Illinois Statewide

Technical Reference Manual

for Energy Efficiency

Version 3.0

February 24, 2014

Effective:

June 1st, 2014

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TABLE OF CONTENTS

TABLES & FIGURES

Acknowledgements

This document was created through a 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 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 iltrmadministrator@veic.org.

SAG Stakeholders[1]
Ameren Illinois Company (Ameren)
Center for Neighborhood Technology (CNT)
Citizen's Utility Board (CUB)
City of Chicago
Commonwealth Edison Company (ComEd)
Energy Resources Center at the University of Illinois, Chicago (ERC)
Environment IL
Environmental Law and Policy Center (ELPC)
Future Energy Enterprises LLC
Illinois Attorney General's Office (AG)
Illinois Commerce Commission Staff (ICC Staff)
Illinois Department of Commerce and Economic Opportunity (DCEO)
Independent Evaluators (ADM, Cadmus, Itron, Navigant)
Integrys (Peoples Gas and North Shore Gas)
Metropolitan Mayor's Caucus (MMC)
Midwest Energy Efficiency Association (MEEA)
Natural Resources Defense Council (NRDC)
Nicor Gas

[1] Being an open forum, this list of SAG stakeholders and participants may change at any time.

Table 1.1: Document Revision History

Document Title	Applicable to PY Beginning
Illinois_Statewide_TRM_Effective_060112_Version_1.0_091412_Clean.doc	6/1/12
Illinois_Statewide_TRM_Effective_060113_Version_2.0_060713_Clean.docx	6/1/13
Illinois_Statewide_TRM_Effective_060114_Version_3.0_022414_Clean.docx	6/1/14

Summary of Measure Revisions

The following tables summarize the evolution of measures that are new, revised or errata. This version of the TRM contains 68 measure-level changes as described in the following table.

Table 1.2: Summary of Measure-Level Changes

Change Type	# Changes
Errata	8
Revision	47
New Measure	13
Total Changes	**68**

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, 2013. Measures that are identified as 'Revised' were included in the second 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, 2014.

The following table provides an overview of the 68 measure-level changes that are included in this version of the TRM.

Table 1.3: Summary of Measure Revisions

Mkt	End Use	Measure Name	Measure Code	Change Type	Explanation	Impact on Savings
Res	Appliances	ENERGY STAR and CEE Tier 2 and 3 Clothes Washers	RS-APL-ESCL-V02-140601	Revision	Updated analysis to be based on models available in last 3 years	Increased kWh/ kW / Therms
Res	Appliances	ENERGY STAR Dishwasher	RS-APL-ESDI-V02-130601	Errata	Updated Federal Standard effective May 30, 2013. Removed Compact units since new standard is equal to ENERGY STAR level.	Reduced kWh/kW
Res	Appliances	ENERGY STAR Freezer	RS-APL-ESFR-V02-140601	Revision	Added assumptions for post September 2014 with new Federal Standard baseline and ENERGY STAR specifications.	Reduced kWh/kW
Res	Appliances	ENERGY STAR and CEE Tier 2 Refrigerator	RS-APL-ESRE-V02-140601	Revision	Added early replacement assumptions. Added assumptions for post September 2014 with new Federal Standard baseline and ENERGY STAR specifications.	Reduced kWh/kW
Res	Appliances	ENERGY STAR and CEE Tier 1 Room Air Conditioner	RS-APL-ESRA-V03-140601	Revision	Added early replacement assumptions.	N/A

Mkt	End Use	Measure Name	Measure Code	Change Type	Explanation	Impact on Savings
Res	Appliances	Refrigerator and Freezer Recycling	RS-APL-RFRC-V03-140601	Revision	Updated language on Part Use Factor to use survey results from most recent evaluation. Used PY5 Ameren evaluation for illustrative purposes.	No change
Res	HVAC	Air Source Heat Pump	RS-HVC-ASHP-V03-140601	Revision	Added footnote to explain HSPF ratings being seasonal averages from zone 4 and therefore not requiring adjustments due to back up heat requirements. Updated Coincidence Factor	Reduced kW
Res	HVAC	Central Air Conditioning	RS-HVC-CAC1-V03-140601	Revision	Updated Coincidence Factor	Reduced kW
Res	HVAC	Duct Insulation and Sealing	RS-HVC-DINS-V02-140601	Revision	Updated Coincidence Factor Clarified input heating v cooling capacity	Reduced kW
Res	HVAC	Furnace Blower Motor	RS-HVC-FBMT-V02-140601	Revision	Updated Coincidence Factor	Reduced kW
Res	HVAC	Gas High Efficiency Furnace	RS-HVC-GHEF-V03-140601	Revision	Heating Load estimates updated using PY1 Nicor Furnace Metering Study, August 2013.	Increased Therms
Res	HVAC	Ground Source Heat Pump	RS-HVC-GSHP-V03-140601	Revision	Updated Coincidence Factor	Reduced kW
Res	HVAC	HVAC Tune Up	RS-HVC-TUNE-V02-140601	Revision	Updated Coincidence Factor	Reduced kW
Res	HVAC	Programmable Thermostats	RS-HVC-PROG-V03-140601	Revision	Added text to confirm savings are at household level. Updated consumption values based on PY1 Nicor Furnace Metering Study, August 2013.	Increased Therms
Res	HVAC	Ductless Heat Pumps	RS-HVC-DHP-V01-140601	New	New DHP that calculates savings for use as supplemental heating and cooling	N/A
Res	Hot Water	Gas Water Heater	RS-HWE-GWHT-V02-140601	Revision	Adjusted algorithm such that water consumption now based upon household size and Gallons Per Day per person.	Reduced Therms
Res	Hot Water	Heat Pump Water Heaters	RS-HWE-HPWH-V02-140601	Revision	Adjusted algorithm such that water consumption now based upon household size and Gallons Per Day per person.	Reduced Therms
Res	Hot Water	Low Flow Faucet Aerators	RS-HWE-LFFA-V03-140601	Revision	Consumption and temperature assumptions updated based upon Michigan metering study. Clarification that base flow rate assumption includes existing low flow fixtures and therefore freerider rate should be 0.	Increased kWh/ kW / Therms

Mkt	End Use	Measure Name	Measure Code	Change Type	Explanation	Impact on Savings
Res	Hot Water	Low Flow Showerheads	RS-HWE-LFSH-V03-140601	Revision	Consumption and temperature assumptions updated based upon Michigan metering study. Direct Install Multi Family In Service Rate updated based on Final ComEd-Nicor Gas evaluation.	Reduced kWh/ kW / Therms
Res	Hot Water	Water Heater Temperature Setback	RS-HWE-TMPS-V03-140601	Revision	Algorithm adjusted to allow custom entry of pre and post temperatures.	No change
Res	Lighting	ENERGY STAR Compact Fluorescent Lamp (CFL)	RS-LTG-ESCF-V03-140601	Revision	First phase of EISA adjustments removed. Deemed RES v non-RES assumption updated. Time of Sale In Service Rate assumption updated. Costs updated based upon pricing forecast developed by Applied Proactive Technologies Inc. O&M assumptions updated.	Increased kWh / kW
Res	Lighting	ENERGY STAR Specialty Compact Fluorescent Lamp (CFL)	RS-LTG-ESCC-V03-140601	Revision	First phase of EISA adjustments removed. Deemed RES v non-RES assumption updated. Time of Sale In Service Rate assumption updated.	Increased kWh / kW
Res	Lighting	Exterior Hardwired Compact Fluorescent Lamp (CFL) Fixture	RS-LTG-EFIX-V03-140601	Revision	First phase of EISA adjustments removed. Costs updated. O&M assumptions updated.	No change
Res	Lighting	Interior Hardwired Compact Fluorescent Lamp (CFL) Fixture	RS-LTG-IFIX-V03-140601	Revision	First phase of EISA adjustments removed. O&M assumptions updated.	No change
Res	Lighting	LED Downlights	RS-LTG-LEDD-V02-140601	Revision	WattsBase table updated to be consistent with other measures.	Dependent on inputs
Res	Lighting	LED Screw Based Omnidirectional Bulbs	RS-LTG-LEDA-V01-140601	New	New measure for LED Screw Based Omnidirectional (A-Type) lamps.	N/A
Res	Shell	Airsealing	RS-SHL-AIRS-V02-140601	Revision	Updated Coincidence Factor	Reduced kW
Res	Shell	Basement Sidewall Insulation	RS-SHL-BINS-V04-140201	Mid year Errata / Revision	Fixed default baseline R-value assumption. Adjustment Factors added. Framing Factor assumption updated.	Reduced kWh / kW / Therms

Mkt	End Use	Measure Name	Measure Code	Change Type	Explanation	Impact on Savings
Res	Shell	Floor Insulation Above Crawlspace	RS-SHL-BINS-V04-140201	Mid year Errata / Revision	Fixed default baseline R-value assumption. Adjustment Factors added. Framing Factor assumption updated.	Reduced kWh / kW / Therms
Res	Shell	Wall and Ceiling/Attic Insulation	RS-SHL-AINS-V04-140201	Mid year Errata / Revision	Adjustment Factors added. Framing Factor assumption updated.	Reduced kWh / kW / Therms
C&I	Hot Water	Low Flow Faucet Aerators	CI-HW_-LFFA-V04-130601	Errata	Fixed error in Usage table, calculation of annual gallons mixed water per faucet.	Dependent on inputs
C&I	Hot Water	Ozone Laundry	CI-HW-OZLD-V01-140601	New	New measure for add-on ozone laundry system.	N/A
C&I	HVAC	Guest Room Energy Management	CI-HVC-GREM-V02-140601	Revision	New modeling methodology	Dependent on inputs
C&I	HVAC	Package Terminal Air Conditioner (PTAC) and Package Terminal Heat Pump (PTHP)	CI-HVC-PTAC-V04-140601	Revision	Added early replacement assumptions.	N/A
C&I	HVAC	Small Commercial Programmable Thermostat	CI-HVC-PROG-V01-140601	New	New measure for programmable thermostats in select single zone buildings.	N/A
C&I	Lighting	Hours / Interactive Effects Table	V02_140601	Revision	Added electric resistance and heat pump waste heat factors.	N/A
C&I	Lighting	Commercial ENERGY STAR Compact Fluorescent Lamp (CFL)	CI-LTG-CCFL-V03-140601	Revision	First phase of EISA adjustments removed. Deemed RES v non-RES assumptions updated. In Service Rate assumption updated. Costs updated based upon pricing forecast developed by Applied Proactive Technologies Inc. Electric heating penalty section added. O&M assumptions updated.	Increased kWh / kW
C&I	Lighting	Fluorescent Delamping	CI-LTG-DLMP-V02-140601	Revision	Electric heating penalty section added.	N/A
C&I	Lighting	High Performance and Reduced Wattage T8 Fixtures and Lamps	CI-LTG-T8FX-V02-140601	Revision	In Service Rate assumption updated. Electric heating penalty section added.	Increased kWh / kW

Mkt	End Use	Measure Name	Measure Code	Change Type	Explanation	Impact on Savings
C&I	Lighting	LED Bulbs and Fixtures	CI-LTG-LEDB-V02-140601	Revision	First phase of EISA adjustments removed. Watts assumptions updated to be consistent with other measures. Electric heating penalty section added. O&M assumptions updated.	N/A
C&I	Lighting	Commercial LED Exit Signs	CI-LTG-LEDE-V02-140601	Revision	Electric heating penalty section added.	N/A
C&I	Lighting	Lighting Power Density	CI-LTG-LPDE-V02-140601	Revision	Electric heating penalty section added. Baseline updated to IECC 2012	Dependent on inputs
C&I	Lighting	Miscellaneous Commercial/Industrial Lighting	CI-LTG-MSCI-V02-140601	Revision	Electric heating penalty section added.	N/A
C&I	Lighting	Multi-Level Lighting Switch	CI-LTG-MLLC-V02-140601	Revision	Electric heating penalty section added.	N/A
C&I	Lighting	Occupancy Sensor Lighting Controls	CI-LTG-OSLC-V02-140601	Revision	Vacancy sensor assumptions added. Electric heating penalty section added.	N/A
C&I	Lighting	Solar Light Tubes	CI-LTG-STUB-V02-140601	Revision	Electric heating penalty section added.	N/A
C&I	Lighting	T5 Fixtures and Lamps	CI-LTG-T5FX-V02-140601	Revision	Electric heating penalty section added. In Service Rate updated	Increased kWh / kW
C&I	Lighting	Occupancy Controlled Bi-Level Lighting Fixtures	CI-LTG-OCBL-V01-140601	New	New measure for replacing existing uncontrolled continuous lighting fixtures with bi-level light fixtures.	N/A
C&I	HVAC	Demand Controlled Ventilation	CI-HVC-DCV-V01-140601	New	New Measure for demand controlled ventilation in commercial buildings	N/A
C&I	HVAC	Linkageless Boiler Controls	CI-HVC-LBC-V04-140601	New	New Measure for Linkageless Boiler Controls in commercial buildings	N/A
C&I	HVAC	Oxygen Trim Boiler Controls	CI-HVC-O2TC-V01-140601	New	New Measure for Oxygen Trim Boiler Controls in commercial buildings	N/A
C&I	HVAC	Shut Off Damper for Space heating Boilers	CI-HVC-SODP-V01-140601	New	New Measure for Boiler Draft Damper Controls in commercial buildings	N/A
C&I	HVAC	High Turndown Burner Control for Space Heating Boiler	CI-HVAC-HTBC-V04-140601	New	New Measure for Boiler Improved Turndown Burner in commercial buildings	N/A
C&I	FSE	Kitchen Hood Demand Control Ventilation	CI-FSE-VENT-V02-140601	Revision	Added space heating savings for Kitchen Hood Demand Control Ventilation	Increases therms

Mkt	End Use	Measure Name	Measure Code	Change Type	Explanation	Impact on Savings
C&I	HVAC	Space Heating Boiler Tune-up	CI-HVC-BLRT-V03-130601	Errata	Moved EFLH table to 1.4 HVAC section. Errata as to change savings formula from using input capacity for calculating savings by removing efficiency variable.	Decresae therms
C&I	HVAC	Boiler Lockout/Reset Controls	CI-HVC-BLRC-V02-130601	Errata	moved EFLH table to 1.4 HVAC section. Errata was to change savings formula from using input capacity for calculating savings by removing efficiency variable.	Decrease therms
C&I	HVAC	Electric Chiller	CI-HVC-CHIL-V021-140601	Revision	Moved EFLH to 1.4 HVAC section. Changed baseline to IECC 2012	N/A
C&I	HVAC	Heat Pump Systems	CI-HVC-HPSY-V021-140601	Revision	Moved EFLH to 1.4 HVAC section. . Changed baseline to IECC 2012	N/A
C&I	HVAC	High Efficiency Boiler	CI-HVC-BOIL-V04-130601	Errata	Moved EFLH table to 1.4 HVAC section. Errata was to change savings formula from using input capacity for calculating savings by removing efficiency variable.	Decrease Therms
C&I	HVAC	High Efficiency Furnace	CI-HVC-FRNC-V03-130601	Errata	Moved EFLH table to 1.4 HVAC section. Errata was to change savings formula from using input capacity for calculating savings by removing efficiency variable.	Decrease Therms
C&I	HVAC	Pipe Insulation	CI-HVC-PINS-V02-140601	Revision	Added equivalent straight lengths for tees and valves. Included Thermal regain factor for pipes depending on location.	Reduced Therms for some installation, no change for others
C&I	HVAC	Single-Package and Split System Unitary Air Conditioners	CI-HVC-V02-140601	Revision	Moved EFLH to 1.4 HVAC section. Changed baseline to IECC 2012	N/A
C&I	HVAC	Steam Trap Replacement or Repair	CI-HVC-STRE-V03-140601	Revision	Added High pressure to leaking and blow through table	N/A
C&I	RFG	Refrigeration Economizers	CI-RFG-ECON-V04-140601	New	New Measure for refrigeration economizers	N/A
C&I	MISC	Compressed Air Low Pressure Drop Filters	CI-MSC-CALPDF-V01-140601	New	New Measure for Compressed Air Low Pressure Drop Filters	N/A
C&I	MISC	Compressed Air No-Loss Condensate Drain	CI-MSC-CANLCD-V01-140601	New	New measure for Compressed Air No-Loss Condensate Drain	N/A

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[2] which are administered by the Department of Commerce and Economic Opportunity (DCEO) and the state's largest electric and gas Utilities[3] (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."[5]

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[2] 220 ILCS 5/8-103 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.

[5] Illinois Statewide Technical Reference Manual Request for Proposals, August 22, 2011, pages 3-4, http://ilsag.org/yahoo_site_admin/assets/docs/TRM_RFP_Final_part_1.230214520.pdf

1.1 Enabling ICC Policy

This Illinois Statewide Technical Reference Manual (TRM) was developed to comply with the Illinois Commerce Commission (ICC or Commission) Final Orders from the electric and gas Utilities'[6] Energy Efficiency Plan dockets. In the Final Orders, the ICC required the utilities to work with DCEO and the SAG to develop a statewide TRM. *See, e.g.,* ComEd's Final Order *(Docket No. 10-0570, Final Order[7] at 59-60, December 21, 2010);* Ameren's Final Order *(Docket No. 10-0568, Order on Rehearing[8] at 19, May 24, 2011);* Peoples Gas/North Shore Gas' Final Order *(Docket No. 10-0564, Final Order[9]at 76, May 24, 2011),* and Nicor's Final Order *(Docket No. 10-0562, Final Order[10] at 30, May 24, 2011).*

As directed in the Utilities' Efficiency Plan Orders, the SAG had the opportunity to, and also participated in, every aspect of the development of the TRM. Interested members of the SAG participated in weekly teleconferences to review, comment, and participate in the development of the TRM. The active participants in the TRM were designated as the "Technical Advisory Committee" (TAC). The TAC participants were representatives from the following organizations: the Utilities (ComEd, Ameren IL, Nicor Gas, Peoples Gas/North Shore Gas), DCEO, 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), CNT Energy, the independent evaluators (Navigant and Opinion Dynamics Corporation), The University of Illinois at Chicago, and ICC Staff.

1.2 Development Process

The first edition of the IL-TRM was approved by the Commission in ICC Docket No. 12-0528[11]. The second edition of the IL-TRM was approved by the Commission in ICC Docket No. 13-0437[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[13]. This document represents the third edition of the IL-TRM. It contains a series of new measures, as well as a series of errata items and updates to existing measures that were already present in the first and second editions.

Like the first and second 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. 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.

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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.

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

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

[9] http://www.icc.illinois.gov/docket/files.aspx?no=10-0564&docId=167023

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

[11] http://www.icc.illinois.gov/docket/files.aspx?no=12-0528&docId=187554

[12] http://www.icc.illinois.gov/docket/files.aspx?no=13-0437&docId=200492

[13] http://www.icc.illinois.gov/docket/files.aspx?no=13-0077&docId=203903; http://www.icc.illinois.gov/docket/files.aspx?no=13-0077&docId=195913; http://www.icc.illinois.gov/downloads/public/edocket/339744.pdf

2 Using the TRM

For each measure characterization, this TRM includes engineering algorithm(s) and a value(s) for each parameter in the equation(s)[14]. 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*[15] 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.

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.

[14] As noted in the RFP, the net-to-gross ratios are provided by the evaluators and are listed in the appendices.

[15] Emphasis has been added to denote the difference between a "deemed value" and a "deemed savings estimate". A deemed value refers to a single input value to an algorithm, while a deemed savings estimate is the result of calculating the end result of all of the values in the savings algorithm.

2.1 Organizational Structure

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

1. **Market Sectors**[16]
    - 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[17]

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

3. **Measure & Technology**
    - 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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[16] 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.

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

2.2 Measure Code Specification

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

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

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

Table 2.2: Measure Code Specification Key

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

2.3 Components of TRM Measure Characterizations

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

DESCRIPTION

DEFINITION OF EFFICIENT EQUIPMENT

DEFINITION OF BASELINE EQUIPMENT

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

DEEMED MEASURE COST

LOADSHAPE

COINCIDENCE FACTOR

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS

SUMMER COINCIDENT PEAK DEMAND SAVINGS

NATURAL GAS SAVINGS

WATER IMPACT DESCRIPTIONS AND CALCULATION

DEEMED O&M COST ADJUSTMENT CALCULATION

MEASURE CODE

2.4 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.

2.4.1 C&I Custom Value Use in Measure Implementation

This section defines the requirements for capturing custom variables stated in the commercial and industrial (C&I) 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.

2.4.2 Custom Variables

The following table defines which C&I measures this custom approach can be applied to and further, what variables can be adjusted. This table does not include variables that require actually installed numbers that are collected from the customer, but maps those values where a default value is provided that can be replaced with a custom value. Also indicated is the type of validation required to update a custom figure. Information should be collected and stored based on existing utility procedures.

Table 2.3: Allowable Custom C&I Variables

Measure Number	Measure Title	Adjustable Variable	Adjustable Variable Description	Documentation	Notes
4.2.3	Commercial Steam Cooker	$HOURS_{day}$	Average Daily Operation (hours)	Customer input or measured value	
		F	Food cooked per day (lb)	Customer input or measured value	
		$Days_{Year}$	Annual Days of Operation (days)	Customer input or measured value	
4.2.2	Commercial Solid and Glass Door Refrigerators & Freezers	V	Chilled or frozen compartment volume, ft^3	Customer input or measured value	

Measure Number	Measure Title	Adjustable Variable	Adjustable Variable Description	Documentation	Notes
4.2.5	ENERGY STAR Convection Oven	HOURSday	Average Daily Operation (hours)	Customer input or measured value	
		Days	Annual Days of Operation (days	Customer input or measured value	
		LB	Food cooked per day (lb)	Customer input or measured value	
		EffENERGYSTAR	Cooking Efficiency ENERGY STAR	From ENERGY STAR product data	
		EffBase	Cooking Efficiency Baseline	Customer input or measured value	
		PCENERGYSTAR	Production Capacity ENERGY STAR (lbs/hr)	Customer input or measured value	
		PCBase	Production Capacity base (lbs/hr)	Customer input or measured value	
		PPreheatNumberENERGYSTAR	Number of preheats per day ENERGY STAR	From ENERGY STAR product data	
		PreheatNumber base	Number of preheats per day Base	Customer input or measured value	
		PreheatTimeENERGYSTAR	preheat length ENERGY STAR, min	From ENERGY STAR product data	
		PreheatTimeBase	preheat length base, min	Customer input or measured value	
		PreheatRateENERGYSTAR	preheat energy rate ENERGY STAR, btu/h	From ENERGY STAR product data	
		PreheatRateBase	preheat energy rate baseline, btu/h	Customer input or measured value	
		IdleENERGYSTAR	Idle energy rate ENERGY STAR, btu/h	From ENERGY STAR product data	
		IdleBase	Idle energy rate baseline, btu/h	Customer input or measured value	
		IdleBaseTime	BASE Idle Time, hours	Customer input or measured value	

Measure Number	Measure Title	Adjustable Variable	Adjustable Variable Description	Documentation	Notes
4.2.5	ENERGY STAR Convection Oven	HOURSday	Average Daily Operation (hours)	Customer input or measured value	
		Days	Annual Days of Operation (days)	Customer input or measured value	
		LB	Food cooked per day (lb)	Customer input or measured value	
		EffENERGYSTAR	Cooking Efficiency ENERGY STAR	From ENERGY STAR product data	
		EffBase	Cooking Efficiency Baseline	Customer input or measured value	
		PCENERGYSTAR	Production Capacity ENERGY STAR (lbs/hr)	Customer input or measured value	
		PCBase	Production Capacity base (lbs/hr)	Customer input or measured value	
		PPreheatNumberENERGYSTAR	Number of preheats per day ENERGY STAR	From ENERGY STAR product data	
		PreheatNumber base	Number of preheats per day Base	Customer input or measured value	
		PreheatTimeENERGYSTAR	preheat length ENERGY STAR, min	From ENERGY STAR product data	
		PreheatTimeBase	preheat length base, min	Customer input or measured value	
		PreheatRateENERGYSTAR	preheat energy rate ENERGY STAR, Btu/hr	From ENERGY STAR product data	
		PreheatRateBase	preheat energy rate baseline, Btu/hr	Customer input or measured value	
		IdleENERGYSTAR	Idle energy rate ENERGY STAR, Btu/hr	From ENERGY STAR product data	
		IdleBase	Idle energy rate baseline, Btu/hr	Customer input or measured value	
		IdleBaseTime	BASE Idle Time, hours	Customer input or measured value	

Measure Number	Measure Title	Adjustable Variable	Adjustable Variable Description	Documentation	Notes
4.2.7	ENERGY STAR Fryer	HOURSday	Average Daily Operation (hours)	Customer input or measured value	
		Days	Annual Days of Operation (days)	Customer input or measured value	
		LB	Food cooked per day (lb)	Customer input or measured value	
		EffENERGYSTAR	Cooking Efficiency ENERGY STAR	From ENERGY STAR product data	
		EffBase	Cooking Efficiency Baseline	Customer input or measured value	
		PCENERGYSTAR	Production Capacity ENERGY STAR (lbs/hr)	Customer input or measured value	
		PCBase	Production Capacity base (lbs/hr)	Customer input or measured value	
		PPreheatNumberENERGYSTAR	Number of preheats per day ENERGY STAR	From ENERGY STAR product data	
		PreheatNumber base	Number of preheats per day Base	Customer input or measured value	
		PreheatTimeENERGYSTAR	preheat length ENERGY STAR, min	From ENERGY STAR product data	
		PreheatTimeBase	preheat length base, min	Customer input or measured value	
		PreheatRateENERGYSTAR	preheat energy rate ENERGY STAR, Btu/hr	From ENERGY STAR product data	
		PreheatRateBase	preheat energy rate baseline, Btu/hr	Customer input or measured value	
		IdleENERGYSTAR	Idle energy rate ENERGY STAR, Btu/hr	From ENERGY STAR product data	
		IdleBase	Idle energy rate baseline, Btu/hr	Customer input or measured value	
		IdleBaseTime	BASE Idle Time, hours	Customer input or measured value	

Measure Number	Measure Title	Adjustable Variable	Adjustable Variable Description	Documentation	Notes
4.4.8	ENERGY STAR Griddle	HOURSday	Average Daily Operation (hours)	Customer input or measured value	Electric and Gas
		Days	Annual Days of Operation (days)	Customer input or measured value	Electric and Gas
		LB	Food cooked per day (lb)	Customer input or measured value	Electric and Gas
		Width	Width of griddle (ft)	Customer input or measured value	Electric and Gas
		Depth	Depth of griddle (ft)	Customer input or measured value	
		EffENERGYSTAR	Cooking Efficiency ENERGY STAR	From ENERGY STAR product data	Electric and Gas
		EffBase	Cooking Efficiency Baseline	Customer input or measured value	Electric and Gas
		PCENERGYSTAR	Production Capacity ENERGY STAR (lbs/hr)	Customer input or measured value	Electric and Gas
		PCBase	Production Capacity base (lbs/hr)	Customer input or measured value	Electric and Gas
		PreheatNumber ENERGYSTAR	Number of preheats per day ENERGY STAR	From ENERGY STAR product data	Electric and Gas
		PreheatNumber base	Number of preheats per day Base	Customer input or measured value	Electric and Gas
		PreheatTimeENERGYSTAR	preheat length ENERGY STAR, min	From ENERGY STAR product data	Electric and Gas
		PreheatTimeBase	preheat length base, min	Customer input or measured value	Electric and Gas
		IdleENERGYSTAR	Idle energy rate ENERGY STAR, Btu/hr	From ENERGY STAR product data	Electric and Gas
		IdleBase	Idle energy rate baseline, Btu/hr	Customer input or measured value	Electric and Gas
4.2.9	ENERGY STAR Hot Food Holding Cabinet	PowerBaseline	Baseline power of cabinet, Watts	Customer input or measured value	
		PowerENERGYSTAR	cabinet, Watts	From ENERGY STAR product data	
		HOURSday	Average Daily Operation (hours)	Customer input or measured value	
		Days	Annual Days of Operation (days)	Customer input or measured value	

Measure Number	Measure Title	Adjustable Variable	Adjustable Variable Description	Documentation	Notes
4.2.10	ENERGY STAR Ice Maker	H	Harvest rate (lb/hr)	Custom input or measures value	
4.2.11	High Efficiency Pre-Rinse Spray Valve	Tout	Outlet Water Temperature	Customer input or measured value	
		Tin	Inlet Water Temperature	Customer input or measured value	
		EFF	Efficiency of water heater supplying hot water	Customer input or measured value or Manufacturer specification	Electric and Gas
		FLObase	Base case flow in gallons per minute	Customer input or measured value or Manufacturer specification	
		FLOeff	Efficient case flow in gallons per minute	Customer input or measured value or Manufacturer specification	
		$HOURS_{day}$	Hours of use per day	Customer input or measured value	
		$Days_{Year}$	Days of use per year	Customer input or measured value	
4.2.16	Kitchen Demand Ventilation Controls	HP	Fan Horsepower	Customer input or measured value	
		Eff(heat)	Heating Efficiency	Customer input or measures value	
4.3.2	Low Flow Faucet Aerators	NOPF	Number of occupants per faucet	Customer input	
		GPM_base	Average flow rate, in gallons per minute, of the baseline faucet “as-used”	Documented value based on study or report	
		GPM_low	Average flow rate, in gallons per minute, of the low-flow faucet aerator “as-used”	Documented value based on study or report	
		L_base	Average baseline length faucet use per capita for all faucets in minutes	Documented value based on study or report	
		L_low	Average retrofit length faucet use per capita for all faucets in minutes	Documented value based on study or report	

