb, decorative candle with medium or intermediate base (<40W), shatter resistant and reflector bulbs and standard bulbs greater than 2601 lumens, and those non-exempt from EISA 2007: dimmable, globes (less than 5” diameter and >40W), candle (shapes B, BA, CA >40W, candelabra base lamps >60W) and intermediate base lamps (>40W).

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 6.8 year\textsuperscript{1273}.

Exterior bulbs: The expected measure life is 3.2 years\textsuperscript{1274} for bulbs installed June 2012 – May 2017. For bulbs installed June 2017-May 2018 this would be reduced to 3 years.

DEEMED MEASURE COST

For the Retail (Time of Sale) measure, the incremental capital cost for this measure is $5\textsuperscript{1275}.

For the Direct Install measure, the full cost of $8.50 should be used plus $5 labor\textsuperscript{1276} for a total of $13.50. However actual program delivery costs should be utilized if available.

For bulbs provided in Efficiency Kits, the actual program delivery costs should be utilized.

\textsuperscript{1272} RES v C&I split is based on a weighted (by sales volume) average of ComEd PY4, PY5 and PY6 and Ameren PY5 and PY6 in store intercept survey results. See ‘RESvCI Split_122014.xls’.
\textsuperscript{1273} 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).
\textsuperscript{1274} Based on using 8,000 hour rated life assumption since more switching and use outdoors. 8,000/2475 = 3.2 years
\textsuperscript{1275} NEEP Residential Lighting Survey, 2011
\textsuperscript{1276} Based on 15 minutes at $20 per hour.
LOADSHAPE

Loadshape R06 - Residential Indoor Lighting
Loadshape R07 - Residential Outdoor Lighting

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:

<table>
<thead>
<tr>
<th>Bulb Type</th>
<th>Peak CF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Three-way</td>
<td>0.078</td>
</tr>
<tr>
<td>Dimmable</td>
<td>0.078</td>
</tr>
<tr>
<td>Interior reflector (incl. dimmable)</td>
<td>0.091</td>
</tr>
<tr>
<td>Exterior reflector</td>
<td>0.273</td>
</tr>
<tr>
<td>Candelabra base and candle medium and intermediate base</td>
<td>0.121</td>
</tr>
<tr>
<td>Bug light</td>
<td>0.273</td>
</tr>
<tr>
<td>Post light (&gt;100W)</td>
<td>0.273</td>
</tr>
<tr>
<td>Daylight</td>
<td>0.081</td>
</tr>
<tr>
<td>Plant light</td>
<td>0.081</td>
</tr>
<tr>
<td>Globe</td>
<td>0.075</td>
</tr>
<tr>
<td>Vibration or shatterproof</td>
<td>0.081</td>
</tr>
<tr>
<td>Standard spirals &gt;= 2601 lumens, Residential, Multi-family in unit</td>
<td>0.071</td>
</tr>
<tr>
<td>Standard spirals &gt;= 2601 lumens, unknown</td>
<td>0.081</td>
</tr>
<tr>
<td>Standard spirals &gt;= 2601 lumens, exterior</td>
<td>0.273</td>
</tr>
<tr>
<td>Specialty - Generic</td>
<td>0.081</td>
</tr>
</tbody>
</table>

\[1277\] Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.

\[1278\] Based on average of bedroom, dining room, office and living room results from the lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.

\[1279\] Ibid
Algorithm

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

\[ \Delta \text{kWh} = \left( \frac{\text{WattsBase} - \text{WattsEE}}{1000} \right) \times \text{ISR} \times (1-\text{Leakage}) \times \text{Hours} \times \text{WHFe} \]

Where:

\( \text{WattsBase} \) = Actual wattage equivalent of incandescent specialty bulb, use the tables below to obtain the incandescent bulb equivalent wattage\(^{1280}\); use 60W if unknown\(^{1281}\)

EISA exempt bulb types:

<table>
<thead>
<tr>
<th>Bulb Type</th>
<th>Lower Lumen Range</th>
<th>Upper Lumen Range</th>
<th>WattsBase</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Standard Spirals &gt;=2601</strong></td>
<td>2601</td>
<td>2999</td>
<td>150</td>
</tr>
<tr>
<td></td>
<td>3000</td>
<td>5279</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td>5280</td>
<td>6209</td>
<td>300</td>
</tr>
<tr>
<td><strong>3-Way</strong></td>
<td>250</td>
<td>449</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>450</td>
<td>799</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>800</td>
<td>1099</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>1100</td>
<td>1599</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td>1600</td>
<td>1999</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>2000</td>
<td>2549</td>
<td>125</td>
</tr>
<tr>
<td></td>
<td>2550</td>
<td>2999</td>
<td>150</td>
</tr>
<tr>
<td><strong>Globe</strong></td>
<td>90</td>
<td>179</td>
<td>10</td>
</tr>
<tr>
<td><em>(medium and intermediate bases less than 750 lumens)</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>180</td>
<td>249</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>250</td>
<td>349</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>350</td>
<td>749</td>
<td>40</td>
</tr>
<tr>
<td><strong>Decorative</strong></td>
<td>70</td>
<td>89</td>
<td>10</td>
</tr>
</tbody>
</table>

\(^{1280}\) Based upon the draft ENERGY STAR specification for lamps (http://energystar.gov/products/specs/sites/products/files/ENERGY_STAR_Lamps_V1_0_Draft%203.pdf) and the Energy Policy and Conservation Act of 2012.

### 5.5.2 ENERGY STAR Specialty Compact Fluorescent Lamp (CFL)

#### Bulb Type Lower Lumen Range Upper Lumen Range Watts Base

<table>
<thead>
<tr>
<th>Bulb Type</th>
<th>Lower Lumen Range</th>
<th>Upper Lumen Range</th>
<th>Watts Base</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Shapes B, BA, C, CA, DC, F, G, medium and intermediate bases less than 750 lumens)</td>
<td>90</td>
<td>149</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>150</td>
<td>299</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>300</td>
<td>749</td>
<td>40</td>
</tr>
<tr>
<td>Globe</td>
<td>90</td>
<td>179</td>
<td>10</td>
</tr>
<tr>
<td>(candelabra bases less than 1050 lumens)</td>
<td>180</td>
<td>249</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>250</td>
<td>349</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>350</td>
<td>499</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>500</td>
<td>1049</td>
<td>60</td>
</tr>
<tr>
<td>Decorative</td>
<td>70</td>
<td>89</td>
<td>10</td>
</tr>
<tr>
<td>(Shapes B, BA, C, CA, DC, F, G, candelabra bases less than 1050 lumens)</td>
<td>90</td>
<td>149</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>150</td>
<td>299</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>300</td>
<td>499</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>500</td>
<td>1049</td>
<td>60</td>
</tr>
</tbody>
</table>

**Directional Lamps** - ENERGY STAR Minimum Luminous Efficacy = 40Lm/W for lamps with rated wattages less than 20W and 50 Lm/W for lamps with rated wattages >= 20 watts.\(^{1282}\)

For Directional R, BR, and ER lamp types:\(^{1283}\):

<table>
<thead>
<tr>
<th>Bulb Type</th>
<th>Lower Lumen Range</th>
<th>Upper Lumen Range</th>
<th>Watts Base</th>
</tr>
</thead>
<tbody>
<tr>
<td>R, ER, BR with medium screw bases w/ diameter &gt;2.25&quot; (*see exceptions below)</td>
<td>420</td>
<td>472</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>473</td>
<td>524</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>525</td>
<td>714</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>715</td>
<td>937</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td>938</td>
<td>1259</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td>1260</td>
<td>1399</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td>1400</td>
<td>1739</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>1740</td>
<td>2174</td>
<td>120</td>
</tr>
<tr>
<td></td>
<td>2175</td>
<td>2624</td>
<td>150</td>
</tr>
</tbody>
</table>

---

\(^{1282}\) From pg 10 of the Energy Star Specification for lamps v1.1

\(^{1283}\) From pg 11 of the Energy Star Specification for lamps v1.1
### Bulb Type - Lower Lumen Range | Upper Lumen Range | Watts
--- | --- | ---
R, BR, and ER with medium screw bases w/ diameter <=2.25" | 400 | 449
| 450 | 499
| 500 | 649
| 650 | 1199
*ER30, BR30, BR40, or ER40 | 400 | 449
| 450 | 499
| 500 | 649
*BR30, BR40, or ER40 | 650 | 1419
*R20 | 400 | 449
| 450 | 719
*All reflector lamps below lumen ranges specified above | 200 | 299
| 300 | 399

Directional lamps are exempt from EISA regulations.

For PAR, MR, and MRX Lamps Types:

For these highly focused directional lamp types, it is necessary to have Center Beam Candle Power (CBCP) and beam angle measurements to accurately estimate the equivalent baseline wattage. The formula below is based on the Energy Star Center Beam Candle Power tool. If CBCP and beam angle information are not available, refer to the R, BR, and ER lumen based method above.

\[
\text{Wattbase} = 375.1 - 4.355(D) - \sqrt{227,800 - 937.9(D) - 0.9903(D^2) - 1479(BA) - 12.82(D \times BA) + 14.69(BA^2) - 16,720 + \ln(CBCP)}
\]

Where:

- **D** = Bulb diameter (e.g. for PAR20 D = 20)
- **BA** = Beam angle
- **CBCP** = Center beam candle power

The result of the equation above should be rounded DOWN to the nearest wattage established by Energy Star:

[1284](http://energystar.supportportal.com/link/portal/23002/23018/Article/32655/)
### Diameter and Permitted Wattages

<table>
<thead>
<tr>
<th>Diameter</th>
<th>Permitted Wattages</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>20, 35, 40, 45, 50, 60, 75</td>
</tr>
<tr>
<td>20</td>
<td>50</td>
</tr>
<tr>
<td>30S</td>
<td>40, 45, 50, 60, 75</td>
</tr>
<tr>
<td>30L</td>
<td>50, 75</td>
</tr>
<tr>
<td>38</td>
<td>40, 45, 50, 55, 60, 65, 75, 85, 90, 100, 120, 150, 250</td>
</tr>
</tbody>
</table>

#### EISA non-exempt bulb types:

<table>
<thead>
<tr>
<th>Bulb Type</th>
<th>Lower Lumen Range</th>
<th>Upper Lumen Range</th>
<th>Incandescent Equivalent Post-EISA 2007 (WattsBase)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimmable Twist, Globe (less than 5&quot; in diameter and &gt; 749 lumens), candle (shapes B, BA, CA &gt; 749 lumens), Candelabra Base Lamps (&gt;1049 lumens), Intermediate Base Lamps (&gt;749 lumens)</td>
<td>310</td>
<td>749</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td>750</td>
<td>1049</td>
<td>43</td>
</tr>
<tr>
<td></td>
<td>1050</td>
<td>1489</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td>1490</td>
<td>2600</td>
<td>72</td>
</tr>
</tbody>
</table>

**WattsEE** = Actual wattage of energy efficient specialty bulb purchased, use 15W if unknown\(^{1285}\)

**ISR** = In Service Rate, the percentage of units rebated that are actually in service.

<table>
<thead>
<tr>
<th>Program</th>
<th>Weighted Average 1st year In Service Rate (ISR)</th>
<th>2nd year Installations</th>
<th>3rd year Installations</th>
<th>Final Lifetime In Service Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retail (Time of Sale)</td>
<td>88.0(^{1286})</td>
<td>5.4%</td>
<td>4.6%</td>
<td>98.0(^{1287})</td>
</tr>
</tbody>
</table>

---


\(^{1286}\) 1st year in service rate is based upon review of PY4-6 evaluations from ComEd and PY5-6 from Ameren (see ‘IL RES Lighting ISR_122014.xls’ for more information. The average first year ISR was calculated weighted by the number of bulbs in the each year’s survey.

\(^{1287}\) 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
Direct Install & 96.9% & & & \\
Efficiency Kits & & & & \\
CFL Distribution & 59% & 13% & 11% & 83% \\
School Kits & 61% & 13% & 11% & 86% \\
Direct Mail Kits & 66% & 14% & 12% & 93% \\

Leakage = Adjustment to account for the percentage of bulbs purchased that move out (and in if deemed appropriate) of the Utility Jurisdiction.

Upstream (TOS) Lighting programs = Determined through evaluation.

All other programs = 0

Hours = Average hours of use per year, varies by bulb type as presented below.

<table>
<thead>
<tr>
<th>Bulb Type</th>
<th>Annual hours of use (HOU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Three-way</td>
<td>850</td>
</tr>
<tr>
<td>Dimmable</td>
<td>850</td>
</tr>
<tr>
<td>Interior reflector (incl. dimmable)</td>
<td>861</td>
</tr>
<tr>
<td>Exterior reflector</td>
<td>2475</td>
</tr>
</tbody>
</table>

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.

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.

In Service Rates provided are for the bulb within a kit only. Given the significant differences in program design and the level of education provided through Efficiency Kits programs, the evaluators should apply the ISR estimated through evaluations (either past evaluations or the current program year evaluation) of the specific Efficiency Kits program. In cases where program-specific evaluation results for an ISR are unavailable, the default ISR values for Efficiency Kits provide may be used.

Free bulbs provided without request, with little or no education. Consistent with Standard CFL assumptions.

Kits provided free to students through school, with education program. Consistent with Standard CFL assumptions.

Opt-in program to receive kits via mail, with little or no education. Consistent with Standard CFL assumptions.

Using a leakage estimate from the current program year evaluation, from past evaluation results, or a rolling average of leakage estimates from previous years.

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. Values for Reflector, Decorative and Globe are taken directly from the lighting logger study conducted as part of the PY5/PY6 ComEd Residential Lighting Program evaluation. All other hours have been updated based on the room specific hours of use from the PY5/PY6 logger study.
<table>
<thead>
<tr>
<th>Bulb Type</th>
<th>Annual hours of use (HOU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Candelabra base and candle medium and intermediate base</td>
<td>1190</td>
</tr>
<tr>
<td>Bug light</td>
<td>2475</td>
</tr>
<tr>
<td>Post light (&gt;100W)</td>
<td>2475</td>
</tr>
<tr>
<td>Daylight</td>
<td>847</td>
</tr>
<tr>
<td>Plant light</td>
<td>847</td>
</tr>
<tr>
<td>Globe</td>
<td>639</td>
</tr>
<tr>
<td>Vibration or shatterproof</td>
<td>847</td>
</tr>
<tr>
<td>Standard Spiral &gt;2601 lumens, Residential, Multi Family in-unit</td>
<td>759</td>
</tr>
<tr>
<td>Standard Spiral &gt;2601 lumens, unknown</td>
<td>847</td>
</tr>
<tr>
<td>Standard Spiral &gt;2601 lumens, Exterior</td>
<td>2475</td>
</tr>
<tr>
<td>Specialty - Generic</td>
<td>847</td>
</tr>
</tbody>
</table>

WHFe = Waste heat factor for energy to account for cooling savings from efficient lighting

<table>
<thead>
<tr>
<th>Bulb Location</th>
<th>WHFe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interior single family or unknown location</td>
<td>1.06</td>
</tr>
<tr>
<td>Multi family in unit</td>
<td>1.04</td>
</tr>
<tr>
<td>Exterior or uncooled location</td>
<td>1.0</td>
</tr>
</tbody>
</table>

**Deferred Installs**

As presented above, the characterization assumes that a percentage of bulbs purchased are not installed until Year

---

1295 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)

1296 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
2 and Year 3 (see ISR assumption above). The Illinois Technical Advisory Committee has determined the following methodology for calculating the savings of these future installs.

Year 1 (Purchase Year) installs: Characterized using assumptions provided above or evaluated assumptions if available.

Year 2 and 3 installs: Characterized using delta watts assumption and hours of use from the Install Year i.e. the actual deemed (or evaluated if available) assumptions active in Year 2 and 3 should be applied.

The NTG factor for the Purchase Year should be applied.

For example, for a 13W dimmable CFL impacted by EISA 2007 (60W standard incandescent and 43W EISA qualified incandescent/halogen) purchased in 2013.

\[
\Delta kWh_{1\text{st year installs}} = \left(\frac{60 - 13}{1000}\right) \times 0.823 \times 850 \times 1.06 = 34.9 \text{ kWh}
\]
\[
\Delta kWh_{2\text{nd year installs}} = \left(\frac{43 - 13}{1000}\right) \times 0.085 \times 850 \times 1.06 = 2.3 \text{ kWh}
\]

Note: Here we assume no change in hours assumption. NTG value from Purchase year applied.

\[
\Delta kWh_{3\text{rd year installs}} = \left(\frac{43 - 13}{1000}\right) \times 0.072 \times 850 \times 1.06 = 1.9 \text{ kWh}
\]

Note: delta watts is equivalent to install year. Here we assume no change in hours assumption.

**HEATING PENALTY**

If electric heated home (if heating fuel is unknown assume gas, see Natural Gas section):

\[
\Delta kWh = - \left(\frac{(\text{WattsBase} - \text{WattsEE})}{1000}\right) \times \text{ISR} \times \text{Hours} \times \text{HF} / \eta_{\text{Heat}}
\]

Where:

- HF = Heating Factor or percentage of light savings that must be heated
  - 49% \(^{1298}\) for interior or unknown location
  - 0% \(^{1298}\) for exterior location
- \(\eta_{\text{Heat}}\) = Efficiency in COP of Heating equipment
  - actual. If not available use \(^{1299}\):

<table>
<thead>
<tr>
<th>System Type</th>
<th>Age of Equipment</th>
<th>HSPF Estimate</th>
<th>(\eta_{\text{Heat}})</th>
</tr>
</thead>
</table>

\(^{1297}\) Negative value because this is an increase in heating consumption due to the efficient lighting.

\(^{1298}\) 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.

\(^{1299}\) 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.
ENERGY STAR Specialty Compact Fluorescent Lamp (CFL)

<table>
<thead>
<tr>
<th>Heat Pump</th>
<th>(COP Estimate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before 2006</td>
<td>6.8</td>
</tr>
<tr>
<td>2006 - 2014</td>
<td>7.7</td>
</tr>
<tr>
<td>2015 on</td>
<td>8.2</td>
</tr>
<tr>
<td>Resistance</td>
<td>N/A</td>
</tr>
</tbody>
</table>

For example, a 15W globe CFL replacing a 60W incandescent specialty bulb installed in home with 2.0 COP Heat Pump:

\[
\Delta \text{kWh}_{1\text{st year}} = -\frac{((60 - 15) / 1000) * 0.823 * 639 * 0.49}{2.0}
\]

\[
= -5.8 \text{ kWh}
\]

Second and third year savings should be calculated using the appropriate ISR.

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

\[
\Delta \text{kW} = ((\text{WattsBase} - \text{WattsEE}) / 1000) * \text{ISR} * \text{WHFd} * \text{CF}
\]

Where:

- \(\text{WHFd}\) = Waste heat factor for demand to account for cooling savings from efficient lighting.

<table>
<thead>
<tr>
<th>Bulb Location</th>
<th>WHFd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interior single family or unknown location</td>
<td>1.11 (^{1300})</td>
</tr>
<tr>
<td>Multi family in unit</td>
<td>1.07 (^{1301})</td>
</tr>
<tr>
<td>Exterior or uncooled location</td>
<td>1.0</td>
</tr>
</tbody>
</table>

\(\text{CF}\) = Summer Peak Coincidence Factor for measure. Coincidence factors by bulb types are presented below \(^{1302}\)

<table>
<thead>
<tr>
<th>Bulb Type</th>
<th>Peak CF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Three-way</td>
<td>0.078 (^{1303})</td>
</tr>
</tbody>
</table>

\(^{1300}\) 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.

\(^{1301}\) As above but using estimate of 45% of multifamily 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);


\(^{1302}\) Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.

\(^{1303}\) Based on average of bedroom, dining room, office and living room results from the lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.
<table>
<thead>
<tr>
<th>Bulb Type</th>
<th>Peak CF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimmable</td>
<td>0.078</td>
</tr>
<tr>
<td>Interior reflector (incl. dimmable)</td>
<td>0.091</td>
</tr>
<tr>
<td>Exterior reflector</td>
<td>0.273</td>
</tr>
<tr>
<td>Candelabra base and candle medium and intermediate base</td>
<td>0.121</td>
</tr>
<tr>
<td>Bug light</td>
<td>0.273</td>
</tr>
<tr>
<td>Post light (&gt;100W)</td>
<td>0.273</td>
</tr>
<tr>
<td>Daylight</td>
<td>0.081</td>
</tr>
<tr>
<td>Plant light</td>
<td>0.081</td>
</tr>
<tr>
<td>Globe</td>
<td>0.075</td>
</tr>
<tr>
<td>Vibration or shatterproof</td>
<td>0.081</td>
</tr>
<tr>
<td>Standard Spiral &gt;=2601 lumens, Residential, Multi-family in unit</td>
<td>0.071</td>
</tr>
<tr>
<td>Standard spirals &gt;= 2601 lumens, unknown</td>
<td>0.081</td>
</tr>
<tr>
<td>Standard spirals &gt;= 2601 lumens, exterior</td>
<td>0.273</td>
</tr>
<tr>
<td>Specialty - Generic</td>
<td>0.081</td>
</tr>
</tbody>
</table>

Other factors as defined above

For example, a 15W specialty CFL replacing a 60W incandescent specialty bulb:

\[ \Delta kW_{1st\ year} = \left( \frac{60 - 15}{1000} \right) \times 0.823 \times 1.11 \times 0.081 \]

\[ = 0.003 \text{ kW} \]

Second and third year savings should be calculated using the appropriate ISR.

**NATURAL GAS SAVINGS**

Heating Penalty if Natural Gas heated home (or if heating fuel is unknown):

\[ \Delta \text{Therms}^{1305} = - \left( \frac{(\text{WattsBase} - \text{WattsEE})}{1000} \right) \times \text{ISR} \times \text{Hours} \times \eta_{\text{Heat}} \times 0.03412 \]

Where:

\[ \text{HF} = \text{Heating Factor or percentage of light savings that must be heated} \]

\[ = 49\%^{1306} \text{ for interior or unknown location} \]

\[ = 0\% \text{ for exterior location} \]

---

1304 Ibid
1305 Negative value because this is an increase in heating consumption due to the efficient lighting.
1306 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.
0.03412 = Converts kWh to Therms
ηHeat = Efficiency of heating system
= 70%\textsuperscript{1307}

For example, a 15W Globe specialty CFL replacing a 60W incandescent specialty bulb:

\[
\Delta\text{Therms} = - \frac{((60 - 15) / 1000) \times 0.823 \times 639 \times 0.49 \times 0.03412}{0.7} = -0.57 \text{ Therms}
\]

Second and third year savings should be calculated using the appropriate ISR.

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

For those bulbs types exempt from EISA the following O&M assumptions should be used: Life of the baseline bulb is assumed to be 1.32 year\textsuperscript{1308}; baseline replacement cost is assumed to be $3.5\textsuperscript{1309}.

For non-exempt EISA bulb types defined above, the following O&M assumptions should be used: Life of the baseline bulb is assumed to be 1.32 year\textsuperscript{1310}; baseline replacement cost is assumed to be $5\textsuperscript{1311}.

**MEASURE CODE: RS-LTG-ESCC-V03-150601**

\textsuperscript{1307} 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:

\[
(0.24 * 0.92) + (0.76 * 0.8) * (1 - 0.15) = 0.70
\]

\textsuperscript{1308} Assuming 1000 hour rated life for incandescent bulb: 1000/759 = 1.32

\textsuperscript{1309} NEEP Residential Lighting Survey, 2011

\textsuperscript{1310} Assuming 1000 hour rated life for halogen bulb: 1000/759 = 1.32

\textsuperscript{1311} NEEP Residential Lighting Survey, 2011
5.5.3 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\(^\text{1312}\).

DEEMED MEASURE COST
The incremental cost for this measure is assumed to be $5\(^\text{1313}\).

LOADSHAPE
Loadshape R06 - Residential Indoor Lighting
Loadshape R07 - Residential Outdoor Lighting

COINCIDENCE FACTOR
The summer peak coincidence factor for this measure is 7.1% for Residential and in-unit Multi Family bulbs and 8.1% for bulbs installed in unknown locations\(^\text{1314}\).


\(^{1313}\) DEER 2008 Database Technology and Measure Cost Data (www.deeresources.com) and consistent with Efficiency Vermont TRM.