Measure Number	Measure Title	Adjustable Variable	Adjustable Variable Description	Documentation	Notes
4.3.3	Low Flow Showerheads	GPM_base	Average flow rate, in gallons per minute, of the baseline faucet “as-used”	Documented flow rate from installed equipment	
		NSPF	Number of showers per faucet	Customer input	
4.3.4	Commercial Pool Cover	Size of Pool	Size of pool	Customer input or measured value	
4.3.5	Tankless Water Heater	Wgal	Annual Water use for equipment	Customer input or measured value	
		Tout	Outlet Water Temperature	Customer input or measured value	
		Tin	Inlet Water Temperature	Customer input or measured value	
		SL	Stand-by Loss in Base Case Btu/hr	Customer input or measured value	
		Eff_ee	Rated Efficiency of water Heater	Customer input or documented value based on study or report	
		Tank Volume	Tank Volume	Customer input or documented value based on study or report	
4.3.6	Ozone Laundry	HP	Brake horsepower of boiler feed water pump	Customer input or measured value	Electric
		Hours	Actual associated boiler feed water pump hours	Customer input or measured value	Electric
		WUtiliz	Washer utilization factor: the annual pounds of clothes washed per year	Customer input or measured value	Gas
4.4.2	Space Boiler Tune-up	Ngi	Boiler gas input size	Customer input or measured value	
		SF	Savings Factor	Customer input or measured value	
		Effpre	Boiler Efficiency before Tune-up	Customer input or measured value	
4.4.3	Process Boiler Tune-up	Ngi	Boiler gas input size	Customer input or measured value	
		UF	Utilization Factor	Customer input or measured value	
		Effpre	Boiler Combustion Efficiency before Tune-up	Customer input or measured value	
		$Eff_{measured}$	Boiler Combustion Efficiency before Tune-up	Customer input or measured value	

Measure Number	Measure Title	Adjustable Variable	Adjustable Variable Description	Documentation	Notes
4.4.4	Boiler Lockout/Reset Controls	Binput	Boiler Input Capacity	Customer input or measured value	
		SF	Savings Factor	Customer input or measured value	
		Effpre	Boiler Efficiency	Customer input or measured value	
4.4.6	Electric Chiller	TONS	Chiller nominal cooling capacity in tons	Customer input or measured value	
		IPLVbase	Efficiency of baseline equipment expressed as Integrated Part Load Value(kW/ton)	Customer input or measured value	
		IPLVee	Efficiency of high efficiency equipment expressed as Integrated Part Load Value (kW/ton)	Customer input or measured value	
		PEbase	Peak efficiency of baseline equipment expressed as Full Load EER	Customer input or measured value	
		PEee	Peak efficiency of high efficiency equipment expressed as Full Load EER	Customer input or measured value	
4.4.7	ENERGY STAR and CEE Tier 1 Room Air Conditioner	Btu/H	Size of unit	Customer input or measured value	
		EERee	Efficiency of ENERGY STAR or CEE Tier 1 unit	Customer input or measured value or Manufacturer specification	

Measure Number	Measure Title	Adjustable Variable	Adjustable Variable Description	Documentation	Notes
4.4.9	Heat Pump Systems	$kBtu/hr_{cool}$	capacity of the cooling equipment in kBtu per hour	Customer input or measured value or Manufacturer specification	
		SEERee	Seasonal Energy Efficiency Ratio of the energy efficient equipment	Customer input or measured value or Manufacturer specification	
		HSPFee	Heating Seasonal Performance Factor of the energy efficient equipment	Customer input or measured value or Manufacturer specification	
		EERee	Energy Efficiency Ratio of the energy efficient equipment	Customer input or measured value or Manufacturer specification	
		COPee	Coefficient of performance of the energy efficient equipment	Customer input or measured value or Manufacturer specification	
4.4.10	High Efficiency Boiler	Capacity	Nominal Heating Capacity Boiler Size	Customer input or measured value	
		AFUE(base)	Efficient Furnace Annual Fuel Utilization Efficiency Rating	Customer input or measured value	
		AFUE(eff)	Efficient Furnace Annual Fuel Utilization Efficiency Rating	Customer input or measured value	

Measure Number	Measure Title	Adjustable Variable	Adjustable Variable Description	Documentation	Notes
4.4.11	High Efficiency Furnace	Capacity	Nominal Furnace input capacity	Customer input or measured value	
		AFUE(base)	Efficient Furnace Annual Fuel Utilization Efficiency Rating	Customer input or measured value	
		AFUE(eff)	Efficient Furnace Annual Fuel Utilization Efficiency Rating	Customer input or measured value	
4.4.13	Package Terminal Air Condition (PTAC) and Package Terminal Heat Pump (PTHP)	$kBtu/hr_{cool}$	Capacity of the cooling equipment in kBtu per hour	Customer input or measured value or Manufacturer specification	
		EERexist	Energy Efficiency Ratio of existing equipment	Customer input or measured value	
		EERee	Energy Efficiency Ratio of the energy efficient equipment	Customer input or measured value or Manufacturer specification	
		$kBtu/hr_{heat}$	Capacity of heating equipment in kBtu per hour	Customer input or measured value or Manufacturer specification	
		COPexist	Coefficient of performance of the existing equipment	Customer input or measured value	
		COPee	Coefficient of performance of the energy efficient equipment	Customer input or measured value or Manufacturer specification	
4.4.14	Pipe Insulation	HOURS	Annual	Customer input or measured value	
		L_{sp}	Length of straight pipe to be insulated (linear foot)	Customer input or measured value	
		$L_{oc,I}$	Total equivalent length of the other components (valves and tees) of pipe to be insulated	Calculated value based on custom count of fittings	

Measure Number	Measure Title	Adjustable Variable	Adjustable Variable Description	Documentation	Notes
4.4.15	Single Package and Split System Unitary Air Conditioners	$kBtu/hr_{cool}$	Capacity of the cooling equipment in kBtu per hour	Customer input or measured value	
		SEERee	Seasonal Energy Efficiency Ratio of the energy efficient equipment	Customer input or measured value or Manufacturer specification	
		EERee	Energy Efficiency Ratio of the energy efficient equipment	Customer input or measured value or Manufacturer specification	
4.4.16	Steam Trap Replacement or Repair	B	Boiler Efficiency	Customer input or measured value	
		L	Leaking and blow-thru percentage	Customer input or documented value based on study or report	
4.4.17	VSD for HVAC	HP	Motor HP	Customer input or measured value	
		Load Factor	Motor Load Factor	Customer input or measured value	
		Hours	Actual hours for equipment operations	Customer input or measured value	
		ESF	VDS Energy Savings Factors	Custom calculated values	
		CF	Coincidence factor	Custom calculated values	
4.4.18	Small Commercial Programmable Thermostats	Capacity	Nominal Input Heating Capacity Furnace Size (Btu/hr.)	Customer input or measured value	
		Degree of Setback	The degrees in Farenheit the temperature is setback from the space temperature setpoint (°F)	Customer input or measured value	
4.4.19	Demand Control Ventilation	Conditioned Space	actual square footage of conditioned space controlled by sensor	Customer input or measured value	
4.4.20	High Turndown Burner for Space Heating Boilers	Ngi	Boiler gas input size (kBtu/hr)	Customer input or measured value	
		H_cycling	Hours base boiler is cycling at % of base boiler load	Customer input or measured value	
		H	Total Number of Hours in Heating Season	Customer input or measured value	

Measure Number	Measure Title	Adjustable Variable	Adjustable Variable Description	Documentation	Notes
4.4.21	Linkageless Boiler Controls for Space Heating	Ngi	Boiler gas input size (kBtu/hr)	Customer input or measured value	
4.4.22	Oxygen Trim Controls for Space Heating Boilers	Ngi	Boiler gas input size (kBtu/hr)	Customer input or measured value	
4.4.23	Shut Off Damper for Space Heating Boilers or Furnaces	Ngi	Boiler gas input size (kBtu/hr)	Customer input or measured value	
4.5.1	Commercial ENERGY STAR Compact Fluorescent Lamp (CFL)	$Watts_{base}$	Base Wattage	Customer input or measured value	
		$Watts_{EE}$	Efficiency Wattage	Customer input or measured value	
4.5.3	HPT8 Lighting	$Watts_{base}$	Base Wattage	Customer input or measured value	This will allow for reduced wattage applications
		$Watts_{EE}$	Efficiency Wattage	Customer input or measured value	This will allow for reduced wattage applications
		Hours	Average use hours	Customer input or documented value based on study or report	

Measure Number	Measure Title	Adjustable Variable	Adjustable Variable Description	Documentation	Notes
4.5.5	Commercial LED Exit Signs	$Watts_{base}$	Base Wattage	Customer input or measured value	
		$Watts_{EE}$	Efficiency Wattage	Customer input or measured value	
		Hours	Average use hours	Customer input or documented value based on study or report	
4.5.7	Lighting Power Density Reduction	WSF_{effic}	The actual installed lighting watts per square foot or linear foot	Customer input	
		SF	Square footage of the building area applicable to the lighting design	Customer input	
		Hours	Hours of use	Customer input	
4.5.8	Miscellaneous Commercial/Industrial Lighting	$Watts_{base}$	Base Wattage	Customer input or measured value	
		$Watts_{EE}$	Efficiency Wattage	Customer input or measured value	
		Hours	Average use hours	Customer input or documented value based on study or report	
4.5.9	Multi-Level Lighting Switch	$KW_{connected}$	Total Connected kW load	Customer input or measured value	
		Hours	Hours of use	Customer input or documented value based on study or report	
		ESF	Energy Savings Factor	Customer input or documented value based on study or report	
4.5.10	Occupancy Sensor Lighting Controls	$KW_{controlled}$	Total Controlled kW load	Customer input or measured value	
		Hours	Hours of use	Customer input or documented value based on study or report	
		ESF	Energy Savings Factor	Customer input or documented value based on study or report	

Measure Number	Measure Title	Adjustable Variable	Adjustable Variable Description	Documentation	Notes
4.5.12	T5 Lighting	$Watts_{base}$	Base Wattage	Customer input or measured value	This will allow for reduced wattage applications
		$Watts_{EE}$	Efficiency Wattage	Customer input or measured value	This will allow for reduced wattage applications
		Hours	Average use hours	Customer input or documented value based on study or report	
4.5.13	Occupancy Controlled Bi-Level Lighting Fixture	$KW_{Baseline}$	Total baseline lighting load of the existing/baseline fixture	Customer input or measured value	
		$KW_{controlled}$	Total Controlled kW load	Customer input or measured value	
		Hours	Hours of use	Customer input or documented value based on study or report	
		ESF	Energy Savings Factor	Customer input or documented value based on study or report	
4.6.3	Door Heater Controls for Cooler or Freezer	kWbase	Connected load kW for typical reach-in refrigerator or freezer door and frame with a heater	Customer input or measured value	
		NUMdoors	number of reach-in refrigerator or freezer doors controlled by sensor	Customer input or measured value	
4.6.8	Refrigeration Economizers	HP	Compressor HP	Customer input or measured value	
		Hours	Actual hours for economizer operations	Customer input or measured value	
		kWEvap	Connected load kW of each evaporator fan	Customer input or measured value	
		kWCirc	Connected load kW of the circulating fan	Customer input or measured value	
		nFans	Number of evaporator fans	Customer input or measured value	

Measure Number	Measure Title	Adjustable Variable	Adjustable Variable Description	Documentation	Notes
4.7.1	VSD Air Compressor	$hp_{compressor}$	Compressor motor nominal	Customer input or measured value	
		DCEcon	Duty cycle of the economizer fan on days that are cool enough for the economizer to be working	Customer input or measured value	
		kWEcon	Connected load kW of the economizer fan	Customer input or measured value	

2.5 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 2.4: Program Delivery Types

Program	Attributes
Time of Sale (TOS)	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
New Construction (NC)	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
Retrofit (RF)	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
Early Replacement (EREP)	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
Early Retirement (ERET)	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
Direct Install (DI)	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

Program	Attributes
	standard industry practice. 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 five categories, and are organized within each measure characterization by the program delivery type to which it applies.

1. **Building Code:** As defined by the minimum specifications required under state energy code or applicable federal standards.
2. **Existing Equipment**: As determined by the most representative (or average) example of equipment that is in the existing stock. Existing equipment baselines apply over the equipment's remaining useful life.
3. **New Equipment**: As determined by the equipment that represents standard practice in the current market environment. New equipment baselines apply over the effective useful life of the measure.
4. **Dual Baseline**: A baseline that begins as the existing equipment and shifts to new equipment after the expected life of the existing equipment is over.

2.6 High Impact Measures

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

Table 2.5: Commercial and Industrial High Impact Measures

Section	End-use	Technology / Measure
4.2.3	Food Service	Commercial Steam Cooker
4.2.11	Food Service	High Efficiency Pre-Rinse Spray Valve
4.3.5	Hot Water	Tankless Water Heater
4.4.3	HVAC	Process Boiler Tune-up
4.4.4	HVAC	Boiler Lockout/Reset Controls
4.4.10	HVAC	High Efficiency Boilers
4.4.11	HVAC	High Efficiency Furnace
4.4.16	HVAC	Steam Trap Replacement or Repair
4.4.17	HVAC	Variable Speed Drives for HVAC
4.5.1	Lighting	Commercial ENERGY STAR CFL
4.5.3	Lighting	High Performance and Reduced Wattage T8 Fixtures and Lamps
4.5.4	Lighting	LED Bulbs & Fixtures
4.5.6	Lighting	LED Traffic and Pedestrian Signals
4.5.7	Lighting	Lighting Power Density Reduction
4.5.10	Lighting	Occupancy Sensor Lighting Controls
4.5.12	Lighting	T5 Fixtures & Lamps

Table 2.6: Residential High Impact Measures

Section	End-use	Technology / Measure
5.1.2	Appliances	Clothes Washer
5.1.8	Appliances	Refrigerator & Freezer Recy.
5.4.2	Hot Water	Gas Water Heater
5.4.3	Hot Water	Heat Pump Water Heater
5.4.4	Hot Water	Low Flow Faucet Aerator
5.4.5	Hot Water	Low Flow Showerhead
5.3.3	HVAC	Central Air Conditioning > 14.5 SEER
5.3.5	HVAC	Furnace Blower Motor
5.3.6	HVAC	Gas High Efficiency Boiler
5.3.7	HVAC	Gas High Efficiency Furnace
5.3.11	HVAC	Programmable Thermostats
5.5.1	Lighting	Energy Star Compact Florescent Lamp
5.5.2	Lighting	ENERGY STAR Specialty CFL
5.5.6	Lighting	LED Downlights
5.6.1	Shell	Air Sealing
5.6.2	Shell	Basement Sidewall Insulation
5.6.4	Shell	Wall and Ceiling Insulation

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).[18] 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 may also be posted to the SAG's public web site (www.ilsag.info).

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.

[18] 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. Finally, as of July 14, 2012, Federal Standards will require that practically all linear fluorescents meet strict performance requirements essentially requiring all T12 users, when they need to purchase new bulbs, to upgrade to high performance T8 lamps and ballasts[19]. We have assumed that this standard will become fully effective in 2016. To account for this, we have included a methodology to address the shifting baseline in the high performance T8 measure and T5 measure which is defined specifically in each measure characterization.

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.

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

Table 3.1: Early Replacement Baseline Criteria[20]

Measure	Section	Criteria
Air Source Heap Pump	5.3.1	SEER <=10 and cost of any repairs <$249 per ton
Central Air	5.3.3	SEER <=10 and cost of any repairs <$190 per ton
Boiler	5.3.6	AFUE <= 75% and cost of any repairs <$709
Furnace	4.4.11, 5.3.7	AFUE <= 75% and cost of any repairs <$528
Ground Source Heat Pump	5.3.8	SEER <=10 and cost of any repairs <$249 per ton

It is only appropriate to use these Early Replacement assumptions where these 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 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.

Updat*e:* On January 14th, 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."[21]

As a result, each of the furnace measures contain 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."[22]

[20] These criteria were documented in a memo entitled, "Early Replacement Measure Issue Summary_0409.docx."
[21] Appliance Standards Awareness Project, http://www.appliance-standards.org/product/furnaces
[22] Illinois Statewide Technical Reference Manual, May 13, 2013, pp 191, 439

3.4 Glossary

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

Building Types[23]:

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

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

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

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

Commercial & Industrial: The market sector that includes measures that apply to any of the building types defined in this TRM, which includes multifamily common areas and public housing[24].

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.

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

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

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

> **EUL** – EUL is based on the manufacturers rating of the effective useful life; how long the equipment will last. For example, a CFL that operates x hours per year will typically have an EUL of y. A house boiler may have a lifetime of 20 years but the EUL is only 15 years since after that time it may be operating at a non-efficient point. An estimate of the median number of years that the measures installed under a program are still in place and operable.
>
> **RUL** – Applies to retrofit or replacement measures. For example, if an existing working refrigerator is replaced with a high efficiency unit, the RUL is an assumption of how many more years the existing unit would have lasted. As a general rule the RUL is usually assumed to be 1/3 of the EUL.

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

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

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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.

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 2.5.1 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. A list of current SAG participants appears in the following table.

Table 3.2: SAG Stakeholder List

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

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

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 3.3: On and Off Peak Energy Definitions

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

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

1. Itron eShapes[26] data for Missouri, reconciled to Illinois loads and provided by Ameren, were used to calculate the percentage of load in to the four categories above.

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

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

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

[26] All loadshape information has been posted to the project's Sharepoint site, and may be provided publically through the Stakeholder Advisory Group's web site at their discretion. http://www.ilsag.info/technical-reference-manual.html

Table 3.4: Loadshapes by Season

		Winter Peak	Winter Off-peak	Summer Peak	Summer Off-peak
	Loadshape Reference Number	Oct-Apr, M-F, non-holiday, 8AM - 11PM	Oct-Apr, All other time	May-Sept, M-F, non-holiday, 8AM - 11PM	May- Sept, All other time
Residential Clothes Washer	R01	47.0%	11.1%	34.0%	8.0%
Residential Dish Washer	R02	49.3%	8.7%	35.7%	6.3%
Residential Electric DHW	R03	43.2%	20.6%	24.5%	11.7%
Residential Freezer	R04	38.9%	16.4%	31.5%	13.2%
Residential Refrigerator	R05	37.0%	18.1%	30.1%	14.7%
Residential Indoor Lighting	R06	48.1%	15.5%	26.0%	10.5%
Residential Outdoor Lighting	R07	18.0%	44.1%	9.4%	28.4%
Residential Cooling	R08	4.1%	0.7%	71.3%	23.9%
Residential Electric Space Heat	R09	57.8%	38.8%	1.7%	1.7%
Residential Electric Heating and Cooling	R10	35.2%	22.8%	31.0%	11.0%
Residential Ventilation	R11	25.8%	32.3%	18.9%	23.0%
Residential - Dehumidifier	R12	12.9%	16.2%	31.7%	39.2%
Residential Standby Losses - Entertainment Center	R13	26.0%	32.5%	18.9%	22.6%
Residential Standby Losses - Home Office	R14	23.9%	34.6%	17.0%	24.5%
Commercial Electric Cooking	C01	40.6%	18.2%	28.7%	12.6%
Commercial Electric DHW	C02	40.5%	18.2%	28.5%	12.8%
Commercial Cooling	C03	4.9%	0.8%	66.4%	27.9%
Commercial Electric Heating	C04	53.5%	43.2%	1.9%	1.4%
Commercial Electric Heating and Cooling	C05	19.4%	13.5%	47.1%	19.9%
Commercial Indoor Lighting	C06	40.1%	18.6%	28.4%	12.9%
Grocery/Conv. Store Indoor Lighting	C07	31.4%	26.4%	22.8%	19.3%
Hospital Indoor Lighting	C08	29.1%	29.0%	21.0%	20.9%
Office Indoor Lighting	C09	42.1%	16.0%	30.4%	11.5%
Restaurant Indoor Lighting	C10	32.1%	25.7%	23.4%	18.8%
Retail Indoor Lighting	C11	35.5%	22.3%	25.8%	16.3%
Warehouse Indoor Lighting	C12	39.4%	18.5%	28.6%	13.5%
K-12 School Indoor Lighting	C13	45.8%	22.6%	20.2%	11.4%

		Winter Peak	Winter Off-peak	Summer Peak	Summer Off-peak
	Loadshape Reference Number	Oct-Apr, M-F, non-holiday, 8AM - 11PM	Oct-Apr, All other time	May-Sept, M-F, non-holiday, 8AM - 11PM	May- Sept, All other time
Indust. 1-shift (8/5) (e.g., comp. air, lights)	C14	50.5%	7.2%	37.0%	5.3%
Indust. 2-shift (16/5) (e.g., comp. air, lights)	C15	47.5%	10.2%	34.8%	7.4%
Indust. 3-shift (24/5) (e.g., comp. air, lights)	C16	34.8%	23.2%	25.5%	16.6%
Indust. 4-shift (24/7) (e.g., comp. air, lights)	C17	25.8%	32.3%	18.9%	23.0%
Industrial Indoor Lighting	C18	44.3%	13.6%	32.4%	9.8%
Industrial Outdoor Lighting	C19	18.0%	44.1%	9.4%	28.4%
Commercial Outdoor Lighting	C20	23.4%	35.3%	13.0%	28.3%
Commercial Office Equipment	C21	37.7%	20.9%	26.7%	14.7%
Commercial Refrigeration	C22	38.5%	20.6%	26.7%	14.2%
Commercial Ventilation	C23	38.1%	20.6%	29.7%	11.6%
Traffic Signal - Red Balls, always changing or flashing	C24	25.8%	32.3%	18.9%	23.0%
Traffic Signal - Red Balls, changing day, off night	C25	37.0%	20.9%	27.1%	14.9%
Traffic Signal - Green Balls, always changing	C26	25.8%	32.3%	18.9%	23.0%
Traffic Signal - Green Balls, changing day, off night	C27	37.0%	20.9%	27.1%	14.9%
Traffic Signal - Red Arrows	C28	25.8%	32.3%	18.9%	23.0%
Traffic Signal - Green Arrows	C29	25.8%	32.3%	18.9%	23.0%
Traffic Signal - Flashing Yellows	C30	25.8%	32.3%	18.9%	23.0%
Traffic Signal - “Hand” Don’t Walk Signal	C31	25.8%	32.3%	18.9%	23.0%
Traffic Signal - “Man” Walk Signal	C32	25.8%	32.3%	18.9%	23.0%
Traffic Signal - Bi-Modal Walk/Don’t Walk	C33	25.8%	32.3%	18.9%	23.0%
Industrial Motor	C34	47.5%	10.2%	34.8%	7.4%
Industrial Process	C35	47.5%	10.2%	34.8%	7.4%
HVAC Pump Motor (heating)	C36	38.7%	48.6%	5.9%	6.8%
HVAC Pump Motor (cooling)	C37	7.8%	9.8%	36.8%	45.6%
HVAC Pump Motor (unknown use)	C38	23.2%	29.2%	21.4%	26.2%
VFD - Supply fans <10 HP	C39	38.8%	16.1%	28.4%	16.7%
VFD - Return fans <10 HP	C40	38.8%	16.1%	28.4%	16.7%
VFD - Exhaust fans <10 HP	C41	34.8%	23.2%	20.3%	21.7%
VFD - Boiler feedwater pumps <10 HP	C42	42.9%	44.2%	6.6%	6.3%

		Winter Peak	Winter Off-peak	Summer Peak	Summer Off-peak
	Loadshape Reference Number	Oct-Apr, M-F, non-holiday, 8AM - 11PM	Oct-Apr, All other time	May-Sept, M-F, non-holiday, 8AM - 11PM	May- Sept, All other time
VFD - Chilled water pumps <10 HP	C43	11.2%	5.5%	40.7%	42.6%
VFD Boiler circulation pumps <10 HP	C44	42.9%	44.2%	6.6%	6.3%
Refrigeration Economizer	C45	36.3%	50.8%	5.6%	7.3%
Evaporator Fan Control	C46	24.0%	35.9%	16.7%	23.4%
Standby Losses - Commercial Office	C47	8.2%	50.5%	5.6%	35.7%
VFD Boiler draft fans <10 HP	C48	37.3%	48.9%	6.4%	7.3%
VFD Cooling Tower Fans <10 HP	C49	7.9%	5.2%	54.0%	32.9%
Engine Block Heater Timer	C50	26.5%	61.0%	4.1%	8.5%
Door Heater Control	C51	30.4%	69.6%	0.0%	0.0%
Beverage and Snack Machine Controls	C52	10.0%	48.3%	7.4%	34.3%
Flat	C53	36.3%	21.8%	26.2%	15.7%
Religious Indoor Lighting	C54	26.8%	31.4%	18.9%	22.8%

Table 3.5: Loadshapes by Month and Day of Week

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

		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
		M-F	S-S	M-F	S-S	M-F	S-S	M-F	S-S	M-F	S-S	M-F	S-S	M-F	S-S	M-F	S-S	M-F	S-S	M-F	S-S	M-F	S-S	M-F	S-S
Commercial Electric Cooking	C01	6.0%	2.6%	5.4%	2.4%	5.7%	2.9%	5.8%	2.5%	5.9%	2.5%	5.5%	2.6%	6.0%	2.4%	5.7%	2.6%	5.6%	2.5%	6.1%	2.5%	5.6%	2.7%	5.9%	2.6%
Commercial Electric DHW	C02	6.0%	2.6%	5.4%	2.4%	5.7%	2.9%	5.8%	2.5%	5.8%	2.5%	5.5%	2.6%	6.0%	2.4%	5.7%	2.7%	5.6%	2.5%	6.1%	2.5%	5.6%	2.7%	5.9%	2.6%
Commercial Cooling	C03	0.7%	0.1%	0.6%	0.1%	0.7%	0.1%	0.7%	0.1%	13.6%	5.5%	12.8%	5.7%	13.9%	5.2%	13.3%	5.9%	13.0%	5.5%	0.7%	0.1%	0.7%	0.1%	0.7%	0.1%
Commercial Electric Heating	C04	7.9%	6.1%	7.1%	5.7%	7.6%	6.8%	7.7%	5.9%	0.4%	0.3%	0.4%	0.3%	0.4%	0.3%	0.4%	0.3%	0.4%	0.3%	8.0%	5.9%	7.4%	6.5%	7.8%	6.3%
Commercial Electric Heating and Cooling	C05	2.9%	1.9%	2.6%	1.8%	2.8%	2.1%	2.8%	1.9%	9.6%	4.0%	9.1%	4.1%	9.8%	3.7%	9.4%	4.2%	9.2%	4.0%	2.9%	1.9%	2.7%	2.0%	2.8%	2.0%
Commercial Indoor Lighting	C06	5.9%	2.6%	5.3%	2.5%	5.7%	2.9%	5.7%	2.6%	5.8%	2.6%	5.5%	2.6%	5.9%	2.4%	5.7%	2.7%	5.5%	2.6%	6.0%	2.6%	5.5%	2.8%	5.9%	2.7%
Grocery/Conv. Store Indoor Lighting	C07	4.7%	3.7%	4.2%	3.5%	4.4%	4.2%	4.5%	3.6%	4.7%	3.8%	4.4%	3.9%	4.8%	3.6%	4.6%	4.1%	4.5%	3.8%	4.7%	3.6%	4.3%	3.9%	4.6%	3.8%
Hospital Indoor Lighting	C08	4.3%	4.1%	3.9%	3.8%	4.1%	4.6%	4.2%	4.0%	4.3%	4.2%	4.0%	4.3%	4.4%	3.9%	4.2%	4.4%	4.1%	4.2%	4.4%	4.0%	4.0%	4.3%	4.3%	4.2%
Office Indoor Lighting	C09	6.2%	2.3%	5.6%	2.1%	6.0%	2.5%	6.0%	2.2%	6.2%	2.3%	5.9%	2.4%	6.4%	2.2%	6.1%	2.4%	5.9%	2.3%	6.3%	2.2%	5.8%	2.4%	6.2%	2.3%
Restaurant Indoor Lighting	C10	4.8%	3.6%	4.3%	3.4%	4.5%	4.1%	4.6%	3.5%	4.8%	3.7%	4.5%	3.8%	4.9%	3.5%	4.7%	4.0%	4.6%	3.7%	4.8%	3.5%	4.4%	3.8%	4.7%	3.7%
Retail Indoor Lighting	C11	5.3%	3.1%	4.7%	3.0%	5.0%	3.5%	5.1%	3.1%	5.3%	3.2%	5.0%	3.3%	5.4%	3.1%	5.2%	3.4%	5.0%	3.2%	5.3%	3.1%	4.9%	3.3%	5.2%	3.2%
Warehouse Indoor Lighting	C12	5.8%	2.6%	5.2%	2.5%	5.6%	2.9%	5.6%	2.5%	5.8%	2.7%	5.5%	2.8%	6.0%	2.5%	5.7%	2.8%	5.6%	2.7%	5.9%	2.5%	5.4%	2.8%	5.8%	2.7%
K-12 School Indoor Lighting	C13	6.8%	3.2%	6.1%	3.0%	6.5%	3.6%	6.6%	3.1%	4.1%	2.3%	3.9%	2.3%	4.2%	2.1%	4.0%	2.4%	3.9%	2.3%	6.9%	3.1%	6.3%	3.4%	6.7%	3.3%
Indust. 1-shift (8/5) (e.g., comp. air, lights)	C14	7.5%	1.0%	6.7%	1.0%	7.1%	1.1%	7.2%	1.0%	7.5%	1.1%	7.1%	1.1%	7.7%	1.0%	7.4%	1.1%	7.2%	1.1%	7.6%	1.0%	7.0%	1.1%	7.4%	1.0%
Indust. 2-shift	C15	7.0%	1.4%	6.3%	1.4%	6.7%	1.6%	6.8%	1.4%	7.1%	1.5%	6.7%	1.5%	7.3%	1.4%	6.9%	1.6%	6.8%	1.5%	7.1%	1.4%	6.6%	1.5%	7.0%	1.5%

		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
		M-F	S-S	M-F	S-S	M-F	S-S	M-F	S-S	M-F	S-S	M-F	S-S	M-F	S-S	M-F	S-S	M-F	S-S	M-F	S-S	M-F	S-S	M-F	S-S
(16/5) (e.g., comp. air, lights)																									
Indust. 3-shift (24/5) (e.g., comp. air, lights)	C16	5.1%	3.3%	4.6%	3.1%	4.9%	3.7%	5.0%	3.2%	5.2%	3.3%	4.9%	3.4%	5.3%	3.1%	5.1%	3.5%	5.0%	3.3%	5.2%	3.2%	4.8%	3.5%	5.1%	3.4%
Indust. 4-shift (24/7) (e.g., comp. air, lights)	C17	3.8%	4.6%	3.4%	4.3%	3.6%	5.1%	3.7%	4.4%	3.8%	4.6%	3.6%	4.7%	3.9%	4.3%	3.8%	4.8%	3.7%	4.6%	3.9%	4.4%	3.6%	4.8%	3.8%	4.7%
Industrial Indoor Lighting	C18	6.6%	1.9%	5.9%	1.8%	6.3%	2.1%	6.3%	1.9%	6.6%	1.9%	6.2%	2.0%	6.8%	1.8%	6.5%	2.0%	6.3%	1.9%	6.6%	1.9%	6.1%	2.0%	6.5%	2.0%
Industrial Outdoor Lighting	C19	2.7%	6.2%	2.4%	5.9%	2.6%	7.0%	2.6%	6.0%	1.9%	5.7%	1.8%	5.8%	2.0%	5.3%	1.9%	6.0%	1.8%	5.7%	2.7%	6.0%	2.5%	6.6%	2.6%	6.4%
Commercial Outdoor Lighting	C20	3.5%	5.0%	3.1%	4.7%	3.3%	5.6%	3.3%	4.8%	2.7%	5.6%	2.5%	5.8%	2.7%	5.3%	2.6%	5.9%	2.5%	5.6%	3.5%	4.8%	3.2%	5.3%	3.4%	5.1%
Commercial Office Equipment	C21	5.6%	3.0%	5.0%	2.8%	5.3%	3.3%	5.4%	2.9%	5.4%	2.9%	5.1%	3.0%	5.6%	2.7%	5.3%	3.1%	5.2%	2.9%	5.6%	2.9%	5.2%	3.1%	5.5%	3.0%
Commercial Refrigeration	C22	5.7%	2.9%	5.1%	2.7%	5.4%	3.2%	5.5%	2.8%	5.5%	2.8%	5.1%	2.9%	5.6%	2.7%	5.3%	3.0%	5.2%	2.8%	5.8%	2.8%	5.3%	3.1%	5.6%	3.0%
Commercial Ventilation	C23	5.6%	2.9%	5.1%	2.7%	5.4%	3.3%	5.4%	2.8%	6.1%	2.3%	5.7%	2.4%	6.2%	2.2%	5.9%	2.4%	5.8%	2.3%	5.7%	2.8%	5.3%	3.1%	5.6%	3.0%
Traffic Signal - Red Balls, always changing or flashing	C24	3.8%	4.6%	3.4%	4.3%	3.6%	5.1%	3.7%	4.4%	3.8%	4.6%	3.6%	4.7%	3.9%	4.3%	3.8%	4.8%	3.7%	4.6%	3.9%	4.4%	3.6%	4.8%	3.8%	4.7%
Traffic Signal - Red Balls, changing day, off night	C25	5.5%	2.9%	4.9%	2.8%	5.2%	3.3%	5.3%	2.9%	5.5%	3.0%	5.2%	3.1%	5.7%	2.8%	5.4%	3.1%	5.3%	3.0%	5.5%	2.9%	5.1%	3.1%	5.4%	3.0%
Traffic Signal - Green Balls, always changing	C26	3.8%	4.6%	3.4%	4.3%	3.6%	5.1%	3.7%	4.4%	3.8%	4.6%	3.6%	4.7%	3.9%	4.3%	3.8%	4.8%	3.7%	4.6%	3.9%	4.4%	3.6%	4.8%	3.8%	4.7%
Traffic Signal - Green Balls,	C27	5.5%	2.9%	4.9%	2.8%	5.2%	3.3%	5.3%	2.9%	5.5%	3.0%	5.2%	3.1%	5.7%	2.8%	5.4%	3.1%	5.3%	3.0%	5.5%	2.9%	5.1%	3.1%	5.4%	3.0%

		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
		M-F	S-S	M-F	S-S	M-F	S-S	M-F	S-S	M-F	S-S	M-F	S-S	M-F	S-S	M-F	S-S	M-F	S-S	M-F	S-S	M-F	S-S	M-F	S-S
changing day, off night																									
Traffic Signal - Red Arrows	C28	3.8%	4.6%	3.4%	4.3%	3.6%	5.1%	3.7%	4.4%	3.8%	4.6%	3.6%	4.7%	3.9%	4.3%	3.8%	4.8%	3.7%	4.6%	3.9%	4.4%	3.6%	4.8%	3.8%	4.7%
Traffic Signal - Green Arrows	C29	3.8%	4.6%	3.4%	4.3%	3.6%	5.1%	3.7%	4.4%	3.8%	4.6%	3.6%	4.7%	3.9%	4.3%	3.8%	4.8%	3.7%	4.6%	3.9%	4.4%	3.6%	4.8%	3.8%	4.7%
Traffic Signal - Flashing Yellows	C30	3.8%	4.6%	3.4%	4.3%	3.6%	5.1%	3.7%	4.4%	3.8%	4.6%	3.6%	4.7%	3.9%	4.3%	3.8%	4.8%	3.7%	4.6%	3.9%	4.4%	3.6%	4.8%	3.8%	4.7%
Traffic Signal - “Hand” Don’t Walk Signal	C31	3.8%	4.6%	3.4%	4.3%	3.6%	5.1%	3.7%	4.4%	3.8%	4.6%	3.6%	4.7%	3.9%	4.3%	3.8%	4.8%	3.7%	4.6%	3.9%	4.4%	3.6%	4.8%	3.8%	4.7%
Traffic Signal - “Man” Walk Signal	C32	3.8%	4.6%	3.4%	4.3%	3.6%	5.1%	3.7%	4.4%	3.8%	4.6%	3.6%	4.7%	3.9%	4.3%	3.8%	4.8%	3.7%	4.6%	3.9%	4.4%	3.6%	4.8%	3.8%	4.7%
Traffic Signal - Bi-Modal Walk/Don’t Walk	C33	3.8%	4.6%	3.4%	4.3%	3.6%	5.1%	3.7%	4.4%	3.8%	4.6%	3.6%	4.7%	3.9%	4.3%	3.8%	4.8%	3.7%	4.6%	3.9%	4.4%	3.6%	4.8%	3.8%	4.7%
Industrial Motor	C34	7.0%	1.4%	6.3%	1.4%	6.7%	1.6%	6.8%	1.4%	7.1%	1.5%	6.7%	1.5%	7.3%	1.4%	6.9%	1.6%	6.8%	1.5%	7.1%	1.4%	6.6%	1.5%	7.0%	1.5%
Industrial Process	C35	7.0%	1.4%	6.3%	1.4%	6.7%	1.6%	6.8%	1.4%	7.1%	1.5%	6.7%	1.5%	7.3%	1.4%	6.9%	1.6%	6.8%	1.5%	7.1%	1.4%	6.6%	1.5%	7.0%	1.5%
HVAC Pump Motor (heating)	C36	5.7%	6.9%	5.2%	6.4%	5.5%	7.7%	5.5%	6.6%	1.2%	1.4%	1.1%	1.4%	1.2%	1.3%	1.2%	1.4%	1.2%	1.4%	5.8%	6.6%	5.3%	7.3%	5.7%	7.1%
HVAC Pump Motor (cooling)	C37	1.2%	1.4%	1.0%	1.3%	1.1%	1.5%	1.1%	1.3%	7.5%	9.1%	7.1%	9.3%	7.7%	8.5%	7.3%	9.6%	7.2%	9.1%	1.2%	1.3%	1.1%	1.5%	1.1%	1.4%
HVAC Pump Motor (unknown use)	C38	3.4%	4.1%	3.1%	3.9%	3.3%	4.6%	3.3%	4.0%	4.4%	5.2%	4.1%	5.4%	4.5%	4.9%	4.3%	5.5%	4.2%	5.2%	3.5%	4.0%	3.2%	4.4%	3.4%	4.2%
VFD - Supply fans <10 HP	C39	5.7%	2.3%	5.2%	2.1%	5.5%	2.5%	5.6%	2.2%	5.8%	3.3%	5.5%	3.4%	5.9%	3.1%	5.7%	3.5%	5.5%	3.3%	5.8%	2.2%	5.4%	2.4%	5.7%	2.3%
VFD - Return fans <10 HP	C40	5.7%	2.3%	5.2%	2.1%	5.5%	2.5%	5.6%	2.2%	5.8%	3.3%	5.5%	3.4%	5.9%	3.1%	5.7%	3.5%	5.5%	3.3%	5.8%	2.2%	5.4%	2.4%	5.7%	2.3%
VFD - Exhaust fans <10 HP	C41	5.1%	3.3%	4.6%	3.1%	4.9%	3.7%	5.0%	3.2%	4.1%	4.3%	3.9%	4.4%	4.2%	4.1%	4.1%	4.6%	4.0%	4.3%	5.2%	3.2%	4.8%	3.5%	5.1%	3.4%
VFD - Boiler feedwater	C42	6.4%	6.2%	5.7%	5.9%	6.1%	7.0%	6.1%	6.0%	1.3%	1.3%	1.3%	1.3%	1.4%	1.2%	1.3%	1.3%	1.3%	1.3%	6.4%	6.0%	5.9%	6.6%	6.3%	6.4%

		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
		M-F	S-S	M-F	S-S	M-F	S-S	M-F	S-S	M-F	S-S	M-F	S-S	M-F	S-S	M-F	S-S	M-F	S-S	M-F	S-S	M-F	S-S	M-F	S-S
pumps <10 HP																									
VFD - Chilled water pumps <10 HP	C43	1.7%	0.8%	1.5%	0.7%	1.6%	0.9%	1.6%	0.8%	8.3%	8.5%	7.8%	8.7%	8.5%	8.0%	8.1%	8.9%	7.9%	8.5%	1.7%	0.8%	1.6%	0.8%	1.6%	0.8%
VFD Boiler circulation pumps <10 HP	C44	6.4%	6.2%	5.7%	5.9%	6.1%	7.0%	6.1%	6.0%	1.3%	1.3%	1.3%	1.3%	1.4%	1.2%	1.3%	1.3%	1.3%	1.3%	6.4%	6.0%	5.9%	6.6%	6.3%	6.4%
Refrigeration Economizer	C45	5.4%	7.2%	4.8%	6.7%	5.1%	8.0%	5.2%	7.0%	1.1%	1.5%	1.1%	1.5%	1.2%	1.4%	1.1%	1.5%	1.1%	1.5%	5.4%	7.0%	5.0%	7.6%	5.3%	7.4%
Evaporator Fan Control	C46	3.6%	5.1%	3.2%	4.8%	3.4%	5.7%	3.4%	4.9%	3.4%	4.7%	3.2%	4.8%	3.5%	4.4%	3.3%	4.9%	3.3%	4.7%	3.6%	4.9%	3.3%	5.4%	3.5%	5.2%
Standby Losses - Commercial Office	C47	1.2%	7.1%	1.1%	6.7%	1.2%	8.0%	1.2%	6.9%	1.1%	7.1%	1.1%	7.3%	1.2%	6.7%	1.1%	7.5%	1.1%	7.1%	1.2%	6.9%	1.1%	7.5%	1.2%	7.3%
VFD Boiler draft fans <10 HP	C48	5.5%	6.9%	5.0%	6.5%	5.3%	7.7%	5.3%	6.7%	1.3%	1.5%	1.2%	1.5%	1.3%	1.4%	1.3%	1.5%	1.2%	1.5%	5.6%	6.7%	5.2%	7.3%	5.5%	7.1%
VFD Cooling Tower Fans <10 HP	C49	1.2%	0.7%	1.1%	0.7%	1.1%	0.8%	1.1%	0.7%	11.0%	6.5%	10.4%	6.7%	11.3%	6.2%	10.8%	6.9%	10.5%	6.5%	1.2%	0.7%	1.1%	0.8%	1.2%	0.8%
Engine Block Heater Timer	C50	3.9%	8.6%	3.5%	8.1%	3.7%	9.6%	3.8%	8.3%	0.8%	1.7%	0.8%	1.7%	0.8%	1.6%	0.8%	1.8%	0.8%	1.7%	4.0%	8.3%	3.7%	9.1%	3.9%	8.9%
Door Heater Control	C51	4.5%	9.8%	4.0%	9.2%	4.3%	11.0%	4.3%	9.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.5%	9.5%	4.2%	10.4%	4.4%	10.1 %
Beverage and Snack Machine Controls	C52	1.5%	6.8%	1.3%	6.4%	1.4%	7.6%	1.4%	6.6%	1.5%	6.8%	1.4%	7.0%	1.5%	6.4%	1.5%	7.2%	1.4%	6.8%	1.5%	6.6%	1.4%	7.2%	1.5%	7.0%
Flat	C53	5.4%	3.1%	4.8%	2.9%	5.1%	3.4%	5.2%	3.0%	5.3%	3.1%	5.0%	3.2%	5.5%	2.9%	5.2%	3.3%	5.1%	3.1%	5.4%	3.0%	5.0%	3.3%	5.3%	3.2%
Religious Indoor Lighting	C54	4.0%	4.4%	3.6%	4.2%	3.8%	5.0%	3.8%	4.3%	3.9%	4.5%	3.6%	4.7%	3.9%	4.3%	3.8%	4.8%	3.7%	4.5%	4.0%	4.3%	3.7%	4.7%	3.9%	4.6%

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[27] 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[28]. Residential cooling is based on 65F in agreement with a field study in Wisconsin[29]. 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[30]. Custom degree-days with building specific base temperatures are recommended for large C&I projects.

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

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

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

Figure 1: Cooling Degree-Day Zones by County

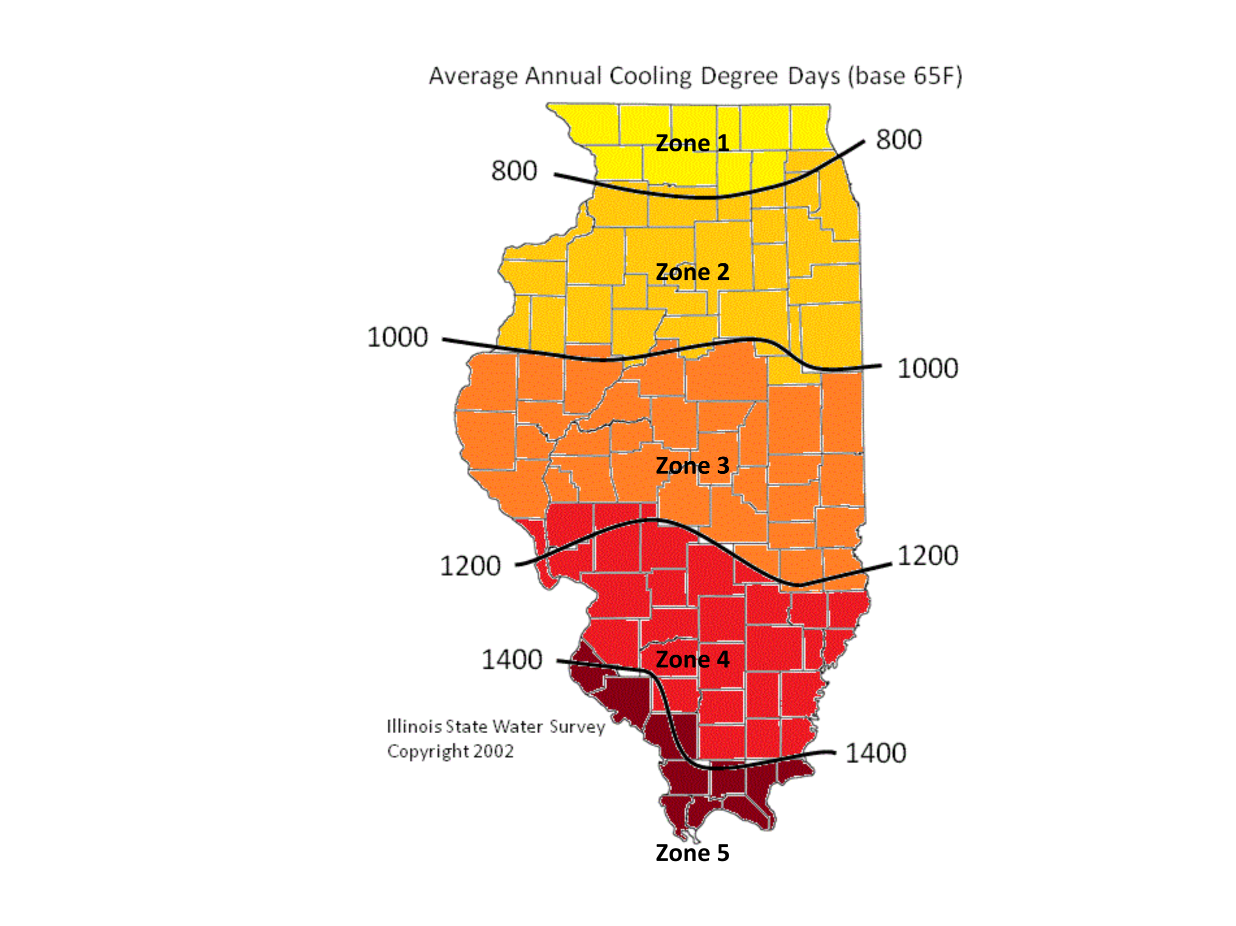

Figure 2: Heating Degree-Day Zones by County

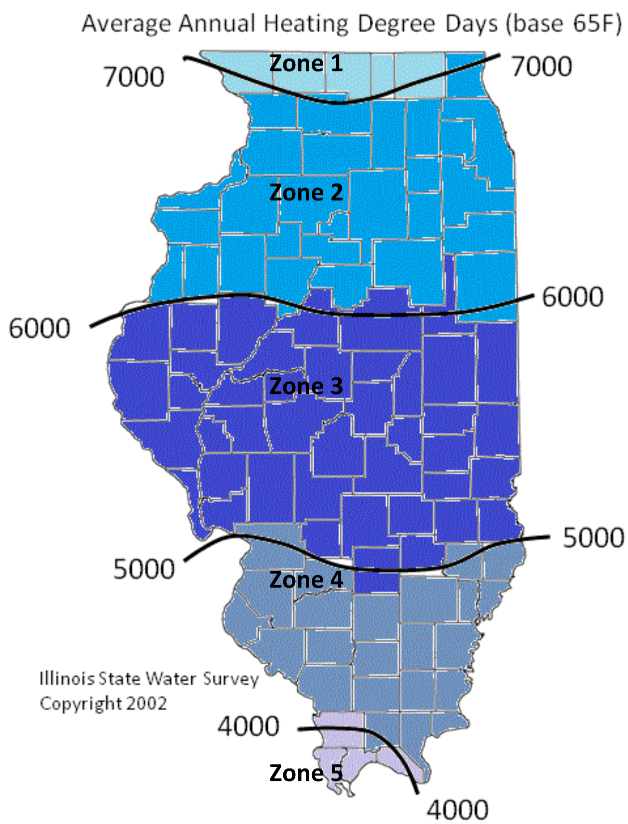

Table 3.7: Heating Degree-Day Zones by County

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

Table 3.8: Cooling Degree-day Zones by County

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

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	
Baseline Case:	O&M costs equal $150 every two years.
Efficient Case:	O&M costs equal $50 every five years.

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

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

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[31]. 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[32]

DEEMED MEASURE COST

The incremental cost per installed plug-in timer is $10.19[33].

COINCIDENCE FACTOR

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

[32]Equipment life is expected to be longer, but measure life is more conservative to account for possible attrition in use over time.
[33]Based on bulk pricing reported by EnSave, which administers the rebate in Vermont

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

ΔkWh = ISR * Use Season * %Days * HrSave/Day * kW_{heater} - ParaLd

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

= 664 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-APL-ESDH-V01-120601

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]:

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

LOADSHAPE

Loadshape C34 - Industrial Motor

COINCIDENCE FACTOR

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

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

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:

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

SUMMER COINCIDENT PEAK DEMAND SAVINGS[38]

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

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

NATURAL GAS ENERGY SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-AGE-HVSF-V01-120601

[37] Ibid.
[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].

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

Definition of Baseline Equipment

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

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 7 years[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 therefor a coincidence factor is not applied.

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

Algorithm

Calculation of Savings

Electric Energy Savings [42]

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

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

Summer Coincident Peak Demand Savings[43]

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

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

Natural Gas Energy Savings

N/A

Water Impact Descriptions and Calculation

N/A

Deemed O&M Cost Adjustment Calculation

N/A

Measure Code: CI-AGE-HSF_-V01-120601

[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 years[45].

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 therefor a coincidence factor is not applied

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS [47]

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

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

SUMMER COINCIDENT PEAK DEMAND SAVINGS

The annual kW savings from this measure is a deemed value and assumed to be 0.525 kW. [48]

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

[48] Ibid.

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 ≥ 38% and convection mode cooking efficiency ≥ 44% utilizing ASTM standard F2861 and meet idle requirements below[49]:

Idle Rate Requirements for Commercial Combination Ovens/Steamers

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

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

[49] http://www.fishnick.com/saveenergy/rebates/combis.pdf
[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.[52]

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

[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].

[53] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Effective/Remaining Useful Life Values", California Public Utilities Commission, December 16, 2008.
http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf

DEEMED MEASURE COST

The incremental capital cost for this measure is provided below[54].

Type	Refrigerator incremental Cost, per unit	Freezer Incremental Cost, per unit
Solid or Glass Door		
0 < V < 15	$143	$142
15 ≤ V < 30	$164	$166
30 ≤ V < 50	$164	$166
V ≥ 50	$249	$407

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

ΔkWh = (kWhbase – kWhee) * 365.25

Where:

kWhbase= baseline maximum daily energy consumption in kWh

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

[54] Estimates of the incremental cost of commercial refrigerators and freezers varies widely by source. Nadel, S., Packaged Commercial Refrigeration Equipment: A Briefing Report for Program Planners and Implementers, ACEEE, December 2002, indicates that incremental cost is approximately zero. Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010, assumed incremental cost ranging from $75 to $125 depending on equipment volume. ACEEE notes that incremental cost ranges from 0 to 10% of the baseline unit cost <http://www.aceee.org/ogeece/ch5_reach.htm>. For the purposes of this characterization, assume and incremental cost adder of 5% on the full unit costs presented in Goldberg et al, State of Wisconsin Public Service Commission of Wisconsin, Focus on Energy Evaluation, Business Programs: Incremental Cost Study, KEMA, October 28, 2009.
[55] The CF for Commercial Refrigeration was calculated based upon the Ameren provided eShapes

in the table below.

Type	kWhbase[56]
Solid Door Refrigerator	0.10 * V + 2.04
Glass Door Refrigerator	0.12 * V + 3.34
Solid Door Freezer	0.40 * V + 1.38
Glass Door Freezer	0.75 * V + 4.10

kWhee[57] = efficient maximum daily energy consumption in kWh

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

Type	Refrigerator kWhee	Freezer kWhee
Solid Door		
0 < V < 15	≤ 0.089V + 1.411	≤ 0.250V + 1.250
15 ≤ V < 30	≤ 0.037V + 2.200	≤ 0.400V – 1.000
30 ≤ V < 50	≤ 0.056V + 1.635	≤ 0.163V + 6.125
V ≥ 50	≤ 0.060V + 1.416	≤ 0.158V + 6.333
Glass Door		
0 < V < 15	≤ 0.118V + 1.382	≤ 0.607V + 0.893
15 ≤ V < 30	≤ 0.140V + 1.050	≤ 0.733V – 1.000
30 ≤ V < 50	≤ 0.088V + 2.625	≤ 0.250V + 13.500
V ≥ 50	≤ 0.110V + 1.500	≤ 0.450V + 3.500

V = the chilled or frozen compartment volume (ft^3) (as defined in the Association of Home Appliance Manufacturers Standard HRF1–1979)

= Actual installed

365.25 = days per year

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

[57] ENERGY STAR Program Requirements for Commercial Refrigerators and Freezers Partner Commitments Version 2.0, U.S. Environmental Protection Agency, Accessed on 7/7/10. < http://www.energystar.gov/ia/partners/product_specs/program_reqs/commer_refrig_glass_prog_req.pdf>

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

ΔkWh = (3.54 – 2.76) * 365.25

= 285 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ΔkWh / HOURS * CF

Where:

HOURS = equipment is assumed to operate continuously, 24 hours per day, 365.25 days per year.

= 8766

CF = Summer Peak Coincidence Factor for measure

= 0.937

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

ΔkW = 285/ 8766 * .937

=0.030 kW

NATURAL GAS ENERGY SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

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:

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

Definition of Baseline Equipment

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

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 12 years[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

[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 - PGECOFST104.1 - Commercial Steam Cooker - Electric and Gas as reference by KEMA in the ComEd C & I TRM.

COINCIDENCE FACTOR

Summer Peak Coincidence Factor for measure is provided below for different building type[61]:

Location	CF
Fast Food Limited Menu	0.32
Fast Food Expanded Menu	0.41
Pizza	0.46
Full Service Limited Menu	0.51
Full Service Expanded Menu	0.36
Cafeteria	0.36
Unknown	0.40

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

ΔSavings = (ΔIdle Energy + ΔPreheat Energy + ΔCooking Energy) * Z

For a gas cooker: ΔSavings = ΔBtu * 1/100,000 *Z

For an electric steam cooker: ΔSavings = ΔkWh *Z

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

Where:

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

[61] Minnesota 2012 Technical Reference Manual, Electric Food Service_v03.2.xls, http://mn.gov/commerce/energy/topics/conservation/Design-Resources/Deemed-Savings.jspech. Unknown is an average of other location types

Where:

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

= 90%[62]

$IDLE_{Base}$ = Idle Energy Rate of Base Steamer[63]

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

PC_{Base} = Production Capacity of Base Steamer[64]

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

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

=105 Btu/lb[65] (gas steamers) or 0.0308[8] (electric steamers)

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

=15%[66] (gas steamers) or 26%[9] (electric steamers)

$HOURS_{day}$ = Average Daily Operation (hours)

---

[62]Food Service Technology Center 2011 Savings Calculator

[63]Food Service Technology Center 2011 Savings Calculator

[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® savings calculator uses 23.3 lb/hr per pan for both electric and natural gas baseline steamers.

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

[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.

Type of Food Service	Hoursday[67]
Fast Food, limited menu	4
Fast Food, expanded menu	5
Pizza	8
Full Service, limited menu	8
Full Service, expanded menu	7
Cafeteria	6
Unknown	6[68]
Custom	Varies

F = Food cooked per day (lbs/day)

= custom or if unknown, use 100 lbs/day[69]

$CSM_{\%ENERGYSTAR}$ = ENERGY STAR Steamer's Time in Manual Steam Mode (% of time)[70]

= 0%

$IDLE_{ENERGYSTAR}$ = Idle Energy Rate of ENERGY STAR®[71]

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

PC_{ENERGY} = Production Capacity of ENERGY STAR® Steamer[72]

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

[68] Unknown is average of other locations

[69] Reference amount used by both Food Service Technology Center and ENERGY STAR® savings calculator

[70] Reference information from the Food Service Technology Center siting that ENERGY STAR® steamers are not typically operated in constant steam mode, but rather are used in timed mode. Reference ENERGY STAR® savings calculator at http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COC for efficient steamer. Both baseline & efficient steamer mode values should be considered for users in Illinois market.

[71] Food Service Technology Center 2011 Savings Calculator

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

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

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

=38%[73] (gas steamer) or 50%[15] (electric steamer)

PRE_{number} = Number of preheats per day

=1[74] (if unknown, use 1)

Where:

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

Where:

PRE_{number} = Number of Preheats per Day

=1[75](if unknown, use 1)

PRE_{heat} = Preheat energy savings per preheat

= 11,000 Btu/preheat[76] (gas steamer) or 0.5 kWh/preheat[77] (electric steamer)

Where:

ΔCooking Energy = ((1/ EFFBASE) - (1/ EFFENERGY STAR®)) * F * E_{FOOD}

Where:

---

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

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

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.

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

=15%[78] (gas steamer) or 26%[28] (electric steamer)

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

=38%[79] (gas steamer) or 50%[23] (electric steamer)

F = Food cooked per day (lbs/day)

= custom or if unknown, use 100 lbs/day[80]

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

E_{FOOD} - gas(Btu/lb)	E_{FOOD} (kWh/lb)
105[82]	0.0308[83]

[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 restaurant

ΔSavings = ΔIdle Energy + ΔPreheat Energy + ΔCooking Energy *Z * 1/100.000

ΔIdle Energy = ((((1- .9)* 11000 + .9 * 65 * 105 /.15)*(12 - (100 / 65)-(1-.25))) - (((1-0) * 6250 + 0 * 55 * 105 / 0.38) * (12 - (100 / 55) - (1-0.25)))) +

ΔPreheat Energy = (1 *11,000) +

ΔCooking Energy = (((1/ 0.15) - (1/ 0.38)) * (100 lb/day * 105 btu/lb)))

* 365.25 days)) *1/100,000 =

=1536 therms

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

ΔSavings = ΔIdle Energy + ΔPreheat Energy + ΔCooking Energy *Z

ΔIdle Energy = ((((1- .9)* 1.0 + .9 * 70 * 0.0308 /.26)*(12 - (100 / 70)-(1*.25))) - (((1-0) * 0.4 + 0 * 50 * .0308 / 0.50) * (12 - (100 / 50) - (1*.25)))) +

ΔPreheat Energy = (1 *0.5)) +

ΔCooking Energy = (((1/ 0.26) - (1/ 0.5)) * (100 * 0.0308)))

* 365.25 days=

30,533kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

This is only applicable to the electric steam cooker.