\(^{1314}\) Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.
Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

\[
\Delta \text{kWh} = \left(\frac{\Delta \text{Watts}}{1000}\right) \times \text{ISR} \times (1-\text{Leakage}) \times \text{HOURS} \times \text{WHFe}
\]

Where:

- \(\Delta \text{Watts}\) = Average delta watts per purchased ENERGY STAR torchiere
  = 115.8 \text{1315}
- ISR = In Service Rate or percentage of units rebated that get installed.
  = 0.86 \text{1316}
- Leakage = Adjustment to account for the percentage of bulbs purchased that move out (and in if deemed appropriate) of the Utility Jurisdiction.
- Upstream (TOS) Lighting programs = Determined through evaluation \text{1317}
  All other programs = 0
- HOURS = Average hours of use per year

<table>
<thead>
<tr>
<th>Installation Location</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential and in-unit Multi Family</td>
<td>1095 (3.0 hrs per day) \text{1318}</td>
</tr>
</tbody>
</table>

WHFe = Waste Heat Factor for Energy to account for cooling savings from efficient lighting

<table>
<thead>
<tr>
<th>Bulb Location</th>
<th>WHFe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interior single family or unknown location</td>
<td>1.06 \text{1319}</td>
</tr>
</tbody>
</table>

\text{1315} 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)

\text{1316} 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](http://publicservice.vermont.gov/energy/ee_files/efficiency/eval/marivtreportfinal100104.pdf)

\text{1317} Using a leakage estimate from the current program year evaluation, from past evaluation results, or a rolling average of leakage estimates from previous years.

\text{1318} 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)

\text{1319} 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 \((-0.02 \times \text{SEER}) + (1.12 \times \text{SEER})\) 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](http://www.eia.gov/consumption/residential/data/2009/xls/HC7.9%20Air%20Conditioning%20in%20Midwest%20Region.xls)
### ENERGY STAR Torchiere

<table>
<thead>
<tr>
<th>Bulb Location</th>
<th>WHFe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multi family in unit</td>
<td>1.04</td>
</tr>
<tr>
<td>Exterior or uncooled location</td>
<td>1.0</td>
</tr>
</tbody>
</table>

For single family buildings:

\[
\Delta \text{kWh} = \frac{(115.8 \times 10^{-3}) \times 0.86 \times 1095 \times 1.06}{1000}
\]

\[= 116 \text{ kWh}\]

For multi family in unit:

\[
\Delta \text{kWh} = \frac{(115.8 \times 10^{-3}) \times 0.86 \times 1095 \times 1.04}{1000}
\]

\[= 113 \text{ kWh}\]

### Heating Penalty

If electric heated home (if heating fuel is unknown assume gas, see Natural Gas section):

\[
\Delta \text{kWh} = - \left(\frac{(\Delta \text{Watts})}{1000} \times \text{ISR} \times \text{HOURS} \times \text{HF}\right) / \eta_{\text{Heat}}
\]

Where:

- HF = Heating Factor or percentage of light savings that must be heated
  - 49%[^1] for interior or unknown location
- \(\eta_{\text{Heat}}\) = Efficiency in COP of Heating equipment
  - Actual. If not available use defaults provided below[^2].

<table>
<thead>
<tr>
<th>System Type</th>
<th>Age of Equipment</th>
<th>HSPF Estimate</th>
<th>(\eta_{\text{Heat}}) (COP Estimate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat Pump</td>
<td>Before 2006</td>
<td>6.8</td>
<td>2.00</td>
</tr>
<tr>
<td></td>
<td>2006 - 2014</td>
<td>7.7</td>
<td>2.26</td>
</tr>
<tr>
<td></td>
<td>2015 on</td>
<td>8.2</td>
<td>2.40</td>
</tr>
<tr>
<td>Resistance</td>
<td>N/A</td>
<td>N/A</td>
<td>1.00</td>
</tr>
</tbody>
</table>

[^1]: 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](http://205.254.135.7/consumption/residential/data/2009/xls/HC7.1%20Air%20Conditioning%20by%20Housing%20Unit%20Type.xls)

[^2]: Negative value because this is an increase in heating consumption due to the efficient lighting.

[^3]: 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.

[^4]: 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.
For example, an ES torchiere installed in a house with a newer heat pump:

\[
\Delta \text{kWh} = - \left( \frac{115.8}{1000} \right) \times 0.86 \times 1095 \times 0.49 / 2.26 \\
= -23.6 \text{ kWh}
\]

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

\[
\Delta \text{kW} = \frac{\Delta \text{Watts}}{1000} \times \text{ISR} \times \text{WHFd} \times \text{CF}
\]

Where:

- **WHFd** = Waste Heat Factor for Demand to account for cooling savings from efficient lighting
- **CF** = Summer Peak Coincidence Factor for measure

<table>
<thead>
<tr>
<th>Bulb Location</th>
<th>WHFd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interior single family or unknown location</td>
<td>1.11(^{1324})</td>
</tr>
<tr>
<td>Multi family in unit</td>
<td>1.07(^{1325})</td>
</tr>
<tr>
<td>Exterior or uncooled location</td>
<td>1.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bulb Location</th>
<th>CF(^{1326})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interior single family or Multi family in unit</td>
<td>7.1%</td>
</tr>
<tr>
<td>Unknown location</td>
<td>8.1%</td>
</tr>
</tbody>
</table>

For single family and multi-family in unit buildings:

\[
\Delta \text{kW} = \frac{115.8}{1000} \times 0.86 \times 1.11 \times 0.071
\]

\[
= 0.008 \text{kW}
\]

For unknown location:

\[
\Delta \text{kW} = \frac{115.8}{1000} \times 0.86 \times 1.07 \times 0.081
\]

\[
= 0.009 \text{ kW}
\]

\(^{1324}\) 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.

\(^{1325}\) 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](http://205.254.135.7/consumption/residential/data/2009/xls/HC7.1%20Air%20Conditioning%20by%20Housing%20Unit%20Type.xls).

\(^{1326}\) Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.
NATURAL GAS SAVINGS

Heating penalty if Natural Gas heated home, or if heating fuel is unknown.

\[
\Delta \text{Therms}_{\text{WH}} = - \left( \frac{\Delta \text{Watts}}{1000} \times \text{ISR} \times \text{HOURS} \times 0.03412 \times \text{HF} \right) / \eta_{\text{Heat}}
\]

Where:

- \( \Delta \text{Therms}_{\text{WH}} \) = 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% \(^{1327}\)
- \( \eta_{\text{Heat}} \) = average heating system efficiency = 70% \(^{1328}\)

\[
\Delta \text{Therms}_{\text{WH}} = - \left( \frac{115.8}{1000} \times 0.86 \times 1095 \times 0.03412 \times 0.49 \right) / 0.70
\]

= - 2.60 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

Life of the baseline bulb is assumed to be 1.83 years \(^{1329}\) for residential and multifamily in unit. Baseline bulb cost replacement is assumed to be $6. \(^{1330}\)

MEASURE CODE: RS-LTG-ESTO-V02-150601

\(^{1327}\) 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.

\(^{1328}\) 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:

\[
(0.24 \times 0.92) + (0.76 \times 0.8) \times (1 - 0.15) = 0.70
\]

\(^{1329}\) Based on VEIC assumption of baseline bulb (mix of incandescent and halogen) average rated life of 2000 hours, 2000/1095 = 1.83 years.

\(^{1330}\) Derived from Efficiency Vermont TRM.
5.5.4 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 required 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 has therefore become bulbs (improved incandescent or halogen) that meet the new standard.

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 EISA qualified incandescent or halogen exterior fixture as provided in the table provided in the Electric Energy Savings section.

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The expected life of an exterior fixture is 20 years. 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 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.

**DEEMED MEASURE COST**

The incremental cost for an exterior fixture is assumed to be $32.

---


1332 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.

LOADSHAPE

Loadshape R07 - Residential Outdoor Lighting

COINCIDENCE FACTOR

The summer peak coincidence factor is assumed to be 27.3\(^{1334}\)%.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

\[ \Delta \text{kWh} = \left( \frac{\text{WattsBase} - \text{WattsEE}}{1000} \right) \times \text{ISR} \times (1 - \text{Leakage}) \times \text{Hours} \]

Where:

WattsBase = Based on lumens of CFL bulb and program year purchased:

<table>
<thead>
<tr>
<th>Minimum Lumens</th>
<th>Maximum Lumens</th>
<th>Incandescent Equivalent Post-EISA 2007 (WattsBase)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5280</td>
<td>6209</td>
<td>300</td>
</tr>
<tr>
<td>3000</td>
<td>5279</td>
<td>200</td>
</tr>
<tr>
<td>2601</td>
<td>2999</td>
<td>150</td>
</tr>
<tr>
<td>1490</td>
<td>2600</td>
<td>72</td>
</tr>
<tr>
<td>1050</td>
<td>1489</td>
<td>53</td>
</tr>
<tr>
<td>750</td>
<td>1049</td>
<td>43</td>
</tr>
<tr>
<td>310</td>
<td>749</td>
<td>29</td>
</tr>
<tr>
<td>250</td>
<td>309</td>
<td>25</td>
</tr>
</tbody>
</table>

WattsEE = Actual wattage of CFL purchased

ISR = In Service Rate or the percentage of units rebated that get installed.

\(^{1334}\) Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.
### Deferred Installs

As presented above, the characterization assumes that a percentage of bulbs purchased are not installed until Year 2 and Year 3 (see ISR assumption above). The Illinois Technical Advisory Committee has determined the following methodology for calculating the savings of these future installs.

- **Year 1 (Purchase Year) installs:** Characterized using assumptions provided above or evaluated assumptions if available.
- **Year 2 and 3 installs:** Characterized using delta watts assumption and hours of use from the Install Year i.e. the actual deemed (or evaluated if available) assumptions active in Year 2 and 3 should be applied.

---

1335 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.

1336 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.

1337 In the absence of evaluation results for Direct Install Fixtures specifically, this is made consistent with the Direct Install CFL measure which is based upon review of the PY2 and PY3 ComEd Direct Install program surveys.

1338 Using a leakage estimate from the current program year evaluation, from past evaluation results, or a rolling average of leakage estimates from previous years.

1339 Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.
The NTG factor for the Purchase Year should be applied.

For example, for a 2 x 14W pin based CFL fixture (43W EISA qualified incandescent/halogen) purchased in 2014.

\[
\Delta kWH_{1st\ year\ installs} = \frac{(86 - 28)}{1000} \times 0.875 \times 2475
\]

\[
= 125.6 \text{kWh}
\]

\[
\Delta kWH_{2nd\ year\ installs} = \frac{(86 - 28)}{1000} \times 0.057 \times 2475
\]

\[
= 8.2 \text{kWh}
\]

Note: Here we assume no change in hours assumption. NTG value from Purchase year applied.

\[
\Delta kWH_{3rd\ year\ installs} = \frac{(86 - 28)}{1000} \times 0.048 \times 2475
\]

\[
= 6.9 \text{kWh}
\]

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

\[
\Delta kW = \frac{(WattsBase - WattsEE)}{1000} \times ISR \times CF
\]

Where:

CF = Summer Peak Coincidence Factor for measure.

= 27.3%\(^{1340}\)

Other factors as defined above

For example, a 2 x 14W pin-based CFL fixture is purchased in 2013:

\[
\Delta kW_{1st\ year} = \frac{(86 - 28)}{1000} \times 0.875 \times 0.273
\]

\[
= 0.0142 \text{kW}
\]

Second and third year install savings should be calculated using the appropriate ISR and the delta watts and hours from the install year.

**NATURAL GAS SAVINGS**

N/A

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

\(^{1340}\) Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.
DEEMED O&M COST ADJUSTMENT CALCULATION

Bulb replacement costs assumed in the O&M calculations are provided below.\textsuperscript{1341}

<table>
<thead>
<tr>
<th>Year</th>
<th>Std Inc.</th>
<th>EISA Compliant Halogen</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>$0.34</td>
<td>$1.25</td>
</tr>
<tr>
<td>2015</td>
<td>$0.34</td>
<td>$0.90</td>
</tr>
<tr>
<td>2016</td>
<td>$0.34</td>
<td>$0.80</td>
</tr>
<tr>
<td>2017</td>
<td>$0.34</td>
<td>$0.70</td>
</tr>
<tr>
<td>2018</td>
<td>$0.34</td>
<td>$0.60</td>
</tr>
<tr>
<td>2019</td>
<td>$0.34</td>
<td>$0.60</td>
</tr>
<tr>
<td>2020 &amp; after</td>
<td>$0.34</td>
<td>N/A</td>
</tr>
</tbody>
</table>

In order to account for the falling EISA Qualified bulb replacement cost provided above, an equivalent annual levelized baseline replacement cost over the lifetime of the CFL bulb is calculated. Note that the measure life for these measures is capped to the number of years remaining until 2020 and that the efficient case also assumes replacement cost only if the first replacement occurs before the end of the measure life. The delta O&M cost should be used in cost effectiveness screening.

The NPV for replacement lamps and annual levelized replacement costs using the statewide real discount rate of 5.23% are presented below:

<table>
<thead>
<tr>
<th>Lumen Level</th>
<th>NPV of replacement costs for period</th>
<th>Levelized annual replacement cost savings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>June 2015 - May 2016</td>
<td>June 2016 - May 2017</td>
</tr>
<tr>
<td>Lumens &lt;310 or &gt;2600 (non-EISA compliant)</td>
<td>$3.30</td>
<td>$2.64</td>
</tr>
<tr>
<td>Lumens ≥ 310 and ≤ 2600 (EISA compliant)</td>
<td>$6.90</td>
<td>$5.17</td>
</tr>
<tr>
<td>Efficient bulb CFL</td>
<td>$0.06</td>
<td>$0 - No replacement bulb within measure life</td>
</tr>
<tr>
<td></td>
<td>June 2015 - May 2016</td>
<td>June 2016 - May 2017</td>
</tr>
<tr>
<td></td>
<td>$0.65</td>
<td>$0.61</td>
</tr>
<tr>
<td></td>
<td>$1.37</td>
<td>$1.20</td>
</tr>
<tr>
<td></td>
<td>$0.01</td>
<td>$0 - No replacement bulb within measure life</td>
</tr>
</tbody>
</table>

For halogen bulbs, we assume the same replacement cycle as incandescent bulbs.\textsuperscript{1342} The replacement cycle is based on the location of the lamp and varies based on the hours of use for that location. Both incandescent and halogen lamps are assumed to last for 1,000 hours before needing replacement, CFLs in Residential and in-unit multifamily assume 8000 hours and multifamily common areas assume 10,000 (longer run hours and less switching

\textsuperscript{1341} Based upon pricing forecast developed by Applied Proactive Technologies Inc (APT) based on industry input and provided to Ameren.

\textsuperscript{1342} 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.
leads to longer lamp life).

**Measure Code:** RS-LTG-EFIX-V04-150601
5.5.5 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 required 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 has therefore become bulbs (improved incandescent or halogen) that meet the new standard.

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 EISA qualified incandescent or halogen interior fixture as provided in the Electric Energy Savings section.

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The expected life of an interior fixture is 20 years. 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 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.

**DEEMED MEASURE COST**

The incremental cost for an interior fixture is assumed to be $32.

---


1344 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.

**LOADSHAPE**

Loadshape R06 - Residential Indoor Lighting

**COINCIDENCE FACTOR**

The summer peak coincidence factor is assumed to be 7.1%\(^{1346}\) for Residential and in-unit Multi Family bulbs.

---

**Algorithm**

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

\[ \Delta \text{kWh} = \left( \frac{\text{WattsBase} - \text{WattsEE}}{1000} \right) \times \text{ISR} \times (1 - \text{Leakage}) \times \text{Hours} \times \text{WHFe} \]

Where:

- \( \text{WattsBase} \) = Based on lumens of CFL bulb and program year purchased:

<table>
<thead>
<tr>
<th>Minimum Lumens</th>
<th>Maximum Lumens</th>
<th>Incandescent Equivalent Post-EISA 2007 ((\text{Watts}_{\text{Base}}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>5280</td>
<td>6209</td>
<td>300</td>
</tr>
<tr>
<td>3000</td>
<td>5279</td>
<td>200</td>
</tr>
<tr>
<td>2601</td>
<td>2999</td>
<td>150</td>
</tr>
<tr>
<td>1490</td>
<td>2600</td>
<td>72</td>
</tr>
<tr>
<td>1050</td>
<td>1489</td>
<td>53</td>
</tr>
<tr>
<td>750</td>
<td>1049</td>
<td>43</td>
</tr>
<tr>
<td>310</td>
<td>749</td>
<td>29</td>
</tr>
<tr>
<td>250</td>
<td>309</td>
<td>25</td>
</tr>
</tbody>
</table>

- \( \text{WattsEE} \) = Actual wattage of CFL purchased
- \( \text{ISR} \) = In Service Rate or the percentage of units rebated that get installed.

\(^{1346}\) Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.
### Interior Hardwired Compact Fluorescent Lamp (CFL) Fixture

<table>
<thead>
<tr>
<th>Program</th>
<th>Weighted Average 1st year In Service Rate (ISR)</th>
<th>2nd year Installations</th>
<th>3rd year Installations</th>
<th>Final Lifetime In Service Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retail (Time of Sale)</td>
<td>87.5%(^{1347})</td>
<td>5.7%</td>
<td>4.8%</td>
<td>98.0%(^{1348})</td>
</tr>
<tr>
<td>Direct Install</td>
<td>96.9(^{1349})</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Leakage** = Adjustment to account for the percentage of bulbs purchased that move out (and in if deemed appropriate) of the Utility Jurisdiction.

**Upstream (TOS) Lighting programs** = Determined through evaluation\(^{1350}\).

**All other programs** = 0

**Hours** = Average hours of use per year

<table>
<thead>
<tr>
<th>Installation Location</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential and in-unit Multi Family</td>
<td>759(^{1351})</td>
</tr>
</tbody>
</table>

**WHFe** = Waste heat factor for energy to account for cooling energy savings from efficient lighting

<table>
<thead>
<tr>
<th>Bulb Location</th>
<th>WHFe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interior single family or unknown location</td>
<td>1.06(^{1352})</td>
</tr>
</tbody>
</table>

\(^{1347}\) 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.

\(^{1348}\) 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.

\(^{1349}\) In the absence of evaluation results for Direct Install Fixtures specifically, this is made consistent with the Direct Install CFL measure which is based upon review of the PY2 and PY3 ComEd Direct Install program surveys.

\(^{1350}\) Using a leakage estimate from the current program year evaluation, from past evaluation results, or a rolling average of leakage estimates from previous years.

\(^{1351}\) Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.

\(^{1352}\) 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;
**Interior Hardwired Compact Fluorescent Lamp (CFL) Fixture**

<table>
<thead>
<tr>
<th>Bulb Location</th>
<th>WHFe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multi family in unit</td>
<td>1.04</td>
</tr>
</tbody>
</table>

**DEFERRED Installs**

As presented above, the characterization assumes that a percentage of bulbs purchased are not installed until Year 2 and Year 3 (see ISR assumption above). The Illinois Technical Advisory Committee has determined the following methodology for calculating the savings of these future installs.

- **Year 1 (Purchase Year) installs:** Characterized using assumptions provided above or evaluated assumptions if available.
- **Year 2 and 3 installs:** Characterized using delta watts assumption and hours of use from the Install Year i.e. the actual deemed (or evaluated if available) assumptions active in Year 2 and 3 should be applied.
  - The NTG factor for the Purchase Year should be applied.

For example, for a 2 x 14W pin based CFL fixture (43W EISA qualified incandescent/halogen) purchased in 2013.

\[
\Delta kWh_{1\text{st\ year\ installs}} = \left(\frac{86 - 28}{1000}\right) \times 0.875 \times 759 \times 1.06 = 40.8\ kWh \\
\Delta kWh_{2\text{nd\ year\ installs}} = \left(\frac{86 - 28}{1000}\right) \times 0.057 \times 759 \times 1.06 = 2.7\ kWh \\
\Delta kWh_{3\text{rd\ year\ installs}} = \left(\frac{86 - 28}{1000}\right) \times 0.048 \times 759 \times 1.06 = 2.2\ kWh
\]

**Heating Penalty**

If electric heated building:

\[
\Delta kWh = -\left(\frac{(Watts\text{Base} - Watts\text{EE})}{1000}\right) \times ISR \times Hours \times HF / \eta_{\text{Heat}} \\
\]

Where:

- HF = Heating Factor or percentage of light savings that must be heated
  - 49% for interior or unknown location
  - 0% for unheated location

http://www.eia.gov/consumption/residential/data/2009/xls/HC7.9%20Air%20Conditioning%20in%20Midwest%20Region.xls

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

Negative value because this is an increase in heating consumption due to the efficient lighting.

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\textsuperscript{1356}:

<table>
<thead>
<tr>
<th>System Type</th>
<th>Age of Equipment</th>
<th>HSPF Estimate</th>
<th>ηHeat (COP Estimate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat Pump</td>
<td>Before 2006</td>
<td>6.8</td>
<td>2.00</td>
</tr>
<tr>
<td></td>
<td>2006 - 2014</td>
<td>7.7</td>
<td>2.26</td>
</tr>
<tr>
<td></td>
<td>2015 on</td>
<td>8.2</td>
<td>2.40</td>
</tr>
<tr>
<td>Resistance</td>
<td>N/A</td>
<td>N/A</td>
<td>1.00</td>
</tr>
</tbody>
</table>

For example, a 2 x 14W pin-based CFL fixture is purchased in 2013 and installed in home with 2.0 COP Heat Pump:

\[ \Delta \text{kWh}_{1\text{st year}} = - \left( \frac{(86 - 28)}{1000} \right) \times 0.875 \times 759 \times 0.49 / 2.0 \]
\[ = - 9.4 \text{ kWh} \]

Second and third year install savings should be calculated using the appropriate ISR and the delta watts and hours from the install year.

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

\[ \Delta \text{kW} = \left(\frac{\text{WattsBase} - \text{WattsEE}}{1000}\right) \times \text{ISR} \times \text{WHFd} \times \text{CF} \]

Where:

\[ \text{WHFd} = \text{Waste heat factor for demand to account for cooling savings from efficient lighting.} \]

<table>
<thead>
<tr>
<th>Bulb Location</th>
<th>WHFd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interior single family or unknown location</td>
<td>1.11\textsuperscript{1357}</td>
</tr>
<tr>
<td>Multi family in unit</td>
<td>1.07\textsuperscript{1358}</td>
</tr>
<tr>
<td>Exterior or uncooled location</td>
<td>1.0</td>
</tr>
</tbody>
</table>

\textsuperscript{1356} 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.

\textsuperscript{1357} The value is estimated at 1.11 (calculated as 1 + (0.66 * 0.466 / 2.8)). See footnote relating to WHFes 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.

\textsuperscript{1358} 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);

$\text{CF} = \text{Summer Peak Coincidence Factor for measure.}$

<table>
<thead>
<tr>
<th>Bulb Location</th>
<th>$\text{CF}^{1359}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interior single family or unknown location</td>
<td>7.1%</td>
</tr>
<tr>
<td>Multi family in unit</td>
<td>7.1%</td>
</tr>
</tbody>
</table>

Other factors as defined above

For example, a 14W pin-based CFL fixture is purchased in 2013:

\[
\Delta \text{kW}_{\text{1st year}} = \left(\frac{(86-28)}{1000}\right) \times 0.875 \times 1.11 \times 0.071
\]

\[
= 0.004 \text{ kW}
\]

Second and third year install savings should be calculated using the appropriate ISR and the delta watts and hours from the install year.

**NATURAL GAS SAVINGS**

\[
\Delta \text{Therms}^{1360} = -\left(\frac{\text{(WattsBase - WattsEE)}}{1000}\right) \times \text{ISR} \times \text{Hours} \times \text{HF} \times 0.03412 / \eta_{\text{Heat}}
\]

Where:

\[
\text{HF} = \text{Heating Factor or percentage of light savings that must be heated}
\]

\[
= 49\%^{1361} \text{ for interior or unknown location}
\]

\[
= 0\% \text{ for unheated location}
\]

\[
0.03412 = \text{Converts kWh to Therms}
\]

\[
\eta_{\text{Heat}} = \text{Efficiency of heating system}
\]

\[
= 70\%^{1362}
\]

---

1359 Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.

1360 Negative value because this is an increase in heating consumption due to the efficient lighting.

1361 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.

1362 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:

\[
(0.24 \times 0.92) + (0.76 \times 0.8) \times (1-0.15) = 0.70
\]
For example, a 2 x 14W pin-based CFL fixture is purchased in 2013 and installed in home with gas heat at 70% efficiency:

\[ \Delta \text{Therms}_{1\text{st year}} = -\frac{(86 - 28) / 1000 \times 0.875 \times 759 \times 0.49 \times 0.03412}{0.7} \]

\[ = 0.9 \text{ Therms} \]

Second and third year install savings should be calculated using the appropriate ISR and the delta watts and hours from the install year.

### WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

### DEEMED O&M COST ADJUSTMENT CALCULATION

Bulb replacement costs assumed in the O&M calculations are provided below\textsuperscript{1363}.

<table>
<thead>
<tr>
<th>Year</th>
<th>Std Inc</th>
<th>EISA Compliant Halogen</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>$0.34</td>
<td>$1.25</td>
</tr>
<tr>
<td>2015</td>
<td>$0.34</td>
<td>$0.90</td>
</tr>
<tr>
<td>2016</td>
<td>$0.34</td>
<td>$0.80</td>
</tr>
<tr>
<td>2017</td>
<td>$0.34</td>
<td>$0.70</td>
</tr>
<tr>
<td>2018</td>
<td>$0.34</td>
<td>$0.60</td>
</tr>
<tr>
<td>2019</td>
<td>$0.34</td>
<td>$0.60</td>
</tr>
<tr>
<td>2020 &amp; after</td>
<td>$0.34</td>
<td>N/A</td>
</tr>
</tbody>
</table>

In order to account for the falling EISA Qualified bulb replacement cost provided above, an equivalent annual levelized baseline replacement cost over the lifetime of the CFL bulb is calculated. Note that the measure life for these measures is capped to the number of years remaining until 2020 and that the efficient case also assumes replacement cost only if the first replacement occurs before the end of the measure life. The delta O&M cost should be used in cost effectiveness screening.

The NPV for replacement lamps and annual levelized replacement costs using the statewide real discount rate of 5.23% are presented below:

\textsuperscript{1363} Based upon pricing forecast developed by Applied Proactive Technologies Inc (APT) based on industry input and provided to Ameren.
<table>
<thead>
<tr>
<th>Location</th>
<th>Lumen Level</th>
<th>NPV of replacement costs for period</th>
<th>Levelized annual replacement cost savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential and in-unit Multi Family</td>
<td>Lumens &lt;310 or &gt;2600 (non-EISA compliant)</td>
<td>$0.86</td>
<td>$0.66</td>
</tr>
<tr>
<td></td>
<td>Lumens ≥ 310 and ≤ 2600 (EISA compliant)</td>
<td>$1.73</td>
<td>$1.24</td>
</tr>
<tr>
<td></td>
<td>Efficient bulb CFL</td>
<td>$0 - No replacement bulb within measure life</td>
<td>$0 - No replacement bulb within measure life</td>
</tr>
</tbody>
</table>

For halogen bulbs, we assume the same replacement cycle as incandescent bulbs. The replacement cycle is based on the location of the lamp and varies based on the hours of use for that location. Both incandescent and halogen lamps are assumed to last for 1,000 hours before needing replacement, CFLs in Residential and in-unit multi family assume 8000 hours.

**Measure Code:** RS-LTG-IFIX-V04-150601

---

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.
5.5.6 LED Downlights

**DESCRIPTION**

This measure describes savings from a variety of LED downlight lamp types. 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.\(^{1365}\)

<table>
<thead>
<tr>
<th>Bulb Type</th>
<th>Measure Life (yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAR20, PAR30, PAR38 screw-in lamps</td>
<td>10</td>
</tr>
<tr>
<td>MR16/PAR16 pin-based lamps</td>
<td>10</td>
</tr>
<tr>
<td>Recessed downlight luminaries</td>
<td>15</td>
</tr>
<tr>
<td>Track lights</td>
<td>15</td>
</tr>
</tbody>
</table>

**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\(^{1366}\):

<table>
<thead>
<tr>
<th>Bulb Type</th>
<th>Baseline Cost</th>
<th>LED Cost</th>
<th>Incremental Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAR20, PAR30, PAR38 screw-in lamps</td>
<td>$4.00</td>
<td>$44.00</td>
<td>$40.00</td>
</tr>
<tr>
<td>MR16/PAR16 pin-based lamps</td>
<td>$3.00</td>
<td>$28.00</td>
<td>$25.00</td>
</tr>
</tbody>
</table>

\(^{1365}\) Limited by persistence. NEEP EMV Emerging Technologies Research Report (December 2011)

\(^{1366}\) 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.
<table>
<thead>
<tr>
<th>Bulb Type</th>
<th>Baseline Cost</th>
<th>LED Cost</th>
<th>Incremental Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recessed downlight luminaries</td>
<td>$4.00</td>
<td>$94.00</td>
<td>$90.00</td>
</tr>
<tr>
<td>Track lights</td>
<td>$4.00</td>
<td>$60.00</td>
<td>$56.00</td>
</tr>
</tbody>
</table>

**LOADSHAPE**

Loadshape R06 - Residential Indoor Lighting

Loadshape R07 - Residential Outdoor Lighting

**COINCIDENCE FACTOR**

The summer Peak Coincidence Factor is assumed to be 9.1% for Residential and in-unit Multi Family bulbs, 27.3% for bulbs installed in Exterior locations, and 9.4% for bulbs installed in unknown locations\(^\text{1367}\).

**Algorithm**

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

\[ \Delta \text{kWh} = \left( \frac{\text{WattsBase} - \text{WattsEE}}{1000} \right) \times \text{ISR} \times (1 - \text{Leakage}) \times \text{Hours} \times \text{WHE} \]

Where:

- \(\text{Watts}_{\text{base}}\) = Input wattage of the existing or baseline system. Reference the table below for default values.
- \(\text{Watts}_{\text{EE}}\) = Actual wattage of LED purchased / installed. If unknown, use default provided below:
  - ENERGY STAR Minimum Luminous Efficacy = 40Lm/W for lamps with rated wattages less than 20W and 50 Lm/W for lamps with rated wattages >= 20 watts\(^\text{1368}\).
  - For Directional R, BR, and ER lamp types\(^\text{1369}\):

<table>
<thead>
<tr>
<th>Bulb Type</th>
<th>Lower Lumen Range</th>
<th>Upper Lumen Range</th>
<th>Watts(_{\text{Base}})</th>
<th>Lumens used to calculate LED Wattage (midpoint)</th>
<th>LED Wattage (Watts(_{\text{EE}}))</th>
<th>Delta Watts</th>
</tr>
</thead>
<tbody>
<tr>
<td>R, ER, BR with medium screw bases w/</td>
<td>420</td>
<td>472</td>
<td>40</td>
<td>446</td>
<td>11</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td>473</td>
<td>524</td>
<td>45</td>
<td>499</td>
<td>12</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>525</td>
<td>714</td>
<td>50</td>
<td>620</td>
<td>15</td>
<td>35</td>
</tr>
</tbody>
</table>

\(^\text{1367}\) Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.

\(^\text{1368}\) From pg 10 of the Energy Star Specification for lamps v1.1

\(^\text{1369}\) From pg 11 of the Energy Star Specification for lamps v1.1
<table>
<thead>
<tr>
<th>Bulb Type</th>
<th>Lower Lumen Range</th>
<th>Upper Lumen Range</th>
<th>Watts&lt;sub&gt;Base&lt;/sub&gt;</th>
<th>Lumens used to calculate LED Wattage (midpoint)</th>
<th>LED Wattage (Watts&lt;sub&gt;EE&lt;/sub&gt;)</th>
<th>Delta Watts</th>
</tr>
</thead>
<tbody>
<tr>
<td>diameter &gt;2.25&quot; (*see exceptions below)</td>
<td>715</td>
<td>937</td>
<td>65</td>
<td>826</td>
<td>21</td>
<td>44</td>
</tr>
<tr>
<td>938</td>
<td>1259</td>
<td>75</td>
<td>1099</td>
<td>22</td>
<td>53</td>
<td></td>
</tr>
<tr>
<td>1260</td>
<td>1399</td>
<td>90</td>
<td>1330</td>
<td>27</td>
<td>63</td>
<td></td>
</tr>
<tr>
<td>1400</td>
<td>1739</td>
<td>100</td>
<td>1570</td>
<td>31</td>
<td>69</td>
<td></td>
</tr>
<tr>
<td>1740</td>
<td>2174</td>
<td>120</td>
<td>1957</td>
<td>39</td>
<td>81</td>
<td></td>
</tr>
<tr>
<td>2175</td>
<td>2624</td>
<td>150</td>
<td>2400</td>
<td>48</td>
<td>102</td>
<td></td>
</tr>
<tr>
<td>2625</td>
<td>2999</td>
<td>175</td>
<td>2812</td>
<td>56</td>
<td>119</td>
<td></td>
</tr>
<tr>
<td>3000</td>
<td>4500</td>
<td>200</td>
<td>3750</td>
<td>75</td>
<td>125</td>
<td></td>
</tr>
<tr>
<td>*R, BR, and ER with medium screw bases w/diameter &lt;=2.25&quot;</td>
<td>400</td>
<td>449</td>
<td>40</td>
<td>425</td>
<td>11</td>
<td>29</td>
</tr>
<tr>
<td>450</td>
<td>499</td>
<td>45</td>
<td>475</td>
<td>12</td>
<td>33</td>
<td></td>
</tr>
<tr>
<td>500</td>
<td>649</td>
<td>50</td>
<td>575</td>
<td>14</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td>650</td>
<td>1199</td>
<td>65</td>
<td>925</td>
<td>23</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td>*ER30, BR30, BR40, or ER40</td>
<td>400</td>
<td>449</td>
<td>40</td>
<td>425</td>
<td>11</td>
<td>29</td>
</tr>
<tr>
<td>450</td>
<td>499</td>
<td>45</td>
<td>475</td>
<td>12</td>
<td>33</td>
<td></td>
</tr>
<tr>
<td>500</td>
<td>649</td>
<td>50</td>
<td>575</td>
<td>14</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td>*BR30, BR40, or ER40</td>
<td>650</td>
<td>1419</td>
<td>65</td>
<td>1035</td>
<td>21</td>
<td>44</td>
</tr>
<tr>
<td>*R20</td>
<td>400</td>
<td>449</td>
<td>40</td>
<td>425</td>
<td>11</td>
<td>29</td>
</tr>
<tr>
<td>450</td>
<td>719</td>
<td>45</td>
<td>585</td>
<td>15</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>*All reflector lamps below lumen ranges specified above</td>
<td>200</td>
<td>299</td>
<td>20</td>
<td>250</td>
<td>6</td>
<td>14</td>
</tr>
<tr>
<td>300</td>
<td>399</td>
<td>30</td>
<td>350</td>
<td>9</td>
<td>21</td>
<td></td>
</tr>
</tbody>
</table>

Directional lamps are exempt from EISA regulations.

For PAR, MR, and MRX Lamps Types:

For these highly focused directional lamp types, it is necessary to have Center Beam Candle Power (CBCP) and beam angle measurements to accurately estimate the equivalent baseline wattage. The formula below is based on the Energy Star Center Beam Candle Power tool. If CBCP and beam angle information are not available, refer to the R, BR, and ER lumen based method above.

\[
\text{Wattbase} = 375.1 - 4.355(D) - \sqrt{227,800 - 937.9(D) - 0.9903(D^2) - 1479(BA) - 12.02(D \cdot BA) + 14.69(BA^2) - 16,720 \cdot \ln(CBCP)}
\]

Where:

D = Bulb diameter (e.g. for PAR20 D = 20)
BA = Beam angle
CBCP = Center beam candle power

The result of the equation above should be rounded DOWN to the nearest wattage established by Energy Star:

<table>
<thead>
<tr>
<th>Diameter</th>
<th>Permitted Wattages</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>20, 35, 40, 45, 50, 60, 75</td>
</tr>
<tr>
<td>20</td>
<td>50</td>
</tr>
<tr>
<td>30S</td>
<td>40, 45, 50, 60, 75</td>
</tr>
<tr>
<td>30L</td>
<td>50, 75</td>
</tr>
<tr>
<td>38</td>
<td>40, 45, 50, 55, 60, 65, 75, 85, 90, 100, 120, 150, 250</td>
</tr>
</tbody>
</table>

ISR = In Service Rate or the percentage of units rebated that get installed

<table>
<thead>
<tr>
<th>Bulb Type</th>
<th>ISR</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAR20, PAR30, PAR38 screw-in lamps</td>
<td>0.95</td>
</tr>
<tr>
<td>MR16/PAR16 pin-based lamps</td>
<td>0.95</td>
</tr>
<tr>
<td>Recessed downlight luminaries</td>
<td>1.0</td>
</tr>
<tr>
<td>Track lights</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Leakage = Adjustment to account for the percentage of bulbs purchased that move out (and in if deemed appropriate) of the Utility Jurisdiction.

Upstream (TOS) Lighting programs = Determined through evaluation.
All other programs = 0
Hours = Average hours of use per year

<table>
<thead>
<tr>
<th>Installation Location</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential and in-unit Multi Family</td>
<td>861</td>
</tr>
</tbody>
</table>
WHFe  = Waste heat factor for energy to account for cooling savings from efficient lighting

<table>
<thead>
<tr>
<th>Installation Location</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unknown location</td>
<td>891</td>
</tr>
<tr>
<td>Exterior</td>
<td>2475</td>
</tr>
</tbody>
</table>

For example, a 13W PAR20 LED is installed in place of a 750 lumen PAR20 incandescent screw-in lamp with medium screw base, diameter >2.5", installed in single family interior location:

$$\Delta k\text{W} = \frac{(45 - 13)}{1000} \times 0.95 \times 861 \times 1.06$$

= 27.7 kWh

**HEATING PENALTY**

If electric heated home (if heating fuel is unknown assume gas, see Natural Gas section):

$$\Delta k\text{W} = - \frac{((\text{WattsBase} - \text{WattsEE}) / 1000) \times \text{ISR} \times \text{Hours} \times \text{HF}}{\eta \text{Heat}}$$

Where:

HF = Heating Factor or percentage of light savings that must be heated

= 49% for interior or unknown location

---

1374 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](http://www.eia.gov/consumption/residential/data/2009/xls/HC7.9%20Air%20Conditioning%20in%20Midwest%20Region.xls))

1375 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](http://205.254.135.7/consumption/residential/data/2009/xls/HC7.1%20Air%20Conditioning%20by%20Housing%20Unit%20Type.xls)

1376 Negative value because this is an increase in heating consumption due to the efficient lighting.
\( \eta_{\text{Heat}} \) = Efficiency in COP of Heating equipment

= Actual. If not available use.\(^{1378}\)

<table>
<thead>
<tr>
<th>System Type</th>
<th>Age of Equipment</th>
<th>HSPF Estimate</th>
<th>( \eta_{\text{Heat}} ) (COP Estimate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat Pump</td>
<td>Before 2006</td>
<td>6.8</td>
<td>2.00</td>
</tr>
<tr>
<td></td>
<td>After 2006-2014</td>
<td>7.7</td>
<td>2.26</td>
</tr>
<tr>
<td></td>
<td>2015 on</td>
<td>8.2</td>
<td>2.40</td>
</tr>
<tr>
<td>Resistance</td>
<td>N/A</td>
<td>N/A</td>
<td>1.00</td>
</tr>
</tbody>
</table>

For example, a 13W PAR20 LED is installed in place of a 750 lumen PAR20 incandescent screw-in lamp with medium screw base, diameter >2.5", installed in single family interior location:

\[
\Delta \text{kWh} = - \frac{(45 - 13)}{1000} \times 0.95 \times 861 \times 0.49 / 2.26 \\
= -5.67 \text{kWh}
\]

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

\[
\Delta \text{kw} = ((\text{WattsBase} - \text{WattsEE})/1000) \times \text{ISR} \times \text{WHFd} \times \text{CF}
\]

Where:

\( \text{WHFd} \) = Waste heat factor for demand to account for cooling savings from efficient lighting.

<table>
<thead>
<tr>
<th>Bulb Location</th>
<th>WHFd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interior single family or unknown location</td>
<td>1.11(^{1379})</td>
</tr>
<tr>
<td>Multi family in unit</td>
<td>1.07(^{1380})</td>
</tr>
</tbody>
</table>

\(^{1377}\) 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.

\(^{1378}\) 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.

\(^{1379}\) The value is estimated at 1.11 (calculated as 1 + (0.66 * 0.466 / 2.8)). See footnote relating to \( \text{WHFe} \) 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.

\(^{1380}\) 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
Illinois Statewide Technical Reference Manual - 5.5.6 LED Downlights

<table>
<thead>
<tr>
<th>Bulb Location</th>
<th>WHFd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exterior or uncooled location</td>
<td>1.0</td>
</tr>
</tbody>
</table>

**CF** = Summer Peak Coincidence Factor for measure, see above for values.

<table>
<thead>
<tr>
<th>Bulb Location</th>
<th>CF\textsuperscript{1.383}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interior single family or Multi-family in unit</td>
<td>9.1%</td>
</tr>
<tr>
<td>Unknown Location</td>
<td>9.4%</td>
</tr>
<tr>
<td>Exterior Locations</td>
<td>27.3%</td>
</tr>
</tbody>
</table>

Other factors as defined above

For example, a 13W PAR20 LED is installed in place of a 750 lumen PAR20 incandescent screw-in lamp with medium screw base, diameter >2.5", installed in single family interior location:

\[
\Delta kW = \frac{(45 - 13)}{1000} \times 0.95 \times 1.11 \times 0.091 \\
= 0.0031 kW
\]

**NATURAL GAS SAVINGS**

Heating penalty if Natural Gas heated home, or if heating fuel is unknown.

\[
\Delta \text{therms} = - \left(\frac{(\text{WattsBase} - \text{WattsEE})}{1000}\right) \times \text{ISR} \times \text{Hours} \times \text{HF} \times 0.03412 \times \eta_{\text{Heat}}
\]

Where:

\[
\text{HF} = \text{Heating factor, or percentage of lighting savings that must be replaced by heating system.}
\]

- 49% \textsuperscript{1.382} for interior or unknown location
- 0% for exterior location

0.03412 = Converts kWh to Therms
\[
\eta_{\text{Heat}} = \text{Average heating system efficiency.}
\]

- 0.70 \textsuperscript{1.383}

\textsuperscript{1.381} Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.

\textsuperscript{1.382} Average result from REMRate modeling of several different configurations and IL locations of homes

\textsuperscript{1.383} 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.
Other factors as defined above

For example, a 13W PAR20 LED is installed in place of a 750 lumen PAR20 incandescent screw-in lamp with medium screw base, diameter >2.5”, installed in single family interior location with gas heating at 70% total efficiency:

\[
\Delta \text{therms} = - \frac{((45 - 13) / 1000) \times 0.95 \times 861 \times 0.49 \times 0.03412}{0.70}
\]

\[
= - 0.63 \text{ therms}
\]

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

The life of the baseline bulb and the cost of its replacement is presented in the following table:

<table>
<thead>
<tr>
<th>Lamp Type</th>
<th>Baseline Lamp Life (hours)</th>
<th>Baseline Life (Single Family and in unit Multifamily - 1010 hours)</th>
<th>Baseline Replacement Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAR20, PAR30, PAR38 screw-in lamps</td>
<td>2000</td>
<td>2.0</td>
<td>$4.00</td>
</tr>
<tr>
<td>MR16/PAR16 pin-based lamps</td>
<td>2000</td>
<td>2.0</td>
<td>$3.00</td>
</tr>
<tr>
<td>Recessed downlight luminaries</td>
<td>2000</td>
<td>2.0</td>
<td>$4.00</td>
</tr>
<tr>
<td>Track lights</td>
<td>2000</td>
<td>2.0</td>
<td>$4.00</td>
</tr>
</tbody>
</table>

**MEASURE CODE: RS-LTG-LEDD-V04-150601**

Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows:

\[
(0.24 \times 0.92) + (0.76 \times 0.8) \times (1 - 0.15) = 0.70
\]
5.5.7 LED Exit Signs

**DESCRIPTION**

This measure 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 building. 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.

**DEEMED MEASURE COST**

The incremental cost for this measure is assumed to be $30.

**LOADSHAPE**

Loadshape C53 - Flat

**COINCIDENCE FACTOR**

The summer peak coincidence factor for this measure is assumed to be 100%.

---

### Algorithm

**Electric Energy Savings**

\[
\Delta \text{kWh} = ((\text{WattsBase} - \text{WattsEE}) / 1000) \times \text{HOURS} \times \text{WHF}_e
\]

Where:

---

2. **NYSERDA Deemed Savings Database, Labor cost assumes 25 minutes @ $18/hr.**
3. **Assuming continuous operation of an LED exit sign, the Summer Peak Coincidence Factor is assumed to equal 1.0.**
WattsBase = Actual wattage if known, if unknown assume the following:

<table>
<thead>
<tr>
<th>Baseline Type</th>
<th>WattsBase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incandescent</td>
<td>35W</td>
</tr>
<tr>
<td>Fluorescent</td>
<td>11W</td>
</tr>
<tr>
<td>Unknown (e.g. time of sale)</td>
<td>11W</td>
</tr>
</tbody>
</table>

WattsEE = Actual wattage if known, if unknown assume 2W

HOURS = Annual operating hours
= 8766

WHFₚ = Waste heat factor for energy; accounts for cooling savings from efficient lighting.
= 1.04 for multi family buildings

Default if replacing incandescent fixture
\[ \Delta kWH = \frac{(35 - 2)}{1000} \times 8766 \times 1.04 \]
= 301 kWh

Default if replacing fluorescent fixture
\[ \Delta kWH = \frac{(11 - 2)}{1000} \times 8766 \times 1.04 \]
= 82 kWh

**HEATING PENALTY**

If electric heated building (if heating fuel is unknown assume gas, see Natural Gas section):
\[ \Delta kWh^{1391} = -\left( \frac{\text{WattsBase} - \text{WattsEE}}{1000} \times \text{Hours} \times \text{HF} \right) / \eta_{\text{Heat}} \]

Where:

1387 Based on review of available product.
1390 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
1391 Negative value because this is an increase in heating consumption due to the efficient lighting.
HF = Heating Factor or percentage of light savings that must be heated
= 49%\(^{1392}\)

\(\eta_{\text{Heat}}\) = Efficiency in COP of Heating equipment
= Actual. If not available use:\(^{1393}\)

<table>
<thead>
<tr>
<th>System Type</th>
<th>Age of Equipment</th>
<th>HSPF Estimate</th>
<th>(\eta_{\text{Heat}}) (COP Estimate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat Pump</td>
<td>Before 2006</td>
<td>6.8</td>
<td>2.00</td>
</tr>
<tr>
<td></td>
<td>After 2006</td>
<td>7.7</td>
<td>2.26</td>
</tr>
<tr>
<td>Resistance</td>
<td>N/A</td>
<td>N/A</td>
<td>1.00</td>
</tr>
</tbody>
</table>

For example, a 2.0COP Heat Pump heated building:

If incandescent fixture:
\[
\Delta kW = \frac{\left(35 - 2\right) / 1000 \times 8766 \times 0.49}{2}
\]
\[
= -71 \text{ kWh}
\]

If fluorescent fixture:
\[
\Delta kW = \frac{\left(11 - 2\right) / 1000 \times 8766 \times 0.49}{2}
\]
\[
= -19 \text{ kWh}
\]

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

\[
\Delta kW = \left(\frac{\text{WattsBase} - \text{WattsEE}}{1000}\right) \times WHF_d \times CF
\]

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\(^{1394}\) for multi family buildings

\(CF\) = Summer Peak Coincidence Factor for measure
= 1.0

Default if incandescent fixture
\[
\Delta kW = \frac{35 - 2}{1000} \times 1.07 \times 1.0
\]
\[
= 0.035 \text{ kW}
\]

\(^{1392}\) 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.

\(^{1393}\) 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.

\(^{1394}\) The value is estimated at 1.11 (calculated as \(1 + \left(0.45 \times 0.466 / 2.8\right)\)). See footnote relating to WHF_d 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.
Default if fluorescent fixture
\[ \Delta kW = \frac{(11 - 2)}{1000} \times 1.07 \times 1.0 \]
\[ = 0.0096 \text{ kW} \]

**Natural Gas Savings**

Heating penalty if Natural Gas heated building, or if heating fuel is unknown.

\[ \Delta \text{therms} = - \left( \frac{(Watts\text{Base} - Watts\text{EE})}{1000} \times \text{Hours} \times HF \times 0.03412 \right) / \eta\text{Heat} \]

Where:

HF = Heating factor, or percentage of lighting savings that must be replaced by heating system.
\[ = 49\% \quad 1395 \]

0.03412 = Converts kWh to Therms
\[ \eta\text{Heat} = \text{Average heating system efficiency}. \]
\[ = 0.70 \quad 1396 \]

Other factors as defined above

Default if incandescent fixture
\[ \Delta \text{therms} = - \left( \frac{(35 - 2)}{1000} \times 8766 \times 0.49 \times 0.03412 \right) / 0.70 \]
\[ = -6.9 \text{ therms} \]

Default if fluorescent fixture
\[ \Delta \text{therms} = - \left( \frac{(11 - 2)}{1000} \times 8766 \times 0.49 \times 0.03412 \right) / 0.70 \]
\[ = -1.9 \text{ therms} \]

**Water Impact Descriptions and Calculation**

N/A

---

1395 Average result from REMRate modeling of several different configurations and IL locations of homes
1396 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:
\[ (0.24 \times 0.92) + (0.76 \times 0.8) \times (1-0.15) = 0.70 \]
DEEMED O&M COST ADJUSTMENT CALCULATION

The annual O&M Cost Adjustment savings should be calculated using the following component costs and lifetimes.