ΔkW = (ΔkWh/(HOURSDay *DaysYear)) * CF

Where:

CF =Summer Peak Coincidence Factor for measure is provided below for different locations[84]:

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

$Days_{Year}$ =Annual Days of Operation

=custom or 365.25 days a year

Other values as defined above

EXAMPLE

For 3 pan electric steam cooker located in a cafeteria:

ΔkW = (ΔkWh/($HOURS_{Day}$ *$Days_{Year}$)) * CF =

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

2.51 kW

WATER IMPACT DESCRIPTIONS AND CALCULATION

This is applicable to both gas and electric steam cookers.

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

Where

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

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

= 40[85]

$W_{ENERGYSTAR}$ = Water Consumption Rate of ENERGY STAR® Steamer look up[86]

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

$Days_{Year}$ =Annual Days of Operation

=custom or 365.25 days a year[87]

EXAMPLE

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

ΔWater =

ΔWater = [(40 -10)*12*365.25

= 131,490 gallons

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

REFERENCE TABLES

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-FSE-STMC-V02-120601

[85] FSTC (2002). Commercial Cooking Appliance Technology Assessment. Chapter 8: Steamers.

[86] Source Consortium for Energy Efficiency, Inc. September 2010 "Program Design Guidance for Steamers" for Tier 1A and Tier 1B water requirements. Ohio Technical Reference Manual 2010 for 10 gal/hr water consumption which can be used when Tier level is not known.

[87] Source 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

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

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 733 Therms[90].

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

[90] 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 ≥ 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

[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

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

Custom calculation below, otherwise use deemed value of 306 therms. [93]

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

Where:

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

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

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

Where:

HOURSday = Average Daily Operation

= custom or if unknown, use 12 hours

Days = Annual days of operation

= custom or if unknown, use 365.25 days a year

LB = Food cooked per day

= custom or if unknown, use 100 pounds

EffENERGYSTAR = Cooking Efficiency ENERGY STAR

= custom or if unknown, use 44%

EffBase = Cooking Efficiency Baseline

= custom or if unknown, use 30%

PCENERGYSTAR = Production Capacity ENERGY STAR

= custom or if unknown, use 80 pounds/hr

PCBase = Production Capacity base

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

= custom or if unknown, use 70 pounds/hr

PreheatNumberENERGYSTAR = Number of preheats per day

= custom or if unknown, use 1

PreheatNumberBase = Number of preheats per day

= custom or if unknown, use 1

PreheatTimeENERGYSTAR = preheat length

= custom or if unknown, use 15 minutes

PreheatTimeBase = preheat length

= custom or if unknown, use 15 minutes

PreheatRateENERGYSTAR = preheat energy rate high efficiency

= custom or if unknown, use 44000 btu/h

PreheatRateBase = preheat energy rate baseline

= custom or if unknown, use 76000 btu/h

IdleENERGYSTAR = Idle energy rate

= custom or if unknown, use 13000 btu/h

IdleBase = Idle energy rate

= custom or if unknown, use 18000 btu/h

IdleENERGYSTARTime = ENERGY STAR Idle Time

=HOURsday-LB/PCENERGYSTAR –PreHeatTimeENERGYSTAR/60

=12 – 100/80 – 15/60

=10.5 hours

IdleBaseTime = BASE Idle Time

= HOURsday-LB/PCbase –PreHeatTimeBase/60

=Custom or if unknown, use

=12 – 100/70-15/60

=10.3 hours

EFOOD = ASTM energy to food

= 250 btu/pound

EXAMPLE

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

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

Where:

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

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-FSE-ESCV-V01-120

4.2.6 ENERGY STAR Dishwaster

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]

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

[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]

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

LOADSHAPE

Loadshape C01 - Commercial Electric Cooking

SUMMER COINCIDENT PEAK DEMAND SAVINGS

Summer Peak Coincidence Factor for measure is provided below for different restaurant types[96]:

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

Algorithm

ENERGY SAVINGS

ENERGY STAR dishwashers save energy in three categories, building water heating, booster water heating and idle

[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

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

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. [97]

Electric building and booster water heating

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

Electric building and natural gas booster water heating

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

Natural Gas building and electric booster water heating

Dishwasher type		kWh	Therms
Low Temp	Under Counter	0	56
	Door Type	0	562
	Single Tank Conventional	0	527
	Multi Tank Conventional	0	809

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

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

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

WATER SAVINGS

Using standard assumptions water savings would be:

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

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ΔkWh/ AnnualHours

Where:

AnnualHours = Hours * Days

= 365.25 * 18

= 6575 annual hours

Example:

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

ΔkW = ΔkWh/ AnnualHours

= 1213/6575

= 0.184 kW

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

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 ≥ 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

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY 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

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS[100]

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

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

Where:

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

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

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

Where:

HOURSday	= Average Daily Operation
	= custom or if unknown, use 16 hours
Days	= Annual days of operation
	= custom or if unknown, use 365.25 days a year
LB	= Food cooked per day
	= custom or if unknown, use 150 pounds
EffENERGYSTAR	= Cooking Efficiency ENERGY STAR
	= custom or if unknown, use 50%
EffBase	= Cooking Efficiency Baseline
	= 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

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

PreheatNumberENERGYSTAR	= Number of preheats per day
	= custom or if unknown, use 1
PreheatNumberBase	= Number of preheats per day
	= custom or if unknown, use 1
PreheatTimeENERGYSTAR	= preheat length
	= custom or if unknown, use 15 minutes
PreheatTimeBase	= preheat length
	= custom or if unknown, use 15 minutes
PreheatRateENERGYSTAR	= preheat energy rate high efficiency
	= custom or if unknown, use 62000 btu/h
PreheatRateBase	= preheat energy rate baseline
	= custom or if unknown, use 64000 btu/h
IdleENERGYSTAR	= Idle energy rate
	= custom or if unknown, use 9000 btu/h
IdleBase	= Idle energy rate
	= custom or if unknown, use 14000 btu/h
IdleENERGYSTARTime	= ENERGY STAR Idle Time
	= HOURsday-LB/PCENERGYSTAR –PreHeatTimeENERGYSTAR/60
	=Custom or if unknown, use
	=16 – 150/65-15/60
	=13.44 hours
IdleBaseTime	= BASE Idle Time
	= HOURsday-LB/PCbase –PreHeatTimeBase/60
	=Custom or if unknown, use
	=16 – 150/60-15/60
	=13.25 hours
EFOOD	= ASTM energy to food

= 570 btu/pound

EXAMPLE

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

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

Where:

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

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

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[101]

Deemed Measure Cost

The incremental capital cost for this measure is $0 for and electric griddle and $60 for a gas griddle.[102]

Loadshape

Loadshape C01 - Commercial Electric Cooking

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

Coincidence Factor

Summer Peak Coincidence Factor for measure is provided below for different building type[103]:

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

Algorithm

Calculation of Savings [104]

Electric Energy Savings

ΔkWh = (ΔIdle Energy + ΔPreheat Energy + ΔCooking Energy) * Days /1000

Where:

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

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

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

Where:

HOURSday = Average Daily Operation

= custom or if unknown, use 12 hours

Days = Annual days of operation

= custom or if unknown, use 365.25 days a year

LB = Food cooked per day

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

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

= custom or if unknown, use 100 pounds

Width = Griddle Width

= custom or if unknown, use 3 feet

Depth = Griddle Depth

= custom or if unknown, use 2 feet

EffENERGYSTAR = Cooking Efficiency ENERGY STAR

= custom or if unknown, use 70%

EffBase = Cooking Efficiency Baseline

= custom or if unknown, use 65%

PCENERGYSTAR = Production Capacity ENERGY STAR

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

PCBase = Production Capacity base

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

PreheatNumberENERGYSTAR = Number of preheats per day

= custom or if unknown, use 1

PreheatNumberBase = Number of preheats per day

= custom or if unknown, use 1

PreheatTimeENERGYSTAR = preheat length

= custom or if unknown, use 15 minutes

PreheatTimeBase = preheat length

= custom or if unknown, use 15 minutes

PreheatRateENERGYSTAR = preheat energy rate high efficiency

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

PreheatRateBase = preheat energy rate baseline

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

IdleENERGYSTAR = Idle energy rate

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

IdleBase = Idle energy rate

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

EFOOD = ASTM energy to food

= 139 w/pound

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

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

= 3583 W

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

=2000 W

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

=1527 W

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

=2597 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

kW = ΔkWh/Hours * CF

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

=2595 kWh/4308 * .36

= 0.22 kW

NATURAL GAS ENERGY SAVINGS

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

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

Where:

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

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

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

Where (new variables only):

EffENERGYSTAR = Cooking Efficiency ENERGY STAR

= custom or if unknown, use 38%

EffBase = Cooking Efficiency Baseline

= custom or if unknown, use 32%

PCENERGYSTAR = Production Capacity ENERGY STAR

= custom or if unknown, use 7.5 pounds/hr/sq ft

PCBase = Production Capacity base

= custom or if unknown, use 4.17 pounds/hr/sq ft

PreheatRateENERGYSTAR = preheat energy rate high efficiency

= custom or if unknown, use 10000 btu/h/sq ft

PreheatRateBase = preheat energy rate baseline

= custom or if unknown, use 14000 btu/h/sq ft

IdleENERGYSTAR = Idle energy rate

= custom or if unknown, use 2650 btu/h/sq ft

IdleBase = Idle energy rate

= custom or if unknown, use 3500 btu/h/sq ft

EFOOD = ASTM energy to food

= 475 btu/pound

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

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

= 11258 Btu

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

=6000 btu

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

=23438 btu

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

=149 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

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]

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

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[107]:

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

Algorithm

Calculation of Savings

Electric Energy Savings

Custom calculation below, otherwise use deemed values depending on HFHC size[108]

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

ΔkWh = HFHCBaselinekWh – HFHCENERGYSTARkWh

Where:

HFHCBaselinekWh = PowerBaseline* HOURSday * Days/1000

PowerBaseline = Custom, otherwise

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

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

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

HOURSday = Average Daily Operation

= custom or if unknown, use 15 hours

Days = Annual days of operation

= custom or if unknown, use 365.25 days a year

HFHCENERGYSTARkWh = PowerENERGYSTAR* HOURSday * Days/1000

PowerENERGYSTAR = Custom, otherwise

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

HOURSday = Average Daily Operation

= custom or if unknown, use 15 hours

Days = Annual days of operation

= custom or if unknown, use 365.25 days a year

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

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

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

= 9,314 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ΔkWh/Hours * CF

Where: Hours = Hoursday *Days

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

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

=0 .61 kW

NATURAL GAS ENERGY SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

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]

Harvest Rate (H)	Incremental Cost
100-200 lb ice machine	$296
201-300 lb ice machine	$312
301-400 lb ice machine	$559
401-500 lb ice machine	$981
501-1000 lb ice machine	$1,485
1001-1500 lb ice machine	$1,821
>1500 lb ice machine	$2,194

[109] DEER 2008

[110] These values are from electronic work papers prepared in support of San Diego Gas & Electric's "Application for Approval of Electric and Gas Energy Efficiency Programs and Budgets for Years 2009-2011", SDGE, March 2, 2009. Accessed on 7/7/10 <http://www.sdge.com/regulatory/documents/ee2009-2011Workpapers/SW-ComB/Food%20Service/Food%20Service%20Electic%20Measure%20Workpapers%2011-08-05.DOC>.

LOADSHAPE

Loadshape C23 - Commercial Refrigeration

COINCIDENCE FACTOR

The Summer Peak Coincidence Factor is assumed to equal 0.937

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

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

Where:

kWh_{base} = maximum kWh consumption per 100 pounds of ice for the baseline equipment

= calculated as shown in the table below using the actual Harvest Rate (H) of the efficient equipment.

kWh_{ee} = maximum kWh consumption per 100 pounds of ice for the efficient equipment

= calculated as shown in the table below using the actual Harvest Rate (H) of the efficient equipment.

Ice Machine Type	kWhbase111	kWhee112
Ice Making Head (H < 450)	10.26 - 0.0086*H	9.23 - 0.0077*H
Ice Making Head (H ≥ 450)	6.89 – 0.0011*H	6.20 - 0.0010*H
Remote Condensing Unit, without remote compressor (H < 1000)	8.85 – 0.0038*H	8.05 - 0.0035*H
Remote Condensing Unit, without remote compressor (H ≥ 1000)	5.1	4.64
Remote Condensing Unit, with remote compressor (H < 934)	8.85 – 0.0038*H	8.05 - 0.0035*H
Remote Condensing Unit, with remote compressor (H ≥ 934)	5.3	4.82
Self Contained Unit (H < 175)	18 - 0.0469*H	16.7 - 0.0436*H
Self Contained Unit (H ≥ 175)	9.8	9.11

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

DC = Duty Cycle of the ice machine

= 0.57[113]

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

= Actual installed

365.35 = days per year

---

[111]Baseline reflects federal standards which apply to units manufactured on or after January 1, 2010 <http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&rgn=div6&view=text&node=10:3.0.1.4.17.8&idno=10>.

[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>

[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 < http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_Ice_Machines.xls> assumes a value of 75%. A field study of eight ice machines in California indicated an average duty cycle of 57% ("A Field Study to Characterize Water and Energy Use of Commercial Ice-Cube Machines and Quantify Saving Potential", Food Service Technology Center, December 2007). Furthermore, a report prepared by ACEEE assumed a value of 40% (Nadel, S., Packaged Commercial Refrigeration Equipment: A Briefing Report for Program Planners and Implementers, ACEEE, December 2002). The value of 57% was utilized since it appears to represent a high quality data source.

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

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

= 562 kWh

Summer Coincident Peak Demand Savings

ΔkW = ΔkWh / (HOURS * DC) * CF

Where:

HOURS = annual operating hours

= 8766[114]

CF = 0.937

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

ΔkW = 562/(8766*..57) * .937

= 0.105 kW

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[115] indicates that approximately 81% of air-cooled, cube-type machines meet the ENERGY STAR potable water use requirement. Therefore, there are no assumed water impacts for this measure.

Deemed O&M Cost Adjustment Calculation

N/A

Measure Code: CI-FSE-ESIM-V01-120601

[114]Unit is assumed to be connected to power 24 hours per day, 365.25 days per year.
[115]AHRI Certification Directory, Accessed on 7/7/10.
<http://www.ahridirectory.org/ahridirectory/pages/home.aspx>

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:

Time of Sale	Retrofit, Direct Install
The baseline equipment is assumed to be 1.6 gallons per minute. The Energy Policy Act (EPAct) of 2005 sets the maximum flow rate for pre-rinse spray valves at 1.6 gallons per minute at 60 pounds per square inch of water pressure when tested in accordance with ASTM F2324-03. This performance standard went into effect January 1, 2006.	The baseline equipment is assumed to be an existing pre-rinse spray valve with a flow rate of 1.9 gallons per minute.[116] 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

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 5 years[117]

[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)

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

DEEMED MEASURE COST

The cost of this measure is assumed to be $100[118]

LOADSHAPE

Loadshape C01 - Commercial Electric Cooking

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF ENERGY SAVINGS

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

ΔkWH = ΔGallons x 8.33 x 1 x (Tout - Tin) x (1/EFF electric) /3,413 x FLAG

Where:

ΔGallons = 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]

[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.

[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.

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

EXAMPLE

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

ΔkWH = 30,326x 8.33 x 1 x ((70+54.1) - 54.1) x (1/.97) /3,413 x 1
= 5,341kWh

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:

ΔkWH = 47,175 x 8.33 x 1 x ((70+ 54.1) - 54.1) x (1/.97) /3,413 x 1
=8309 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

ΔTherms = ΔGallons x 8.33 x 1 x (Tout - Tin) x (1/EFF) /100,000 Btu

Where (new variables only):

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

= custom, otherwise assume 75%[122]

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

EXAMPLE

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

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

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

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

WATER IMPACT CALCULATION[123]

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

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

Time of Sale	Retrofit, Direct Install
1.6 gal/min124	1.9 gal/min125

FLOeff = Efficient case flow in gallons per minute or custom

Time of Sale	Retrofit, Direct Install
1.06 gal/min[126]	1.06 gal/min[127]

[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_prerinsesprayvavles.pdf.

[125] 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)

[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 web site with the added note that even more efficient models may be available since publishing the data. The average of the nozzles listed on the FSTC website is 1.06.

[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 web site with the added note that even more efficient models may be available since publishing

HOURSday = Hours per day that the pre-rinse spray valve is used at the site, custom, otherwise[128]:

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

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

EXAMPLE

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

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

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

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

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

the data. The average of the nozzles listed on the FSTC website is 1.06.

[128] Hours primarily based on PG& E savings estimates, algorithms, sources (2005), Food Service Pre-Rinse Spray Valves with review of 2010 Ohio Technical Reference Manual and Act on Energy Business Program Technical Resource Manual Rev05.

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[129]

DEEMED MEASURE COST

The incremental capital cost for this measure is $2200[130]

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

[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.

Natural Gas Energy Savings

The annual natural gas energy savings from this measure is a deemed value equaling 661 Therms.[131]

Water Impact Descriptions and Calculation

N/A

Deemed O&M Cost Adjustment Calculation

N/A

Measure Code: CI-FSE-IRCB-V01-120601

[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.

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[132]

Deemed Measure Cost

The incremental capital cost for this measure is $2700[133]

Loadshape

N/A

Coincidence Factor

N/A

Algorithm

Calculation of Savings

Electric Energy Savings

N/A

[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
[133]Ibid.

Summer Coincident Peak Demand Savings

N/A

Natural Gas Energy Savings

The annual natural gas energy savings from this measure is a deemed value equaling 554 Therms[134]

Water Impact Descriptions and Calculation

N/A

Deemed O&M Cost Adjustment Calculation

N/A

Measure Code: CI-FSE-IROV-V01-120601

[134] 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

[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.

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]

WATER IMPACT DESCRIPTIONS AND CALCULATION

DEEMED O&M COST ADJUSTMENT CALCULATION

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[138]

DEEMED MEASURE COST

The incremental capital cost for this measure is $5900[139]

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

[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.

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[140].

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]

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

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

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

Summer Coincident Peak Demand Savings

The following table provides the kW savings

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

Natural Gas Energy Savings

ΔTherms = CFM * HP* Annual Heating Load /(Eff(heat) * 100,000)

Where:

CFM = the average airflow reduction with ventilation controls per hood

= 611 cfm/HP[143]

HP = actual if known, otherwise assume 7.75 HP

Annual Heating Load = Annual heating energy required to heat fan exhaust make-up air, Btu/cfm dependent on location[144]:

[143] PGE 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, 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

Zone	Annual Heating Load, Btu/cfm
1 (Rockford)	154,000
2-(Chicago)	144,000
3 (Springfield)	132,000
4-(Belleville)	102,000
5-(Marion)	104,000

Eff(heat) = Heating Efficiency

= actual if known, otherwise assume 80%[145]

100,000 = conversion from Btu to Therm

EXAMPLE

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

ΔTherms = 611 * 7.75*154,000 / (0.80 * 100,000)
= 9,115 Therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-FSE-VENT-V02-140601

Springfield were obtained from the calculator; values for Belleview and Marion were obtained by using the average savings per HDD from the other values.

[145] Work Paper WPRRSGNGRO301 CLEAResult"Boiler Tune-Up" which cites Focus on Energy Evaluation Business Programs: Deemed Savings Manual V1.0, PA Consulting, KEMA, March 22, 2010

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 paste cooker.

DEFINITION OF BASELINE EQUIPMENT

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

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 12[146].

DEEMED MEASURE COST

The incremental capital cost for this measure is $2400[147].

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

[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.

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].

Water Impact Descriptions and Calculation

N/A

Deemed O&M Cost Adjustment Calculation

N/A

Measure Code: CI-FSE-PCOK-V01-120601

[148] 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.

4.2.18 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

Algorithm

Calculation of Savings

Electric Energy Savings

N/A

[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.

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]

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

[151] 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 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

Gas, High Efficiency	Gas, Standard	Electric
In order for this characterization to apply, the efficient equipment is assumed to have heating capacity over 75,000 Btu/hr and a Thermal Efficiency (TE) greater than or equal to 88%	In order for this characterization to apply, the efficient equipment is assumed to be a gas-fired storage water heaters with 0.67 EF or better installed in a non-residential application Primary applications would include (but not limited to) hotels/motels, small commercial spaces, offices and restaurants	In order for this characterization to apply, the efficient equipment is assumed to have[152].: 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

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

Definition of Baseline Equipment

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

Deemed Lifetime of Efficient Equipment

Gas, High Efficiency	Gas, Standard	Electric
The expected measure life is assumed to be 15 Years[153]	The expected measure life is assumed to be 15 years[154]	The expected measure life is assumed to be 5 years[155].

Deemed Measure Cost

<table>
<tr><th>Gas, High Efficiency</th><th>Gas, Standard</th><th>Electric</th></tr>
<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[156]
<table><tr><th>Tank Size</th><th>Incremental Cost</th></tr><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></table></td></tr>
</table>

Loadshape

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

Coincidence Factor

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

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

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

[155] Ibid.

[156] Ibid.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS [157]

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

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

SUMMER COINCIDENT PEAK DEMAND SAVINGS[158]

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

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

157 Ibid.
158 Ibid.

NATURAL GAS ENERGY SAVINGS

Gas, High Efficiency	Gas, Standard
The annual natural gas energy savings from this measure is a deemed value equaling 251[159]	Gas savings depend on building type and are based on measure case energy factor of 0.67 and a heating capacity of 75 MBtu/hr. These values are averages of qualifying units. Savings values are derived from 2008 DEER Miser, which provides MBtu/hr gas savings per MBtu/hr capacity. Savings presented here are per water heater.[160]

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

[159] 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

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

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

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.

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 9 years.[161]

Deemed Measure Cost

The incremental cost for this measure is $8[162] 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.

[161] Table C-6, Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007. "http://neep.org/Assets/uploads/files/emv/emv-library/measure_life_GDS%5B1%5D.pdf"
[162] 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[163].

ΔkWh = %ElectricDHW * ((GPM_base - GPM_low)/GPM_base) * Usage * EPG_electric * ISR

Where:

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

DHW fuel	%Electric_DHW
Electric	100%
Fossil Fuel	0%

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

= 1.39[164] or custom based on metering studies[165] or if measured during DI:

= Measured full throttle flow * 0.83 throttling factor[166]

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

= 0.94[167] or custom based on metering studies[168] or if measured during DI:

= Rated full throttle flow * 0.95 throttling factor[169]

[163] 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.

[164] Table 56, DeOreo, William B., Mayer, Peter W., Residential End Uses of Water Study Update, 2013. http://www.aquacraft.com/sites/default/files/img/REUWS2%20Project%20Report%2020131204.pdf

[165] 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.

[166] 2008, Schultdt, Marc, and Debra Tachibana. Energy related Water Fixture Measurements: Securing the Baseline for Northwest Single Family Homes. 2008 ACEEE Summer Study on Energy Efficiency in Buildings. Page 1-265. www.seattle.gov/light/Conserve/Reports/paper_10.pdf

[167] 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.

[168] 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.

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):

Building Type	Gallons hot water per unit per day[170] (A)	Unit	Estimated % hot water from Faucets [171] (B)	Multiplier [172] (C)	Unit	Days per year (D)	Annual gallons mixed water per faucet (A*B*C*D)
Small Office	1	person	100%	10	employees per faucet	250	2,500
Large Office	1	person	100%	45	employees per faucet	250	11,250
Fast Food Rest	0.7	meal/day	50%	75	meals per faucet	365	9,581
Sit-Down Rest	2.4	meal/day	50%	36	meals per faucet	365	15,768
Retail	2	employee	100%	5	employees per faucet	365	3,650
Grocery	2	employee	100%	5	employees per faucet	365	3,650
Warehouse	2	employee	100%	5	employees per faucet	250	2,500
Elementary School	0.6	person	50%	50	students per faucet	200	3,000
Jr High/High School	1.8	person	50%	50	students per faucet	200	9,000
Health	90	patient	25%	2	Patients per faucet	365	16,425
Motel	20	room	25%	1	faucet per room	365	1,825
Hotel	14	room	25%	1	faucet per room	365	1,278
Other	1	employee	100%	20	employees per faucet	250	5,000

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

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

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

= 0.0894 kWh/gal

8.33 = Specific weight of water (lbs/gallon)

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

WaterTemp = Assumed temperature of mixed water

= 86F for Bath, 93F for Kitchen 91F for Unknown[173]

[169] 2008, Schultdt, Marc, and Debra Tachibana. Energy related Water Fixture Measurements: Securing the Baseline for Northwest Single Family Homes. 2008 ACEEE Summer Study on Energy Efficiency in Buildings. Page 1-265. www.seattle.gov/light/Conserve/Reports/paper_10.pdf

[170] Table 2-45 Chapter 49, Service Water Heating, 2007 ASHRAE Handbook, HVAC Applications.

[171] Estimated based on data provided in Appendix E; “Waste Not, Want Not: The Potential for Urban Water Conservation in California”; http://www.pacinst.org/reports/urban_usage/appendix_e.pdf

[172] 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.

SupplyTemp = Assumed temperature of water entering building

= 54.1°F [174]

RE_electric = Recovery efficiency of electric water heater

= 98% [175]

3412 = Converts Btu to kWh (Btu/kWh)

ISR = In service rate of faucet aerators dependant on install method as listed in table below[176]

Selection	ISR
Direct Install - Deemed	0.95

EXAMPLE

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

ΔkWh = 1 * ((1.39 – 0.94)/1.39) * 11,250 * 0.0894 * 0.95

= 309 kWh

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

ΔkWh = 1 * ((1.39 – 0.94)/1.39) * 3,000 * 0.0894 * 0.95

= 82.5 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = (ΔkWh / Hours) * CF

[173] 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.

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

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

[176] ComEd Energy Efficiency/ Demand Response Plan: Plan Year 2 (6/1/2009-5/31/2010) Evaluation Report: All Electric Single Family Home Energy Performance Tune-Up Program Table 3-8 http://ilsagfiles.org/SAG_files/Evaluation_Documents/ComEd/ComEd%20EPY2%20Evaluation%20Reports/ComEd_All_Electric_Single_Family_HEP_PY2_Evaluation_Report_Final.pdf

Where:

ΔkWh = calculated value above on a per faucet basis

Hours = Annual electric DHW recovery hours for faucet use

= (Usage * 0.545[177])/GPH

= Calculate if usage is custom, if using default usage use:

Building Type	Annual Recovery Hours
Small Office	24
Large Office	109
Fast Food Rest	93
Sit-Down Rest	153
Retail	36
Grocery	36
Warehouse	24
Elementary School	29
Jr High/High School	88
Health	160
Motel	18
Hotel	12
Other	49

Where:

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

= 56

CF = Coincidence Factor for electric load reduction

= Dependent on building type[178]

[177] 54.5% is the proportion of hot 120F water mixed with 54.1F supply water to give 90°F mixed faucet water.

[178] 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.

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

EXAMPLE

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

$\Delta kW = 309/109 * 0.0288$

$= 0.0816$ kW

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

$\Delta kW = 82.5/29 * 0.0096$

$= 0.0273$ kW

FOSSIL FUEL IMPACT DESCRIPTIONS AND CALCULATION

ΔTherms = %FossilDHW * ((GPM_base - GPM_low)/GPM_base) * Usage * EPG_gas * ISR

Where:

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

DHW fuel	%Fossil_DHW
Electric	0%
Fossil Fuel	100%

EPG_gas = Energy per gallon of mixed water used by faucet (gas water heater)

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

= 0.00446 Therm/gal

Where:

RE_gas = Recovery efficiency of gas water heater

` = 67% [179]

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

Other variables as defined above.

EXAMPLE

For example, a direct installed faucet in a large office with gas DHW:

ΔTherms = 1 * ((1.39 – 0.94)/1.39) * 11,250 * 0.00446 * 0.95

= 15.4 Therms

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

ΔTherms = 1 * ((1.39 – 0.94)/1.39) * 3,000 * 0.00446 * 0.95

= 4.12 Therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

Δgallons = ((GPM_base - GPM_low)/GPM_base) * Usage * ISR

Variables as defined above

EXAMPLE

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

Δgallons = ((1.39 – 0.94)/1.39) * 11,250 * 0.95

= 3,640 gallons

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

Δgallons = ((1.39 – 0.94)/1.39) * 3,000 * 0.95

= 971 gallons

[179] 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.

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

SOURCES USED FOR GPM ASSUMPTIONS

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

MEASURE CODE: CI-HW_-LFFA-V04-140601

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.[180]

Deemed Measure Cost

The incremental cost for this measure is $12[181] or program actual.

Loadshape

Loadshape C02 - Commercial Electric DHW

Coincidence Factor

The coincidence factor for this measure is assumed to be 2.78%[182].

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

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

[182] 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

Algorithm

CALCULATION OF SAVINGS [183]

ELECTRIC ENERGY SAVINGS

Note these savings are per showerhead fixture

ΔkWh =

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

Where:

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

= 1 if electric DHW, 0 if fuel DHW, if unknown assume 16% [184]

GPM_base = Flow rate of the baseline showerhead

= 2.67 for Direct-install programs[185]

GPM_low = As-used flow rate of the low-flow showerhead, which may, as a result of measurements of program evaulations deviate from rated flows, see table below:

Rated Flow
2.0 GPM
1.75 GPM
1.5 GPM
Custom or Actual[186]

L_base = Shower length in minutes with baseline showerhead

= 8.20 min[187]

L_low = Shower length in minutes with low-flow showerhead

= 8.20 min[188]

[183] Based on excel spreadsheet 120911.xls …on SharePoint
[184] Table HC8.9. Water Heating in U.S. Homes in Midwest Region, Divisions, and States, 2009 (RECS)
[185] Based on measured data from Ameren IL EM&V of Direct-Install program. Program targets showers that are rated 2.5 GPM or above.
[186] 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.
[187] Representative value from sources 1, 2, 3, 4, 5, and 6 (See Source Table at end of measure section)
[188] Set equal to L_base.

365.25 = Days per year, on average.