<table>
<thead>
<tr>
<th>Component</th>
<th>Cost</th>
<th>Life (yrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lamp</td>
<td>$7.00</td>
<td>1.37 years</td>
</tr>
</tbody>
</table>

MEASURE CODE: RS-LTG-LEDE-V01-120601

1397 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).
1398 Assumes a lamp life of 12,000 hours and 8766 run hours 12000/8766 = 1.37 years.
5.5.8 LED Screw Based Omnidirectional Bulbs

DESCRIPTION
This characterization provides savings assumptions for LED Screw Based Omnidirectional (e.g. A-Type lamps) lamps within the residential and multifamily sectors. 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, 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.

DEFINITION OF BASELINE EQUIPMENT
In 2012, Federal legislation stemming from the Energy Independence and Security Act of 2007 (EISAs) 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. Since measures installed under this TRM all occur after 2014, baseline equipment are the values after EISA. These are shown in the baseline table below.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT
13.7 years (exterior) to 26 years (residential home), however all installations are capped at 10 years.

DEEMED MEASURE COST
Wherever possible, actual incremental costs should be used. Refer to reference table “Residential LED component Cost & Lifetime” for defaults.

LOADSHAPE
Loadshape R06 – Residential Indoor Lighting
Loadshape R07 – Residential Outdoor Lighting

COINCIDENCE FACTOR
The summer peak coincidence factor is assumed to be 7.1% for Residential and in-unit Multi Family bulbs, 27.3% for exterior bulbs and 8.1% for unknown.

1400 Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.
CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

\[ \Delta k\text{Wh} = \frac{(Watts_{\text{base}} - Watts_{\text{EE}})}{1000} \times IRS \times (1 - \text{Leakage}) \times \text{Hours} \times WHF_e \]

Where:

- \( Watts_{\text{base}} \) = Input wattage of the existing or baseline system. Reference the “LED New and Baseline Assumptions” table for default values.
- \( Watts_{\text{EE}} \) = Actual wattage of LED purchased / installed. If unknown, use default provided below:

**LED New and Baseline Assumptions Table**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>5280</td>
<td>6209</td>
<td>5745</td>
<td>104.4</td>
<td>300.0</td>
<td>195.6</td>
<td>300.0</td>
<td>195.6</td>
</tr>
<tr>
<td>3000</td>
<td>5279</td>
<td>4140</td>
<td>75.3</td>
<td>200.0</td>
<td>124.7</td>
<td>200.0</td>
<td>124.7</td>
</tr>
<tr>
<td>2601</td>
<td>2999</td>
<td>2800</td>
<td>50.9</td>
<td>150.0</td>
<td>99.1</td>
<td>150.0</td>
<td>99.1</td>
</tr>
<tr>
<td>1490</td>
<td>2600</td>
<td>2045</td>
<td>37.2</td>
<td>72.0</td>
<td>34.8</td>
<td>45.4</td>
<td>8.3</td>
</tr>
<tr>
<td>1050</td>
<td>1489</td>
<td>1270</td>
<td>23.1</td>
<td>53.0</td>
<td>29.9</td>
<td>28.2</td>
<td>5.1</td>
</tr>
<tr>
<td>750</td>
<td>1049</td>
<td>900</td>
<td>16.4</td>
<td>43.0</td>
<td>26.6</td>
<td>20.0</td>
<td>3.6</td>
</tr>
<tr>
<td>310</td>
<td>749</td>
<td>530</td>
<td>9.6</td>
<td>29.0</td>
<td>19.4</td>
<td>11.8</td>
<td>2.1</td>
</tr>
<tr>
<td>250</td>
<td>309</td>
<td>280</td>
<td>5.6</td>
<td>25.0</td>
<td>19.4</td>
<td>25.0</td>
<td>19.4</td>
</tr>
</tbody>
</table>

- \( IRS \) = In Service Rate, the percentage of units rebated that are actually in service.

1401 Based on ENERGY STAR specs – minimum luminous efficacy for Omnidirectional Lamps. For LED lamp power <10W = 50lm/W and for LED lamp power >=10W = 55lm/W.
1402 Calculated as 45lm/W for all EISA non-exempt bulbs.
<table>
<thead>
<tr>
<th>Program</th>
<th>Weighted Average 1st year In Service Rate (ISR)</th>
<th>2nd year Installations</th>
<th>3rd year Installations</th>
<th>Final Lifetime In Service Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retail (Time of Sale)</td>
<td>95%\textsuperscript{1403}</td>
<td>1.6%</td>
<td>1.4%</td>
<td>98.0%\textsuperscript{1404}</td>
</tr>
<tr>
<td>Direct Install</td>
<td>96.9%\textsuperscript{1405}</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Efficiency Kits\textsuperscript{1406}</td>
<td>CFL Distribution\textsuperscript{1407}</td>
<td>59%</td>
<td>13%</td>
<td>83%</td>
</tr>
<tr>
<td></td>
<td>School Kits\textsuperscript{1408}</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Direct Mail Kits\textsuperscript{1409}</td>
<td>66%</td>
<td>14%</td>
<td>93%</td>
</tr>
</tbody>
</table>

**Leakage** = Adjustment to account for the percentage of bulbs purchased that move out (and in if deemed appropriate) of the Utility Jurisdiction.

**Upstream (TOS) Lighting programs** = Determined through evaluation\textsuperscript{1410}.

All other programs = 0

**Hours** = Average hours of use per year

\textsuperscript{1403} 1\textsuperscript{st} year in service rate is based upon analysis of ComEd PY7 intercept data.

\textsuperscript{1404} The 98% Lifetime ISR assumption is based upon the standard CFL measure in the absence of any better reference. This value 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 2\textsuperscript{nd} and 3\textsuperscript{rd} year installations should be counted as part of those future program year savings.


\textsuperscript{1406} Kits provided free to students through school, with education program. Consistent with Standard CFL assumptions.

\textsuperscript{1407} Opt-in program to receive kits via mail, with little or no education. Consistent with Standard CFL assumptions.

\textsuperscript{1408} Free bulbs provided without request, with little or no education. Consistent with Standard CFL assumptions.

\textsuperscript{1409} Using a leakage estimate from the current program year evaluation, from past evaluation results, or a rolling average of leakage estimates from previous years.
### Installation Location

<table>
<thead>
<tr>
<th>Installation Location</th>
<th>Hours&lt;sup&gt;1411&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential and in-unit Multi Family</td>
<td>759</td>
</tr>
<tr>
<td>Exterior</td>
<td>2475</td>
</tr>
<tr>
<td>Unknown</td>
<td>847</td>
</tr>
</tbody>
</table>

**WHFe** = Waste heat factor for energy to account for cooling energy savings from efficient lighting

<table>
<thead>
<tr>
<th>Bulb Location</th>
<th>WHFe&lt;sup&gt;1412&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interior single family or unknown location</td>
<td>1.06</td>
</tr>
<tr>
<td>Multi family in unit</td>
<td>1.04</td>
</tr>
<tr>
<td>Exterior or uncooled location</td>
<td>1.0</td>
</tr>
</tbody>
</table>

### Mid Life Baseline Adjustment

During the lifetime of a standard Omnidirectional LED, the baseline incandescent/halogen bulb would need to be replaced multiple times. Since the baseline bulb changes over time (except for <300 and 2600+ lumen lamps) 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 2014, the full savings (as calculated above in the Algorithm) should be claimed for the first six years, but a reduced annual savings (calculated energy savings above multiplied by the adjustment factor in the table below) claimed for the remainder of the measure life.

---

<sup>1411</sup> Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.

<sup>1412</sup> 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](http://www.eia.gov/consumption/residential/data/2009/xls/HC7.9%20Air%20Conditioning%20in%20Midwest%20Region.xls))

<sup>1413</sup> 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](http://205.254.135.7/consumption/residential/data/2009/xls/HC7.1%20Air%20Conditioning%20by%20Housing%20Unit%20Type.xls))
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1490</td>
<td>2600</td>
<td>37.2</td>
<td>34.8</td>
<td>8.3</td>
<td>23.8%</td>
</tr>
<tr>
<td>1050</td>
<td>1489</td>
<td>23.1</td>
<td>29.9</td>
<td>5.1</td>
<td>17.1%</td>
</tr>
<tr>
<td>750</td>
<td>1049</td>
<td>16.4</td>
<td>26.6</td>
<td>3.6</td>
<td>13.5%</td>
</tr>
<tr>
<td>310</td>
<td>749</td>
<td>9.6</td>
<td>19.4</td>
<td>2.1</td>
<td>10.8%</td>
</tr>
</tbody>
</table>

For example, an 8W LED lamp, 450 lumens, is installed in the interior of a home in 2014. The customer purchased the lamp through an upstream program:

\[ \Delta \text{kWh} = \left( \frac{29-8}{1000} \right) \times 847 \times 1.06 \times 0.92 \]

\[ = 17.3 \text{ kWh} \]

This value should be claimed for six years, i.e. June 2014 – May 2020, but from May 2020 until the end of the measure life for that same bulb, savings should be reduced to \( (17.3 \times 0.108 \approx) 1.9 \text{ kWh} \) for the remainder of the measure life. Note these adjustments should be applied to kW and fuel impacts as well.

**Deferred Installs**

As presented above, the characterization assumes that a percentage of bulbs purchased are not installed until Year 2 and Year 3 (see ISR assumption above). The Illinois Technical Advisory Committee has determined the following methodology for calculating the savings of these future installs.

- **Year 1 (Purchase Year) installs:** Characterized using assumptions provided above or evaluated assumptions if available.
- **Year 2 and 3 installs:** Characterized using delta watts assumption and hours of use from the Install Year i.e. the actual deemed (or evaluated if available) assumptions active in Year 2 and 3 should be applied.

The NTG factor for the Purchase Year should be applied.

Using the example from above, for an 8W LED, 450 Lumens purchased for the interior of a residential homes through an upstream program in 2014.

\[ \Delta \text{kWh}_{1\text{st year installs}} = \left( \frac{29-8}{1000} \right) \times 847 \times 1.06 \times 0.92 \]

\[ = 17.3 \text{ kWh} \]

\[ \Delta \text{kWh}_{2\text{nd year installs}} = \left( \frac{29-8}{1000} \right) \times 847 \times 1.06 \times 0.032 \]

\[ = 0.6 \text{ kWh} \]

Note: Here we assume no change in hours assumption. NTG value from Purchase year applied.
HEATING PENALTY

If electric heated home (if heating fuel is unknown assume gas, see Natural Gas section):

\[ \Delta kW_{1414} = - \frac{((Watts_{Base} - Watts_{EE}) / 1000) \times ISR \times Hours \times HF}{\eta_{Heat}} \]

Where:

HF = Heating Factor or percentage of light savings that must be heated

= 49%\(^{1415}\) for interior or unknown location

= 0% for exterior or unheated location

\(\eta_{Heat}\) = Efficiency in COP of Heating equipment

= actual. If not available use\(^{1416}\):

<table>
<thead>
<tr>
<th>System Type</th>
<th>Age of Equipment</th>
<th>HSPF Estimate</th>
<th>(\eta_{Heat}) (COP Estimate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat Pump</td>
<td>Before 2006</td>
<td>6.8</td>
<td>2.00</td>
</tr>
<tr>
<td></td>
<td>After 2006 - 2014</td>
<td>7.7</td>
<td>2.26</td>
</tr>
<tr>
<td></td>
<td>2015 on</td>
<td>8.2</td>
<td>2.40</td>
</tr>
<tr>
<td>Resistance</td>
<td>N/A</td>
<td>N/A</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Using the same 8 W LED that is installed in home with 2.0 COP Heat Pump (i.e., the heat pump was installed prior to 2006):

\[ \Delta kW_{1st\ year} = - \frac{((29 - 8) / 1000) \times 0.92 \times 759 \times 0.49}{2.0} \]

\[ \Delta kW_{1st\ year} = - 3.6 \text{ kWh} \]

Second and third year install savings should be calculated using the appropriate ISR and the delta watts and hours from the install year. The appropriate baseline shift adjustment should then be applied to all installs.

\(^{1414}\) Negative value because this is an increase in heating consumption due to the efficient lighting.

\(^{1415}\) 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.

\(^{1416}\) 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

\[ \Delta kW = \frac{(Watts\text{Base} - Watts\text{EE})}{1000} \times ISR \times WHFd \times CF \]

Where:

- **WHFd** = Waste heat factor for demand to account for cooling savings from efficient lighting.
- **CF** = Summer Peak Coincidence Factor for measure.

<table>
<thead>
<tr>
<th>Bulb Location</th>
<th>WHFd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interior single family or unknown location</td>
<td>1.11(^{1417})</td>
</tr>
<tr>
<td>Multi family in unit</td>
<td>1.07(^{1418})</td>
</tr>
<tr>
<td>Exterior or uncooled location</td>
<td>1.0</td>
</tr>
</tbody>
</table>

For the same 8 W LED that is installed in a single family interior location in 2014, the demand savings are:

\[ \Delta kW = \frac{(29-8)}{1000} \times 0.92 \times 1.11 \times 0.071 \]
\[ = 0.0015 \text{ kW} \]

Second and third year install savings should be calculated using the appropriate ISR and the delta watts and hours from the install year. The appropriate baseline shift adjustment should then be applied to all installs.

\(^{1417}\) 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.

\(^{1418}\) 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).

\(^{1419}\) Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluations.
WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

Bulb replacement costs assumed in the O&M calculations are provided below.\textsuperscript{1420}

<table>
<thead>
<tr>
<th>Year</th>
<th>Std Inc.</th>
<th>EISA Compliant Halogen</th>
<th>CFL</th>
<th>LED-A</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>$0.34</td>
<td>$1.25</td>
<td>$2.50</td>
<td>$13.81</td>
</tr>
<tr>
<td>2015</td>
<td>$0.34</td>
<td>$0.90</td>
<td>$2.50</td>
<td>$10.86</td>
</tr>
<tr>
<td>2016</td>
<td>$0.34</td>
<td>$0.80</td>
<td>$2.50</td>
<td>$8.60</td>
</tr>
<tr>
<td>2017</td>
<td>$0.34</td>
<td>$0.70</td>
<td>$2.50</td>
<td>$7.74</td>
</tr>
<tr>
<td>2018</td>
<td>$0.34</td>
<td>$0.60</td>
<td>$2.50</td>
<td>$6.96</td>
</tr>
<tr>
<td>2019</td>
<td>$0.34</td>
<td>$0.60</td>
<td>$2.50</td>
<td>$6.27</td>
</tr>
<tr>
<td>2020 &amp; after</td>
<td>$0.34</td>
<td>N/A</td>
<td>$2.50</td>
<td>$5.64</td>
</tr>
</tbody>
</table>

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 is calculated. The key assumptions used in this calculation are documented below:

<table>
<thead>
<tr>
<th>Installation Location</th>
<th>Omnidirectional LED Measure Hours</th>
<th>Hours of Use per year\textsuperscript{1421}</th>
<th>Measure Life in Years (capped at 10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential and in-unit Multi Family</td>
<td>25,000</td>
<td>759</td>
<td>10</td>
</tr>
<tr>
<td>Exterior</td>
<td>25,000</td>
<td>2475</td>
<td>10</td>
</tr>
<tr>
<td>Unknown</td>
<td>25,000</td>
<td>847</td>
<td>10</td>
</tr>
</tbody>
</table>

The NPV for replacement lamps and annual levelized replacement costs using the statewide real discount rate of 5.23% are presented below:

\textsuperscript{1420} Based upon pricing forecast developed by Applied Proactive Technologies Inc (APT) based on industry input and provided to Ameren.

\textsuperscript{1421} Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluations.
<table>
<thead>
<tr>
<th>Location</th>
<th>Lumen Level</th>
<th>NPV of replacement costs for period</th>
<th>Levelized annual replacement cost savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential and in-unit</td>
<td>Lumens &lt;310 or &gt;2600 (non-EISA compliant)</td>
<td>$1.73</td>
<td>$1.73</td>
</tr>
<tr>
<td>Multi Family</td>
<td>Lumens ≥ 310 and ≤ 2600 (EISA compliant)</td>
<td>$2.52</td>
<td>$2.22</td>
</tr>
<tr>
<td>Exterior</td>
<td>Lumens &lt;310 or &gt;2600 (non-EISA compliant)</td>
<td>$6.10</td>
<td>$6.10</td>
</tr>
<tr>
<td></td>
<td>Lumens ≥ 310 and ≤ 2600 (EISA compliant)</td>
<td>$9.48</td>
<td>$8.35</td>
</tr>
<tr>
<td>Unknown</td>
<td>Lumens &lt;310 or &gt;2600 (non-EISA compliant)</td>
<td>$1.93</td>
<td>$1.93</td>
</tr>
<tr>
<td></td>
<td>Lumens ≥ 310 and ≤ 2600 (EISA compliant)</td>
<td>$2.81</td>
<td>$2.47</td>
</tr>
</tbody>
</table>

Note: incandescent lamps in lumen range <310 and >2600 are exempt from EISA. For halogen bulbs, we assume the same replacement cycle as incandescent bulbs. The replacement cycle is based on the location of the lamp and varies based on the hours of use for that location. Both incandescent and halogen lamps are assumed to last for 1,000 hours before needing replacement.

**Measure Code:** RS-LTG-LEDA-V03-150601

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1422 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.
5.6 Shell End Use

5.6.1 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. The algorithm for this measure can be used when the program implementation does not allow for more detailed forecasting through the use of residential modeling software.

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.\(^{1423}\)

**DEEMED MEASURE COST**

The actual capital cost for this measure should be used in screening.

**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.

\[
CF_{SSP} = \text{Summer System Peak Coincidence Factor for Central A/C (during utility peak hour)}
\]

Air Sealing

\[ CF_{SSP} = \text{Summer System Peak Coincidence Factor for Heat Pumps (during system peak hour)} \]
\[ CF_{SSP} = 68\% \]
\[ CF_{PJM} = \text{PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)} \]
\[ CF_{PJM} = 46.6\% \]

Algorithm

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

\[ \Delta kWh = \Delta kWh_{cooling} + \Delta kWh_{heating} \]

Where:

\[ \Delta kWh_{cooling} = \text{If central cooling, reduction in annual cooling requirement due to air sealing} \]
\[ = \left( \frac{((\text{CFM50}_{existing} - \text{CFM50}_{new})/N_{cool}) \times 60 \times 24 \times \text{CDD} \times \text{DUA} \times 0.018}{1000 \times \eta_{\text{Cool}}} \right) \times \text{LM} \]

\[ \text{CFM50}_{existing} = \text{Infiltration at 50 Pascals as measured by blower door before air sealing.} \]
\[ \text{Actual} \]

\[ \text{CFM50}_{new} = \text{Infiltration at 50 Pascals as measured by blower door after air sealing.} \]
\[ \text{Actual} \]

\[ N_{cool} = \text{Conversion factor from leakage at 50 Pascal to leakage at natural conditions} \]
\[ = \text{Dependent on exposure}^{\text{1427}} \]

<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>Exposure</th>
<th>N-Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone 2</td>
<td>Well Shielded</td>
<td>22.2</td>
</tr>
<tr>
<td></td>
<td>Normal</td>
<td>18.5</td>
</tr>
<tr>
<td></td>
<td>Exposed</td>
<td>16.7</td>
</tr>
<tr>
<td>Zone 3</td>
<td>Well Shielded</td>
<td>25.8</td>
</tr>
<tr>
<td></td>
<td>Normal</td>
<td>21.5</td>
</tr>
</tbody>
</table>

\(^{1424}\) Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.

\(^{1425}\) Based on analysis of metering results from 24 heat pumps in Ameren Illinois service territory in PY5 coincident with AIC’s 2010 system peak; ‘Impact and Process Evaluation of Ameren Illinois Company’s Residential HVAC Program (PYS)’.

\(^{1426}\) 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.

\(^{1427}\) 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.
Climate Zone | Exposure | N-Factor
--- | --- | ---
Exposed | 19.4 | 60 * 24 = Converts Cubic Feet per Minute to Cubic Feet per Day
CDD = Cooling Degree Days
= Dependent on location\(^{1428}\):

<table>
<thead>
<tr>
<th>Climate Zone (City based upon)</th>
<th>CDD 65</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Rockford)</td>
<td>820</td>
</tr>
<tr>
<td>2 (Chicago)</td>
<td>842</td>
</tr>
<tr>
<td>3 (Springfield)</td>
<td>1,108</td>
</tr>
<tr>
<td>4 (Belleville)</td>
<td>1,570</td>
</tr>
<tr>
<td>5 (Marion)</td>
<td>1,370</td>
</tr>
</tbody>
</table>

DUA = Discretionary Use Adjustment (reflects the fact that people do not always operate their AC when conditions may call for it).
= 0.75 \(^{1429}\)
0.018 = Specific Heat Capacity of Air (Btu/ft\(^3\)^\(°\)F)
1000 = Converts Btu to kBtu
\(\eta_{\text{Cool}}\) = Efficiency (SEER) of Air Conditioning equipment (kBtu/kWh)
= Actual (where it is possible to measure or reasonably estimate). If unknown assume the following \(^{1430}\):

<table>
<thead>
<tr>
<th>Age of Equipment</th>
<th>SEER Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before 2006</td>
<td>10</td>
</tr>
<tr>
<td>2006 - 2014</td>
<td>13</td>
</tr>
<tr>
<td>Central AC After 1/1/2015</td>
<td>13</td>
</tr>
<tr>
<td>Heat Pump After 1/1/2015</td>
<td>14</td>
</tr>
</tbody>
</table>

\(^{1428}\) National Climatic Data Center, calculated from 1981-2010 climate normals with a base temp of 65°F.
\(^{1429}\) 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.
\(^{1430}\) 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.
LM = Latent multiplier to account for latent cooling demand
= dependent on location:

<table>
<thead>
<tr>
<th>Climate Zone (City based upon)</th>
<th>LM</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Rockford)</td>
<td>8.5</td>
</tr>
<tr>
<td>2 (Chicago)</td>
<td>6.2</td>
</tr>
<tr>
<td>3 (Springfield)</td>
<td>6.6</td>
</tr>
<tr>
<td>4 (St. Louis, MO)</td>
<td>5.8</td>
</tr>
<tr>
<td>5 (Evansville, IN)</td>
<td>6.6</td>
</tr>
</tbody>
</table>

ΔkWh\_heating = If electric heat (resistance or heat pump), reduction in annual electric heating due to air sealing

\[
\Delta kWh_{\text{heating}} = \frac{[((\text{CFM50}_{\text{existing}} - \text{CFM50}_{\text{new}})/\text{N}_{\text{heat}}) \times 60 \times 24 \times \text{HDD} \times 0.018]}{(\eta_{\text{Heat}} \times 3,412)}
\]

N\_heat = Conversion factor from leakage at 50 Pascal to leakage at natural conditions
= Based on climate zone, building height and exposure level:

<table>
<thead>
<tr>
<th># Stories:</th>
<th>1</th>
<th>1.5</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Well Shielded</td>
<td>22.2</td>
<td>20.0</td>
<td>17.8</td>
<td>15.5</td>
</tr>
<tr>
<td>Normal</td>
<td>18.5</td>
<td>16.7</td>
<td>14.8</td>
<td>13.0</td>
</tr>
<tr>
<td>Exposed</td>
<td>16.7</td>
<td>15.0</td>
<td>13.3</td>
<td>11.7</td>
</tr>
<tr>
<td>Zone 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Well Shielded</td>
<td>25.8</td>
<td>23.2</td>
<td>20.6</td>
<td>18.1</td>
</tr>
<tr>
<td>Normal</td>
<td>21.5</td>
<td>19.4</td>
<td>17.2</td>
<td>15.1</td>
</tr>
<tr>
<td>Exposed</td>
<td>19.4</td>
<td>17.4</td>
<td>15.5</td>
<td>13.5</td>
</tr>
</tbody>
</table>

HDD = Heating Degree Days
= Dependent on location:

---

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-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.

National Climatic Data Center, calculated from 1981-2010 climate normals with a base temp of 65°F. The base temperature was selected to account for the fact that homes receiving airsealing efforts are likely to be more leaky homes where the inside and outside air temperature is more consistent and therefore is more likely to require heating as temperatures drop below 65 degrees. Using this base temperature also reconciles the resulting savings estimates with the results of more sophisticated...
Climate Zone (City based upon) | HDD 65
---|---
1 (Rockford) | 6,569
2 (Chicago) | 6,339
3 (Springfield) | 5,497
4 (Belleville) | 4,379
5 (Marion) | 4,476

\[ \eta_{\text{Heat}} = \text{Efficiency of heating system} \]
\[ = \text{Actual. If not available refer to default table below} \]

<table>
<thead>
<tr>
<th>System Type</th>
<th>Age of Equipment</th>
<th>HSPF Estimate</th>
<th>( \eta_{\text{Heat (Effective COP Estimate)}} = (\text{HSPF/3.413})*0.85 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat Pump</td>
<td>Before 2006</td>
<td>6.8</td>
<td>1.7</td>
</tr>
<tr>
<td></td>
<td>2006 - 2014</td>
<td>7.7</td>
<td>1.92</td>
</tr>
<tr>
<td></td>
<td>2015 on</td>
<td>8.2</td>
<td>2.40</td>
</tr>
<tr>
<td>Resistance</td>
<td>N/A</td>
<td>N/A</td>
<td>1</td>
</tr>
</tbody>
</table>

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:

\[
\Delta \text{kWh} = \Delta \text{kWh\_cooling} + \Delta \text{kWh\_heating}
\]
\[
= \left[ \frac{((3,400 - 2,250)}{22.2} \right] \times 60 \times 24 \times 842 \times 0.75 \times 0.018 \times (1000 \times 10.5)) \times 6.2 \right] + \left[ \frac{((3,400 - 2,250)/17.8}}{60 \times 24 \times 6339 \times 0.018 \times (1.92 \times 3,412)}\right]
\]
\[
= 501 + 1620
\]
\[
= 2,121 \text{ kWh}
\]

\( \Delta \text{kWh\_heating} = \text{If gas furnace heat, kWh savings for reduction in fan run time} \)

1434 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.
\[ \Delta \text{Therms} \times F_e \times 29.3 \]

\[ F_e = \text{Furnace Fan energy consumption as a percentage of annual fuel consumption} \]

\[ 29.3 = \text{kWh per therm} \]

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 (see therm calculation in Natural Gas Savings section:

\[ \Delta \text{kWh} = 152 \times 0.0314 \times 29.3 \]

\[ = 140 \text{ kWh} \]

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

\[ \Delta \text{kW} = (\Delta \text{kWh}_{\text{cooling}} / \text{FLH}_{\text{cooling}}) \times \text{CF} \]

Where:

\[ \text{FLH}_{\text{cooling}} = \text{Full load hours of air conditioning} \]

\[ = \text{Dependent on location}\]

<table>
<thead>
<tr>
<th>Climate Zone (City based upon)</th>
<th>Single Family</th>
<th>Multifamily</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Rockford)</td>
<td>512</td>
<td>467</td>
</tr>
<tr>
<td>2 (Chicago)</td>
<td>570</td>
<td>506</td>
</tr>
<tr>
<td>3 (Springfield)</td>
<td>730</td>
<td>663</td>
</tr>
<tr>
<td>4 (Belleville)</td>
<td>1,035</td>
<td>940</td>
</tr>
<tr>
<td>5 (Marion)</td>
<td>903</td>
<td>820</td>
</tr>
</tbody>
</table>

\[ \text{CF}_{SSP} = \text{Summer System Peak Coincidence Factor for Central A/C (during system peak hour)} \]

\[ = 68\% \]

---

1435 $F_e$ 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.

1436 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](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.
CF_{SSP} = \text{Summer System Peak Coincidence Factor for Heat Pumps (during system peak hour)}
= \text{72\%}^{1438}

CF_{PJM} = \text{PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)}
= \text{46.6\%}^{1439}

Other factors as defined above

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:

\[ \Delta kW_{SSP} = \frac{501}{570} \times 0.68 \]
\[ = 0.60 \text{ kW} \]

\[ \Delta kW_{PJM} = \frac{501}{570} \times 0.466 \]
\[ = 0.410 \text{ kW} \]

**NATURAL GAS SAVINGS**

If Natural Gas heating:

\[ \Delta \text{Therm} = \left( \frac{\text{CMF}_{50_{existing}} - \text{CMF}_{50_{new}}}{N_{heat}} \right) \times 60 \times 24 \times \text{HDD} \times 0.018 \]
\[ \text{Where:} \]
\[ N_{heat} = \text{Conversion factor from leakage at 50 Pascal to leakage at natural conditions} \]
\[ = \text{Based on climate zone, building height and exposure level}^{1440} : \]

<table>
<thead>
<tr>
<th># Stories:</th>
<th>1</th>
<th>1.5</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Well Shielded</td>
<td>22.2</td>
<td>20.0</td>
<td>17.8</td>
<td>15.5</td>
</tr>
<tr>
<td>Normal</td>
<td>18.5</td>
<td>16.7</td>
<td>14.8</td>
<td>13.0</td>
</tr>
<tr>
<td>Exposed</td>
<td>16.7</td>
<td>15.0</td>
<td>13.3</td>
<td>11.7</td>
</tr>
<tr>
<td>Zone 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Well Shielded</td>
<td>25.8</td>
<td>23.2</td>
<td>20.6</td>
<td>18.1</td>
</tr>
<tr>
<td>Normal</td>
<td>21.5</td>
<td>19.4</td>
<td>17.2</td>
<td>15.1</td>
</tr>
<tr>
<td>Exposed</td>
<td>19.4</td>
<td>17.4</td>
<td>15.5</td>
<td>13.5</td>
</tr>
</tbody>
</table>

\text{HDD} = \text{Heating Degree Days}^{1437} \]

\text{Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.}^{1438}

\text{Based on analysis of metering results from 24 heat pumps in Ameren Illinois service territory in PY5 coincident with AIC's 2010 system peak; 'Impact and Process Evaluation of Ameren Illinois Company's Residential HVAC Program (PY5)'}.^{1439}

\text{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.}^{1440}

\text{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.}
Air Sealing

ηHeat = Efficiency of heating system
= Equipment efficiency * distribution efficiency
= Actual\(^{1442}\). If not available use 70%\(^{1443}\).
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:

\[
\Delta \text{Therms} = \frac{(3,400 - 2,250)/17.8) * 60 * 24 * 6339 * 0.018)}{(0.7 * 100,000)} = 152 \text{ therms}
\]

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A


\(^{1442}\) 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](http://www.bpi.org/files/pdf/DistributionEfficiencyTable-BlueSheet.pdf) or by performing duct blaster testing.

\(^{1443}\) 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)](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-AIRS-V03-150601
5.6.2 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.¹⁴⁴⁴

**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.

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during utility peak hour)  
= 68%^{1445}

CF_{SSP} = Summer System Peak Coincidence Factor for Heat Pumps (during system peak hour)  
= 72%^{1446}

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)  
= 46.6%^{1447}

Algorithm

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

Where available savings from shell insulation measures should be determined through a custom analysis. When that is not feasible for the program the following engineering algorithms can be used with the inclusion of an adjustment factor to de-rate the heating savings.

\[
\Delta kWh = (\Delta kWh_{cooling} + \Delta kWh_{heating})
\]

Where:

\[
\Delta kWh_{cooling} = \text{If central cooling, reduction in annual cooling requirement due to insulation}
\]

\[
= (((1/R_{old\ AG} - 1/(R_{added}+R_{old\ AG})) * L_{basement\ wall\ total} * H_{basement\ wall\ AG} * (1-Framing\ factor)) * 24 * CDD * DUA) / (1000 * \eta_{Cool}))
\]

\[
R_{added} = R-value of additional spray foam, rigid foam, or cavity insulation.
\]

\[
R_{old\ AG} = R-value value of foundation wall above grade.
\]

\[
= \text{Actual, if unknown assume 1.0}^{1448}
\]

\[
L_{basement\ wall\ total} = \text{Length of basement wall around the entire insulated perimeter (ft)}
\]

\[
H_{basement\ wall\ AG} = \text{Height of insulated basement wall above grade (ft)}
\]

Framing\ factor = Adjustment to account for area of framing when cavity insulation is used

---

^{1445} Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.

^{1446} Based on analysis of metering results from 24 heat pumps in Ameren Illinois service territory in PY5 coincident with AIC’s 2010 system peak; ‘Impact and Process Evaluation of Ameren Illinois Company’s Residential HVAC Program (PY5)’.

^{1447} 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.

= 0% if Spray Foam or External Rigid Foam

= 25% if studs and cavity insulation

24 = Converts hours to days

CDD = Cooling Degree Days

= Dependent on location and whether basement is conditioned.

<table>
<thead>
<tr>
<th>Climate Zone (City based upon)</th>
<th>Conditioned CDD 65</th>
<th>Unconditioned CDD 65 [1451]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Rockford)</td>
<td>820</td>
<td>263</td>
</tr>
<tr>
<td>2 (Chicago)</td>
<td>842</td>
<td>281</td>
</tr>
<tr>
<td>3 (Springfield)</td>
<td>1,108</td>
<td>436</td>
</tr>
<tr>
<td>4 (Belleville)</td>
<td>1,570</td>
<td>538</td>
</tr>
<tr>
<td>5 (Marion)</td>
<td>1,370</td>
<td>570</td>
</tr>
<tr>
<td>Weighted Average [1452]</td>
<td>947</td>
<td>325</td>
</tr>
</tbody>
</table>

DUA = Discretionary Use Adjustment (reflects the fact that people do not always operate their AC when conditions may call for it).

= 0.75 [1453]

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: [1454]

---

[1449] ASHRAE, 2001, “Characterization of Framing Factors for New Low-Rise Residential Building Envelopes (904-RP),” Table 7.1

[1450] 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.

[1451] 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.

[1452] Weighted based on number of occupied residential housing units in each zone.

[1453] 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.

[1454] 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.
ΔkWh\_heating = If electric heat (resistance or heat pump), reduction in annual electric heating due to insulation

$$\Delta kWh_{\text{heating}} = \frac{((1/R_{\text{old AG}} - 1/(R_{\text{added}} + R_{\text{old AG}})) \times L_{\text{basement\_wall\_total}} \times H_{\text{basement\_wall\_AG}} \times (1 - \text{Framing\_factor}))/((1/R_{\text{old BG}} - 1/(R_{\text{added}} + R_{\text{old BG}})) \times L_{\text{basement\_wall\_total}} \times (H_{\text{basement\_wall\_total}} - H_{\text{basement\_wall\_AG}}) \times (1 - \text{Framing\_factor})) \times 24 \times \text{HDD}}{(3,412 \times \eta_{\text{Heat}})} \times \text{ADJ}_{\text{basement}}$$

Where

- \( R_{\text{old BG}} \) = R-value value of foundation wall below grade (including thermal resistance of the earth)\(^{1455}\)

- = dependent on depth of foundation \((H_{\text{basement\_wall\_total}} - H_{\text{basement\_wall\_AG}})\):

- = Actual R-value of wall plus average earth R-value by depth in table below

### Below Grade R-value

<table>
<thead>
<tr>
<th>Depth below grade (ft)</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earth R-value (°F-ft(^2)-h/Btu)</td>
<td>2.44</td>
<td>4.50</td>
<td>6.30</td>
<td>8.40</td>
<td>10.44</td>
<td>12.66</td>
<td>14.49</td>
<td>17.00</td>
<td>20.00</td>
</tr>
<tr>
<td>Average Earth R-value (°F-ft2-h/Btu)</td>
<td>2.44</td>
<td>3.47</td>
<td>4.41</td>
<td>5.41</td>
<td>6.42</td>
<td>7.46</td>
<td>8.46</td>
<td>9.53</td>
<td>10.69</td>
</tr>
<tr>
<td>Total BG R-value (earth + R-1.0 foundation) default</td>
<td>3.44</td>
<td>4.47</td>
<td>5.41</td>
<td>6.41</td>
<td>7.42</td>
<td>8.46</td>
<td>9.46</td>
<td>10.53</td>
<td>11.69</td>
</tr>
</tbody>
</table>

- \( H_{\text{basement\_wall\_total}} \) = Total height of basement wall (ft)

- HDD = Heating Degree Days

\(^{1455}\) Adapted from Table 1, page 24.4, of the 1977 ASHRAE Fundamentals Handbook
= dependent on location and whether basement is conditioned.\textsuperscript{1456}

<table>
<thead>
<tr>
<th>Climate Zone (City based upon)</th>
<th>Conditioned HDD 60</th>
<th>Unconditioned HDD 50</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Rockford)</td>
<td>5,352</td>
<td>3,322</td>
</tr>
<tr>
<td>2 (Chicago)</td>
<td>5,113</td>
<td>3,079</td>
</tr>
<tr>
<td>3 (Springfield)</td>
<td>4,379</td>
<td>2,550</td>
</tr>
<tr>
<td>4 (Belleville)</td>
<td>3,378</td>
<td>1,789</td>
</tr>
<tr>
<td>5 (Marion)</td>
<td>3,438</td>
<td>1,796</td>
</tr>
<tr>
<td>Weighted Average\textsuperscript{1457}</td>
<td>4,860</td>
<td>2,895</td>
</tr>
</tbody>
</table>

\(\eta_{\text{Heat}}\) = Efficiency of heating system

= Actual. If not available refer to default table below.\textsuperscript{1458}

<table>
<thead>
<tr>
<th>System Type</th>
<th>Age of Equipment</th>
<th>HSPF Estimate</th>
<th>(\eta_{\text{Heat}}) (Effective COP Estimate) ((\text{HSPF/3.413)}\times0.85)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat Pump</td>
<td>Before 2006</td>
<td>6.8</td>
<td>1.7</td>
</tr>
<tr>
<td></td>
<td>After 2006 - 2014</td>
<td>7.7</td>
<td>1.92</td>
</tr>
<tr>
<td></td>
<td>2015 on</td>
<td>8.2</td>
<td>2.40</td>
</tr>
<tr>
<td>Resistance</td>
<td>N/A</td>
<td>N/A</td>
<td>1</td>
</tr>
</tbody>
</table>

\(ADJ_{\text{Basement}}\) = Adjustment for basement wall insulation to account for prescriptive engineering algorithms overclaiming savings.

= 88%\textsuperscript{1459}

\textsuperscript{1456} 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 front of the TRM providing the appropriate city to use for each county of Illinois.

\textsuperscript{1457} Weighted based on number of occupied residential housing units in each zone.

\textsuperscript{1458} 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.

\textsuperscript{1459} Based upon comparing algorithm derived savings estimate and evaluated bill analysis estimate in the following 2012
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 / (2.25 + 6.42) – 1 / (13 + 2.25 + 
6.42)) * (20+25+20+25) * 4 * (1-0))) * 24 * 3079) / (3412 * 1.92)] * 0.88
= (49.3 + 1263.0)
= 1312.3 kWh

ΔkWh_heating = If gas furnace heat, kWh savings for reduction in fan run time
= ΔTherms * Fe * 29.3

Fe = Furnace Fan energy consumption as a percentage of annual fuel consumption
= 3.14%

29.3 = kWh per therm

For example, a single family home in Chicago with a 20 by 25 by 7 foot R-2.25 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:

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, and a 70% efficient furnace (for therm calculation see
Natural Gas Savings section):

= 118.1 * 0.0314 * 29.3
= 109 kWh

SUMMER COINCIDENT PEAK DEMAND

ΔkW = (ΔkWh_cooling / FLH_cooling) * CF

Where:

FLH_cooling = Full load hours of air conditioning

1460 Fe 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% Fe. See
“Programmable Thermostats Furnace Fan Analysis.xlsx” for reference.
= dependent on location\textsuperscript{1461}: 

\begin{table}[h]
\centering
\begin{tabular}{|c|c|c|}
\hline
\textbf{Climate Zone} & \textbf{Single Family} & \textbf{Multifamily} \\
\textbf{(City based upon)} & & \\
\hline
1 (Rockford) & 512 & 467 \\
2 (Chicago) & 570 & 506 \\
3 (Springfield) & 730 & 663 \\
4 (Belleville) & 1,035 & 940 \\
5 (Marion) & 903 & 820 \\
\hline
\textbf{Weighted Average}\textsuperscript{1462} & 629 & 564 \\
\hline
\end{tabular}
\end{table}

\textbf{CF\textsubscript{SSP}} = Summer System Peak Coincidence Factor for Central A/C (during system peak hour) 
\vspace{0.5cm}
= 68\%\textsuperscript{1463}
\vspace{0.5cm}
\textbf{CF\textsubscript{SSP}} = Summer System Peak Coincidence Factor for Heat Pumps (during system peak hour) 
\vspace{0.5cm}
= 72\%\textsuperscript{1464}
\vspace{0.5cm}
\textbf{CF\textsubscript{PJM}} = PJM Summer Peak Coincidence Factor for Central A/C (average during peak period) 
\vspace{0.5cm}
= 46.6\%\textsuperscript{1465}

\begin{itemize}
\item 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:
\end{itemize}

\begin{align*}
\Delta kW\textsubscript{SSP} &= \frac{49.3}{570} \times 0.68 \\
&= 0.059 \text{ kW} \\
\Delta kW\textsubscript{PJM} &= \frac{49.3}{570} \times 0.466 \\
&= 0.040 \text{ kW}
\end{align*}

\textsuperscript{1461} Full load hours for Chicago, Moline and Rockford are provided in “Final Evaluation Report: Central Air Conditioning Efficiency Services (CACES), 2010, Navigant Consulting”, \url{http://ilsagfiles.org/SAG_files/Evaluation_Documents/ComEd/ComEd%20EPY2%20Evaluation%20Reports/ComEd_Central_AC_Efficiency_Services_PY2_Evaluation_Report_Final.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 front of the TRM providing the appropriate city to use for each county of Illinois.

\textsuperscript{1462} Weighted based on number of occupied residential housing units in each zone.

\textsuperscript{1463} Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.

\textsuperscript{1464} Based on analysis of metering results from 24 heat pumps in Ameren Illinois service territory in PY5 coincident with AIC’s 2010 system peak; ‘Impact and Process Evaluation of Ameren Illinois Company’s Residential HVAC Program (PYS)’.

\textsuperscript{1465} 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:

\[
\Delta \text{Therms} = \left( \frac{1}{R_{old\_AG}} - \frac{1}{R_{added}} \right) \times L_{basement\_wall\_total} \times H_{basement\_wall\_AG} \times (1 - \text{Framing\_factor}) + \left( \frac{1}{R_{old\_BG}} - \frac{1}{R_{added}} \right) \times L_{basement\_wall\_total} \times (H_{basement\_wall\_total} - H_{basement\_wall\_AG}) \times (1 - \text{Framing\_factor}) \times 24 \times \text{HDD} / (\eta_{\text{Heat}} \times 100,067) \times \text{ADJ}_{\text{Basement}}
\]

\[\eta_{\text{Heat}} = \text{Efficiency of heating system} \]
\[= \text{Equipment efficiency} \times \text{distribution efficiency} \]
\[= \text{Actual. If unknown assume 70%}^{1466} \]

Other factors as defined above

For example, a single family home in Chicago with a 20 by 25 by 7 foot R-2.25 basement, with 3 feet above grade, insulated with R-13 of interior spray foam, and a 70% efficient furnace:

\[
= \left( \frac{1}{2.25} - \frac{1}{13 + 2.25} \right) \times (20+25+20+25) \times 3 \times (1-0) + \left( \frac{1}{8.67} - \frac{1}{13 + 8.67} \right) \times (20+25+20+25) \times 4 \times (1-0) \times 24 \times 3079 / (0.7 \times 100,067) \times 0.88
\]

= 118.1 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-SHL-BINS-V06-150601

---

1466 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:

\[(0.24 \times 0.92) + (0.76 \times 0.8) \times (1-0.15) = 0.70\]
5.6.3 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.\textsuperscript{1467}

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

\textsuperscript{1467} Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007
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.

\[
\text{CF}_{\text{SSP}} = \text{Summer System Peak Coincidence Factor for Central A/C (during utility peak hour)}
\]
\[
= 68\%^{1468}
\]
\[
\text{CF}_{\text{SSP}} = \text{Summer System Peak Coincidence Factor for Heat Pumps (during system peak hour)}
\]
\[
= 72\%^{1469}
\]
\[
\text{CF}_{\text{PJM}} = \text{PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)}
\]
\[
= 46.6\%^{1470}
\]

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

Where available savings from shell insulation measures should be determined through a custom
analysis. When that is not feasible for the program the following engineering algorithms can be used with the
inclusion of an adjustment factor to de-rate the heating savings.

\[
\Delta \text{kWh} = (\Delta \text{kWh}_\text{cooling} + \Delta \text{kWh}_\text{heating})
\]

Where:

\[
\Delta \text{kWh}_\text{cooling} = \text{If central cooling, reduction in annual cooling requirement due to insulation}
\]
\[
= (((1/\text{R}_\text{old} - 1/(\text{R}_\text{added}+\text{R}_\text{old})) \times \text{Area} \times (1-\text{Framing\_factor}) \times 24 \times \text{CDD} \times \text{DUA}) / (1000 \times \eta\text{Cool}))
\]

\[
\text{R}_\text{old} = \text{R-value value of floor before insulation, assuming 3/4” plywood subfloor and carpet}
\]
\[
= \text{with pad}
\]
\[
= \text{Actual. If unknown assume 3.96}^{1471}
\]

\[
\text{R}_\text{added} = \text{R-value of additional spray foam, rigid foam, or cavity insulation.}
\]

\[
\text{Area} = \text{Total floor area to be insulated}
\]

\[
\text{Framing\_factor} = \text{Adjustment to account for area of framing}
\]
\[
= 12\%^{1472}
\]

1468 Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.
1469 Based on analysis of metering results from 24 heat pumps in Ameren Illinois service territory in PY5 coincident with AIC’s
2010 system peak; ‘Impact and Process Evaluation of Ameren Illinois Company’s Residential HVAC Program (PYS)’.
1470 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.
1471 Based on 2005 ASHRAE Handbook – Fundamentals: assuming 2x8 joists, 16” OC, ¾” subfloor, ½” carpet with rubber pad,
and accounting for a still air film above and below: 1/ [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))] = 3.96
1472 ASHRAE, 2001, “Characterization of Framing Factors for New Low-Rise Residential Building Envelopes (904-RP),” Table 7.1
24 = Converts hours to days
CDD = Cooling Degree Days

<table>
<thead>
<tr>
<th>Climate Zone (City based upon)</th>
<th>Unconditioned CDD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Rockford)</td>
<td>263</td>
</tr>
<tr>
<td>2 (Chicago)</td>
<td>281</td>
</tr>
<tr>
<td>3 (Springfield)</td>
<td>436</td>
</tr>
<tr>
<td>4 (Belleville)</td>
<td>538</td>
</tr>
<tr>
<td>5 (Marion)</td>
<td>570</td>
</tr>
<tr>
<td><strong>Weighted Average</strong></td>
<td><strong>325</strong></td>
</tr>
</tbody>
</table>

DUA = Discretionary Use Adjustment (reflects the fact that people do not always operate their AC when conditions may call for it).

= 0.75

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:

<table>
<thead>
<tr>
<th>Age of Equipment</th>
<th>ηCool Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before 2006</td>
<td>10</td>
</tr>
<tr>
<td>2006 - 2014</td>
<td>13</td>
</tr>
<tr>
<td>Central AC After 1/1/2015</td>
<td>13</td>
</tr>
<tr>
<td>Heat Pump After 1/1/2015</td>
<td>14</td>
</tr>
</tbody>
</table>

ΔkWh_heating = If electric heat (resistance or heat pump), reduction in annual electric heating due to insulation

\[
\Delta k\text{Wh}_{\text{heating}} = \left(\frac{1}{R_{\text{old}}} - 1/(R_{\text{added}} + R_{\text{old}})\right) \times \text{Area} \times (1 - \text{Framing factor}) \times 24 \times \text{HDD} / (3,412 \times \eta_{\text{Heat}}) \times \text{ADJ}_{\text{Floor}}
\]

---

1473 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.

1474 Weighted based on number of occupied residential housing units in each zone.

1475 Energy Center of Wisconsin, May 2008 metering study; “Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research”, p31.