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

EPG_electric = Energy per gallon of hot water supplied by electric

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

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

= 0.127 kWh/gal

8.33 = Specific weight of water (lbs/gallon)

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

ShowerTemp = Assumed temperature of water

= 105°F [189]

SupplyTemp = Assumed temperature of water entering house

= 54.1°F [190]

RE_electric = Recovery efficiency of electric water heater

= 98% [191]

3412 = Converts Btu to kWh (btu/kWh)

ISR = In service rate of showerhead

= Dependant on program delivery method as listed in table below

Selection	ISR[192]
Direct Install - Deemed	0.98

[189] Shower temperature cited from SBW Consulting, Evaluation for the Bonneville Power Authority, 1994, http://www.bpa.gov/energy/n/reports/evaluation/residential/faucet_aerator.cfm

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

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

[192] Deemed values are from ComEd Energy Efficiency/ Demand Response Plan: Plan Year 2 (6/1/2009-5/31/2010) Evaluation Report: All Electric Single Family Home Energy Performance Tune-Up Program Table 3-8. Alternative ISRs may be developed for program delivery methods based on evaluation results.

EXAMPLE

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

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

= 1308.4 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ΔkWh/Hours * CF

Where:

ΔkWh = calculated value above

Hours = Annual electric DHW recovery hours for showerhead use

= ((GPM_base * L_base) *NSPD * 365.25) * 0.773[193] / GPH

Where:

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

= 27.51

CF = Coincidence Factor for electric load reduction

= 0.0278[194]

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[193] 77.3% is the proportion of hot 120F water mixed with 54.1°F supply water to give 105°F shower water

[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*65/365.25 = 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

EXAMPLE

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

ΔkW = (1308.4 / 674.1)*0.0278

FOSSIL FUEL IMPACT DESCRIPTIONS AND CALCULATION

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

Where:

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

DHW fuel	%Fossil_DHW
Electric	0%
Fossil Fuel	100%
Unknown	84%[195]

EPG_gas = Energy per gallon of Hot water supplied by gas

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

= 0.0063 Therm/gal

Where:

RE_gas = Recovery efficiency of gas water heater

= 67% [196]

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

Other variables as defined above.

[195] 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

[196] 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 1.5 GPM showerhead in an office with gas DHW where the number of showers is estimated at 3 per day:

ΔTherms = 1.0 * ((2.67 *8.2) – (1.5 * 8.2)) * 3 * 365.25 * 0.0063 * 0.98

= 64.9 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

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

Variables as defined above

EXAMPLE

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

Δgallons = ((2.67 * 8.20)-(1.5 * 8.20)) * 3 * 365.25 * 0.98

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

Sources

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

Measure Code: CI-HW_-LFSH-V02-120601

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 [197]

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. [198].

[197] 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

[198] Pool Cover Costs: Lincoln Commercial Pool Equipment website. Accessed 8/26/11. http://www.lincolnaquatics.com/shop/catalog/Pool+and+Spa+Covers+and+Accessories/product.html?ProductID=84-010

Cover Size	Edge Style	
	Hemmed (indoor)	Weighted (outdoor)
1000-1,999 sq. ft.	$2.19	$2.24
2,000-2,999 sq. ft.	$2.01	$2.06
3,000+ sq. ft.	$1.80	$1.83
Average	**$2.00**	**$2.04**

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

NET TO GROSS RATIO

Algorithm

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. [199]

ΔTherms = SavingFactor x Size of Pool

Where

Savings factor = dependant on pool location and listed in table below[200]

Location	Therm / sq-ft
Chicago - indoor	2.61
Chicago - outdoor	1.01

Size of Pool = custom input

[199] Full method and supporting information found in reference document: IL TRM - Business Pool Covers WorkPaper.docx
[200] Business Pool Covers.xlsx

WATER IMPACT DESCRIPTIONS AND CALCULATION

ΔTherms = WaterSavingFactor x Size of Pool

Where

WaterSavingFactor = Water savings for this measure dependant on pool location and listed in table below.[201].

Location	Annual Savings Gal / sq-ft
Chicago - indoor	15.28
Chicago - outdoor	8.94

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

[201] 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

Electric	Gas
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	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.

DEFINITION OF BASELINE EQUIPMENT

Electric	Gas
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	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.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

Electric	Gas
The expected measure life is assumed to be 5 years[202].	The expected measure life is assumed to be 20 years[203]

[202] Ohio Technical Reference Manual 8/2/2010 referencing CenterPoint Energy-Triennial CIP/DSM Plan 2010-2012 Report; Additional reference stating >20 years is at Energy Savers.Gov online at http://www.energysavers.gov/your_home/water_heating/index.cfm/mytopic=12820
[203] Ibid.

Deemed Measure Cost

The incremental capital cost for an electric tankless heater this measure is assumed to be[204]

Output (gpm) at delta T 70	Incremental Cost
5	$1050
10	$1050
15	$1950

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

Program	Capital Cost, $ per unit
Retrofit	$3,255[205]
Time of Sale or New Construction	$2,526[206]

Deemed O&M Cost Adjustments

$100[207]

Loadshape

Loadshape C02 - Commercial Electric DHW

Coincidence Factor

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

[204] Act on Energy Technical Reference Manual, Table 9.6.2-3
[205] Based on AOE historical average installation data of 42 tankless gas hot water heaters
[206] http://www.mncee.org/getattachment/7b8982e9-4d95-4bc9-8e64-f89033617f37/, Low contractor estimate used to reflect less labor required in new construction of venting.
[207] 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 [208]

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

Output (gpm) at delta T 70	Savings (kWh)
5.0	2,991.98
10.0	7,904.82
15.0	12,878.51

SUMMER COINCIDENT PEAK DEMAND SAVINGS[209]

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

Output (gpm) at delta T 70	Savings (kW)
5.0	0.34
10.0	0.90
15.0	1.47

NATURAL GAS SAVINGS

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

Where:

Wgal = Annual water use for equipment in gallons

= custom, otherwise assume 21,915 gallons [210]

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

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

[208] Act on Energy Technical Reference Manual, Table 9.6.2-3
[209] Ibid.
[210] 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.

8,766 hr/yr = hours a year

Tout = Unmixed Outlet Water Temperature

= custom, otherwise assume 130 °F[211]

Tin = Inlet Water Temperature

= custom, otherwise assume 54.1 °F[212]

Eff base = Rated efficiency of baseline water heater expressed as Energy Factor (EF) or Thermal Efficiency (Et); see table below[213]

Input Btu/hr of existing, tanked water heater	Eff base	Units
Size: ≤ 75,000 Btu/hr	0.67 - 0.0019*Tank Volume	Energy Factor
Size: >75,000 Btu/hr and ≤ 155,000 Btu/hr	80%	Thermal Efficiency
Size: >155,000 Btu/hr	80%	Thermal Efficiency

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 Themal Efficiency is used in base case, Thermal Efficiency must be used in efficient case.

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

= custom input, if unknown assume 0.84[214]

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[215]

---

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

212 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.

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

214 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.

215 Stand-by loss is provided 2012 International Energy Conservation Code (IECC2012), Table C404.2, Minimum

Input Btu/h of new, tankless water heater	Standby Loss (SL)
Size: ≤ 75,000 Btu/hr	0
Size: >75,000 Btu/hr	(Input rating/800)+(110*√Tank Volume))

Where:

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

Input Value = nameplate Btu/hr rating of water heater

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:

ΔTherms =[[(21,915 x 8.33x 1 x (130 – 54.1) x [(1/.8) - (1/.84)]/100,000] +[(1008.3 x 8,766)/.8]] / 100,000
=115 Therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

The deemed O&M cost adjustment for a gas fired tankless heater is $100

REFERENCE TABLES

Minimum Performance Water Heating Equipment[216]

Performance of Water-Heating Equipment
216 International Energy Conservation Code (IECC)2012

TABLE C404.2
MINIMUM PERFORMANCE OF WATER-HEATING EQUIPMENT

EQUIPMENT TYPE	SIZE CATEGORY (input)	SUBCATEGORY OR RATING CONDITION	PERFORMANCE REQUIRED[a, b]	TEST PROCEDURE
Water heaters, electric	≤ 12 kW	Resistance	0.97 - 0.00132 V, EF	DOE 10 CFR Part 430
	> 12 kW	Resistance	1.73 V + 155 SL, Btu/h	ANSI Z21.10.3
	≤ 24 amps and ≤ 250 volts	Heat pump	0.93 - 0.00132 V, EF	DOE 10 CFR Part 430
Storage water heaters, gas	≤ 75,000 Btu/h	≥ 20 gal	0.67 - 0.0019 V, EF	DOE 10 CFR Part 430
	> 75,000 Btu/h and ≤ 155,000 Btu/h	< 4,000 Btu/h/gal	80% E_t $(Q/800 + 110\sqrt{V})$ SL, Btu/h	ANSI Z21.10.3
	> 155,000 Btu/h	< 4,000 Btu/h/gal	80% E_t $(Q/800 + 110\sqrt{V})$ SL, Btu/h	
Instantaneous water heaters, gas	> 50,000 Btu/h and < 200,000 Btu/h[c]	≥ 4,000 (Btu/h)/gal and < 2 gal	0.62 - 0.0019 V, EF	DOE 10 CFR Part 430
	≥ 200,000 Btu/h	≥ 4,000 Btu/h/gal and < 10 gal	80% E_t	ANSI Z21.10.3
	≥ 200,000 Btu/h	≥ 4,000 Btu/h/gal and ≥ 10 gal	80% E_t $(Q/800 + 110\sqrt{V})$ SL, Btu/h	
Storage water heaters, oil	≤ 105,000 Btu/h	≥ 20 gal	0.59 - 0.0019 V, EF	DOE 10 CFR Part 430
	≥ 105,000 Btu/h	< 4,000 Btu/h/gal	78% E_t $(Q/800 + 110\sqrt{V})$ SL, Btu/h	ANSI Z21.10.3
Instantaneous water heaters, oil	≤ 210,000 Btu/h	≥ 4,000 Btu/h/gal and < 2 gal	0.59 - 0.0019V, EF	DOE 10 CFR Part 430
	> 210,000 Btu/h	≥ 4,000 Btu/h/gal and < 10 gal	80% E_t	ANSI Z21.10.3
	> 210,000 Btu/h	≥ 4,000 Btu/h/gal and ≥ 10 gal	78% E_t $(Q/800 + 110\sqrt{V})$ SL, Btu/h	
Hot water supply boilers, gas and oil	≥ 300,000 Btu/h and < 12,500,000 Btu/h	≥ 4,000 Btu/h/gal and < 10 gal	80% E_t	ANSI Z21.10.3
Hot water supply boilers, gas	≥ 300,000 Btu/h and < 12,500,000 Btu/h	≥ 4,000 Btu/h/gal and ≥ 10 gal	80% E_t $(Q/800 + 110\sqrt{V})$ SL, Btu/h	
Hot water supply boilers, oil	> 300,000 Btu/h and < 12,500,000 Btu/h	> 4,000 Btu/h/gal and > 10 gal	78% E_t $(Q/800 + 110\sqrt{V})$ SL, Btu/h	
Pool heaters, gas and oil	All	—	78% E_t	ASHRAE 146
Heat pump pool heaters	All	—	4.0 COP	AHRI 1160
Unfired storage tanks	All	—	Minimum insulation requirement R-12.5 $(h \cdot ft^2 \cdot °F)/Btu$	(none)

For SI: °C = [(°F) - 32]/1.8, 1 British thermal unit per hour = 0.2931 W, 1 gallon = 3.785 L, 1 British thermal unit per hour per gallon = 0.078 W/L.

a. Energy factor (EF) and thermal efficiency (E_t) are minimum requirements. In the EF equation, V is the rated volume in gallons.

b. Standby loss (SL) is the maximum Btu/h based on a nominal 70°F temperature difference between stored water and ambient requirements. In the SL equation, Q is the nameplate input rate in Btu/h. In the SL equation for electric water heaters, V is the rated volume in gallons. In the SL equation for oil and gas water heaters and boilers, V is the rated volume in gallons.

c. Instantaneous water heaters with input rates below 200,000 Btu/h must comply with these requirements if the water heater is designed to heat water to temperatures 180°F or higher.

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.[217]

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[218].

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[219].

[217] Aligned with other national energy efficiency programs and confirmed with national vendors
[218] 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)
[219] Washer savings were reviewed but were considered negligible and not included in the algorithm (0.00082 kWh

$$\Delta kWh_{PUMP} = HP * HP_{CONVERSION} * Hours * \%water\_savings$$

Where:

ΔkWh_{PUMP} = Electric savings from reduced pumping load

HP = Brake horsepower of boiler feed water pump;
= Actual or use 5 HP if unknown[220]

$HP_{CONVERSION}$ = Conversion from Horsepower to Kilowatt

= 0.746

Hours = Actual associated boiler feed water pump hours

= 800 hours if unknown[221]

%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%[222]

Using defaults above:

ΔkWh_{PUMP} = 5 * 0.746 * 800 * 0.25
= 746 kWh

Default per lb capacity: = ΔkWh_{PUMP} / lb capacity

Where:

Lbs-Capacity = Average Capacity in lbs of washer

=254.38[223]

/ 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.

[220] Assumed average horsepower for boilers connected to applicable washer

[221] 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.

[222] 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

[223] Average lbs-capacity per project site was generated using data collected from existing ozone laundry projects

ΔkWh_{PUMP} / lb capacity = 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.

$\Delta kW = 0$

NATURAL GAS SAVINGS

$\Delta Therm = Therm_{Baseline} * \%hot\_water\_savings$

Where:

ΔTherm = Gas savings resulting from a reduction in hot water use, in therm.

$Therm_{Baseline}$ = Annual Baseline Gas Consumption

= WHE * WUtiliz * WUsage_hot

Where:

WHE = water heating energy: energy required to heat the hot water used

= 0.00885 therm/gallon[224]

WUtiliz = washer utilitzation factor: the annual pounds of clothes washed per year

= actual, if unknown use 916,150 lbs laundry[225], approximately equivalent to 13 cycles/day

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

224 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

225 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

WUsage_hot = hot water usage factor: how much hot water a typical conventional washing machine utilizes, normalized per pounds of clothes washed

= 1.19 gallons/lbs laundry[226]

Using defaults above:

$Therm_{Baseline}$ = 0.00885 * 916,150 * 1.19

= 9,648 therms

Default per lb capacity:

$Therm_{Baseline}$ / lb capacity = 9,648 / 254.38

= 37.9 therms / lb-capacity

%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

= 81%[227]

Savings using defaults above:

ΔTherm = $Therm_{Baseline}$ * %hot_water_savings

= 9648 * 0.81

= 7,815 therms

Default per lb capacity:

ΔTherm / lb-capacity = 7815 / 254.38

= 30.7 therms / 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:

Δgallons = WUsage * WUtiliz * %water_savings

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

[227] 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 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

Where:

Δgallons = reduction in total water use from implementing an ozone washing system to the base case

WUsage = water usage factor: how efficiently a typical conventional washing machine utilized hot and cold water normalized per unit of clothes washed

= 2.03 gallons/lbs laundry[228]

WUtiliz = washer utilitzation factor: the annual pounds of clothes washed per year

= actual, if unknown use 916,150 lbs laundry[229], approximately equivalent to 13 cycles/day

%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%[230]

Savings using defaults above:

ΔGallons = WUsage * WUtiliz * %water_savings

= 2.03 * 916,150 * 0.25

= 464,946 gallons

Default per lb capacity:

Δ Gallons / lb-capacity = 464,946 / 254.38

= 1,828 gallons / lb-capacity

DEEMED O&M COST ADJUSTMENT CALCULATION

Maintenance is required for the following components annually:[231]

- Ozone Generator: filter replacement, check valve replacement, fuse replacement, reaction chamber

[228] Average water usage factors were generated using data collected from existing ozone laundry projects that received incentives under the NRR-DR program. summarizes data gathered from several NRR-DR projects

[229] 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

[230] 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

[231] Confirmed through communications with national vendors and available references E.g. http://ozonelaundry.wordpress.com/2010/11/17/the-importance-of-maintenance/

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

1 "Lodging Report", December 2008, California Travel & Tourism Commission, http://tourism.visitcalifornia.com/media/uploads/files/editor/Research/CaliforniaTourism_200812.pdf

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

3 Fourth Quarter 2008 Facts and Fictures, California Department of Corrections & Rehabilitation (CDCR), http://www.cdcr.ca.gov/Divisions_Boards/Adult_Operations/docs/Fourth_Quarter_2008_Facts_and_Figures.pdf

4 Jail Profile Survey (2008), California Department of Corrections & Rehabilitation (CDCR), http://www.cdcr.ca.gov/Divisions_Boards/CSA/FSO/Docs/2008_4th_Qtr_JPS_full_report.pdf

5 DEER2011_NTGR_2012-05-16.xls from DEER Database for Energy-Efficient Resources; Version 2011 4.01 found at :http://www.deeresources.com/index.php?option=com_content&view=article&id=68&Itemid=60

Under: DEER2011 Update Documentation linked at: DEER2011 Update Net-To-Gross table Cells: T56 and U56

6 The Benefits of Ozone in Hospitality On-Premise Laundry Operations, PG&E Emerging Technologies Program, Application Assessment Report #0802, April 2009.

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

4.4 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.

Equivalent Full Load Hours is calculated using the annual energy use divided by the peak load. The team identified 15 building types to calculate EFLH. The method establish was to obtain energy models for typical building stock and then run the energy models to establish annual energy use and peak load to then calculate EFLH.

The goal was to find pre-developed energy models that could be run through eQuest software and output reports would provide the energy use and peak load. The team explored using California DEER models or ComEd models. It was determined that the ComEd models better represented IL building stock and equipment vintages than the California models[232].

A summary of the inputs to the building models is summarized in Building Descriptions.xls. After the buildings were run through eQuest, “Space Heating" value in MBtu/y found on the "Building Energy Performance Summary" was divided by "Maximum Heating Load" in kBtu/y found on the "Building HVAC Load Summary" to calculate hours.

The building characteristics are found in the tables below.

Table 4.4.1 – eQuest Modeling Inputs by Building Type (Part 1)

Building Type	Healthcare Clinic	Hospital	Lodging Hotel/Motel /Multifamily	Office – Low-rise	Office – Mid-rise	Office - High-rise	Religious Facility
Square Feet	67,500	200,000	56,000	7,500	50,000	537,600	30,000
Number of Floors Above Grade	3	4	2	1	5	20	1
Number of Floors Below Grade	0	1	0	0	0	1	1
Flr-to-Flr Height [ft]	13	14	10	13	13	13	Worship: 20'; other 13'
Flr-to-Ceiling Height [ft]	8	9	9	8	8	8	Worship: 20'; other 10'
Roof Construction	Flat, membrane, R-14 rigid insulation	Flat, membrane, R-14 rigid insulation	Flat, membrane, R-14 rigid insulation	Flat, membrane, R-14 rigid insulation	Flat, membrane, R-14 rigid insulation	Flat, membrane, R-14 rigid insulation	Sloped, attic, slate, no insulation
Above-ground Wall Constructio	2x4 steel frame, R-11 batt, brick	2x4 steel frame, R-11 batt, brick	2x4 steel frame, R-11 batt, brick	2x4 steel frame, R-11 batt, brick	2x4 steel frame, R-11 batt, brick	2x4 steel frame, R-11 batt, brick	12" masonry, no insulation

[232] A full description of the ComEd model development is found in “ComEd Portfolio Modeling Report. Energy Center of Wisconsin July 30, 2010”

Building Type	Healthcare Clinic	Hospital	Lodging Hotel/Motel /Multifamily	Office – Low-rise	Office – Mid-rise	Office - High-rise	Religious Facility
n							
Below-ground Wall Construction	N/A	12" concrete, no insulation	N/A	N/A	N/A	12" concrete, no insulation	12" concrete, no insulation
Window Type	2-pane, clear, alum frame w/o thm brk	2-pane, clear, alum frame w/o thm brk	2-pane, clear, alum frame w/o thm brk	2-pane, clear, alum frame w/o thm brk	2-pane, clear, alum frame w/o thm brk	2-pane, clear, alum frame w/o thm brk	Single-pane, clear, wood frame
Window U-value	0.48	0.48	0.48	0.48	0.48	0.48	1.04
Window SHGC	0.76	0.76	0.76	0.76	0.76	0.76	0.86
Window VT	0.81	0.81	0.81	0.81	0.81	0.81	0.9
Window-Wall Ratio	0.2	0.2	0.04 on ends, 0.15 on faces	0.2	0.33	0.4	0.2
Weekday	7am-7pm	24/7	24/7	8am-5pm	8am-5pm	8am-5pm	Office: 8am-5pm, other: closed
Saturday	9am-5pm	24/7	24/7	closed	20% 8am-noon	20% 8am-noon	closed
Sunday	closed	24/7	24/7	closed	closed	closed	8am-1pm
Holiday	closed	24/7	24/7	closed	closed	closed	closed
Lighting Power Density [W/sf]	2.52	Basement: 1, First Fl: 1.5, Second:1.5, Top 2	office: 1.4, laundry 1.1, Mtg room 2.3, exercise 1.5, employee lounge 1.8, guest room 2, corridor 0.95	1.9	1.7	1.6	worship: 3; other: 2
Plug Loads [W/sf]	2	Basement: .1, First Fl: 1.5, Second:1.5,	office: 1.5, laundry 2.2, mtg room 1.3, exercise 1.1, employee	0.8	0.8	0.8	Classroom .5, Kitchen 2, Office 1

Building Type	Healthcare Clinic	Hospital	Lodging Hotel/Motel /Multifamily	Office – Low-rise	Office – Mid-rise	Office - High-rise	Religious Facility
		Top 1.7	lounge 5.0, guest room 1.4				
Air System	Constant volume packaged rooftop unit	Constant volume indoor units	Packaged terminal heat pump	Constant volume packaged rooftop unit	Variable Air Volume (VAV)	Variable Air Volume (VAV)	none
Cooling Equip. Type	DX	Centrifugal water cooled chiller	Packaged terminal AC	DX	Centrifugal water cooled chiller	Centrifugal water cooled chiller	none
Cooling EER	10.8	9.6	11.1	10.8	9.6	9.6	11
Heating Equip. Type	Natural gas heater in RTU	Natural gas heater in RTU	Heat pump, supplemental electric	Natural gas heater in RTU	Boiler, hot water	Boiler, hot water	Boiler, steam
Heating Efficiency [%]	78%	78%	2.0 COP	78%	78%	78%	78%

Table 4.1.2 eQuest Modeling Inputs by Building Type (Part 2)

Building Type	Restaurant	Retail - Department Store	Retail - Strip Mall	Elementary School	High School	Convenience Store
Square Feet	7,500	45,000	3,000	75,000	225,000	6,000
Number of Floors Above Grade	1	1	1	2	2	1
Number of Floors Below Grade	0	0	0	0	0	0
Flr-to-Flr Height [ft]	13	20	15	13	13	15
Flr-to-Ceiling Height [ft]	9	20	10	9	9	10
Roof Construction	Flat, membrane, R-14 rigid insulation	Flat, membrane, R-14 rigid insulation	Flat, membrane, R-14 rigid insulation	Flat, membrane, R-14 rigid insulation	Flat, membrane, R-14 rigid insulation	Flat, membrane, R-14 rigid insulation
Above-ground Wall Construction	2x4 steel frame, R-11 batt, brick	2x4 steel frame, R-11 batt, brick	2x4 steel frame, R-11 batt, brick	2x4 steel frame, R-11 batt, brick	2x4 steel frame, R-11 batt, brick	2x4 steel frame, R-11 batt, brick
Below-ground Wall Construction	N/A	N/A	N/A	N/A	N/A	N/A

Building Type	Restaurant	Retail - Department Store	Retail - Strip Mall	Elementary School	High School	Convenience Store
Window Type	2-pane, clear, alum frame w/o thm brk	2-pane, clear, alum frame w/o thm brk	2-pane, clear, alum frame w/o thm brk	2-pane, clear, alum frame w/o thm brk	2-pane, clear, alum frame w/o thm brk	2-pane, clear, alum frame w/o thm brk
Window U-value	0.48	0.48	0.48	0.48	0.48	0.48
Window SHGC	0.76	0.76	0.76	0.76	0.76	0.76
Window VT	0.81	0.81	0.81	0.81	0.81	0.81
Window-Wall Ratio	Dining: 0.25; Kitchen: 0	Front: 0.25; Other 0	Front: 0.5; Other 0	0.35	0.35	Front: 0.5; Other 0
Weekday	7am-8pm	9am-9pm	9am-9pm	8am-4pm (20% in summer)	8am-4pm (20% in summer)	7am-10pm
Saturday	7am-8pm	9am-9pm	9am-9pm	closed	closed	9am-9pm
Sunday	7am-8pm	10am-5pm	10am-5pm	closed	closed	10am-5pm
Holiday	closed	10am-5pm	10am-5pm	closed	closed	10am-5pm
Lighting Power Density [W/sf]	kitchen: 1.6; dining: 2.0	sales floor: 3.0; back space: 1.3	sales floor: 3.0; back space: 1.3	classrooms: 2.15, corridors: 0.93, offices 2.0, gym 1.1, kitchen 1.7, cafeteria 1.4, library 1.6	classrooms: 2.15, corridors: 0.93, offices 2.0, gym 1.1, kitchen 1.7, cafeteria 1.4, library 1.6, aud. 1.2	office: 1.9, dry storage: 1.2,sales floor: 3.0
Plug Loads [W/sf]	kitchen .1, dining 0	point of sale 2.2, back space 0.8, rest 0.3	4.3	classrooms: 1.5, office 1, kitchen 19, cafeteria 2.5, library 1.5	classrooms: 1.5, office .75, kitchen .334, cafeteria 1.4, library .25	office: 0.8, deli & bakery 5.4, sales floor 0.5
Air System	Constant volume packaged rooftop unit	Constant volume packaged rooftop unit	Constant volume packaged rooftop unit	Constant volume unit ventilators	Constant volume unit ventilators	Constant volume packaged rooftop unit
Cooling Equip. Type	DX	DX	DX	Screw air cooled chiller	Screw air cooled chiller	DX
Cooling EER	10.8	11	10.8	9.6	11	11

Building Type	Restaurant	Retail - Department Store	Retail - Strip Mall	Elementary School	High School	Convenience Store
Heating Equip. Type	Natural gas heater in RTU	Natural gas heater in RTU	Natural gas heater in RTU	Boiler, hot water	Boiler, hot water	Natural gas heater in RTU
Heating Efficiency [%]	78%	78%	78%	78%	78%	78%

Heating Equivalent Full Load Hours ($EFLH_{heating}$)

Building Type	Heating EFLH				
	Zone 1 (Rockford)	Zone 2 (Chicago)	Zone 3 (Springfield)	Zone 4 (Belleville/	Zone 5 (Marion)
Office - High Rise	2,746	2,768	2,656	2,155	2,420
Office - Mid Rise	996	879	824	519	544
Office - Low Rise	797	666	647	343	329
Convenience Store	696	550	585	272	297
Healthcare Clinic	1,118	1,036	1,029	694	737
Manufacturing Facility	1,116	1,123	904	771	857
Lodging Hotel/Motel/Multifamily	2,098	2,050	1,780	1,365	1,666
High School	969	807	999	569	674
Hospital	2,031	1,929	1,863	1,497	1,800
Elementary School	970	840	927	524	637
Religious Facility	1,830	1,657	1,730	1,276	1,484
Restaurant	1,496	1,379	1,291	872	1,185
Retail - Strip Mall	1,266	1,147	1,151	732	863
Retail - Department Store	1,065	927	900	578	646
College/ University	373	404	376	187	187
Warehouse	416	443	427	226	232
Unknown	1,205	1,119	1,084	752	873

Equivalent Full Load Hours for Cooling ($EFLH_{cooling}$)

System Type[233]	EFLH by Zone[234]				
	1 (Rockford)	2 (Chicago)	3 (Springfield)	4 (Belleville)	5 (Marion)
CV reheat, no economizer	2,723	4,206	3,341	3,872	2,734
CV reheat, economizer	870	1,343	1,067	1,237	873
VAV reheat, economizer	803	1,241	985	1,142	806

[233]Cooling EFLHs have been modified from the "Technical Reference Manual (TRM) for Ohio and adjusted by CDD for IL locations. These appear reasonable, but are recommended for further study.
[234]Act on Energy Commercial Technical Reference Manual No. 2010-4

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 and straighten indoor and outdoor fan blades
- Clean indoor coil with spray-on cleaner and straighten fins
- Repair damaged insulation – suction line
- Change air filter
- Measure and record blower amp draw
- Measure and record compressor integrity (MOhm)
- Measure and record condenser fan motor amp draw

A copy of contractor invoices that detail the work performed to identify tune-up items, as well as additional labor and parts to improve/repair air conditioner performance must be submitted to the program

Definition of Baseline Equipment

In order for this characterization to apply, the baseline condition is assumed to be an AC system that that does not have a standing maintenance contract or a tune up within in the past 36 months.

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 3 years.[235]

Deemed Measure Cost

The incremental capital cost for this measure is $35[236] per ton.

Loadshape

Loadshape C03 - Commercial Cooling

[235] Ibid.
[236] Ibid.

COINCIDENCE FACTOR

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

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

The measure has a deemed savings which applies to all building types and air conditioning unit size and equals an average value of 878 kWh a year.[237]

SUMMER COINCIDENT PEAK DEMAND SAVINGS

The measure has a deemed savings which applies to all building types and air conditioning unit size and equals an average value 0.39 kW a year.[238]

NATURAL GAS ENERGY SAVINGS

WATER IMPACT DESCRIPTIONS AND CALCULATION

DEEMED O&M COST ADJUSTMENT CALCULATION

MEASURE CODE: CI-HVC-ACTU-V01-120601

[237] Ibid.
[238] Act on Energy Commercial Technical Reference Manual No. 2010-4. These deemed values should be compared to PY evaluation and revised as necessary.