1476 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: 1477

<table>
<thead>
<tr>
<th>Climate Zone (City based upon)</th>
<th>Unconditioned HDD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Rockford)</td>
<td>3,322</td>
</tr>
<tr>
<td>2 (Chicago)</td>
<td>3,079</td>
</tr>
<tr>
<td>3 (Springfield)</td>
<td>2,550</td>
</tr>
<tr>
<td>4 (Belleville)</td>
<td>1,789</td>
</tr>
<tr>
<td>5 (Marion)</td>
<td>1,796</td>
</tr>
<tr>
<td>Weighted Average</td>
<td>2,895</td>
</tr>
</tbody>
</table>

\( \eta_{\text{Heat}} \) = Efficiency of heating system

\( \eta_{\text{Heat}} \) = Actual. If not available refer to default table below: 1479

<table>
<thead>
<tr>
<th>System Type</th>
<th>Age of Equipment</th>
<th>HSPF Estimate</th>
<th>( \eta_{\text{Heat}} ) (Effective COP Estimate) (HSPF/3.413)*0.85</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat Pump</td>
<td>Before 2006</td>
<td>6.8</td>
<td>1.7</td>
</tr>
<tr>
<td></td>
<td>2006 - 2014</td>
<td>7.7</td>
<td>1.92</td>
</tr>
<tr>
<td></td>
<td>2015 on</td>
<td>8.2</td>
<td>2.40</td>
</tr>
<tr>
<td>Resistance</td>
<td>N/A</td>
<td>N/A</td>
<td>1</td>
</tr>
</tbody>
</table>

\( \text{ADJ}_{\text{floor}} \) = Adjustment for floor insulation to account for prescriptive engineering algorithms overclaiming savings.

\( \text{ADJ}_{\text{floor}} \) = 88% 1480

Other factors as defined above

---

1477 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.

1478 Weighted based on number of occupied residential housing units in each zone.

1479 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.

1480 Based upon comparing algorithm derived savings estimate and evaluated bill analysis estimate in the following 2012 Massachusetts report: “Home Energy Services Impact Evaluation”, August 2012. See “Insulation ADJ calculations.xls” for details or calculation. Note that basement wall is used as a proxy for crawlspace ceiling.
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:

\[ \Delta k\text{Wh} = (\Delta k\text{Wh}_{\text{cooling}} + \Delta k\text{Wh}_{\text{heating}}) \]

\[ = (1/(3.96 - 1/(30+3.96)) ∗ (20 ∗ 25) ∗ (1 - 0.12) ∗ 24 ∗ 281 ∗ 0.75) / (1000 ∗ 10.5) + (((1/3.96 - 1/(30+3.96)) ∗ (20 ∗ 25) ∗ (1 - 0.15) ∗ 24 ∗ 3079) / (3412 ∗ 1.92)) ∗ 0.88 \]

\[ = (47.3 + 941.1) \]

\[ = 988.4 \text{ kWh} \]

\[ \Delta k\text{Wh}_{\text{heating}} = \text{If gas furnace heat, kWh savings for reduction in fan run time} \]

\[ = \Delta \text{Therms} ∗ F_e ∗ 29.3 \]

\[ F_e = \text{Furnace Fan energy consumption as a percentage of annual fuel consumption} \]

\[ = 3.14\%^{1481} \]

\[ 29.3 = \text{kWh per therm} \]

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 (for therm calculation see Natural Gas Savings section):

\[ \Delta k\text{Wh} = 91.2 ∗ 0.0314 ∗ 29.3 \]

\[ = 83.9 \text{ kWh} \]

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

\[ \Delta kW = (\Delta k\text{Wh}_{\text{cooling}} / \text{FLH}_{\text{cooling}}) ∗ CF \]

Where:

\[ \text{FLH}_{\text{cooling}} = \text{Full load hours of air conditioning} \]

\[ = \text{Dependent on location}^{1482} \]

<table>
<thead>
<tr>
<th>Climate Zone (City based upon)</th>
<th>Single Family</th>
<th>Multifamily</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Rockford)</td>
<td>512</td>
<td>467</td>
</tr>
<tr>
<td>2 (Chicago)</td>
<td>570</td>
<td>506</td>
</tr>
</tbody>
</table>

\(^{1481}\) \text{F}_e\text{ 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% \text{F}_e. See “Programmable Thermostats Furnace Fan Analysis.xlsx” for reference.}

\(^{1482}\) \text{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.}
Illinois Statewide Technical Reference Manual - 5.6.3 Floor Insulation Above Crawlspace

<table>
<thead>
<tr>
<th>Climate Zone (City based upon)</th>
<th>Single Family</th>
<th>Multifamily</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 (Springfield)</td>
<td>730</td>
<td>663</td>
</tr>
<tr>
<td>4 (Belleville)</td>
<td>1,035</td>
<td>940</td>
</tr>
<tr>
<td>5 (Marion)</td>
<td>903</td>
<td>820</td>
</tr>
<tr>
<td>Weighted Average (^{1483})</td>
<td>629</td>
<td>564</td>
</tr>
</tbody>
</table>

\(^{1483}\) Weighted based on number of occupied residential housing units in each zone.

\(^{1484}\) Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.

\(^{1485}\) Based on analysis of metering results from 24 heat pumps in Ameren Illinois service territory in PY5 coincident with AIC’s 2010 system peak; ‘Impact and Process Evaluation of Ameren Illinois Company’s Residential HVAC Program (PY5)’.

\(^{1486}\) 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.

\(CF_{SSP}\) = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)  
\(CF_{SSP}\) = 68\(^{1484}\)

\(CF_{SSP}\) = Summer System Peak Coincidence Factor for Heat Pumps (during system peak hour)  
\(CF_{SSP}\) = 72\(^{1485}\)%

\(CF_{PJM}\) = PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)  
\(CF_{PJM}\) = 46.6\(^{1486}\)%

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:

\(\Delta kW_{SSP} = \frac{47.3}{570} \times 0.68\)  
= 0.056 kW

\(\Delta kW_{SSP} = \frac{47.3}{570} \times 0.466\)  
= 0.039 kW

**NATURAL GAS SAVINGS**

If Natural Gas heating:

\[\Delta \text{Therms} = \frac{\left(\frac{1}{R_{\text{old}}} - \frac{1}{(R_{\text{added}}+R_{\text{old}})}\right) \times \text{Area} \times (1-\text{Framing\_factor}) \times 24 \times \text{HDD}}{(100,000 \times \eta_{\text{Heat}}) \times ADJ_{\text{Floor\_Gas\_Heat}}}\]

Where

\(^{1483}\) Weighted based on number of occupied residential housing units in each zone.
ηHeat = Efficiency of heating system

= Equipment efficiency * distribution efficiency

= Actual. If unknown assume 70% \(^{1487}\)

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:

\[
\text{ΔTherms} = \frac{1}{3.96} - \frac{1}{(30 + 3.96)} \times 20 \times 25 \times (1 - 0.12) \times 24 \times 3079 \times (100,000 \times 0.70) \times 0.88
\]

= 91.2 therms

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: RS-SHL-FINS-V06-150601**

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\(^{1487}\) 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:

\[ (0.24 \times 0.92) + (0.76 \times 0.8) \times (1 - 0.15) = 0.70 \]
5.6.4 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.¹⁴⁸⁸

DEEMED MEASURE COST
The actual installed cost for this measure should be used in screening.

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.

\[ CF_{SSP} = \text{Summer System Peak Coincidence Factor for Central A/C (during utility peak hour)} \]
\[ = 68\% \]¹⁴⁸⁹

\[ CF_{SSP} = \text{Summer System Peak Coincidence Factor for Heat Pumps (during system peak hour)} \]

¹⁴⁸⁹ Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.
Algorithm

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

Where available savings from shell insulation measures should be determined through a custom analysis. When that is not feasible for the program the following engineering algorithms can be used with the inclusion of an adjustment factor to de-rate the heating savings.

\[
\Delta k\text{Wh} = (\Delta k\text{Wh}_{\text{cooling}} + \Delta k\text{Wh}_{\text{heating}})
\]

Where

\[
\Delta k\text{Wh}_{\text{cooling}} = \text{If central cooling, reduction in annual cooling requirement due to insulation}
\]

\[
= \left(\left(\frac{1}{R_{\text{old}}} - \frac{1}{R_{\text{wall}}}\right) \cdot A_{\text{wall}} \cdot (1 - \text{Framing factor}_{\text{wall}}) + \left(\frac{1}{R_{\text{old}}} - \frac{1}{R_{\text{attic}}}\right) \cdot A_{\text{attic}} \cdot (1 - \text{Framing factor}_{\text{attic}})\right) \cdot 24 \cdot \text{CDD} \cdot \text{DUA} / (1000 \cdot \eta_{\text{Cool}})
\]

\[
R_{\text{wall}} = \text{R-value of new wall assembly (including all layers between inside air and outside air)}.
\]

\[
R_{\text{attic}} = \text{R-value of new attic assembly (including all layers between inside air and outside air)}.
\]

\[
R_{\text{old}} = \text{R-value value of existing assemble and any existing insulation. (Minimum of R-5 for uninsulated assemblies)}
\]

\[
A_{\text{wall}} = \text{Net area of insulated wall (ft}^2\text{)}
\]

\[
A_{\text{attic}} = \text{Total area of insulated ceiling/attic (ft}^2\text{)}
\]

\[
\text{Framing factor}_{\text{wall}} = \text{Adjustment to account for area of framing}
\]

\[
= 25\%^{1493}
\]

\[
\text{Framing factor}_{\text{attic}} = \text{Adjustment to account for area of framing}
\]

\[
= 7\%^{1494}
\]

\[
24 = \text{Converts hours to days}
\]

\[
\text{CDD} = \text{Cooling Degree Days}
\]

---

1490 Based on analysis of metering results from 24 heat pumps in Ameren Illinois service territory in PY5 coincident with AIC’s 2010 system peak; ‘Impact and Process Evaluation of Ameren Illinois Company’s Residential HVAC Program (PY5)’.  
1491 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.  
1492 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).  
1493 ASHRAE, 2001, “Characterization of Framing Factors for New Low-Rise Residential Building Envelopes (904-RP),” Table 7.1  
1494 Ibid.
= dependent on location:

<table>
<thead>
<tr>
<th>Climate Zone (City based upon)</th>
<th>CDD 65</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Rockford)</td>
<td>820</td>
</tr>
<tr>
<td>2 (Chicago)</td>
<td>842</td>
</tr>
<tr>
<td>3 (Springfield)</td>
<td>1,108</td>
</tr>
<tr>
<td>4 (Belleville)</td>
<td>1,570</td>
</tr>
<tr>
<td>5 (Marion)</td>
<td>1,370</td>
</tr>
<tr>
<td>Weighted Average</td>
<td>947</td>
</tr>
</tbody>
</table>

DUA = Discretionary Use Adjustment (reflects the fact that people do not always operate their AC when conditions may call for it).

= 0.75

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:

<table>
<thead>
<tr>
<th>Age of Equipment</th>
<th>ηCool Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before 2006</td>
<td>10</td>
</tr>
<tr>
<td>2006 - 2014</td>
<td>13</td>
</tr>
<tr>
<td>Central AC After 1/1/2015</td>
<td>13</td>
</tr>
<tr>
<td>Heat Pump After 1/1/2015</td>
<td>14</td>
</tr>
</tbody>
</table>

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_wall) * ADJ_Wall ) + (1/R_old - 1/R_attic) * A_attic * (1-Framing_factor_attic) * ADJ_Attic) * 24 * HDD] / (ηHeat * 3412)

1495 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.

1496 Weighted based on number of occupied residential housing units in each zone.

1497 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.

1498 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.\(^{1499}\)

<table>
<thead>
<tr>
<th>Climate Zone (City based upon)</th>
<th>HDD 60</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Rockford)</td>
<td>5,352</td>
</tr>
<tr>
<td>2 (Chicago)</td>
<td>5,113</td>
</tr>
<tr>
<td>3 (Springfield)</td>
<td>4,379</td>
</tr>
<tr>
<td>4 (Belleville)</td>
<td>3,378</td>
</tr>
<tr>
<td>5 (Marion)</td>
<td>3,438</td>
</tr>
<tr>
<td>Weighted Average(^{1500})</td>
<td>4,860</td>
</tr>
</tbody>
</table>

\(\eta_{\text{Heat}}\) = Efficiency of heating system

= Actual. If not available refer to default table below.\(^{1501}\)

<table>
<thead>
<tr>
<th>System Type</th>
<th>Age of Equipment</th>
<th>HSPF Estimate</th>
<th>(\eta_{\text{Heat}}) (Effective COP Estimate) (HSPF/3.413)*0.85</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat Pump</td>
<td>Before 2006</td>
<td>6.8</td>
<td>1.7</td>
</tr>
<tr>
<td></td>
<td>2006 - 2014</td>
<td>7.7</td>
<td>1.92</td>
</tr>
<tr>
<td></td>
<td>2015 on</td>
<td>8.2</td>
<td>2.40</td>
</tr>
<tr>
<td>Resistance</td>
<td>N/A</td>
<td>N/A</td>
<td>1</td>
</tr>
</tbody>
</table>

3412 = Converts Btu to kWh

\(ADJ_{\text{Wall}}\) = Adjustment for wall insulation to account for prescriptive engineering algorithms overclaiming savings.

= 63%\(^{1502}\)

\(^{1499}\) 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.

\(^{1500}\) Weighted based on number of occupied residential housing units in each zone.

\(^{1501}\) 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.

\(^{1502}\) Based upon comparing algorithm derived savings estimate and evaluated bill analysis estimate in the following 2012 Massachusetts report: “Home Energy Services Impact Evaluation”, August 2012. See “Insulation ADJ calculations.xls” for details or calculation.
ADJ_{Attic} = Adjustment for attic insulation to account for prescriptive engineering algorithms overclaiming savings.

= 74\%^{1503}

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:

\[
\Delta kWh = (\Delta kWh_{cooling} + \Delta kWh_{heating})
\]

\[
= \left(\frac{((1/5 - 1/11) \times 990 \times (1-0.25)) \times 700 \times (1-0.07)) \times 842 \times 0.75 \times 24}{(1000 \times 10.5)} \right) + \left(\frac{((1/5 - 1/38) \times 990 \times (1-0.25) \times 0.63) \times 700 \times (1-0.07) \times 0.74)) \times 5113 \times 24}{(1.92 \times 3412)}\right)
\]

\[= 280 + 2523\]

\[= 2803 \text{ kWh}\]

\[
\Delta kWh_{heating} = \text{If gas furnace heat, kWh savings for reduction in fan run time}
\]

\[= \Delta Therms \times F_e \times 29.3\]

\[F_e = \text{Furnace Fan energy consumption as a percentage of annual fuel consumption}\]

\[= 3.14\%^{1504}\]

\[29.3 = \text{kWh per therm}\]

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\% (for therm calculation see Natural Gas Savings section):

\[
\Delta kWh = 250.3 \times 0.0314 \times 29.3
\]

\[= 230 \text{ kWh}\]

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

\[
\Delta kW = (\Delta kWh_{cooling} / FLH_{cooling}) \times CF
\]

Where:

---

$^{1503}$ Based upon comparing algorithm derived savings estimate and evaluated bill analysis estimate in the following 2012 Massachusetts report: “Home Energy Services Impact Evaluation”, August 2012. See “Insulation ADJ calculations.xls” for details or calculation. Note that basement walls is used as a proxy for crawlspace ceiling.

$^{1504}$ $F_e$ 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.
FLH\textsubscript{cooling} = Full load hours of air conditioning

= Dependent on location as below:\textsuperscript{1505}

<table>
<thead>
<tr>
<th>Climate Zone (City based upon)</th>
<th>Single Family</th>
<th>Multifamily</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Rockford)</td>
<td>512</td>
<td>467</td>
</tr>
<tr>
<td>2 (Chicago)</td>
<td>570</td>
<td>506</td>
</tr>
<tr>
<td>3 (Springfield)</td>
<td>730</td>
<td>663</td>
</tr>
<tr>
<td>4 (Belleville)</td>
<td>1,035</td>
<td>940</td>
</tr>
<tr>
<td>5 (Marion)</td>
<td>903</td>
<td>820</td>
</tr>
<tr>
<td>Weighted Average\textsuperscript{1506}</td>
<td>629</td>
<td>564</td>
</tr>
</tbody>
</table>

CF\textsubscript{SSP} = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)

= 68%\textsuperscript{1507}

CF\textsubscript{SSP} = Summer System Peak Coincidence Factor for Heat Pumps (during system peak hour)

= 72%\textsuperscript{1508}

CF\textsubscript{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)

= 46.6%\textsuperscript{1509}

For example, a single family home in Chicago with 990 ft\textsuperscript{2} of R-5 walls insulated to R-11 and 700 ft\textsuperscript{2} of R-5 attic insulated to R-38, 10.5SEER Central AC and 2.26 COP Heat Pump:

\[ \Delta kW\textsubscript{SSP} = \frac{280}{570} \times 0.68 \]

= 0.33 kW

\[ \Delta kW\textsubscript{PJM} = \frac{280}{570} \times 0.466 \]

= 0.23 kW

\textsuperscript{1505} 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.

\textsuperscript{1506} Weighted based on number of occupied residential housing units in each zone.

\textsuperscript{1507} Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.

\textsuperscript{1508} Based on analysis of metering results from 24 heat pumps in Ameren Illinois service territory in PY5 coincident with AIC’s 2010 system peak; ‘Impact and Process Evaluation of Ameren Illinois Company’s Residential HVAC Program (PY5)’.

\textsuperscript{1509} 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:

\[
\Delta \text{Therms} = \frac{(((1/R_{\text{old}} - 1/R_{\text{wall}}) \times A_{\text{wall}} \times (1\text{-Framing\_factor\_wall}) \times \text{ADJ}_{\text{Wall}}) + ((1/R_{\text{old}} - 1/R_{\text{attic}}) \times A_{\text{attic}} \times (1\text{-Framing\_factor\_attic}) \times \text{ADJ}_{\text{Attic}})) \times 24 \times \text{HDD}}{(\eta_{\text{Heat}} \times 100,067 \text{ Btu/therm})}
\]

Where:

\[\text{HDD} = \text{Heating Degree Days}\]
\[= \text{Dependent on location}\]^{1510}

<table>
<thead>
<tr>
<th>Climate Zone (City based upon)</th>
<th>HDD 60</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Rockford)</td>
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</tr>
<tr>
<td>2 (Chicago)</td>
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<tr>
<td>3 (Springfield)</td>
<td>4,379</td>
</tr>
<tr>
<td>4 (Belleville)</td>
<td>3,378</td>
</tr>
<tr>
<td>5 (Marion)</td>
<td>3,438</td>
</tr>
<tr>
<td>Weighted Average^{1511}</td>
<td>4,860</td>
</tr>
</tbody>
</table>

\[\eta_{\text{Heat}} = \text{Efficiency of heating system}\]
\[= \text{Equipment efficiency} \times \text{distribution efficiency}\]
\[= \text{Actual}^{1512}\] If unknown assume 70%.^{1513}

Other factors as defined above

---

^{1510} 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.

^{1511} Weighted based on number of occupied residential housing units in each zone.

^{1512} 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](http://www.bpi.org/files/pdf/DistributionEfficiencyTable-BlueSheet.pdf) or by performing duct blaster testing.

^{1513} 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](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: \((0.24\times0.92) + (0.76\times0.8) \times (1-0.15) = 0.70\)
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%:

\[
\Delta \text{Therms} = \frac{\left(\frac{1}{5} - \frac{1}{11}\right) \times 990 \times (1-0.25) \times 0.63 + \left(\frac{1}{5} - \frac{1}{38}\right) \times 700 \times (1-0.07) \times 0.74 \right) \times 24 \times 5113}{(0.66 \times 100,067)}
\]

\[= 250.3 \text{ therms}\]

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: RS-SHL-AINS-V05-150601**

Attachment A

Illinois Statewide Net-to-Gross Methodologies

February 24th, 2015

FINAL

Effective for Evaluation: June 1st, 2015
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I. Illinois Statewide Net-to-Gross Methodologies

A. Policy Context for this Information

The Illinois Evaluation Teams (Opinion Dynamics, Cadmus Group, Navigant Consulting, Itron, and ADM Associates) are working with the Illinois Stakeholder Advisory Group (SAG) to create an Illinois Statewide Net-to-Gross (NTG) Methodologies document (IL-NTG Methods). The IL-NTG Methods document is included as an attachment to the Illinois Statewide Technical Reference Manual for Energy Efficiency (IL-TRM). Through five different dockets, the Illinois Commerce Commission (ICC) has directed the Evaluation Teams to compile and formalize standard NTG methods for use in Illinois energy-efficiency (EE) evaluation, measurement and verification (EM&V) work. The ICC EE dockets are shown in the following table.

<table>
<thead>
<tr>
<th>ICC Order Docket No. and Date</th>
<th>Program Administrator</th>
<th>NTG Discussion – Order Pages</th>
<th>ICC Link</th>
</tr>
</thead>
<tbody>
<tr>
<td>13-0550 (5/20/14)</td>
<td>North Shore Gas Company (North Shore Gas) and The Peoples Gas Light and Coke Company (Peoples Gas) (collectively, PG&amp;NSG or Integrys)</td>
<td>54-55, 66</td>
<td>ICC Order Docket No. 13-0550</td>
</tr>
</tbody>
</table>

To provide clarity to the ICC directives, the relevant section on IL-NTG Methods is shown in its entirety from the Nicor Gas Order (Docket No. 13-0549). The Nicor Gas Order provides the most detail on the ICC NTG directive in comparison to the other EE orders. The Nicor language is as follows:

The Commission believes that Staff’s recommendations concerning Commission adoption of consistent statewide net-to-gross methodologies (“IL-NTG Methods”) for use by the evaluators are reasonable and will aid in future evaluation of the energy efficiency programs. To help ensure the independence of the evaluators, to improve efficiency in the evaluation process, and to ensure programs across the state as delivered by the various program administrators can be meaningfully and consistently evaluated, the Commission hereby adopts Staff’s recommendation that consistent IL-NTG Methods be established for use in the evaluations of comparable energy efficiency programs offered by different Illinois program administrators. The Commission notes that Section 8-104(k) of the Act encourages statewide coordination and consistency between the gas and electric energy efficiency programs and Staff’s proposal would help ensure consistency in the evaluation of program performance. The Commission notes that this directive is not to create entirely “new” NTG methodologies for every energy efficiency program, but rather to assess NTG methodologies and survey instruments that have been used to evaluate energy efficiency programs offered in Illinois, and to compile the most
justifiable and well-vetted methodologies (or potentially combine certain components from the existing approaches to better represent the most justifiable and well-vetted method consistent with best practices) in an attachment to the Updated IL-TRM that would get submitted to the Commission for approval. The Commission notes that the IL-NTG Methods will be flexible and adaptable to multiple program designs and budgets and tailored to appropriately assess the specifics of each of the program administrators’ energy efficiency programs, consistent with standard NTG methodologies adopted in other states that were filed in this proceeding. The Commission agrees with Staff that in the interest of efficiency, the current program evaluators should take the lead in compiling and formalizing standard methodologies for NTG in Illinois taking into consideration SAG input. Because the existing Plan 1 evaluators are under contract with the Company for the evaluation of the program year three energy efficiency programs, it is appropriate for these existing evaluators to work on and complete the compilation of the IL-NTG Methods over the next year. The Commission recognizes that each year considerable time may be spent vetting NTG methodologies for each program evaluation separately for each utility under the existing evaluation plan review practices; adoption of IL-NTG Methods would save on these limited evaluation resources by having a common reference document for the evaluators to use in estimating net savings for Illinois.

The Commission hereby directs the Company to require its evaluators to collaborate with the other Illinois evaluators and the SAG to use best efforts to reach consensus on the approaches used in assessing NTG in particular markets for both residential and non-residential energy efficiency programs in a manner consistent with the direction described herein. (Pages 41-42)

(16) Northern Illinois Gas Company shall require its evaluators to collaborate with the other Illinois evaluators and the SAG to reach consensus on the most defensible and well-vetted methodologies for assessing net-to-gross ratios in particular markets for both residential and non-residential energy efficiency programs in a manner consistent with the direction provided herein;

(17) ICC Staff shall file the agreed-upon consensus statewide NTG methodologies with the Commission as an attachment to the Updated IL-TRM, and if consensus is not reached on a certain component of the statewide NTG methodologies, that particular non-consensus component should be submitted in a manner consistent with the approach used for non-consensus IL-TRM Updates; (Page 78)

**B. Programs Currently Covered in this Document**

This document will be updated over time to cover a range of programs. To facilitate completion of part of the IL-NTG Methods sections prior to March 1, 2015, this document includes methods specific for three program types: 1) Commercial, Industrial, and Public Sector Standard/Prescriptive and Custom programs, 2) Appliance Recycling programs, and 3) Residential Upstream Lighting programs. All NTG data collection and analysis activities for the program types covered by this document that start after the effective date, June 1, 2015, shall conform to the NTG methods set forth herein.
C. Updating the IL-NTG Methods

This attachment is part of the IL-TRM and follows the timeline for updating of the IL-TRM as specified in the IL-TRM Policy Document. In general, the following will take place:

- Updates will occur annually.
- Any changes to the IL-NTG Methods document will be circulated to the full SAG and SAG participants will have a ten business day review process.
- Updates will be discussed within the SAG and completed by March 1st.
- The ICC Staff will then submit a Staff Report (with the consensus Updated TRM attached) to the Commission with a request for expedited review and approval.

D. Diverging from the IL-NTG Methods

The NTG methods for the programs outlined in this document are partially binding. The criteria for deviating from the IL-NTG Methods document are set forth below. In all cases, the evaluators (or any interested stakeholder) submits the proposed deviation to the full SAG for a ten business day SAG review and comment period. In the event of an objection by a SAG participant, efforts may be made to see if consensus can be reached on the proposed deviation in a subsequent monthly SAG meeting. In this case, a final opportunity for SAG review and comment to the proposed deviation will be provided following the SAG meeting.

Evaluators may modify the approaches described in this document if the following three conditions have been satisfied:

1. Evaluators must explicate within the annual evaluation research plan (or other document) how specific items in the proposed modified NTG method will diverge from what is written in this document. Evaluators must justify why the divergence is appropriate.
2. Prior to the use of the modified NTG method for a particular program, evaluation teams must be in agreement on the use and execution of the modified NTG method.
3. No objection from SAG participants is received regarding the proposed modified NTG method within a ten business day SAG review and comment period.

Evaluators may test alternative methods of estimating NTG for a particular program (either in lieu of the NTG methods outlined in this document or in addition to the NTG methods outlined in this document), if the following three conditions have been satisfied:

1. Evaluators must explicate within the annual evaluation research plan (or other document) the proposed alternative NTG method. Evaluators must explain why the proposed alternative NTG method might be superior to the NTG methods outlined in this document for the particular program. Evaluators must discuss the foundation for expecting that the proposed alternative NTG method is likely to produce meaningful results.

2. Prior to the use of the alternative NTG method for a particular program, evaluation teams must be in agreement on the key details of the approach for implementing the alternative NTG method.

3. No objection from SAG participants is received regarding the proposed alternative NTG method for the particular program within a ten business day SAG review and comment period.

When performing alternative NTG methods for a particular program, the choice of methods may vary across the state. For example, if ComEd’s evaluator chooses to test Methods 1 and 2 for a particular program, Ameren’s and DCEO’s evaluators do not also have to perform Methods 1 and 2 for a similar program.

E. Procedure for Non-Consensus Items

Non-consensus items that arise during the development and updating of the IL-NTG Methods document will be handled in substantially the same way as non-consensus IL-TRM Updates are addressed. The approach to be used is as follows.

- Once the Illinois NTG Working Group\textsuperscript{1515} has progressed as far as they can on the methodology, and it has been found that there is non-consensus on a specific Net-to-Gross Methods topic or procedure, the Illinois NTG Working Group shall submit to the ICC Staff and the Stakeholder Advisory Group’s (SAG) Technical Advisory Committee (TAC) a Comparison Exhibit of Non-Consensus Net-to-Gross Methods topics/procedures within 1 week after the Illinois NTG Working Group has failed to reach consensus. The TAC will then deliberate on the issue with a goal of reaching consensus.

- If consensus does not emerge in the TAC regarding a particular Net-to-Gross Methods topic or procedure, the Comparison Exhibit of Non-Consensus NTG Methods topics/procedures is then sent to the full SAG for their deliberations and input. 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.

- If the full SAG is unable to reach consensus, the non-consensus item will be referred to the ICC for resolution at the time of the IL-TRM Update proceeding. After receipt of the Comparison Exhibit of Non-Consensus Net-to-Gross Methods topics/procedures, the ICC Staff will submit a Staff Report to the Commission to initiate a proceeding separate from the consensus IL-TRM Update proceeding to resolve the non-consensus Net-to-Gross Methods topics/procedures.

\textsuperscript{1515} The Illinois NTG Working Group consists primarily of the subset of Evaluators deliberating on NTG methodologies; however, any interested party may participate in the Illinois NTG Working Group.
II. Attribution in Energy Efficiency Programs in General

One of the most difficult aspects of evaluation, and not just within evaluation of energy efficiency programs, is attributing results to a program. Attribution provides credible evidence that there is a causal link between the program activities and the outcomes achieved by the program. Attribution research estimates the difference between the outcomes and those that would have occurred absent the program (i.e., the counterfactual). Put in research terms, evaluators must reject the null hypothesis of no causality through probabilistic statements (e.g., “strong evidence”, “high probability”). As such, it is important to realize that the concept of the counterfactual cannot be proven with certainty. So even though the NTG ratio is a single value, conceptually it is a probabilistic statement. One of the main academics within evaluation stated that there is a “…total and inevitable absence of certain knowledge [arising] from the methods social scientists use” when assessing the counterfactual. (Shadish, et al., 2002) This statement is not about poor methods, but about the counterfactual itself. Because programs work with people and are not a laboratory experiment that can be replicated over and over, to find out what actions people would have taken absent an intervention, one would need a time machine to take people back in time and not provide the program. Since time machines do not exist, evaluators have developed methods that approximate the counterfactual to the best of their ability.

For energy efficiency programs, evaluators differentiate between savings at a “gross” and “net” level as described below in the short set of relevant definitions. These definitions are not all encompassing or meant to restrict evaluation in any way, but to provide context before additional detail is provided in later sections. Research to determine attribution occurs to allow for a better understanding of the net level of savings.

Relevant Definitions:

<table>
<thead>
<tr>
<th>Concept</th>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumers</td>
<td>Nonparticipant</td>
<td>Any consumer who was eligible but did not participate in the subject efficiency program, in a given program year.</td>
</tr>
<tr>
<td></td>
<td>Participant</td>
<td>A consumer that received a service offered through the subject efficiency program, in a given program year; also called program participant. The term “service” is used in this definition to suggest that the service can be a wide variety of inducements, including financial rebates, technical assistance, product installations, training, energy efficiency information or other services, items, or conditions. Each evaluation plan should define “participant” as it applies to the specific evaluation.</td>
</tr>
<tr>
<td>Impacts</td>
<td>Gross Impacts</td>
<td>The change in energy consumption and/or demand that results directly from program-related actions taken by participants in an energy efficiency program, regardless of why they participated.</td>
</tr>
</tbody>
</table>

1516 A probabilistic statement is not the same as the confidence and precision information calculated based on sampling theory.
<table>
<thead>
<tr>
<th>Concept</th>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attribution</td>
<td>Net Impacts</td>
<td>The change in energy consumption and/or demand that is attributable to a particular energy efficiency program. This change in energy use and/or demand may include, implicitly or explicitly, consideration of factors such as free ridership, participant and nonparticipant spillover, and induced market effects. These factors may be considered in how a baseline is defined (e.g., common practice) and/or in adjustments to gross savings values.</td>
</tr>
<tr>
<td></td>
<td>Net-to-Gross</td>
<td>A factor representing net program savings divided by gross program savings that is applied to gross program impacts to convert them into net program impacts. The factor itself may be made up of a variety of factors that create differences between gross and net savings, commonly including free riders and spillover. The factor can be estimated and applied separately to either energy or demand savings.</td>
</tr>
<tr>
<td></td>
<td>Ratio</td>
<td></td>
</tr>
<tr>
<td>free rider</td>
<td>Free Rider</td>
<td>A program participant who would have implemented the program’s measure(s) or practice(s) in the absence of the program. Free riders can be (1) total, in which the participant’s activity would have completely replicated the program measure; (2) partial, in which the participant’s activity would have partially replicated the program measure; or (3) deferred, in which the participant’s activity would have partially or completely replicated the program measure, but at a future time.</td>
</tr>
<tr>
<td></td>
<td>Spillover</td>
<td>Reductions in energy consumption and/or demand caused by the presence of an energy efficiency program, beyond the program-claimed gross savings of the participants. There can be participant and/or nonparticipant spillover. Participant spillover is the additional energy savings that occur as a result of the program’s influence when a program participant independently installs incremental energy efficiency measures or applies energy-saving practices after having participated in the energy efficiency program. Nonparticipant spillover refers to energy savings that occur when a program nonparticipant installs energy efficiency measures or applies energy savings practices as a result of a program’s influence.</td>
</tr>
<tr>
<td></td>
<td>Market</td>
<td>The commercial activity (e.g., manufacturing, distributing, buying, and selling) associated with products and services that affect energy use.</td>
</tr>
<tr>
<td></td>
<td>Market Effects</td>
<td>A change in the structure of a market or the behavior of participants in a market that is reflective of an increase (or decrease) in the adoption of energy efficient products, services, or practices and is causally related to market interventions (e.g., programs). Examples of market effects include increased levels of awareness of energy efficient technologies among customers and suppliers, increased</td>
</tr>
<tr>
<td>Concept</td>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>---------</td>
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</tr>
<tr>
<td>availability of energy efficient technologies through retail channels, reduced prices for energy efficient models, build out of energy efficient model lines, and—the end goal—increased market share for energy efficient goods, services, and design practices.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Market Assessment | An analysis that provides an assessment of how and how well a specific market or market segment is functioning with respect to the definition of well-functioning markets or with respect to other specific policy objectives. A market assessment generally includes a characterization or description of the specific market or market segments, including a description of the types and number of buyers and sellers in the market, the key actors that influence the market, the type and number of transactions that occur on an annual basis, and the extent to which market participants consider energy efficiency an important part of these transactions. This analysis may also include an assessment of whether a market has been sufficiently transformed to justify a reduction or elimination of specific program interventions. Market assessment can be blended with strategic planning analysis to produce recommended program designs or budgets. One particular kind of market assessment effort is a baseline study, or the characterization of a market before the commencement of a specific intervention in the market for the purpose of guiding the intervention and/or assessing its effectiveness later. |  

III. Attribution within the Commercial, Industrial, and Public Sectors

Over thirty programs across a number of types of Commercial, Industrial, or Public Sector programs are expected to be offered in Illinois in electric program year 8 (EPY8) and gas program year 5 (GPY5) (i.e., June 2015 – May 2016). The evaluation team has worked partially through the NTG method for the Commercial & Industrial (C&I) and Public Sector Standard/Prescriptive and Custom programs. Future updates to this document will include a full NTG method for these programs as well as other programs.

A. Standard/Prescriptive and Custom Programs

All C&I and Public Sector Standard/Prescriptive and Custom programs offered in Illinois in GPY5/EPY8 are similar enough in scope and implementation to fall under the consistent methods outlined in this section. The detail drafted below documents agreements reached by the evaluation teams through approximately 10 hours of discussion spread out over five meetings which began in October 2014 and continued through early January 2015. Additionally, evaluators spent considerable amount of time prior to official meetings delving into NTG details. Consensus reached so far pertains to the self-report approach and is documented below.

1. Free Ridership

There have been several core agreements reached by the evaluation teams. These agreements should reduce potential methodological differences employed by different evaluation contractors. Each is bulleted below.

- **Multiple Questions**: Evaluators will use program participant responses to multiple survey questions as inputs to the free ridership calculation algorithm. Evaluators will not use the response to a single question to establish a survey respondent as either a complete free rider or a complete non-free rider.

- **Program and Non-Program Factors**: Evaluators will administer survey questions to obtain respondent ratings on a numeric scale of the impact, influence, or importance on the decision to implement energy efficiency measures or take energy efficiency actions. A series of questions will focus on factors that the evaluator determines are a function of the program. Such program factors may, for instance, include availability of the program incentive, technical assistance from program staff, program staff recommendations, program-administrator marketing materials, and endorsement or recommendation by utility account manager or program partner staff. Previous experience with the program is not a program factor for purposes of obtaining respondent ratings of program impact, influence, or importance on the decision to implement energy efficiency measures. Evaluators will also administer a series of questions to obtain respondent ratings on a numeric scale of the impact, influence, or importance on the decision to implement energy efficiency measures or factors that the evaluator determines are not a function of the program. Such non-program factors may include, for example, age or condition of existing equipment, previous experience with the measure, standard business or industry practice, and organizational policy or guidelines.

- **Mediation of Numeric Scales**: Evaluators will administer survey questions referencing numeric scoring scales for the purpose of quantifying free ridership. The numeric scales shall be based upon 11 points ranging from 0 to 10. Survey respondent numeric scores obtained from the administration of these questions will serve as inputs to the applied free ridership calculation algorithm. In calculating free ridership, survey respondent numeric scores may be mediated by other algorithmic components.
• **Vendor Recommendations**: Equipment vendor or contractor recommendations may also be a program factor to the extent that such recommendation is a function of the program. The evaluator may administer survey questions to vendors or contractors to verify their involvement with participant projects and to obtain respondent ratings – on a numeric scale – of the impact, influence, or importance of the program on the decision to recommend the energy efficiency measure(s) to the program participant.

• **Counterposing Program and Non-Program Factors**: Evaluators will administer a survey question that asks respondents to quantify the impact, influence, or importance on the decision to implement energy efficiency measures of factors that the evaluator determines are a function of the program relative to factors that the evaluator determines are not a function of the program.

• **Likelihood to Implement**: Evaluators will administer a survey question to obtain respondent ratings on a numeric scale of the likelihood of the respondent, in the absence of the program, to implement specified energy efficiency measures. The evaluator may administer questions to collect respondent self-report data regarding the respondent course of action, in the absence of the program, relating to the likelihood and timing of implementation, project scope, and measure characteristics.

• **Consistency Checks**: Evaluators should administer survey questions as checks on the consistency of responses associated with a core free ridership assessment methodology. Evaluators may also reference available data, including consistency check data, to perform documented modifications to individual free ridership estimates resulting from the application of a core free ridership assessment methodology.

The survey questions referenced above constitute basic guidelines for evaluators to use in the development and application of a core free ridership assessment methodology – these survey questions are not all encompassing and other survey questions may be asked by evaluators.

a) **Scoring Algorithm**

The evaluation teams have not yet reached agreement on the specific algorithm to use. There have been thoughtful discussions around the status quo algorithms, multiplying specific inputs rather than averaging them, and including partial free ridership through a very different approach of time-varying free ridership values\(^\text{1517}\).

The evaluation teams will continue discussions in 2015 with the intent of using future evaluations to pilot the algorithms.

2. **Spillover**

Spillover has not yet been discussed by the evaluation teams in terms of reaching consensus on spillover methods. Future methods will be informed by current spillover study results.

\(^{1517}\) Within time-varying free ridership, free ridership may vary over the course of measure life due to respondents’ self-reported timing of implementing actions under the counterfactual scenario (i.e., absence of the program). Free ridership may also vary based on project scope and measure characteristics associated with respondents’ self-reported actions under the counterfactual no-program scenario. As stated above, evaluators may, on a pilot basis, separately calculate the free ridership rate applicable to annualized first year gross energy savings and the free ridership rate applicable to gross energy savings occurring over the lifetime of implemented measures.
IV. Attribution within the Residential and Low Income Sectors

Over 30 programs across a number of types of Residential programs are expected to be offered in Illinois in EPY8/GPY5 (i.e., June 2015 – May 2016). The evaluation team has worked partially through the NTG method for Appliance Recycling programs and Residential Upstream Lighting programs. Future updates to this document will include a full NTG method for these programs as well as other programs.

A. Appliance Recycling Programs

Appliance recycling programs (ARPs) typically offer some mix of incentives and free pickups for the removal of old-but-operable refrigerators, freezers, or room air conditioners. These programs encourage consumers to undertake the following:

- Discontinue use of secondary or inefficient appliances;
- Relinquish appliances previously used as primary units upon their replacement (rather than keeping the old appliance as a secondary unit); and
- Prevent the continued use of old appliances in other households through direct transfers (i.e., giving it away or selling it) or indirect transfers (resale in the used appliance market).

As the program theory and logic for appliance recycling differ significantly from standard “downstream” incentive programs (which typically offer rebates for purchases of efficient products), the free ridership estimation approach also significantly differs.

There are basic and enhanced methods described next.

Basic Method

1. Free Ridership

Free ridership is based on participants’ anticipated plans had the program not been available, thus classifying a free rider as a participant who would have removed the unit from service regardless of the program.

Estimating net savings for ARPs should adopt a multistep process to segment participants into different groups, each with specific attributable savings.

In general, independent of program intervention, participating appliances would have been subject to one of the following options:

1. The appliance would have been kept by the participating household.
2. The appliance would have been discarded in a way that transfers the unit to another customer for continued use.
3. The appliance would have been discarded in a way that would have permanently removed the unit from service.

Only Option 3 constitutes free ridership (the proportion of units that would have been taken off the grid absent the program). Options 1 and 2 both indicate non-free riders. However, these respondents need to be further classified to account for potential induced replacement and secondary market impacts, both described below.
a) Data Collection

A participant survey—drawn from a random sample of participants—will serve as the primary source of data collected for estimating NTG for the ARP. To determine the percentage of participants in each of the three options, evaluators will begin by asking surveyed participants about the likely fate of their recycled appliance had it not been decommissioned through the program. Responses provided by participants generally can be categorized as follows:

1. Kept the appliance.
2. Sold the appliance to a private party (either an acquaintance or through a posted advertisement).
3. Sold or gave the appliance to a used-appliance dealer.
4. Gave the appliance to a private party, such as a friend or neighbor.
5. Gave the appliance to a charity organization, such as Goodwill Industries or a church.
6. Had the appliance removed by the dealer from whom the new or replacement appliance was obtained.
7. Hauled the appliance to a landfill or recycling center.
8. Hired someone else to haul the appliance away for junking, dumping, or recycling.

Additional, follow-up questions will be included to validate the viability of all responses.

Next evaluators will assess whether each participant’s final response indicates free ridership.

• Some final responses clearly indicate free ridership, such as: “I would have taken it to the landfill or recycling center myself.”

• Other responses clearly indicate no free ridership, as when the appliance would have remained active within the participating home (“I would have kept it and continued to use it”) or used elsewhere within the utility’s service territory (“I would have given it to a family member, neighbor, or friend to use”).

If the respondent planned to have the unit picked up by the retailer and the retailer would likely resell the unit in the secondary market, they are not a free rider. Absent retailer survey primary research described in the Enhanced Options below, the evaluators will utilize data from the most recent research conducted of the ComEd program to determine the proportion of free riders unless another metric is mutually agreed upon by the evaluators.\(^{1518}\)

\(^{1518}\) Note that such retailer interviews are being conducted annually for the ComEd ARP evaluation, and answers are used directly in the calculation of the NTG ratio in cases where: (1) the respondent planned to have the unit picked up by the retailer; and (2) the retailer was interviewed.
2. Secondary Market Impacts

In the event that the unit would have been transferred to another household (Option 2 above), the question then becomes what purchasing decisions are made by the would-be acquirers of participating units now that these units are unavailable. These would-be acquirers could:

1. Not purchase/acquire another unit.
2. Purchase/acquire another used unit.

Adjustments to savings based on these factors are referred to as the program’s secondary market impacts.

If it is determined that the participant would have directly or indirectly (through a market actor) transferred the unit to another customer on the grid, the next question addresses what that potential acquirer did because that unit was unavailable. There are three possibilities:

A. None of the would-be acquirers would find another unit. That is, program participation would result in a one-for-one reduction in the total number of appliances operating on the grid. In this case, the total energy consumption of avoided transfers (participating appliances that otherwise would have been used by another customer) should be credited as savings to the program. This position is consistent with the theory that participating appliances are essentially convenience goods for would-be acquirers. (That is, the potential acquirer would have accepted the appliance had it been readily available, but because the appliance was not a necessity, the potential acquirer would not seek out an alternate unit.)

B. All of the would-be acquirers would find another unit. Thus, program participation has no effect on the total number of appliances operating on the grid. This position is consistent with the notion that participating appliances are necessities and that customers will always seek alternative units when participating appliances are unavailable.

C. Some of the would-be acquirers would find another unit, while others would not. This possibility reflects the awareness that some acquirers were in the market for an appliance and would acquire another unit, while others were not (and would only have taken the unit opportunistically).

The evaluators will assume Possibility C unless primary research within a utility’s service territory to assess the secondary appliance market is undertaken as described in the Enhanced Options below. Specifically, evaluators will assume that half (0.5, the midpoint of Possibilities A and B) of the would-be acquirers of avoided transfers found an alternate unit.

Once the proportion of would-be acquirers who are assumed to find alternate units is determined, the next question is whether the alternate unit was likely to be another used appliance (similar to those recycled through the program) or, with fewer used appliances presumably available in the market due to program activity, would the customer acquire a new standard-efficiency unit instead.

Again, unless primary research is undertaken as described in the Enhanced Options below for an assessment of the appliance market, evaluators will apply a midpoint approach assuming half (0.5) of the would-be acquirers of program units would find a similar, used appliance and half (0.5) would acquire a new, standard-efficiency unit.
3. Induced Replacement

If, however, the unit would have been kept by the participating household, the next question is whether the appliance was replaced and, if so, whether the household would have replaced the appliance regardless of the program.

The purchase of a refrigerator in conjunction with program participation does not necessarily indicate induced replacement. (The refrigerator market is continuously replacing older refrigerators with new units, independent of any programmatic effects.) However, if a customer would not have purchased the replacement unit (put another appliance on the grid) in the absence of the program, the net program savings should reflect this fact. This is, in effect, akin to negative spillover and will be used to adjust net program savings downward.

Estimating the proportion of households induced to replace their appliance should be done through participant surveys. As an example, participants could be asked, “Would you have purchased your replacement refrigerator if the recycling program had not been offered?”

Because an incentive ranging from $35 to $50 is unlikely to be sufficient motivation for purchasing an otherwise-unplanned replacement unit (which can cost $500 to $2,000), it is critical that evaluators include a follow-up question. That question should confirm the participants’ assertions that the program alone caused them to replace their refrigerator. For example, participants could be asked, “Let me be sure I understand correctly. Are you saying that you chose to purchase a new appliance because of the appliance recycling program, or are you saying that you would have purchased the new appliance regardless of the program?”

When assessing participant survey responses to calculate induced replacement, evaluators will consider the appliance recycled through the program, as well as the participant’s stated intentions in the absence of the program. For example, if customers indicate they would have discarded their primary refrigerator independent of the program, it is not possible that the replacement was induced (because it is extremely unlikely the participant would live without a primary refrigerator). Induced replacement is a viable response for all other usage types and stated intention combinations.

As one might expect, previous evaluations have shown the number of induced replacements to be considerably smaller than the number of naturally occurring replacements unrelated to the program. Once the number of induced replacements is determined, this information is combined with the energy consumption replacement appliance to determine the total energy consumption induced by the program (on a per-unit basis).
4. Integrating Free Ridership, Secondary Market Impacts, and Induced Replacement

The flow chart shown in Figure 1 illustrates how net savings will be derived for an ARP. As shown, below, expected savings fall into four different scenarios.

**Figure 1. Appliance Retirement Scenarios**


a) **Scoring Algorithm**

Net savings will be assigned individually to each respondent, based on responses provided to the questions discussed above. Net savings will be averaged across all respondents to calculate program-level net savings. The following equation will be used:

\[
FR = (\text{free ridership and secondary market impacts} \% - \text{induced replacement} \%)
\]
Table 2 demonstrates the proportion of a sample population classified into each of the seven potential categories and the resulting weighted net savings.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Classification</th>
<th>Population (%)</th>
<th>UEC (kWh) w/out Program</th>
<th>UEC (kWh) w/ Program</th>
<th>kWh Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Would have kept unit</strong></td>
<td>Scenario A: Kept but Induced Replacement</td>
<td>Non-ES unit</td>
<td>3%</td>
<td>1,026</td>
<td>520</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ES unit</td>
<td>2%</td>
<td>1,026</td>
<td>404</td>
</tr>
<tr>
<td></td>
<td>Scenario B: Kept but NO Induced Replacement</td>
<td>N/A</td>
<td>25%</td>
<td>1,026</td>
<td>0</td>
</tr>
<tr>
<td><strong>Would have removed unit</strong></td>
<td>Scenario C: Transferred</td>
<td>Retailer would Recycle</td>
<td>12.5%</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Retailer would Resell</td>
<td>12.5%</td>
<td>1,026</td>
<td>520</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No Replacement</td>
<td>25%</td>
<td>1,026</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Scenario D: Removed from Service</td>
<td>N/A</td>
<td>20%</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Net Savings (kWh)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*The percent values presented in this table serve only as examples; actual research should be conducted to determine the percentage of units falling into each of these categories. Note that Unit Energy Consumption (UEC) values presented in the table represent example values, factoring in part-use.