4.4.2 Space Heating Boiler Tune-up [239]

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[240] 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[241]

[239] High Impact Measure
[240] Act on Energy Commercial Technical Reference Manual No. 2010-4, 9.2.2 Gas Boiler Tune-up
[241] Act on Energy Commercial Technical Reference Manual No. 2010-4, 9.2.2 Gas Boiler Tune-up

Deemed Measure Cost

The cost of this measure is \$0.83/MBtu/hr[242] 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

Δtherms= Ngi* SF * EFLH/(100))

Where:

Ngi = Boiler gas input size (kBtu/hr)

= custom

SF = Savings factor

Note: Savings factor is the percentage reduction in gas consumption as a result of the tune-up

= 1.6%[243] or custom

EFLH = Equivalent Full Load Hours for heating are provided in section 4.4 HVAC End Use

[242] Work Paper – Tune up for Boilers serving Space Heating and Process Load by Resource Solutions Group, January 2012

[243] Work Paper WPRRSGNGRO301 Resource Solutions Group "Boiler Tune-Up" which cites Focus on Energy Evaluation Business Programs: Deemed Savings Manual V1.0, PA Consulting, KEMA, March 22, 2010

EXAMPLE

For example, a 1050 kBtu boiler in Chicago at a high rise office:

$$\Delta Therms = 1050 * 0.016 * 2768 / (100)$$
$$= 465 \text{ Therms}$$

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-V04-140601

4.4.3 Process Boiler Tune-up[244]

DESCRIPTION

This measure is for a non-residential boiler for process loads. For space heating, see measure 5.2.1. .The tune-up will improve boiler efficiency by cleaning and/or inspecting burners, combustion chamber, and burner nozzles. Adjust air flow and reduce excessive stack temperatures, adjust burner and gas input. Check venting, safety controls, and adequacy of combustion air intake. Combustion efficiency should be measured before and after tune-up using an electronic flue gas analyzer.

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the facility must, as applicable, complete the tune-up requirements[245] 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[246]

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[244] High Impact Measure
[245] Act on Energy Commercial Technical Reference Manual No. 2010-4, 9.2.2 Gas Boiler Tune-up
[246] Act on Energy Commercial Technical Reference Manual No. 2010-4, 9.2.2 Gas Boiler Tune-up

DEEMED MEASURE COST

The cost of this measure is $0.83/MBtu/hr[247] per tune-up

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

$$\Delta therms=((Ngi * 8766*UF)/100) * (1- (Eff_{pre}/Eff_{measured}))$$

Where:

Ngi = Boiler gas input size (kBtu/hr)

= custom

UF = Utilization Factor

= 41.9%[248] or custom

Eff_{pre} = Boiler Combustion Efficiency Before Tune-Up

= 80%[249] or custom

[247] Work Paper – Tune up for Boilers serving Space Heating and Process Load by Resource Solutions Group, January 2012

[248] Work Paper – Tune up for Boilers serving Space Heating and Process Load by Resource Solutions Group, January 2012

$Eff_{measured}$ = Boiler Combustion Efficiency After Tune-Up

= 81.3%[250] or custom

100 =converstion from kBtu to therms

8766 = hours a year

EXAMPLE

For example, a 1050 kBtuboiler:

Δtherms =((1050 * 8766*0.419)/100) * (1- (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-V03-130601

[249] Work Paper – Tune up for Boilers serving Space Heating and Process Load by Resource Solutions Group, January 2012,which cites Focus on Energy Evaluation Business Programs: Deemed Savings Manual V1.0, PA Consulting, KEMA, March 22, 2010

[250] Work Paper – Tune up for Boilers serving Space Heating and Process Load by Resource Solutions Group, January 2012,which cites Focus on Energy Evaluation Business Programs: Deemed Savings Manual V1.0, PA Consulting, KEMA, March 22, 2010

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[251]

Deemed Measure Cost

The cost of this measure is $612[252]

Loadshape

N/A

Coincidence Factor

N/A

[251] CLEAResultreferences the Brooklyn Union Gas Company, High Efficiency Heating and Water and Controls, Gas Energy Efficiency Program Implementation Plan.
[252] Nexant. Questar DSM Market Characterization Report. August 9, 2006.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

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%[253] 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

ΔTherms = 800 * 0.08 * 1,496 / (100)
= 957 Therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

[253] Savings factor is the estimate of annual gas consumption that is saved due to adding boiler reset controls. The CLEAResultuses 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.

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-BLRC-V02-130601

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[254]

Deemed Measure Cost

The incremental capital cost for a unit heater is $676[255]

Loadshape

N/A

Coincidence Factor

N/A

Algorithm

Calculation of Savings

Electric Energy Savings

N/A

[254] DEER 2008

[255] 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

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

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

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 the2009 International Energy Conservation Code, Table 503.2.3(7).

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 20 years [256].

Deemed Measure Cost

The incremental capital cost for this measure is provided below.

Equipment Type	Size Category	Incremental Cost ($/ton)257
Air cooled, electrically operated	All capacities	$127/ton[258]
Water cooled, electrically operated, positive displacement (reciprocating)	All capacities	$22/ton

[256] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Effective/Remaining Useful Life Values", California Public Utilities Commission, December 16, 2008 (http://deeresources.com/deer0911planning/downloads/EUL_Summary_10-1-08.xls)

[257] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Cost Values and Summary Documentation", California Public Utilities Commission, December 16, 2008 (http://deeresources.com/deer0911planning/downloads/DEER2008_Costs_ValuesAndDocumentation_080530Rev1.zip)

[258] 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

Equipment Type	Size Category	Incremental Cost ($/ton)257
Water cooled, electrically operated, positive displacement (rotary screw and scroll)	< 150 tons	$128/ton
	>= 150 tons and < 300 tons	$70/ton
	>= 300 tons	$48/ton

LOADSHAPE

Loadshape C03 - Commercial Cooling

COINCIDENCE FACTOR

The summer peak coincidence factor for cooling is provided in two different ways below. The first is used to estimate peak savings during the utility peak hour and is most indicative of actual peak benefits, and the second represents the *average* savings over the defined summer peak period, and is presented so that savings can be bid into PJM's Forward Capacity Market. Both values provided are based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren.

CF_{SSP} = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)

= 91.3% [259]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)

= 47.8% [260]

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

ΔkWH = TONS * ((IPLVbase) – (IPLVee)) * EFLH

Where:

TONS = chiller nominal cooling capacity in tons (note: 1 ton = 12,000 Btu/hr)

= Actual installed

[259] 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.

[260] 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

IPLVbase = efficiency of baseline equipment expressed as Integrated Part Load Value(kW/ton). Chiller units are dependent on chiller type. See Chiller Units, Convertion Values and Baseline Efficiency Values by Chiller Type and Capacity in the Reference Tables section.

IPLVee[261] = efficiency of high efficiency equipment expressed as Integrated Part Load Value (kW/ton)[262]

= Actual installed

EFLH = Equivalent Full Load Hours for cooling are provided in section 4.4 HVAC End Use:

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:

ΔkWH = 100 * ((0.96) – (0.86)) * 899

= 9,247 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW_{SSP} = TONS * ((PEbase) – (PEee)) * CF_{SSP}

ΔkW_{PJM} = TONS * ((PEbase) – (PEee)) * CF_{PJM}

Where:

PEbase = Peak efficiency of baseline equipment expressed as Full Load (kW/ton)

PEee = Peak efficiency of high efficiency equipment expressed as Full Load (kW/ton)

= Actual installed

CF_{SSP} = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)

= 91.3%

CF_{PJM} = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)

= 47.8%

[261] 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.

[262] 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 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:

ΔkW_{SSP} = 100 * ((1.3) – (1.0)) * .913

=23 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 Ratings- Chillers are rated with different units depending on equipment type as shown below

Equipment Type	Unit
Air cooled, electrically operated	EER
Water cooled, electrically operated, positive displacement (reciprocating)	kW/ton
Water cooled, electrically operated, positive displacement (rotary screw and scroll)	kW/ton

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

kW/ton = 12 / EER
kW/ton = 12 / (COP x 3.412)
COP = EER / 3.412
COP = 12 / (kW/ton) / 3.412
EER = 12 / kW/ton
EER = COP x 3.412

Baseline Efficiency Values by Chiller Type and Capacity[263]

[263] International Energy Conservation Code (IECC)2012

TABLE C403.2.3(7)
MINIMUM EFFICIENCY REQUIREMENTS:
WATER CHILLING PACKAGES[a]

EQUIPMENT TYPE	SIZE CATEGORY	UNITS	BEFORE 1/1/2010		AS OF 1/1/2010[b]				TEST PROCEDURE[c]
					PATH A		PATH B		
			FULL LOAD	IPLV	FULL LOAD	IPLV	FULL LOAD	IPLV	
Air-cooled chillers	< 150 tons	EER	≥ 9.562	≥ 10.416	≥ 9.562	≥ 12.500	NA	NA	AHRI 550/590
	≥ 150 tons	EER			≥ 9.562	≥ 12.750	NA	NA	
Air cooled without condenser, electrical operated	All capacities	EER	≥ 10.586	≥ 11.782	Air-cooled chillers without condensers shall be rated with matching condensers and comply with the air-cooled chiller efficiency requirements				
Water cooled, electrically operated, reciprocating	All capacities	kW/ton	≤ 0.837	≤ 0.696	Reciprocating units shall comply with water cooled positive displacement efficiency requirements				
Water cooled, electrically operated, positive displacement	< 75 tons	kW/ton	≤ 0.790	≤ 0.676	≤ 0.780	≤ 0.630	≤ 0.800	≤ 0.600	
	≥ 75 tons and < 150 tons	kW/ton			≤ 0.775	≤ 0.615	≤ 0.790	≤ 0.586	
	≥ 150 tons and < 300 tons	kW/ton	≤ 0.717	≤ 0.627	≤ 0.680	≤ 0.580	≤ 0.718	≤ 0.540	
	≥ 300 tons	kW/ton	≤ 0.639	≤ 0.571	≤ 0.620	≤ 0.540	≤ 0.639	≤ 0.490	
Water cooled, electrically operated, centrifugal	< 150 tons	kW/ton	≤ 0.703	≤ 0.669	≤ 0.634	≤ 0.596	≤ 0.639	≤ 0.450	
	≥ 150 tons and < 300 tons	kW/ton	≤ 0.634	≤ 0.596					
	≥ 300 tons and < 600 tons	kW/ton	≤ 0.576	≤ 0.549	≤ 0.576	≤ 0.549	≤ 0.600	≤ 0.400	
	≥ 600 tons	kW/ton	≤ 0.576	≤ 0.549	≤ 0.570	≤ 0.539	≤ 0.590	≤ 0.400	
Air cooled, absorption single effect	All capacities	COP	≥ 0.600	NR	≥ 0.600	NR	NA	NA	AHRI 560
Water cooled, absorption single effect	All capacities	COP	≥ 0.700	NR	≥ 0.700	NR	NA	NA	
Absorption double effect, indirect fired	All capacities	COP	≥ 1.000	≥ 1.050	≥ 1.000	≥ 1.050	NA	NA	
Absorption double effect, direct fired	All capacities	COP	≥ 1.000	≥ 1.000	≥ 1.000	≥ 1.000	NA	NA	

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-V02-140601

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:[264]

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

Casement	Federal Standard (EER)	ENERGY STAR (EER)
Casement-only	8.7	9.6
Casement-slider	9.5	10.5

[264] http://www.energystar.gov/index.cfm?c=roomac.pr_crit_room_ac and http://www.cee1.org/resid/seha/rm-ac/rm-ac_specs.pdf
Side louvers that extend from a room air conditioner model in order to position the unit in a window. A model without louvered sides is placed in a built-in wall sleeve and are commonly referred to as "through-the-wall" or "built-in" models.
Casement-only refers to a room air conditioner designed for mounting in a casement window of a specific size.
Casement-slider refers to a room air conditioner with an encased assembly designed for mounting in a sliding or casement window of a specific size.
Reverse cycle refers to the heating function found in certain room air conditioner models.
http://www.energystar.gov/ia/partners/product_specs/program_reqs/room_air_conditioners_prog_req.pdf

Reverse Cycle - Product Class (Btu/H)	Federal Standard EER, with louvered sides	Federal Standard EER, without louvered sides	ENERGY STAR EER, with louvered sides	ENERGY STAR EER, without louvered sides
< 14,000	N/A	8.5	N/A	9.4
>= 14,000	N/A	8	N/A	8.8
< 20,000	9	N/A	9.9	N/A
>= 20,000	8.5	N/A	9.4	N/A

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

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.[265]

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.[266]

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

[265] Energy Star Room Air Conditioner Savings Calculator, http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=AC http://neep.org/uploads/EMV%20Forum/EMV%20Studies/measure_life_GDS%5B1%5D.pdf

[266] Based on field study conducted by Efficiency Vermont

into PJM's Forward Capacity Market. Both values provided are based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren.

CF_{SSP} = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)

= 91.3% [267]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)

= 47.8% [268]

Algorithm

CALCULATION OF SAVINGS

ENERGY SAVINGS

$\Delta kWh = (FLH_{RoomAC} * Btu/H * (1/EERbase - 1/EERee))/1000$

Where:

FLH_{RoomAC} = Full Load Hours of room air conditioning unit

= dependent on location:[269]

Zone	FLH_{RoomAC}
1 (Rockford)	253
2-(Chicago)	254
3 (Springfield)	310
4-(Belleville)	391
5-(Marion)	254

[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.
[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
[269] Full load hours for room AC is significantly lower than for central AC. The average ratio of FLH for Room AC (provided in RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008: http://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/117_RLW_CF%20Res%20RAC.pdf) to FLH for Central Cooling for the same location (provided by AHRI: http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_CAC.xls) is 31%. This ratio has been applied to the FLH from the unitary and split system air conditioning measure.

Btu/H = Size of unit

= Actual. If unknown assume 8500 Btu/hr [270]

EERbase = Efficiency of baseline unit

= As provided in tables above

EERee = Efficiency of ENERGY STAR or CEE Tier 1 unit

= Actual. If unknown assume minimum qualifying standard as provided in tables above

For example for an 8,500 Btu/H capacity ENERGY STAR unit, with louvered sides, in Rockford:

$\Delta kWH_{ENERGY\ STAR}$ = (253 * 8500 * (1/9.8 – 1/10.8)) / 1000

= 20.3 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = Btu/H * ((1/EERbase - 1/EERee))/1000) * CF

Where:

CF_{SSP} = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)
= 91.3% [271]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)

= 47.8%[272]

Other variable as defined above

For example for an 8,500 Btu/H capacity ENERGY STAR unit, with louvered sides, in Rockford during system peak

$\Delta kW_{ENERGY\ STAR}$ = (8500 * (1/9.8 – 1/10.8)) / 1000 * 0.913

= 0.073 kW

[270] Based on maximum capacity average from the RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008

[271] 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.

[272] 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

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

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 [273].

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[274].

Deemed O&M Cost Adjustments

N/A

Loadshape

Loadshape C03 - Commercial Cooling

[273] DEER 2008 value for energy management systems
[274] This value was extracted from Smart Ideas projects in PY1 and PY2.

COINCIDENCE FACTOR

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

Algorithm

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[275]. Model outputs are normalized to the installed capacity and reported here as kWh/Ton, coincident peak kW/Ton and Therms/Ton.

ELECTRIC ENERGY SAVINGS

Motel Electric Energy Savings			
Climate Zone (City based upon)	Heating Source	Baseline	Electric Savings (kWh/Ton)
1 (Rockford)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	744
		No Housekeeping Setback	1,786
	PTAC w/ Gas Heating	Housekeeping Setback	63
		No Housekeeping Setback	155
	PTHP	Housekeeping Setback	385
		No Housekeeping Setback	986
2 (Chicago)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	506
		No Housekeeping Setback	1,582
	PTAC w/ Gas Heating	Housekeeping Setback	51
		No Housekeeping Setback	163
	PTHP	Housekeeping Setback	211
		No Housekeeping Setback	798
3 (Springfield)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	462
		No Housekeeping Setback	1,382
	PTAC w/ Gas Heating	Housekeeping Setback	65
		No Housekeeping Setback	198
	PTHP	Housekeeping Setback	202
		No Housekeeping Setback	736
4 (Belleville)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	559

275 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'.

Motel Electric Energy Savings			
Climate Zone (City based upon)	Heating Source	Baseline	Electric Savings (kWh/Ton)
		No Housekeeping Setback	1,877
	PTAC w/ Gas Heating	Housekeeping Setback	85
		No Housekeeping Setback	287
	PTHP	Housekeeping Setback	260
		No Housekeeping Setback	1,023
5 (Marion-Williamson)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	388
		No Housekeeping Setback	1,339
	PTAC w/ Gas Heating	Housekeeping Setback	81
		No Housekeeping Setback	274
	PTHP	Housekeeping Setback	174
		No Housekeeping Setback	682

Hotel Electric Energy Savings			
Climate Zone (City based upon)	Heating Source	Baseline	Electric Savings (kWh/Ton)
1 (Rockford)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	298
		No Housekeeping Setback	716
	PTAC w/ Gas Heating	Housekeeping Setback	242
		No Housekeeping Setback	594
	PTHP	Housekeeping Setback	263
		No Housekeeping Setback	673
	Central Hot Water Fan Coil w/ Electric Resistance Heating	Housekeeping Setback	228
		No Housekeeping Setback	546
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	171
		No Housekeeping Setback	421
2 (Chicago)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	323
		No Housekeeping Setback	1,010
	PTAC w/ Gas Heating	Housekeeping Setback	249
		No Housekeeping Setback	793
	PTHP	Housekeeping Setback	276
		No Housekeeping Setback	1,046
	Central Hot Water Fan Coil w/ Electric Resistance Heating	Housekeeping Setback	251
		No Housekeeping Setback	785
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	176
		No Housekeeping Setback	563
3 (Springfield)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	288

Hotel Electric Energy Savings			
Climate Zone (City based upon)	**Heating Source**	**Baseline**	**Electric Savings (kWh/Ton)**
		No Housekeeping Setback	863
	PTAC w/ Gas Heating	Housekeeping Setback	259
		No Housekeeping Setback	785
	PTHP	Housekeeping Setback	270
		No Housekeeping Setback	983
	Central Hot Water Fan Coil w/ Electric Resistance Heating	Housekeeping Setback	211
		No Housekeeping Setback	632
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	182
		No Housekeeping Setback	551
4 (Belleville)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	322
		No Housekeeping Setback	1,083
	PTAC w/ Gas Heating	Housekeeping Setback	259
		No Housekeeping Setback	876
	PTHP	Housekeeping Setback	283
		No Housekeeping Setback	1,113
	Central Hot Water Fan Coil w/ Electric Resistance Heating	Housekeeping Setback	245
		No Housekeeping Setback	822
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	182
		No Housekeeping Setback	615
5 (Marion-Williamson)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	321
		No Housekeeping Setback	1,109
	PTAC w/ Gas Heating	Housekeeping Setback	260
		No Housekeeping Setback	885
	PTHP	Housekeeping Setback	283
		No Housekeeping Setback	1,110
	Central Hot Water Fan Coil w/ Electric Resistance Heating	Housekeeping Setback	244
		No Housekeeping Setback	842
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	183
		No Housekeeping Setback	622

SUMMER COINCIDENT PEAK DEMAND SAVINGS

Motel Coincident Peak Demand Savings			
Climate Zone (City based upon)	Heating Source	Baseline	Coincident Peak Demand Savings (kW/Ton)
1 (Rockford)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	0.08
		No Housekeeping Setback	0.17
	PTAC w/ Gas Heating	Housekeeping Setback	0.08
		No Housekeeping Setback	0.17
	PTHP	Housekeeping Setback	0.08
		No Housekeeping Setback	0.17
2 (Chicago)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	0.06
		No Housekeeping Setback	0.17
	PTAC w/ Gas Heating	Housekeeping Setback	0.06
		No Housekeeping Setback	0.17
	PTHP	Housekeeping Setback	0.06
		No Housekeeping Setback	0.17
3 (Springfield)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	0.07
		No Housekeeping Setback	0.17
	PTAC w/ Gas Heating	Housekeeping Setback	0.07
		No Housekeeping Setback	0.17
	PTHP	Housekeeping Setback	0.07
		No Housekeeping Setback	0.17
4 (Belleville)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	0.10
		No Housekeeping Setback	0.28
	PTAC w/ Gas Heating	Housekeeping Setback	0.10
		No Housekeeping Setback	0.28
	PTHP	Housekeeping Setback	0.10
		No Housekeeping Setback	0.28
5 (Marion-Williamson)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	0.08
		No Housekeeping Setback	0.21
	PTAC w/ Gas Heating	Housekeeping Setback	0.08
		No Housekeeping Setback	0.21
	PTHP	Housekeeping Setback	0.08
		No Housekeeping Setback	0.21

Hotel Coincident Peak Demand Savings			
Climate Zone (City based upon)	Heating Source	Baseline	Coincident Peak Demand Savings (kW/Ton)
1 (Rockford)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	0.03
		No Housekeeping Setback	0.07
	PTAC w/ Gas Heating	Housekeeping Setback	0.03
		No Housekeeping Setback	0.06
	PTHP	Housekeeping Setback	0.03
		No Housekeeping Setback	0.06
	Central Hot Water Fan Coil w/ Electric Resistance Heating	Housekeeping Setback	0.03
		No Housekeeping Setback	0.06
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	0.02
		No Housekeeping Setback	0.04
2 (Chicago)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	0.04
		No Housekeeping Setback	0.10
	PTAC w/ Gas Heating	Housekeeping Setback	0.03
		No Housekeeping Setback	0.08
	PTHP	Housekeeping Setback	0.03
		No Housekeeping Setback	0.09
	Central Hot Water Fan Coil w/ Electric Resistance Heating	Housekeeping Setback	0.03
		No Housekeeping Setback	0.08
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	0.02
		No Housekeeping Setback	0.06
3 (Springfield)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	0.03
		No Housekeeping Setback	0.08
	PTAC w/ Gas Heating	Housekeeping Setback	0.03
		No Housekeeping Setback	0.07
	PTHP	Housekeeping Setback	0.03
		No Housekeeping Setback	0.07
	Central Hot Water Fan Coil w/ Electric Resistance Heating	Housekeeping Setback	0.02
		No Housekeeping Setback	0.06
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	0.02
		No Housekeeping Setback	0.05
4 (Belleville)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	0.04
		No Housekeeping Setback	0.10
	PTAC w/ Gas Heating	Housekeeping Setback	0.03
		No Housekeeping Setback	0.08
	PTHP	Housekeeping Setback	0.03
		No Housekeeping Setback	0.09

Hotel Coincident Peak Demand Savings			
Climate Zone (City based upon)	Heating Source	Baseline	Coincident Peak Demand Savings (kW/Ton)
	Central Hot Water Fan Coil w/ Electric Resistance Heating	Housekeeping Setback	0.03
		No Housekeeping Setback	0.08
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	0.02
		No Housekeeping Setback	0.06
5 (Marion-Williamson)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	0.04
		No Housekeeping Setback	0.10
	PTAC w/ Gas Heating	Housekeeping Setback	0.03
		No Housekeeping Setback	0.08
	PTHP	Housekeeping Setback	0.03
		No Housekeeping Setback	0.08
	Central Hot Water Fan Coil w/ Electric Resistance Heating	Housekeeping Setback	0.03
		No Housekeeping Setback	0.07
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	0.02
		No Housekeeping Setback	0.05

NATURAL GAS ENERGY SAVINGS

For PTACs with gas heating:

Motel Natural Gas Energy Savings		
Climate Zone (City based upon)	Baseline	Gas Savings (Therms/Ton)
1 (Rockford)	Housekeeping Setback	30
	No Housekeeping Setback	71
2 (Chicago)	Housekeeping Setback	20
	No Housekeeping Setback	62
3 (Springfield)	Housekeeping Setback	17
	No Housekeeping Setback	52
4 (Belleville)	Housekeeping Setback	21
	No Housekeeping Setback	70
5 (Marion-Williamson)	Housekeeping Setback	13
	No Housekeeping Setback	47

Hotel Natural Gas Energy Savings			
Climate Zone (City based upon)	Heating Source	Baseline	Gas Savings (Therms/Ton)
1 (Rockford)	PTAC w/ Gas Heating	Housekeeping Setback	2.5
		No Housekeeping Setback	5.9
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	2.4
		No Housekeeping Setback	5.7
2 (Chicago)	PTAC w/ Gas Heating	Housekeeping Setback	3.3
		No Housekeeping Setback	10.2
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	3.2
		No Housekeeping Setback	9.9
3 (Springfield)	PTAC w/ Gas Heating	Housekeeping Setback	1.3
		No Housekeeping Setback	3.9
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	1.3
		No Housekeeping Setback	3.8
4 (Belleville)	PTAC w/ Gas Heating	Housekeeping Setback	2.8
		No Housekeeping Setback	9.3
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	2.7
		No Housekeeping Setback	9.0
5 (Marion-Williamson)	PTAC w/ Gas Heating	Housekeeping Setback	2.7
		No Housekeeping Setback	9.3
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	2.6
		No Housekeeping Setback	9.0

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-GREM-V02-140601

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,.

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,. 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.[276]

DEEMED MEASURE COST

For analysis purposes, the incremental capital cost for this measure is assumed as $100 per ton for air-cooled units.[277] The incremental cost for all other equipment types should be determined on a site-specific basis

LOADSHAPE

Loadshape C05 - Commercial Electric Heating and Cooling

[276] Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, Inc., June 2007.

[277] Based on a review of TRM incremental cost assumptions from Vermont, Wisconsin, and California.

COINCIDENCE FACTOR

The summer peak coincidence factor for cooling is provided in two different ways below. The first is used to estimate peak savings during the utility peak hour and is most indicative of actual peak benefits, and the second represents the *average* savings over the defined summer peak period, and is presented so that savings can be bid into PJM's Forward Capacity Market. Both values provided are based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren.

CF_{SSP} = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)

= 91.3% [278]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)

= 47.8% [279]

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

For units with cooling capacities less than 65 kBtu/hr:

$\Delta kWh = \text{Annual kWh Savings}_{cool} + \text{Annual kWh Savings}_{heat}$

$\text{Annual kWh Savings}_{cool} = (kBtu/hr_{cool}) * [(1/SEERbase) – (1/SEERee)] * EFLH_{cool}$

$\text{Annual kWh Savings}_{heat} = (kBtu/hr_{cool}) * [(1/HSPFbase) – (1/HSPFee)] * EFLH_{heat}$

For units with cooling capacities equal to or greater than 65 kBtu/hr:

$\Delta kWh = \text{Annual kWh Savings}_{cool} + \text{Annual kWh Savings}_{heat}$

$\text{Annual kWh Savings}_{cool} = (kBtu/hr_{cool}) * [(1/EERbase) – (1/EERee)] * EFLH_{cool}$

$\text{Annual kWh Savings}_{heat} = (kBtu/hr_{heat})/3.412 * [(1/COPbase) – (1/COPee)] * EFLH_{heat}$

Where:

$kBtu/hr_{cool}$ = capacity of the cooling equipment in kBtu per hour (1 ton of cooling capacity equals 12 kBtu/hr).

= Actual installed

SEERbase =Seasonal Energy Efficiency Ratio of the baseline equipment; see table below for values. [280]

[278] 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.

[279] 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

[280] International Energy Conservation Code (IECC) 2012

TABLE C403.2.3(2)
MINIMUM EFFICIENCY REQUIREMENTS:
ELECTRICALLY OPERATED UNITARY AND APPLIED HEAT PUMPS

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
Air cooled (cooling mode)	< 65,000 Btu/h[b]	All	Split System	13.0 SEER	AHRI 210/240
			Single Packaged	13.0 SEER	
Through-the-wall, air cooled	≤ 30,000 Btu/h[b]	All	Split System	13.0 SEER	
			Single Packaged	13.0 SEER	
Single-duct high-velocity air cooled	< 65,000 Btu/h[b]	All	Split System	10.0 SEER	
Air cooled (cooling mode)	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER 11.2 IEER	AHRI 340/360
		All other	Split System and Single Package	10.8 EER 11.0 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	10.6 EER 10.7 IEER	
		All other	Split System and Single Package	10.4 EER 10.5 IEER	
	≥ 240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	9.5 EER 9.6 IEER	
		All other	Split System and Single Package	9.3 EER 9.4 IEER	
Water source (cooling mode)	< 17,000 Btu/h	All	86°F entering water	11.2 EER	ISO 13256-1
	≥ 17,000 Btu/h and < 65,000 Btu/h	All	86°F entering water	12.0 EER	
	≥ 65,000 Btu/h and < 135,000 Btu/h	All	86°F entering water	12.0 EER	
Ground water source (cooling mode)	< 135,000 Btu/h	All	59°F entering water	16.2 EER	
		All	77°F entering water	13.4 EER	
Water-source water to water (cooling mode)	< 135,000 Btu/h	All	86°F entering water	10.6 EER	ISO 13256-2
			59°F entering water	16.3 EER	
Ground water source Brine to water (cooling mode)	< 135,000 Btu/h	All	77°F entering fluid	12.1 EER	
Air cooled (heating mode)	< 65,000 Btu/h[b]	—	Split System	7.7 HSPF	AHRI 210/240
		—	Single Package	7.7 HSPF	
Through-the-wall, (air cooled, heating mode)	≤ 30,000 Btu/h[b] (cooling capacity)	—	Split System	7.4 HSPF	
		—	Single Package	7.4 HSPF	
Small-duct high velocity (air cooled, heating mode)	< 65,000 Btu/h[b]	—	Split System	6.8 HSPF	

(continued)

TABLE C403.2.3(2)—continued
MINIMUM EFFICIENCY REQUIREMENTS:
ELECTRICALLY OPERATED UNITARY AND APPLIED HEAT PUMPS

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUB-CATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
Air cooled (heating mode)	≥ 65,000 Btu/h and < 135,000 Btu/h (cooling capacity)	—	47°F db/43°F wb Outdoor Air	3.3 COP	AHRI 340/360
			17°F db/15°F wb Outdoor Air	2.25 COP	
	≥ 135,000 Btu/h (cooling capacity)	—	47°F db/43°F wb Outdoor Air	3.2 COP	
			17°F db/15°F wb Outdoor Air	2.05 COP	
Water source (heating mode)	< 135,000 Btu/h (cooling capacity)	—	68°F entering water	4.2 COP	ISO 13256-1
Ground water source (heating mode)	< 135,000 Btu/h (cooling capacity)	—	50°F entering water	3.6 COP	
Ground source (heating mode)	< 135,000 Btu/h (cooling capacity)	—	32°F entering fluid	3.1 COP	
Water-source water to water (heating mode)	< 135,000 Btu/h (cooling capacity)	—	68°F entering water	3.7 COP	ISO 13256-2
		—	50°F entering water	3.1 COP	
Ground source brine to water (heating mode)	< 135,000 Btu/h (cooling capacity)	—	32°F entering fluid	2.5 COP	

For SI: 1 British thermal unit per hour = 0.2931 W, °C = [(°F) - 32]/1.8.