**Enhanced Method**

Results can be enhanced by including three additional research efforts. The basic method has defaults where primary research on enhanced approaches cannot be performed:

1. A retailer survey, to determine the quantity and/or proportion of units returned to a retailer, and that the retailer would deconstruct or recycle. Through this survey, one would determine a retailer’s criteria for reselling used units vs. deconstructing them, based on unit age and condition. Results from the survey and analysis would be used to determine the proportion of those who would have returned an old appliance to the retailer that should be included in Scenario D (free riders). This research was conducted for ComEd in EPY6 evaluation and those results were applied to Ameren.

2. An appliance market assessment study, to determine the size of the secondary appliance market and whether removal of participating units from the market would cause an otherwise would-be receiver to purchase an alternative used or new unit. Savings attributable to these participants are the most difficult to estimate, as the scenario attempts to estimate what the prospective buyer of a used appliance would do in the absence of finding a program-recycled unit in the marketplace (i.e., the program took the unit off the grid, so the prospective purchaser faced, in theory, a smaller supply of used appliances). It is difficult to answer this question with certainty, absent utility-specific
information regarding the change in the total number of appliances (overall and used appliances specifically) that were active before and after program implementation. In some cases outside of Illinois, evaluators have conducted in-depth market research to estimate both the program’s impact on the secondary market and the appropriate attribution of savings for this scenario. Although these studies are imperfect, they can provide utility-specific information related to the program’s net energy impact. Where feasible, evaluators and utilities should design and implement such an approach. Unfortunately, this type of research tends to be cost-prohibitive, or the necessary data may simply be unavailable.

3. However, it is possible to estimate through nonparticipant surveys which of the disposal responses given by nonparticipants were most likely to have been to an opportunistic would-be-acquirer. Transfers would most likely have been opportunistic are determined primarily based on the cost to the recipient. If the appliance was sold or transferred to a retailer, there would have been a cost to the recipient of that appliance. If the recipient was willing to pay for the appliance or was willing to exert the effort to visit a retail location, this suggests the recipient was actively seeking an appliance. However, if the unit were given away for free there was little cost to the recipient and is a reasonable proxy for the proportion of opportunistic acquirers. This proportion would replace the 50% default assumption (scenario C in Figure 1) of would-be-acquirers that would or would not find an alternate unit.

4. A nonparticipant survey can be used to assess how nonparticipants acquire and dispose of used units. As nonparticipants do not have the same perceived response bias as participants, they can help offset some of this potential bias in estimating the true proportion of the population that would have recycled their units in program’s absence. The evaluators will average the results of the nonparticipant survey with the participant survey if the nonparticipant survey is of sufficient sample size. Otherwise, results may be used for a qualitative characterization of potential bias. Though recommended, use of a nonparticipant survey need not be required, given budget and time considerations. A nonparticipant survey was completed as part of ComEd’s EPY6 evaluation and used qualitatively to validate participant results.

5. **Participant Spillover**

Unlike many programs, recycling programs face reduced opportunities for spillover due to the lack of general energy education and the small likelihood of participants having further units to recycle on their own. This program could directly impact decisions to replace refrigerators or freezers with ENERGY STAR units rather than standard efficiency units, given that the program offers marketing and education related to the operating costs of refrigerators and freezers. Reliable methods of conducting this analysis have yet to be developed. One attempted method compared proportions of ENERGY STAR appliances replaced by program participants to proportions of ENERGY STAR new appliance shipments in a similar area. Due to the difficulty in isolating the shipment area to the program area, this has not yielded noticeable spillover in Illinois.

6. **Nonparticipant Spillover**

The specific approach and method for measuring spillover has not yet been discussed by the evaluation teams to reach a consensus. However, effective program marketing and outreach generates program participation and increases general energy-efficiency awareness among customers. The cumulative effect of sustained utility program marketing (which often occurs concurrently for multiple programs) can affect customers’ perceptions of their energy usage and, in some cases, motivates customers to take efficiency actions outside of the utility’s program. This phenomenon—called nonparticipant spillover (NPSO)—results in energy savings. Marketing of the Appliance Recycling program specifically may induce
nonparticipants to either reduce the use of the secondary refrigerator or freezer that they keep, or when they are purchasing a new refrigerator or freezer, to buy one that is more energy efficient.

B. Residential Upstream Lighting Programs

The Illinois Residential Upstream Lighting programs to date have provided discounts on efficient lighting through retailers at the point of purchase. Such programs often remain transparent to customers purchasing incentivized lighting. Program administrators also do not know the identity of most customers purchasing the program-discounted lighting; so these customers cannot easily be contacted once they leave the store for a traditional self-report net-to-gross (NTG) evaluation survey (i.e., an after-the-fact, direct solicitation of customers regarding what they would have done in the program’s absence). Similar surveys can be conducted with customers within program retailers after they have made their lighting purchasing decision but before they leave the store. For programs such as this, in-store customer surveys are preferable to the traditional self-report telephone surveys that ask customers to recall their past light bulb purchases. Light bulbs are a small and relatively insignificant purchase for most people thus the recall bias could be substantial.

Further, as upstream programs work with multiple market actors and can include wide-reaching marketing campaigns promoting energy efficiency to the general public, they tend to stimulate spillover and “market effects.” As a result, estimating NTG for upstream residential lighting programs can be challenging. Multiple methods exist, each with their own strengths and weaknesses.

Ameren and ComEd implement their residential lighting programs comparably, and the evaluation teams have used a consistent primary NTG evaluation method. This section details the consensus NTG methodology, which has been used multiple times for both ComEd and Ameren and is considered the most well-vetted and defensible NTG method that has been successfully used in Illinois.

For EPY5 and EPY6, Ameren and ComEd used a customer self-report methodology to estimate NTG for their upstream residential lighting programs.\(^\text{1519}\) Customer self-report data in this method are collected during surveys conducted within program retailers with customers purchasing program bulbs (i.e., in-store intercept surveys). This method separately estimates free ridership, participant spillover, and nonparticipant spillover. Details follow on the primary data collection and scoring algorithms.

1. Free Ridership

Free ridership is the proportion of program bulbs that would have been purchased if the program did not exist. Three alternative scenarios could occur:

1. Full Free Rider: The customer would have purchased the same quantity of efficient bulbs (CFLs or LEDs) in the program’s absence.
2. Partial Free Rider: The customer would have purchased fewer efficient bulbs (CFLs or LEDs) in the program’s absence.
3. Non-Free Rider: The customer would have not purchased any efficient bulbs (CFLs or LEDs) in the program’s absence.

\(^\text{1519}\) ComEd has used this method since EPY2. Ameren began using it in EPY5.
Free ridership is calculated as the average of two distinct scores: a program influence score and a non-program score. These scores are defined as follows:

1. The *program influence score* captures the maximum level of program influence, reported by a survey respondent, of the residential lighting program on their decisions to purchase program bulbs on the day of the survey. This program influence can take a number of forms, such as: the monetary incentive provided to decrease the cost of high-efficiency bulbs; program-sponsored educational materials that explain the benefits of efficient lighting; in-store product placement of efficient bulbs; and program bulb recommendations provided by retail store personnel.

2. The *non-program score* is used to estimate how many program bulbs a survey respondent would have purchased in the absence of the residential lighting program.

   a) **Data Collection**

To estimate free ridership, the evaluation teams will conduct in-store intercept surveys with customers purchasing program-discounted lighting at participating retailers. Customers are asked questions that are used to estimate a program influence score and a non-program score for each customer and efficient bulb type purchased.

**Primary Program Influence Score Questions**

1. Light bulb purchasing plans for current shopping trip (Yes/No)
2. If planning to purchase bulbs:
   a. Bulb type (CFL, LED, Incandescent, Halogen)
   b. Utility-incentivized bulbs (Yes/No)
3. Influence of various program factors:
   a. Program incentive
   b. In-store information (printed materials or information from utility representatives or retail personnel)
   c. Positioning of discounted bulbs within the store

**Primary Non-Program Score Questions**

1. Stated preference of light bulb purchases had the utility incentive not been available (purchase all, some or none of efficient bulbs)
2. Quantity of light bulbs purchased absent the utility incentive

b) **Scoring Algorithms**

Using the data collected from program participants during the in-store intercept surveys, program influence and non-program scores are calculated for each survey respondent and then combined to estimate a respondent-specific free ridership score.

**Calculation of the Program Influence Score:**

Survey respondents purchasing one or more program-discounted bulbs are assigned a preliminary program influence score based on the maximum program influence level (on a 0 to 10 scale) they assigned to one or more program factors (e.g., monetary incentive/informational materials (printed or from store personnel)/product positioning). The influence level assigned to the monetary incentive
should be increased for survey respondents (using a linear decreasing function\textsuperscript{1520}) who indicated that absent the incentive they would not have purchased any of the program bulbs they were purchasing that day.

After the preliminary program influence score is assigned, a secondary algorithm is run that adjusts the preliminary program influence based on survey data regarding the customers purchasing plans when they entered the store. Survey respondents who indicate they planned to purchase high-efficiency bulbs prior to entering the store and who had not come to the store specifically to buy utility-incentivized program bulbs, should have their program influence score cut in half. This adjustment makes the final program influence score reflective of their stated planned intention to purchase efficient bulbs in the program’s absence.

**Calculation of the Non-Program Score:**
The non-program score is based on whether a respondent states they would have purchased all, some, or none of the program-discounted bulbs in the absence of utility incentives. Respondents reporting they would have purchased all of the efficient bulbs without the incentive should be considered free riders and receive a non-program score of zero. Those reporting they would have purchased none of the efficient bulbs without the incentives should be classified as non-free riders and receive a non-program score of 10, the maximum. Respondents reporting they would have purchased some of the efficient bulbs without the incentive should be assigned a non-program score between 0 and 10, reflective of the percentage of efficient bulbs they would not have purchased absent the program.

Respondents reporting they would have purchased all of the program-discounted bulbs in the program’s absence, but in-store materials provided by the utility had a moderate to high influence on their decision should have their non-program scores adjusted to equal the level of influence they attributed to these program-sponsored informational materials.

**Calculation of Free Ridership:**
Free Ridership = 1 – (Program Influence Score + Non-Program Score)/20

Using the calculated program influence and non-program scores, free ridership is calculated as one minus the sum of the two scores (program influence score plus non-program score), divided by 20. Dividing the sum of scores by 20 results in a ratio (between 0 and 1) that is representative of the average of the two zero to 10 scores. Subtracting this ratio from one reverses the score, thus representing the free ridership level. If either the non-program or program influence scores are missing, free ridership can be calculated using the single available score divided by 10. Evaluators may also reference available data to perform documented modifications to individual free ridership estimates resulting from the application of a core free ridership assessment methodology.

\textsuperscript{1520} The function, adjusted monetary score = (monetary score + 10)/2, increases the monetary score using a decreasing linear function. This function results in an increase in the monetary influence score of between 0 and 5 points depending on their original monetary score (i.e., an original score of 0 would become a 5, a 5 would become a 7.5, and a 10 would remain a 10. In past Illinois evaluations, this adjustment has typically changed less than 10% of all monetary scores.
2. **Participant Spillover**

Participant spillover results from purchases of non-discounted efficient bulbs by program bulb purchasers who are influenced by their participation in the residential lighting program to purchase additional non-discounted efficient bulbs.

   a) **Data Collection**

Data collected during in-store intercept surveys with customers purchasing program bulbs should be used to estimate participant spillover. During these surveys, customers purchasing program-discounted and non-discounted efficient bulbs should be asked questions to determine whether the residential lighting program influenced their purchases of non-discounted efficient bulbs.

   b) **Scoring Algorithm**

To estimate participant spillover, the number of program-influenced, non-discounted efficient bulbs purchased by program participants is divided by the total number of program bulbs purchased by these program participants. This results in the participant spillover rate.

3. **Nonparticipant Spillover**

Nonparticipant spillover results from purchases of non-discounted efficient bulbs by customers who are not purchasing program-discounted bulbs, but report that the residential lighting program influenced their decision to purchase non-discounted efficient bulbs.

   a) **Data Collection**

Data collected during in-store intercept surveys with customers purchasing efficient bulbs not discounted by the program should be used to estimate nonparticipant spillover. During these surveys, customers purchasing non-discounted efficient bulbs should be asked questions to determine whether the residential lighting program influenced their purchases of non-discounted efficient bulbs.

   b) **Scoring Algorithm**

To estimate nonparticipant spillover, one must first calculate the number of program-influenced, non-discounted efficient bulbs purchased by the population of program nonparticipants surveyed. This yields a survey nonparticipant spillover rate. This rate is then extrapolated to the estimated population of nonparticipating utility customers to determine the estimated total quantity of non-program efficient bulbs being purchased within the utility service territory. Dividing this result by the total number of program bulbs results in the nonparticipant spillover rate.

4. **Method Advantages and Disadvantages**

The in-store intercept method described above has certain advantages and disadvantages.

**Advantages:** This approach catches customers at their point of purchase, before they leave the store and can no longer be contacted directly. Given the interview’s timing, customers can more easily recall price factors leading to their purchase choices. Also, as customers are intercepted at the store rather than surveyed by telephone, a higher cooperation rate results.

**Disadvantages:** Customers may not fully connect the impact that in-store education, product placement, and advertising have on their decision making. While many consumers believe they are not influenced by advertising, retailers know advertising and product placement work. Further, store intercepts typically must be coordinated with education events, and many retailers do not allow interviews to take place in their stores. Consequently, results are not based on random samples of customers purchasing program-discounted lighting throughout the year and across all participating retailers, which could bias the results.
V. Appendix A: Overview of NTG Methods

The evaluation teams present information in this appendix to provide a relatively quick overview of NTG methods for readers unaccustomed to the possible methods that evaluators may deploy. It is not meant to be a complete or deep discussion about each of the methods presented. However, the evaluators in Illinois considered the inclusion of this appendix to be very important in acknowledging the current suite of methods deployed by evaluators throughout the U.S. and giving a framework for work within Illinois.

Much of the information shown below is taken directly from a single source — the national Uniform Methods Project, Chapter 17: Estimating Net Savings: Common Practices. (Violette and Rathbun, 2014) This document has done a nice job of summarizing the eight most common attribution methods currently in use across the U.S. The evaluation teams recommend that readers go first to this reference for further information. Additionally, while there are slightly over 100 references within the Violette and Rathbun document, other non-duplicative references are included where reasonable as additional resources for those interested in further research into any specific method.

A. Survey-Based Approaches

Virtually all Illinois based evaluations use a survey-based approach for programs where primary data is used to determine net savings. (The main exception is for Behavioral programs which use statistical analysis based on a randomized control trial program design.) Survey based approaches obtain data from program participants and nonparticipants using a structured data collection instrument implemented via phone, in person or on-line. At times, evaluators create and use an unstructured depth-interview guide to collect information about attribution and this provides both contextual data and quantitative data about a given project.

1. Self-Report Approach

The self-report approach relies on the abilities of customers to discuss the program influence as well as the somewhat abstract ideas of the counterfactual (i.e., what would have occurred absent the program) after making a choice to purchase an energy efficient item or take an energy efficient action unrelated to a purchase. For program participants, this could include doing nothing (i.e., leaving the existing equipment as-is), installing the same energy efficient equipment as they did through the program, or an intermediate step of installing equipment that is more efficient than what they had in place previously, but less efficient than what they installed through the program. Evaluators also use this approach when collecting information from trade allies or distributors. This self-report approach is not new, nor is it exclusively used by the energy efficiency industry. An important attribute of this approach is its reliance on well-designed and fielded survey questions, so that the data underlying subsequent analyses are accurate and complete.

The output of this approach is a NTG ratio which can be considered an index of the program’s influence on the decision to install energy efficient equipment. The NTG ratio is applied to gross savings in order to obtain an estimate of net savings. The NTG ratio may include free ridership, spillover, or market effects, depending on the survey and analytical design. NTG ratios may be calculated at the measure, suite of measures, or program level and are typically average values weighted by savings. If sufficient information is available, analysis of NTG ratios among certain customer segments may be done to further inform changes to program design.
References
  • Sudman, 1996
  • Stone, et al., 2000
  • Bradburn, et al., 2004

2. Econometric/Revealed Preference Approach

The econometric/revealed preference approach, while still considered a survey approach due to how data is collected, moves beyond asking people about the counterfactual and instead uses the observations of the evaluator to collect information for analysis of a NTG ratio. Within this approach, evaluators typically deploy similar sampling designs as for the self-report approach to collect data, but actively gather what a person is doing (i.e., what is being purchased in a store) to determine attribution.

B. Randomized Control Trials (RCT) and Quasi-Experimental Designs

As mentioned earlier, evaluators deploy an RCT for estimating savings from the Behavioral programs within Illinois. Additionally, quasi-experimental designs (QED) have been used in the past in Illinois to estimate net savings from the upstream CFL program, and CFL, insulation and air sealing measures within the Home Performance with Energy Star program.

RCT and QED use statistical analysis to determine regularities within the data that reveal net savings due to a program intervention.\(^ {1521}\) The analytical design attempts to control for factors that can confound net analysis.\(^ {1522}\) When estimating net savings within both an RCT and QED, two groups are included within the analysis: 1) a group that has been exposed to (i.e., treated by) a program and 2) a group that has not been exposed to the program. Evaluators must carefully consider the choice of the non-exposed group (called a control group for RCTs or comparison group for QEDs).

RCT – This design must be integral to a program’s implementation. Without the ability to randomly assign customers to one group or another (or at least randomly encourage customers to participate in a program), the ability of the design to yield unambiguous estimates of net impacts is compromised. Evaluators often help design how a program is implemented and, if not involved at the outset, carefully review choices made by the implementation team.

QED – A QED may be designed after a program has been implemented. It relies on determination of an equivalent comparison group, which is often chosen based on energy use. QED is difficult to perform well within the commercial sector due to the heterogeneity of end uses within the sector.

The output of an RCT or QED is the average net savings for the population within the statistical model. Evaluators may also analyze the data to help understand the savings within specific known segments if sufficient information and data points are available.

References
  • Mohr, 1995
  • Shadish, Cook, Campbell, 2002

\(^ {1521}\) Net savings are calculated when a comparison or control group of non-treated customers are part of the design. Statistical analyses can also obtain gross savings.

\(^ {1522}\) Economists strongly support this approach, but among program evaluators, the idea that an RCT is a “gold standard” for attribution research has been hotly debated for decades.
C. Deemed or Stipulated NTG Ratios

A deemed (or stipulated) NTG ratio is a value known prior to implementing a program and applied to estimate net savings for that program in a certain year.

Deemed or stipulated NTG ratios may be based on previous primary data collection, review of secondary data, or agreed to among stakeholders. In Illinois, deemed or stipulated NTG ratios should reflect best estimates of likely future actual NTG ratios for the relevant program year, taking into consideration stakeholder input, the evaluator’s expertise, and the best and most up-to-date information.

D. Common Practice Baseline Approaches

For this method, the evaluation team estimates what a typical consumer would have done at the time of the project implementation. Essentially, what is “commonly done” becomes the basis for baseline energy consumption and calculation of net savings. No gross impacts are calculated in this approach. This baseline is defined as the counterfactual “i.e., what would have occurred absent the program” and has been referred to as current practice, common practice or industry standard practice. Evaluators determine these practices through multiple methods, but often can be from self-report or on-site audits. The difference between the energy use of measures installed in the program and the energy use associated with current practice is considered by some to be sufficiently close to the net savings.

This approach is not in use in Illinois, but is used elsewhere in the country such as the Pacific Northwest and Delaware.

E. Market Analyses

Market analyses can be done in several ways. Market analyses are often used in theory-driven evaluations of market transformation programs.

Other non-sales data market analyses can be postulated on changes specified in program logic such as: 1) changes in the number of energy efficient units manufactured, 2) changes in market actor behavior around promotion or stocking of energy efficient items, or 3) reduction in prices. The analyses involving non-sales data must make a clear link between the program intervention and the changes found in the market. Additionally, outside of Illinois, while evaluators have extrapolated the market changes to specific energy or demand reductions, this activity may be viewed as tenuous due to assumptions that evaluators must make within the analysis.

Illinois is in a position to begin to discuss market analyses and how specific research may be able to interpret changes that have occurred (or may occur in the future) because of the IOU interventions over the past six years. Market analyses can be backward looking through historical tracing, but is best used when the logic of an intervention is described and specific market metrics are tracked over time. This is a switch from the current annual evaluation of programs and has challenges that stakeholders would need to discuss and reach a consensus on an approach that works for Illinois.

• Scriven, 2008
• Donaldson, 2009
F.  Structured Expert Judgment Approaches

Closely tied to market analysis, this approach is a way for evaluators to gather credible evidence of changes that arise due to the intervention of a program. When deployed, it is often used as a cost-effective approach to estimate market effects or reach agreement on a NTG value when several different types of evidence are available. The key premise of this approach is the use of a select group of known experts that all stakeholders agree can provide unbiased information as well as having sufficient knowledge to judge what may have occurred absent a program intervention.

A Delphi Panel is an example of this approach where data is collected from two or more rounds of data collection (which can occur via email, internet, or in-person). A round is when experts make their thoughts known about a specific subject, the evaluation team synthesizes the data and provides this collated data back to the group to discuss again. Allowing the full experts to see how their peers think about a topic helps to move the group towards consensus.

To date, in Illinois, there has been little need for this approach. However, if more market analyses occur in the future, this is a valuable tool that can be deployed.

References

- Mosenthal, et al., 2000
- Powell, 2002

G.  Program Theory-Driven Approach

This approach is not included in the Violette and Rathbun (2014) document as a high level method, but is discussed by the authors under the historical tracing method. The Illinois evaluators believe that it deserves at least a short discussion within this framework.

A program theory is the written narrative about why the activities of a program are expected to bring about change. Typically associated with this approach is the direct graphical explication of the linkages between activities, outputs, and outcomes through an impact logic model.\(^{1523}\)

A theory-driven evaluation denotes “[A]ny evaluation strategy or approach that explicitly integrates and uses stakeholder, social science, some combination of, or other types of theories in conceptualizing, designing, conducting, interpreting, and applying an evaluation.” (Coryn 2011) Within this approach, the ultimate conclusions regarding the efficacy of a program are based on the preponderance of the evidence and not on the results of any single analysis. Coryn and colleagues systematically examined 45 cases of theory-driven evaluations published over a twenty-year period to ascertain how closely theory-driven evaluation practices comport with the key tenants of theory-driven evaluation as described and prescribed by prominent theoretical writers. One output from this analysis was the identification of the core principles and sub-principles of theory-driven evaluation. If interested, please review the reference under Coryn 2011.

As an approach, it is best used for complex programs and/or causal mechanisms that extend far into the future. Evaluators collect evidence that supports or rejects hypotheses that are explicit in the logic model. The case for program attribution is strengthened based on the extent to which an evaluation

\(^{1523}\) Evaluators may use logic models to show program processes as well, but this is a program flow chart, not an impact model.
shows that the expected changes occur. Additionally, the evaluation team may be able to collect data that will answer questions about the longer term outcomes of a program. This type of data collection may be very similar to market tracking activities described briefly above under Market Analyses.

This approach does not specifically estimate a NTG value, but program administrators can choose to keep, drop or change a program based on intermediary data. Regulators must be convinced that the logic of a program is sound and that the intermediary outcomes are causally linked to expected savings.

**References**
- Weiss, 1997
- Chen, 2000
- Coryn, 2011

**H. Case Studies Design**

Case studies are used extensively in social sciences as well as many other disciplines or practice-oriented areas such as political science, economics, education, and public policy. Case studies help to understand the how and why of a situation and typically retain a holistic aspect of real-life events. As such, they may be a useful approach to determine attribution. As with program theory design, though, the data collected and analyzed within a case study approach will not typically yield a specific NTG value, but can provide credible evidence and insight that supports or refutes the changes brought about by program intervention.

To be used to assess attribution, evaluators must carefully design case studies to assure they account for the threats to causality (i.e. internal validity) that arise in any design. While not typically thought of in this manner, case study design can address multiple types of validity such as construct, internal and external validity as well as assuring reliability. When establishing construct validity and reliability, evaluators must use multiple sources of evidence, create and maintain a study database, and maintain a “chain of evidence” within the analysis. Internal validity is shown through analytic tactics such as pattern matching, explanation building, addressing rival explanations, or using logic models. External validity centers on the ability to generalize the analytical findings to other similar situations. External validity may be shown through replication of findings.

**References**
- Yin, 2003
- Stake, 2006
VI. Appendix B: References