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

b. Single-phase, air-cooled air conditioners less than 65,000 Btu/h are regulated by NAECA. SEER values are those set by NAECA.

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:

HSPFbase = Heating Seasonal Performance Factor of the baseline equipment; see table above for values.

HSPFee = Heating Seasonal Performance Factor of the energy efficient equipment.

= Actual installed

$EFLH_{heat}$ = heating mode equivalent full load hours; see table above for default values.

EERbase = Energy Efficiency Ratio of the baseline equipment; see the table above for values. Since IECC 2006 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.

EERee = Energy Efficiency Ratio of the energy efficient equipment. For air-cooled air conditioners < 65 kBtu/hr, if the actual EERee 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.

COPbase = coefficient of performance of the baseline equipment; see table above for values.

COPee = coefficient of performance of the energy efficient equipment.

= Actual installed

$$\text{Annual kWh Savings}_{cool} = (\text{kBtu/hr}_{cool}) * [(1/\text{SEERbase}) - (1/\text{SEERee})] * \text{EFLH}_{cool}$$

$$\text{Annual kWh Savings}_{heat} = (\text{kBtu/hr}_{heat}) * [(1/\text{HSPFbase}) - (1/\text{HSPFee})] * \text{EFLH}_{heat}$$

For example a 5 ton cooling unit with 60 kbtu heating with an efficient EER of 14 and an efficient HSPF of 9 saves

= [(60) * [(1/13) – (1/14)] * 816] + [(60) * [(1/7.7) – (1/9)] * 1153]

= 1567 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = (\text{kBtu/hr}_{cool}) * [(1/\text{EERbase}) - (1/\text{EERee})] * CF$$

Where CF value is chosen between:

CF_{SSP} = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)

= 91.3% [281]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)

= 47.8% [282]

For example a 5 ton cooling unit with 60 kbtu heating with an efficient EER of 14 and an efficient HSPF of 9 saves

ΔkW = [(60) * [(1/13) – (1/14)] *.913

= 0.3

[281] 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.

[282] 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 ENERGY SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-HPSY-V02-140601

4.4.10 High Efficiency Boiler[283]

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 gasses. Because multiple heat exchangers are used to remove waste heat from the escaping flue gasses, some of the flue gasses condense and must be drained.

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

Definition of Efficient Equipment

To qualify for this measure the installed equipment must be a boiler used 80% or more for space heating, not process, and boiler AFUE, TE (thermal efficiency), or Ec (combustion efficiency) rating must be rated greater than or equal to 85% 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:

Year	Efficiency
Hot Water <300,000 Btu/hr < June 1, 2013[284]	80% AFUE
Hot Water <300,000 Btu/hr ≥ June 1, 2013	82% AFUE
Hot Water ≥300,000 & ≤2,500,000 Btu/hr	80% TE
Hot Water >2,500,000 Btu/hr	82% Ec

[283] High Impact Measure
[284] 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:

Year	Efficiency
Steam <300,000 Btu/hr < June 1, 2013[285]	75% AFUE
Steam <300,000 Btu/hr ≥June 1, 2013	80% AFUE
Steam - all except natural draft ≥300,000 & ≤2,500,000 Btu/hr	79% TE
Steam - natural draft ≥300,000 & ≤2,500,000 Btu/hr	77% TE
Steam - all except natural draft >2,500,000 Btu/hr	79% TE
Steam - natural draft >2,500,000 Btu/hr	77% TE

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 20 years[286]

DEEMED MEASURE COST

The incremental capital cost for this measure depends on efficiency as listed below[287]

Measure Tier	Incr. Cost, per unit
ENERGY STAR® Minimum	$1,470
AFUE 90%	$2,400
AFUE 95%	$3,370
AFUE ≥ 96%	$4,340

[285] Ibid.

[286] 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

[287] 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.

Measure Tier	Incr. Cost, per unit
Boilers > 300,000 Btu/hr with TE (thermal efficiency) rating	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 ENERGY SAVINGS

ΔTherms = EFLH * Capacity * ((EfficiencyRating(actual) - EfficiencyRating(base)/ EfficiencyRating(base)) / 100,000

Where:

EFH = 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) = Efficent Boiler Efficiency Rating use actual value

Measure Type	Actual AFUE
ENERGY STAR® Minimum	85%
AFUE 90%	90%
AFUE 95%	95%
AFUE ≥ 96%	≥ 96%
Custom	Value to one significant digit i.e. 95.7%

EXAMPLE

For example, a 150,000 btu/hr water boiler meeting AFUE 90% in Rockford at a high rise office building , in the year 2012

ΔTherms = 2,746* 150,000 * (0.90-0.80)/0.80) / 100,000 Btu/Therm
= 515 Therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-BOIL-V04-130601

4.4.11 High Efficiency Furnace[288]

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%.

[288] High Impact Measure

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[289]

Remaining life of existing equipment is assumed to be 5.5 years[290].

DEEMED MEASURE COST

Time of Sale: The incremental capital cost for this measure depends on efficiency as listed below[291]:

AFUE	Installation Cost	Incremental Install Cost
80%	$2011	n/a
90%	$2641	$630
91%	$2727	$716
92%	$2813	$802
93%	$3049	$1,038
94%	$3286	$1,275
95%	$3522	$1,511
96%	$3758	$1,747

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

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289 Average of 15-18 year lifetime estimate made by the Consortium for Energy Efficiency in 2010.

290 Assumed to be one third of effective useful life

291 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.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

ΔkWh = Heating Savings + Cooling Savings + Shoulder Season Savings

Where:

Heating Savings = Brushless DC motor or Electronically commutated motor (ECM) = 418 kWh[292]

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[293]

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:

ΔkWh = Heating Savings + Cooling Savings + Shoulder Season Savings
= 418 +251 + 51
= 721 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.

ΔkW = (ΔkWh/HOURSyear) * CF

292 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.

293 The weighted average value is based on assumption that 75% of buildings installing BPM furnace blower motors have Central AC.

Where:

HOURSyear = Actual hours per year if known, otherwise use hours from Table below for building type.

Building Type	Pumps and fans (h/yr)
College/University	4216
Grocery	5840
Heavy Industry	3585
Hotel/Motel	6872
Light Industry	2465
Medical	6871
Office	1766
Restaurant	4654
Retail/Service	3438
School(K-12)	2203
Warehouse	3222
Average=Miscellaneous	4103

CF =Summer Peak Coincidence Factor for measure is provided below for different building types[294]:

Location	CF
Restaurant	0.80
Office	0.66
School (K-12)	0.22
College/University	0.56
Medical	0.75

EXAMPLE

For example, a blower motor in an office building where air conditioning presence is unknown:

ΔkW = (721 kWh/1766) * 0.66 = 0.27 kW

NATURAL GAS ENERGY SAVINGS

Time of Sale:

ΔTherms = EFLH * Capacity * ((AFUE(eff) – AFUE(base)/AFUE(base))/ 100,000 Btu/Therm

Early replacement[295]:

[294] Based on DEER 2008 values

ΔTherms for remaining life of existing unit (1st 5.5 years):

ΔTherms = EFLH * Capacity * (AFUE(eff) – AFUE(exist)/ AFUE(exist)) / 100,000 Btu/Therm

ΔTherms for remaining measure life (next 11 years):

ΔTherms = EFLH * Capacity * (AFUE(eff) - AFUE(base)/AFUE(base)) / 100,000 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% [296].

AFUE(base) = Baseline Furnace Annual Fuel Utilization Efficiency Rating, dependant on year as listed below:

Dependent on program type as listed below[297]:

Program Year	AFUE(base)
Time of Sale	80%
Early Replacement	90%

AFUE(eff) = Efficent Furnace Annual Fuel Utilization Efficiency Rating.

= Actual. If Unknown, assume 95%[298]

[295] 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).

[296] Average nameplate efficiencies of all Early Replacement qualifying equipment in Ameren PY3-PY4.

[297] 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.

[298] Minimum ENERGY STAR efficiency after 2.1.2012.

EXAMPLE

For example, a 150,000 btu/hr 92% efficient furnace at a low rise office building in Rockford, in the year 2012

$$\Delta Therms = 797 * 150,000 * ((0.92-0.80)/0.80)/ 100,000 \text{ Btu/Therm}$$
$$= 179 \text{ Therms}$$

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-FRNC-V03-130601

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[299]

Deemed Measure Cost

The incremental capital cost for this measure is $1716[300]

Loadshape

N/A

Coincidence Factor

N/A

Algorithm

Calculation of Savings

Electric Energy Savings

N/A

[299] 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

[300] Ibid.

Summer Coincident Peak Demand Savings

N/A

Natural Gas Energy Savings

The annual natural gas energy savings from this measure is a deemed value equaling 451 Therms[301]

Water Impact Descriptions and Calculation

N/A

Deemed O&M Cost Adjustment Calculation

N/A

Measure Code: CI-HVC-IRHT-V01-120601

[301] 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. [302]

Remaining life of existing equipment is assumed to be 5 years[303]

DEEMED MEASURE COST

Time of Sale: The incremental capital cost for this equipment is estimated to be $84/ton.[304]

[302] Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, Inc., June 2007
[303] Standard assumption of one third of effective useful life.
[304] DEER 2008. This assumes that baseline shift from IECC 2006 to IECC 2012 carries the same incremental costs.

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. *Default and deferred baseline cost TBD*

LOADSHAPE

Loadshape C03 - Commercial Cooling

COINCIDENCE FACTOR

The summer peak coincidence factor for cooling is provided in two different ways below. The first is used to estimate peak savings during the utility peak hour and is most indicative of actual peak benefits, and the second represents the *average* savings over the defined summer peak period, and is presented so that savings can be bid into PJM's Forward Capacity Market. Both values provided are based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren.

CF_{SSP} = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)

= 91.3% [305]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)

= 47.8% [306]

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:

PTAC ΔkWh[307] = Annual kWh $Savings_{cool}$

PTHP ΔkWh = Annual kWh $Savings_{cool}$ + Annual kWh $Savings_{heat}$

Values should be verified during evaluation

305 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.

306 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

307 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 $Savings_{cool}$ = ($kBtu/hr_{cool}$) * [(1/EERbase) – (1/EERee)] * $EFLH_{cool}$

Annual kWh $Savings_{heat}$ = ($kBtu/hr_{heat}$)/3.412 * [(1/COPbase) – (1/COPee)] * $EFLH_{heat}$

Early Replacement:

ΔkWh for remaining life of existing unit (1^{st} 5years) = Annual kWh $Savings_{cool}$ + Annual kWh $Savings_{heat}$

Annual kWh $Savings_{cool}$ = ($kBtu/hr_{cool}$) * [(1/EERexist) – (1/EERee)] * $EFLH_{cool}$

Annual kWh $Savings_{heat}$ = ($kBtu/hr_{heat}$)/3.412 * [(1/COPexist) – (1/COPee)] * $EFLH_{heat}$

ΔkWh for remaining measure life (next 10 years) = Annual kWh $Savings_{cool}$ + Annual kWh $Savings_{heat}$

Annual kWh $Savings_{cool}$ = ($kBtu/hr_{cool}$) * [(1/EERbase) – (1/EERee)] * $EFLH_{cool}$

Annual kWh $Savings_{heat}$ = ($kBtu/hr_{heat}$)/3.412 * [(1/COPbase) – (1/COPee)] * $EFLH_{heat}$

Where:

$kBtu/hr_{cool}$ = capacity of the cooling equipment in kBtu per hour (1 ton of cooling capacity equals 12 kBtu/hr).

= Actual installed

$EFLH_{cool}$ = Equivalent Full Load Hours for cooling are provided in section 4.4 HVAC End Use:

$EFLH_{heat}$ = Equivalent Full Load Hours for heating are provided in section 4.4 HVAC End Use

EERexist = Energy Efficiency Ratio of the existing equipment

= Actual. If unknown assume 8.1 EER[308]

EERbase = Energy Efficiency Ratio of the baseline equipment; see the table below for values.

[308] 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.

Copy of Table C403.2.3(3), IECC 2012:
Minimum Efficiency Reguirements: Electrically operated packaged terminal air conditioners, packaged terminal heat pumps

Equipment Type	Minimum Efficiency as of 10/08/2012
PTAC (Cooling mode) New Construction	13.8 – (0.300 x Cap/1000) EER
PTAC (Cooling mode) Replacements	10.9 – (0.213 x Cap/1000) EER
PTHP (Cooling mode) New Construction	14.0 – (0.300 x Cap/1000) EER
PTHP (Cooling mode) Replacements	10.8 – (0.213 x Cap/1000) EER
PTHP (Heating mode) New Construction	3.2 – (0.026 x Cap/1000) COP
PTHP (Heating mode) Replacements	2.9 – (0.026 x Cap/1000) COP

"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 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.

EERee = Energy Efficiency Ratio of the energy efficient equipment. For air-cooled air conditioners < 65 kBtu/hr, if the actual EERee 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.

COPexist = coefficient of performance of the existing equipment

= Actual. If unknown assume 1.0 COP for PTAC units and 2.6 COP[309] for PTHPs.

COPbase = coefficient of performance of the baseline equipment; see table above for values.

COPee = coefficient of performance of the energy efficient equipment.

= Actual installed

[309] 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

Time of Sale (assuming new construction baseline):

For example a 1 ton PTAC with an efficient EER of 12 in Rockford saves:

= [(12) * [(1/10.2) – (1/12)] * 816

= 144 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.

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

= (12 * (1/8.1 – 1/12) * 816) + (12/3.412 * (1/1.0 – 1/3.0) * 1153)

= 393 + 2,703

= 3,096 kWh

ΔkWh for remaining measure life (next 10 years)

= (12 * (1/8.3 – 1/12) * 816) + (12/3.412 * (1/1.0 – 1/3.0) * 1153)

= 364 + 2,703

= 3,067 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

Time of Sale:

ΔkW = ($kBtu/hr_{cool}$) * [(1/EERbase) – (1/EERee)] *CF

Early Replacement:

ΔkW for remaining life of existing unit (1^{st} 5years) = ($kBtu/hr_{cool}$) * [(1/EERexist) – (1/EERee)] *CF

ΔkWh for remaining measure life (next 10 years) = ($kBtu/hr_{cool}$) * [(1/EERbase) – (1/EERee)] *CF

Where:

CF_{SSP} = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)

= 91.3% [310]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)

= 47.8% [311]

[310] 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.

Time of Sale:

For example a 1 ton replacement cooling unit with no heating with an efficient EER of 12 in Rockford saves

ΔkW_{SSP} = (12 * (1/10.2 – 1/12) *0.913

= 0.16 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.

ΔkW for remaining life of existing unit (1^{st} 5years):

ΔkW_{SSP} = 12 * (1/8.1 – 1/12) * 0.913

= 0.44 kW

ΔkW for remaining measure life (next 10 years):

ΔkW_{SSP} = 12 * (1/10.2 – 1/12) * 0.913

= 0.16 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-HVC-PTAC-V04-140601

[311] 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

4.4.14 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.[312]

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.

[312] *ASHRAE Handbook—Fundamentals*, 23.14; Hart, G., "Saving energy by insulating pipe components on steam and hot water distribution systems", *ASHRAE Journal*, October 2011

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure life is assumed to be 15 years.[313]

DEEMED MEASURE COST

Actual costs should be used if known. Otherwise the deemed measure costs below based on RS Means[314] pricing reference materials may be used.[315] The following table summarizes the estimated costs for this measure per foot of insulation added and include installation costs:

	INSULATION THICKNESS	
	1 INCH (INDOOR)	2 INCHES (OUTDOOR)
Pipe- RS Means #	220719.10.5170	220719.10.5530
Jacket- RS Means #	220719.10.0156	220719.10.0320
Jacket Type	PVC	Aluminum
Insulation Cost per foot	$9.40	$13.90
Jacket Cost per foot	$4.57	$7.30
Total Cost per foot	**$13.97**	**$21.20**

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

313 Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007.
http://neep.org/uploads/EMV%20Forum/EMV%20Studies/measure_life_GDS%5B1%5D.pdf

314 RS Means 2008. Mechanical Cost Data, pages 106 to 119

315 RS Means 2010: “for fittings, add 3 linear feet for each fitting plus 4 linear feet for each flange of the fitting”

NATURAL GAS SAVINGS

Δtherms per foot[316] = ((Q_{base} – Q_{eff}) * TRF * HOURS) / (100,000 * ηBoiler)

Δtherms = (L_{sp} + $L_{oc,i}$) * Δtherms per foot

Where:

HOURS = annual operating time, in hours

= Actual or defaults by piping use and building type below:

Piping Use	Building Type	EFLH				
		Zone 1 (Rockford)	Zone 2 (Chicago)	Zone 3 (Springfield)	Zone 4 (Belleville/	Zone 5 (Marion)
Space Heating - Non-recirculating[317]	Office - High Rise	2,746	2,768	2,656	2,155	2,420
	Office - Mid Rise	996	879	824	519	544
	Office - Low Rise	797	666	647	343	329
	Convenience	696	550	585	272	297
	Healthcare Clinic	1,118	1,036	1,029	694	737
	Manufacturing Facility	1,116	1,123	904	771	857
	Lodging Hotel/ Motel/Multifamily	2,098	2,050	1,780	1,365	1,666
	High School	969	807	999	569	674
	Hospital	2,031	1,929	1,863	1,497	1,800
	Elementary	970	840	927	524	637
	Religious Facility	1,830	1,657	1,730	1,276	1,484
	Restaurant	1,496	1,379	1,291	872	1,185
	Retail - Strip Mall	1,266	1,147	1,151	732	863
	Retail - Department Store	1,065	927	900	578	646

[316] 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"

[317] Equivalent full load hours for heating were developed using eQuest models for various building types averaged across each climate zones for Illinois for the following building types: office, healthcare/clinic, manufacturing, lodging, high school, hospital, elementary school, religious/assembly, restaurant, retail, college and warehouse. eQuest models were those developed for IL lighting interactive effects.

	College/University	373	404	376	187	187
	Warehouse	416	443	427	226	232
	Unknown	1,205	1,119	1,084	752	873
Space Heating – recirculation heating season only [318]	All buildings (Hours below 55F)	5,039	4,963	4,495	4,021	4,150
Space Heating – recirculation year round [319]	All buildings (All hours)	8,760	8,760	8,760	8,760	8,760
Domestic Hot Water	Recirculation loop	8,760	8,760	8,760	8,760	8,760
Process	Custom	Custom				

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)

ηBoiler = Efficiency of the boiler being used to generate the hot water or steam in the pipe

= 81.9% for water boilers[320]

= 80.7% for steam boilers[321]

= 64.8% for multifamily low-pressure steam boilers[322]

TRF = Thermal Regain Factor for space type, applied only to space heating energy[323]

318 These hours of use represent the number of hours in each climate zone that the outside temperature is below 55 degrees F. This is a consistent assumption of heating set point for commercial buildings. Hourly temperature data is obtained from the National Climactic Data Center (NCDC).

319 For example reheat systems such as VAV and constant volume systems.

320 Average efficiencies of units from the California Energy Commission (CEC).

321 Ibid.

322 Katrakis, J. and T.S. Zawacki. "Field-Measured Seasonal Efficiency of Intermediate-sized Low-Pressure Steam Boilers". ASHRAE V99, pt. 2, 1993.

323 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.

Pipe Location	Assumed Regain	TRF, Thermal Regain Factor
Outdoor	0%	1.0
Indoor, conditioned space	85%	0.15
Indoor, semi-conditioned, (unconditioned space, with heat transfer to conditioned space. E.g.: boiler room, ceiling plenum, basement, crawlspace, wall)	30%	0.70
Indoor, unconditioned, (no heat transfer to conditioned space)	0%	1.0
Location not specified	85%	0.15
Custom	Custom	1 – assumed regain

L_{sp} = Length of straight pipe to be insulated (linear foot)

= actual installed ((linear foot)

$L_{oc,I}$ = Total equivalent length of the other components (valves and tees) of pipe to be insulated

= Actual installed (linear foot). See table "Equivalent Length of Other Components – Elbows and Tees" for equivalent lengths.

The heat loss estimates (Q_{base} and Q_{eff}) were developed using the 3E Plus v4.0 software program.[324] 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_{base} and $Q_{eff.}$

Insulation Type	Conductivity (Btu.in / hr.ft^2.ºF @ 75F)	Max temp (ºF)
Polyethylene foam	0.25	200
Flexible polyurethane-based foam	0.27	200
Fiberglass	0.31	250
Melamine foam	0.26	350
Flexible silicon foam	0.40	392
Calcium silicate	0.40	1200
Cellular glass	0.31	400
Average conductivity of all these materials (Btu.in / hr.ft^2.ºF @ 75ºF)	0.31	

The pipe fluid temperature assumption used depends upon both the system type and whether there is outdoor reset controls:

324 3E Plus is a heat loss calculation software provided by the NAIMA (North American Insulation Manufacturer Association).

System Type	Fluid temperature assumption (°F)
Hot Water space heating with outdoor reset - Non recirculation	145
Hot Water space heating without outdoor reset - Non recirculation	170
Hot Water space heating with outdoor reset – Recirculation heating season only	145
Hot Water space heating without outdoor reset – Recirculation heating season only	170
Hot Water space heating with outdoor reset – Recirculation year round	130
Hot Water space heating without outdoor reset – Recirculation year round	170
Domestic Hot Water	125
Low Pressure Steam	225
High Pressure Steam	312

	Indoor Insulation, Hot Water	Indoor Insulation, Low Pressure Steam	Indoor Insulation, High Pressure Steam	Domestic Hot Water	Outdoor Insulation, Hot Water	Outdoor Insulation, Low Pressure Steam	Outdoor Insulation, High Pressure Steam
Insulation thickness (inch)	1	1	1	1	2	2	2
Temperature, Fluid in Pipe (ºF)	170 (w/o reset) 145 (w/ reset heat) 130 (w/reset year)	225	312	125	170 (w/o reset) 145 (w/ reset heat) 130 (w/reset year)	225	312
Av. steam pressure (psig)	n/a	10.9	82.8	n/a	n/a	10.9	82.8
Operating Time (hrs/yr)	2,746 (non-recirc) 5,039 (recirc heating season) 8,760 (recirc year round)						
Ambient Temperature (ºF)[325]	75	75	75	75	48.6	48.6	48.6
Wind speed (mph)[326]	0	0	0	0	9.4	9.4	9.4
Pipe parameters							
Pipe material	Copper	Steel	Steel	Copper	Copper	Steel	Steel
Pipe size for Heat Loss Calc	2"	2"	2"	2"	2"	2"	2"
Outer Diameter, Pipe, actual	2.38"	2.38"	2.38"	2.38"	2.38"	2.38"	2.38"
Heat Loss, Bare Pipe (from 3EPlus) (Btu/hr.ft)	114 (w/o reset) 78 (w/ reset heat) 58 (w/reset year)	232	432	52	460 (w/o reset) 363 (w/ reset heat) 306 (w/reset year)	710	1101
Insulation parameters							
Outer diameter, insulation	4.38"	4.38"	4.38"	4.38"	4.38"	4.38"	4.38"
Average Heat Loss, Insulation (from 3EPlus) (Btu/hr.ft)	24 (w/o reset) 17 (w/ reset heat) 13 (w/reset year)	40	70	13.25	21 (w/o reset) 16 (w/ reset heat) 13 (w/reset year)	32	52
Annual Energy Savings							
Boiler / Water Heater efficiency	81.9%	80.7%	80.7%	67%	81.9%	80.7%	80.7%
Annual Gas Use, Base Case (therms/yr/ft)	3.8 (w/o reset) 4.8 (w/ reset heat) 6.2 (w/reset year)	7.9 (non recirc) 14.5 (recirc heat) 25.2 (recirc year)	14.7 (non recirc) 27.0 (recirc heat) 46.9 (recirc year)	6.76	15.4 (w/o reset) 22.5 (w/ reset heat) 32.7 (w/reset year)	24.1 (non recirc) 44.3 (recirc heat) 77.0 (recirc year)	37.5 (non recirc) 68.7 (recirc heat) 119.5 (recirc year)
Annual Gas Use, Measure case (therms/yr/ft)	0.8 (w/o reset) 1.1 (w/ reset heat) 1.4 (w/reset year)	1.4 (non recirc) 2.5 (recirc heat) 4.4 (recirc year)	2.4 (non recirc) 4.4 (recirc heat) 7.6 (recirc year)	1.73	0.7 (w/o reset) 1.0 (w/ reset heat) 1.4 (w/reset year)	1.1 (non recirc) 2.0 (recirc heat) 3.4 (recirc year)	1.8 (non recirc) 3.2 (recirc heat) 5.6 (recirc year)
Annual Gas Savings (therms/yr/ft)	3.0 (w/o reset) 3.7 (w/ reset heat) 4.8 (w/reset year)	6.5 (non recirc) 12.0 (recirc heat) 20.8 (recirc year)	12.3 (non recirc) 22.6 (recirc heat) 39.3 (recirc year)	5.0	14.7 (w/o reset) 21.4 (w/ reset heat) 31.3 (w/reset year)	23.1 (non recirc) 42.3 (recirc heat) 73.6 (recirc year)	35.7 (non recirc) 65.5 (recirc heat) 113.9 (recirc year)

Heat = heating season only, year = year round

325 DOE Weather Data. http://apps1.eere.energy.gov/buildings/energyplus/weatherdata/4_north_and_central_america_wmo_region_4/1_usa/USA_IL_Aurora.Muni.AP.744655_TMY3.stat Ibid.

326 Ibid.

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 pages)

			Annual therm Savings per linear foot (therm /ft) (2" pipe / 1" insulation for hot water, 2" insulation for steam)				
Location	**System Type**	**Building Type**	**Zone 1 (Rockford)**	**Zone 2 (Chicago)**	**Zone 3 (Springfield)**	**Zone 4 (Belleville)**	**Zone 5 (Marion)**
Indoor	Hot Water Space Heating with outdoor reset – non-recirculation	Office - High Rise	2.04	2.05	1.97	1.60	1.79
		Office - Mid Rise	0.74	0.65	0.61	0.38	0.40
		Office - Low Rise	0.59	0.49	0.48	0.25	0.24
		Convenience	0.52	0.41	0.43	0.20	0.22
		Healthcare Clinic	0.83	0.77	0.76	0.51	0.55
		Manufacturing Facility	0.83	0.83	0.67	0.57	0.64
		Lodging Hotel/ Motel/MF	1.55	1.52	1.32	1.01	1.23
		High School	0.72	0.60	0.74	0.42	0.50
		Hospital	1.51	1.43	1.38	1.11	1.33
		Elementary	0.72	0.62	0.69	0.39	0.47
		Religious Facility	1.36	1.23	1.28	0.95	1.10
		Restaurant	1.11	1.02	0.96	0.65	0.88
		Retail - Strip Mall	0.94	0.85	0.85	0.54	0.64
		Retail - Department Store	0.79	0.69	0.67	0.43	0.48
		College/University	0.28	0.30	0.28	0.14	0.14
		Warehouse	0.31	0.33	0.32	0.17	0.17
		Unknown	0.93	0.86	0.84	0.58	0.67
	Hot Water Space Heating without outdoor reset – non-recirculation	Office - High Rise	3.00	3.03	2.91	2.36	2.65
		Office - Mid Rise	1.09	0.96	0.90	0.57	0.60
		Office - Low Rise	0.87	0.73	0.71	0.38	0.36
		Convenience	0.76	0.60	0.64	0.30	0.32
		Healthcare Clinic	1.22	1.13	1.13	0.76	0.81
		Manufacturing Facility	1.22	1.23	0.99	0.84	0.94
		Lodging Hotel/ Motel/MF	2.30	2.24	1.95	1.49	1.82
		High School	1.06	0.88	1.09	0.62	0.74
		Hospital	2.22	2.11	2.04	1.64	1.97
		Elementary	1.06	0.92	1.01	0.57	0.70
		Religious Facility	2.00	1.81	1.89	1.40	1.62
		Restaurant	1.64	1.51	1.41	0.95	1.30
		Retail - Strip Mall	1.39	1.25	1.26	0.80	0.94
		Retail - Department Store	1.17	1.01	0.98	0.63	0.71
		College/University	0.41	0.44	0.41	0.20	0.20
		Warehouse	0.46	0.48	0.47	0.25	0.25
		Unknown	1.37	1.27	1.24	0.86	1.00
	Hot Water with outdoor reset - Recirculation heating season only	All buildings (Hours below 55F)	3.73	3.68	3.33	2.98	3.08

			Annual therm Savings per linear foot (therm /ft) (2" pipe / 1" insulation for hot water, 2" insulation for steam)				
Location	System Type	Building Type	Zone 1 (Rockford)	Zone 2 (Chicago)	Zone 3 (Springfield)	Zone 4 (Belleville)	Zone 5 (Marion)
	Hot Water without outdoor reset- Recirculation heating season only	All buildings (Hours below 55F)	5.51	5.43	4.92	4.40	4.54
	Hot Water with outdoor reset- Recirculation year round	All buildings (All hours)	4.79	4.79	4.79	4.79	4.79
	Hot Water without outdoor reset- Recirculation year round	All buildings (All hours)	9.58	9.58	9.58	9.58	9.58
	Domestic Hot Water	DHW circulation loop	5.02	5.02	5.02	5.02	5.02
	LP Steam – non-recirculation	Office - High Rise	6.53	6.59	6.32	5.13	5.76
		Office - Mid Rise	2.37	2.09	1.96	1.23	1.29
		Office - Low Rise	1.90	1.58	1.54	0.82	0.78
		Convenience	1.66	1.31	1.39	0.65	0.71
		Healthcare Clinic	2.66	2.47	2.45	1.65	1.75
		Manufacturing Facility	2.66	2.67	2.15	1.83	2.04
		Lodging Hotel/ Motel/MF	4.99	4.88	4.24	3.25	3.96
		High School	2.31	1.92	2.38	1.35	1.60
		Hospital	4.83	4.59	4.43	3.56	4.28
		Elementary	2.31	2.00	2.21	1.25	1.52
		Religious Facility	4.35	3.94	4.12	3.04	3.53
		Restaurant	3.56	3.28	3.07	2.07	2.82
		Retail - Strip Mall	3.01	2.73	2.74	1.74	2.05
		Retail - Department Store	2.53	2.21	2.14	1.38	1.54
		College/University	0.89	0.96	0.89	0.44	0.44
		Warehouse	0.99	1.05	1.02	0.54	0.55
		Unknown	2.97	2.77	2.69	1.87	2.17
	LP Steam- Recirculation heating season only	All buildings (Hours below 55F)	11.99	11.81	10.70	9.57	9.88
	LP Steam- Recirculation year round	All buildings (All hours)	20.84	20.84	20.84	20.84	20.84
	HP Steam – non-recirculation	Office - High Rise	12.33	12.42	11.92	9.67	10.86
		Office - Mid Rise	4.47	3.95	3.70	2.33	2.44
		Office - Low Rise	3.58	2.99	2.90	1.54	1.48
		Convenience	3.12	2.47	2.63	1.22	1.33
		Healthcare Clinic	5.02	4.65	4.62	3.12	3.31
		Manufacturing Facility	5.01	5.04	4.06	3.46	3.85
		Lodging Hotel/ Motel/MF	9.42	9.20	7.99	6.13	7.48

Location	System Type	Building Type	Annual therm Savings per linear foot (therm /ft) (2" pipe / 1" insulation for hot water, 2" insulation for steam) Zone 1 (Rockford)	Zone 2 (Chicago)	Zone 3 (Springfield)	Zone 4 (Belleville)	Zone 5 (Marion)
		High School	4.35	3.62	4.48	2.55	3.03
		Hospital	9.12	8.66	8.36	6.72	8.08
		Elementary	4.35	3.77	4.16	2.35	2.86
		Religious Facility	8.21	7.44	7.77	5.73	6.66
		Restaurant	6.71	6.19	5.79	3.91	5.32
		Retail - Strip Mall	5.68	5.15	5.17	3.29	3.87
		Retail - Department Store	4.78	4.16	4.04	2.59	2.90
		College/University	1.67	1.81	1.69	0.84	0.84
		Warehouse	1.87	1.99	1.92	1.01	1.04
		Unknown	5.61	5.22	5.07	3.53	4.08
	HP Steam-Recirculation heating season only	All buildings (Hours below 55F)	22.62	22.28	20.18	18.05	18.63
	HP Steam-Recirculation year round	All buildings (All hours)	39.32	39.32	39.32	39.32	39.32

Savings Summary for Outdoor pipe insulation by System Type and Building Type (Δtherms per foot) (continues for 3 pages)

Location	System Type	Building Type	Annual therm Savings per linear foot (therm /ft) (2" pipe / 1" insulation for hot water, 2" insulation for steam) Zone 1 (Rockford)	Location	System Type	Building Type	Zone 1 (Rockford)
Outdoor	Hot Water Space Heating with outdoor reset – non-recirculation	Office - High Rise	11.65	11.74	11.27	9.14	10.27
		Office - Mid Rise	4.23	3.73	3.50	2.20	2.31
		Office - Low Rise	3.38	2.83	2.74	1.46	1.40
		Convenience	2.95	2.33	2.48	1.15	1.26
		Healthcare Clinic	4.74	4.40	4.37	2.94	3.13
		Manufacturing Facility	4.73	4.76	3.84	3.27	3.64
		Lodging Hotel/ Motel/MF	8.90	8.70	7.55	5.79	7.07
		High School	4.11	3.42	4.24	2.41	2.86
		Hospital	8.62	8.18	7.90	6.35	7.64
		Elementary	4.12	3.56	3.93	2.22	2.70
		Religious Facility	7.76	7.03	7.34	5.41	6.30
		Restaurant	6.35	5.85	5.48	3.70	5.03
		Retail - Strip Mall	5.37	4.87	4.88	3.11	3.66
		Retail - Department Store	4.52	3.93	3.82	2.45	2.74
		College/University	1.58	1.71	1.60	0.79	0.79
		Warehouse	1.76	1.88	1.81	0.96	0.98
		Unknown	5.30	4.93	4.79	3.33	3.86
	Hot Water Space Heating without outdoor reset – non-recirculation	Office - High Rise	14.74	14.86	14.26	11.57	12.99
		Office - Mid Rise	5.35	4.72	4.42	2.79	2.92
		Office - Low Rise	4.28	3.57	3.47	1.84	1.77
		Convenience	3.74	2.95	3.14	1.46	1.59
		Healthcare Clinic	6.00	5.56	5.52	3.73	3.96

			Annual therm Savings per linear foot (therm /ft) (2" pipe / 1" insulation for hot water, 2" insulation for steam)				
Location	System Type	Building Type	Zone 1 (Rockford)	Location	System Type	Building Type	Zone 1 (Rockford)
		Manufacturing Facility	5.99	6.03	4.85	4.14	4.60
		Lodging Hotel/ Motel/MF	11.26	11.00	9.55	7.33	8.94
		High School	5.20	4.33	5.36	3.05	3.62
		Hospital	10.90	10.35	10.00	8.04	9.66
		Elementary	5.21	4.51	4.98	2.81	3.42
		Religious Facility	9.82	8.89	9.29	6.85	7.97
		Restaurant	8.03	7.40	6.93	4.68	6.36
		Retail - Strip Mall	6.80	6.16	6.18	3.93	4.63
		Retail - Department Store	5.72	4.98	4.83	3.10	3.47
		College/University	2.00	2.17	2.02	1.00	1.00
		Warehouse	2.23	2.38	2.29	1.21	1.25
		Unknown	6.70	6.24	6.07	4.22	4.88
	Hot Water with outdoor reset - Recirculation heating season only	All buildings (Hours below 55F)	21.38	21.06	19.07	17.06	17.61
	Hot Water without outdoor reset- Recirculation heating season only	All buildings (Hours below 55F)	27.05	26.64	24.13	21.58	22.28
	Hot Water with outdoor reset- Recirculation year round	All buildings (All hours)	37.16	37.16	37.16	37.16	37.16
	Hot Water without outdoor reset- Recirculation year round	All buildings (All hours)	47.02	47.02	47.02	47.02	47.02
	LP Steam – non-recirculation	Office - High Rise	23.07	23.25	22.31	18.10	20.33
		Office - Mid Rise	8.37	7.38	6.92	4.36	4.57
		Office - Low Rise	6.70	5.59	5.44	2.88	2.76
		Convenience	5.85	4.62	4.91	2.29	2.50
		Healthcare Clinic	9.39	8.70	8.64	5.83	6.19
		Manufacturing Facility	9.38	9.43	7.59	6.48	7.20
		Lodging Hotel/ Motel	17.63	17.22	14.95	11.47	14.00
		Multifamily	21.95	21.45	18.62	14.28	17.43
		High School	8.14	6.78	8.39	4.78	5.66
		Hospital	17.06	16.21	15.65	12.58	15.12
		Elementary	8.15	7.06	7.79	4.40	5.35
		Religious Facility	15.37	13.92	14.53	10.72	12.47
		Restaurant	12.57	11.58	10.85	7.33	9.96
		Retail - Strip Mall	10.64	9.64	9.67	6.15	7.25
		Retail - Department Store	8.95	7.79	7.56	4.86	5.43
		College/University	3.13	3.39	3.16	1.57	1.57
		Warehouse	3.49	3.72	3.59	1.90	1.95
		Unknown	10.49	9.77	9.49	6.60	7.64
	LP Steam- Recirculation heating season only	All buildings (Hours below 55F)	42.33	41.69	37.76	33.78	34.86

			Annual therm Savings per linear foot (therm /ft) (2" pipe / 1" insulation for hot water, 2" insulation for steam)				
Location	**System Type**	**Building Type**	**Zone 1 (Rockford)**	**Location**	**System Type**	**Building Type**	**Zone 1 (Rockford)**
	LP Steam- Recirculation year round	All buildings (All hours)	73.59	73.59	73.59	73.59	73.59
	HP Steam – non-recirculation	Office - High Rise	35.71	36.00	34.54	28.02	31.47
		Office - Mid Rise	12.95	11.43	10.72	6.75	7.07
		Office - Low Rise	10.36	8.66	8.41	4.46	4.28
		Convenience	9.05	7.15	7.61	3.54	3.86
		Healthcare Clinic	14.54	13.47	13.38	9.03	9.58
		Manufacturing Facility	14.51	14.60	11.76	10.03	11.14
		Lodging Hotel/ Motel Multifamily	27.28	26.66	23.15	17.75	21.67
		High School	12.60	10.49	12.99	7.40	8.76
		Hospital	26.41	25.09	24.23	19.47	23.41
		Elementary	12.61	10.92	12.06	6.81	8.28
		Religious Facility	23.80	21.55	22.50	16.59	19.30
		Restaurant	19.45	17.93	16.79	11.34	15.41
		Retail - Strip Mall	16.46	14.92	14.97	9.52	11.22
		Retail - Department Store	13.85	12.06	11.70	7.52	8.40
		College/University	4.85	5.25	4.89	2.43	2.43
		Warehouse	5.41	5.76	5.55	2.94	3.02
		Unknown	16.24	15.12	14.69	10.22	11.83
	HP Steam- Recirculation heating season only	All buildings (Hours below 55F)	65.53	64.54	58.45	52.29	53.97
	HP Steam- Recirculation year round	All buildings (All hours)	113.92	113.92	113.92	113.92	113.92

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

Nominal Pipe Diameter	Calculated Surface Area (ft)	
	90 Degree Elbow[327]	Straight Tee[328]
1”	0.10	0.13
2”	0.41	0.39
3”	0.93	0.77
4”	1.64	1.21
5”	2.57	1.77
6”	3.70	2.44
8”	6.58	3.95
10”	10.28	5.98
12”	14.80	8.34

Equivalent Length of Other Components – Elbows and Tees (L_{oc})

Nominal Pipe Diameter	Equivalent Length of Other Components (ft)	
	90 Degree Elbow	Straight Tee
1”	0.30	0.38
2”	0.66	0.63
3”	1.01	0.84
4”	1.40	1.03
5”	1.76	1.22
6”	2.13	1.41
8”	2.91	1.75
10”	3.65	2.13
12”	4.44	2.50

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.

327 Based on the dimensions for diameter, long radius, and short radius given by ANSI/ASME 36.19
328 Based on the center to face and diameter dimensions given by ANSI/ASME B36.19

Calculated Surface Areas of Flanges and Valves

Valves					Flanges				
Class (psi)	150	300	600	900	Class (psi)	150	300	600	900
NPS (in)	ft^2	ft^2	ft^2	ft^2	NPS (in)	ft^2	ft^2	ft^2	ft^2
1	0.69	1.8	1.8	2.4	1	0.36	0.36	0.4	1.23
2	2.21	2.94	2.94	5.2	2	0.71	0.84	0.88	1.54
2.5	2.97	3.51	3.91	6.6					
3	3.37	4.39	4.69	6.5	3	1.06	1.32	1.36	1.85
4	4.68	6.06	7.64	9.37	4	1.44	1.83	2.23	2.64
6	7.03	9.71	13.03	15.8	6	2.04	2.72	3.6	4.37
8	10.3	13.5	18.4	23.8	8	2.92	3.74	4.89	6.4
10	13.8	18	26.5	32.1	10	3.68	4.8	6.93	8.47
12	16.1	24.1	31.9	41.9	12	5.01	6.34	7.97	10.43

Equivalent Length of Other Components - Flanges and Valves (L_{oc})

ANSI Class (psi)	Equivalent Length of Other Components (ft)			
	1” Valve	1” Flange	2” Valve	2” Flange
150	3.56	1.05	3.56	1.14
300	4.73	1.05	4.73	1.35
600	4.73	1.16	4.73	1.42
900	8.37	3.57	8.37	2.48

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-PINS-V02-140601

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.[329]

DEEMED MEASURE COST

The incremental capital cost for this measure is assumed to be $100 per ton.[330]

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

[329] Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, Inc., June 2007.

[330] 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

into PJM's Forward Capacity Market. Both values provided are based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren.

CF_{SSP} = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)

= 91.3% [331]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)

= 47.8% [332]

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

For units with cooling capacities less than 65 kBtu/hr:

ΔkWH = (kBtu/hr) * [(1/SEERbase) – (1/SEERee)] * EFLH

For units with cooling capacities equal to or greater than 65 kBtu/hr:

ΔkWH = (kBtu/hr) * [(1/EERbase) – (1/EERee)] * 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[333]::

[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.

[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

[333] International Energy Conservation Code (IECC) 2012

TABLE C403.2.3(1)
MINIMUM EFFICIENCY REQUIREMENTS:
ELECTRICALLY OPERATED UNITARY AIR CONDITIONERS AND CONDENSING UNITS

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY		TEST PROCEDURE[a]
				Before 6/1/2011	As of 6/1/2011	
Air conditioners, air cooled	< 65,000 Btu/h[b]	All	Split System	13.0 SEER	13.0 SEER	AHRI 210/240
			Single Package	13.0 SEER	13.0 SEER	
Through-the-wall (air cooled)	≤ 30,000 Btu/h[b]	All	Split system	12.0 SEER	12.0 SEER	
			Single Package	12.0 SEER	12.0 SEER	
Small-duct high-velocity (air cooled)	< 65,000 Btu/h[b]	All	Split System	10.0 SEER	10.0 SEER	
Air conditioners, air cooled	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.2 EER 11.4 IEER	11.2 EER 11.4 IEER	AHRI 340/360
		All other	Split System and Single Package	11.0 EER 11.2 IEER	11.0 EER 11.2 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER 11.2 IEER	11.0 EER 11.2 IEER	
		All other	Split System and Single Package	10.8 EER 11.0 IEER	10.8 EER 11.0 IEER	
	≥ 240,000 Btu/h and < 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	10.0 EER 10.1 IEER	10.0 EER 10.1 IEER	
		All other	Split System and Single Package	9.8 EER 9.9 IEER	9.8 EER 9.9 IEER	
	≥ 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	9.7 EER 9.8 IEER	9.7 EER 9.8 IEER	
		All other	Split System and Single Package	9.5 EER 9.6 IEER	9.5 EER 9.6 IEER	
Air conditioners, water cooled	< 65,000 Btu/h[b]	All	Split System and Single Package	12.1 EER 12.3 IEER	12.1 EER 12.3 IEER	AHRI 210/240
	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.5 EER 11.7 IEER	12.1 EER 12.3 IEER	AHRI 340/360
		All other	Split System and Single Package	11.3 EER 11.5 IEER	11.9 EER 12.1 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER 11.2 IEER	12.5 EER 12.7 IEER	
		All other	Split System and Single Package	10.8 EER 11.0 IEER	12.3 EER 12.5 IEER	
	≥ 240,000 Btu/h and < 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER 11.1 IEER	12.4 EER 12.6 IEER	
		All other	Split System and Single Package	10.8 EER 10.9 IEER	12.2 EER 12.4 IEER	
	≥ 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER 11.1 IEER	12.0 EER 12.4 IEER	
		All other	Split System and Single Package	10.8 EER 10.9 IEER	12.0 EER 12.2 IEER	

(continued)

TABLE C403.2.3(1)—continued
MINIMUM EFFICIENCY REQUIREMENTS:
ELECTRICALLY OPERATED UNITARY AIR CONDITIONERS AND CONDENSING UNITS

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUB-CATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY		TEST PROCEDURE[a]
				Before 6/1/2011	As of 6/1/2011	
Air conditioners, evaporatively cooled	< 65,000 Btu/h[b]	All	Split System and Single Package	12.1 EER 12.3 IEER	12.1 EER 12.3 IEER	AHRI 210/240
	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.5 EER 11.7 IEER	12.1 EER 12.3 IEER	AHRI 340/360
		All other	Split System and Single Package	11.3 EER 11.5 IEER	11.9 EER 12.1 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER 11.2 IEER	12.0 EER 12.2 IEER	
		All other	Split System and Single Package	10.8 EER 11.0 IEER	11.8 EER 12.0 IEER	
	≥ 240,000 Btu/h and < 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER 11.1 IEER	11.9 EER 12.1 IEER	
		All other	Split System and Single Package	10.8 EER 10.9 IEER	12.2 EER 11.9 IEER	
	≥ 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	10.0 EER 11.1 IEER	11.7 EER 11.9 IEER	
		All other	Split System and Single Package	10.8 EER 10.9 IEER	11.5 EER 11.7 IEER	
Condensing units, air cooled	≥ 135,000 Btu/h			10.1 EER 11.4 IEER	10.5 EER 14.0 IEER	AHRI 365
Condensing units, water cooled	≥ 135,000 Btu/h			13.1 EER 13.6 IEER	13.5 EER 14.0 IEER	
Condensing units, evaporatively cooled	≥ 135,000 Btu/h			13.1 EER 13.6 IEER	13.5 EER 14.0 IEER	

For SI: 1 British thermal unit per hour = 0.2931 W.

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

b. Single-phase, air-cooled air conditioners less than 65,000 Btu/h are regulated by NAECA. SEER values are those set by NAECA.

SEERee = Seasonal Energy Efficiency Ratio of the energy efficient equipment (actually installed).

EERbase = Energy Efficiency Ratio of the baseline equipment; see table above for default values. Since IECC 2006 does not provide EER requirements for air-cooled air conditioners < 65 kBtu/hr, assume the following conversion from SEER to EER: EER≈SEER/1.1

EERee = Energy Efficiency Ratio of the energy efficient equipment. For air-cooled air conditioners < 65 kBtu/hr, if the actual EERee is unknown, assume the following conversion from SEER to EER: EER≈SEER/1.1.

= Actual installed

EFLH = 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 in Rockford would save

ΔkWH = (60) * [(1/13) – (1/15)] * 816

= 502 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW_{SSP} = (kBtu/hr * (1/EERbase - 1/EERee)) * CF_{SSP}

ΔkW_{PJM} = (kBtu/hr * (1/EERbase - 1/EERee)) * CF_{PJM}

Where:

CF_{SSP} = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)

= 91.3% [334]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)

= 47.8% [335]

For example a 5 ton air cooled split system with a SEER of 15 in Rockford would save

ΔkW_{SSP} = (60) * [(1/13) – (1/15)] * .913

= 0.562

NATURAL GAS ENERGY SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

MEASURE CODE: CI-HVC-SPUA-V02-140601

[334] 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.

[335] 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 [336]

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[337]

[336] High Impact Measure

[337] 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.

DEEMED MEASURE COST

Steam System	Cost per trap[338] ($)
Commercial Dry Cleaners	77
Commercial Heating (including Multifamily), low pressure steam	77
Industrial Medium Pressure >15 psig psig < 30 psig	180
Steam Trap, Industrial Medium Pressure ≥30 <75 psig	223
Steam Trap, Industrial High Pressure ≥75 <125 psig	276
Steam Trap, Industrial High Pressure ≥125 <175 psig	322
Steam Trap, Industrial High Pressure ≥175 <250 psig	370
Steam Trap, Industrial High Pressure ≥250 psig	418
Steam Trap, Industrial Medium Pressure ≥30 <75 psig	223
Steam Trap, Industrial High Pressure ≥75 <125 psig	276
Steam Trap, Industrial High Pressure ≥125 <175 psig	322
Steam Trap, Industrial High Pressure ≥175 <250 psig	370
Steam Trap, Industrial High Pressure ≥250 psig	418

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ENERGY SAVINGS

$$\Delta therm = S * (Hv/B) * Hours * A * L / 100{,}000$$

Where:

[338] Ibid.

S = Maximum theoretical steam loss per trap

Steam System	Avg Steam Loss[339] (lb/hr/trap)
Commercial Dry Cleaners	38.1
Commercial Heating (including Multifamily)LPS	13.8
Industrial Low Pressure, <15 psig	13.8
Industrial Medium Pressure >15 psig < 30 psig	12.7
Steam Trap, Industrial Medium Pressure ≥30 <75 psig	19.0
Steam Trap, Industrial High Pressure ≥75 <125 psig	67.9
Steam Trap, Industrial High Pressure ≥125 <175 psig	105.8
Steam Trap, Industrial High Pressure ≥175 <250 psig	143.7
Steam Trap, Industrial High Pressure ≥250 psig	200.5

Hv = Heat of vaporization of steam

Steam System	Heat of Vaporization[340] (Btu/lb)
Commercial Dry Cleaners	890
Commercial Heating (including Multifamily) LPS	951
Industrial Low Pressure ≤15 psig	951
Industrial Medium Pressure >15 psig < 30 psig	945
Steam Trap, Industrial Medium Pressure ≥30 <75 psig	928
Steam Trap, Industrial High Pressure ≥75 <125 psig	894
Steam Trap, Industrial High Pressure ≥125 <175 psig	868
Steam Trap, Industrial High Pressure ≥175 <250 psig	846
Steam Trap, Industrial High Pressure ≥250 psig	820

[339] CLEAResult"Steam Traps Revision #1" dated August 2011.

[340] 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.

B = Boiler efficiency

= custom, if unknown 0.8[341]

Hours = Annual operating hours of steam plant

Steam System	Hours/Yr[342]	Zone
Commercial Dry Cleaners	2,425	
Industrial Low Pressure ≤15 psig	7,752	
Industrial Medium Pressure >15 psig < 30 psig	7,752	
Steam Trap, Industrial Medium Pressure ≥30 <75 psig	7,752	
Steam Trap, Industrial High Pressure ≥75 <125 psig	7,752	
Steam Trap, Industrial High Pressure ≥125 <175 psig	7,752	
Steam Trap, Industrial High Pressure ≥175 <250 psig	7,752	
Steam Trap, Industrial High Pressure ≥250 psig	7,752	
Industrial Medium Pressure >15 psig < 30 psig	7,752	
Steam Trap, Industrial Medium Pressure ≥30 <75 psig	7,752	
Commercial Heating (including Multifamily)LPS[343]	4,272	1 (Rockford)
	4,029	2 (Chicago O'Hare)
	3,406	3 (Springfield)
	2,515	4 (Belleville)
	2,546	5 (Marion)

A = Adjustment factor

= 50%[344]

This factor is to account for reducing the maximum theortical steam flow (S) to the average steam flow (the Enbridge factor).

L = Leaking & blow-thru

L is 1.0 when applied to the replacment of an individual leaking trap. If a number of

[341] California Energy Commission Efficiency Data for Steam Boilers as sited in CLEAResult"Steam Traps Revision #1" dated August 2011.
[342] CLEAResult"Steam Traps Revision #1" dated August 2011, which references Enbridge service territory data and kW Engineering study.
[343] Since commercial LPS reflect heating systems, Hours/yr are equivalent to HDD55 zone table
[344] 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.

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	%[345]
Custom	Custom
Commercial Dry Cleaners	27%
Industrial Low Pressure ≤15 psig	16%
Industrial Medium and High Pressure >15 psig	16%
Commercial Heating (including Multifamily) LPS	27%

EXAMPLE

For example, a commercial dry cleaning facility with the default hours of operation and boiler efficiency;

ΔTherms = S * (Hv/B) * Hours * A * L

= 38.1 lbs/hr/trap * (890 Btu/lb / 80%)/100,000 * 2,425 * 50% * 27% =

138.8 therms per trap

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-STRE-V03-140601

[345] Dry cleaners survey data as referenced in CLEAResult"Steam Traps Revision #1" dated August 2011.

4.4.17 Variable Speed Drives for HVAC

Description

This measure is applied to variable speed drives (VSD) which are installed on the following HVAC system applications: chilled water pump, hot water pumps, supply fans, return fans. All other VSD applications require custom analysis by the 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 2009 as adopted by the State of Illinois are not eligible for incentives.

Deemed Lifetime of Efficient Equipment

The expected measure life for HVAC application is 15 years;[346] measure life for process is 10 years.[347]

Deemed Measure Cost

Customer provided costs will be used when available. Default measure costs[348] are noted below for up to 20 hp motors. Custom costs must be gathered from the customer for motor sizes not listed below.

HP	Cost
1 -5 HP	$ 1,330
7.5 HP	$ 1,622
10 HP	$ 1,898

[346] Efficiency Vermont TRM 10/26/11 for HVAC VSD motors
[347] DEER 2008
[348] 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.

HP	Cost
15 HP	$ 2,518
20 HP	$ 3,059

LOADSHAPE

Loadshape C39 - VFD - Supply fans <10 HP
Loadshape C40 - VFD - Return fans <10 HP
Loadshape C41 - VFD - Exhaust fans <10 HP
Loadshape C42 - VFD - Boiler feedwater pumps <10 HP
Loadshape C43 - VFD - Chilled water pumps <10 HP
Loadshape C44 - VFD Boiler circulation pumps <10 HP
Loadshape C48 - VFD Boiler draft fans <10 HP
Loadshape C49 - VFD Cooling Tower Fans <10 HP

COINCIDENCE FACTOR

The demand savings factor (DSF) is already based upon coincident savings, and thus there is no additional coincidence factor for this characterization.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$\Delta kWh = kW_{connected} * Hours * ESF$

Where:

$kW_{Connected}$ = kW of equipment is calculated using motor efficiency.

(HP * .746 kw/hp* load factor)/motor efficiency

Motors are assumed to have a load factor of 80% for calculating KW if actual values cannot be determined[349]. Custom load factor may be applied if known. Actual motor efficiency shall be used to calculate KW. If not known a default value of 93% shall be used.[350]

HP	BHP	Load Factor	kW Connected[351]
5 HP	5	80%	3.23

[349] Com Ed TRM June 1, 2010
[350] Ohio TRM 8/6/2010 pp207-209, Com Ed Trm June 1, 2010.
[351] Field data from Illinois evaluations, Navigant, 2011.

HP	BHP	Load Factor	kW Connected[351]
7.5 HP	7.5	80%	4.84
10 HP	10	80%	6.45
15 HP	15	80%	9.68
20 HP	20	80%	12.90

Hours = Default hours are provided for HVAC applications which vary by HVAC application and building type[352]. When available, actual hours should be used.

Building Type		Pumps and fans
College/University		4216
Grocery		5840
Heavy Industry		3585
Hotel/Motel		6872
Light Industry		2465
Medical		6871
Office		1766
Restaurant		4654
Retail/Service		3438
School(K-12)		2203
Warehouse		3222
Average=Miscellaneous		4103

ESF = Energy savings factor varies by VFD application.

[352] Com Ed Trm June 1, 2010 page 139.

Application	ESF[353]
Hot Water Pump	0.482
Chilled Water Pump	0.432
Constant Volume Fan	0.535
Air Foil/inlet Guide Vanes	0.227
Forward Curved Fan, with discharge dampers	0.179
Forward Curved Inlet Guide Vanes	0.092

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$\Delta kW = kW_{connected} * DSF$

Where:

DSF = Demand Savings Factor varies by VFD application.[354] Values listed below are based on typical peak load for the listed application. When possible the actual Demand Savings Factor should be calculated.

Application	DSF
Hot Water Pump	0
Chilled Water Pump	0.299
Constant Volume Fan	0.348
Air Foil/inlet Guide Vanes	0.13
Forward Curved Fan, with discharge dampers	0.136
Forward Curved Inlet Guide Vanes	0.03
Custom Process	custom

[353] CL&P and UI Program Savings Documentation for 2008 Program Year. http://www.ctsavesenergy.com/files/Final%202008%20Program%20Savings%20Document.pdf.
[354] 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-VSDH-V01-120601

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[355] based upon equipment life only[356]. 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 cost for this measure is assumed to be $181[357], as summarized in the table below.

LOADSHAPE

N/A

[355] Table 1, HVAC Controls, Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007

[356] 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.

[357] 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

ΔkWh[358] = (ΔTherms * F_e * 29.3)

Where:

ΔTherms = Therm savings if Natural Gas heating system

= See calculation in Natural Gas section below

F_e = Furnace Fan energy consumption as a percentage of annual fuel consumption

= 3.14%[359]

29.3 = kWh per therm

100,000 =conversion from Btu to therms

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

ΔTherms = (EFLH * Capacity * Degree of Setback * Savings Factor) / 100000

Where:

EFLH = Equivalent Full Load Hours for heating are provided as a reference in section 4.4 HVAC End Use

Capacity = Nominal Input Heating Capacity Furnace Size (Btu/hr.)

= Actual

[358] Relates to furnace fan savings

[359] . 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.

Degree of Setback = The degrees in Farenheit the temperature is setback from the space temperature setpoint (°F). Baseline manual setback should be determined and only the incremental setback due to the programmable thermostat be applied.

= Actual

Savings Factor = The percent heating savings per incremental °F setback.

= Dependent on location and building type[360]:

Savings Factor (Percent Saved/°F)					
Building Type	**Zone 1 (Rockford)**	**Zone 2 (Chicago)**	**Zone 3 (Springfield)**	**Zone 4 (Belleville)**	**Zone 5 (Marion)**
College/University	1.45%	1.47%	1.48%	1.72%	1.50%
Convenience	0.93%	0.86%	0.84%	1.00%	0.97%
Elementary	2.03%	2.10%	2.10%	2.23%	2.00%
Healthcare Clinic	1.50%	1.56%	1.54%	1.70%	1.35%
High School	2.13%	2.18%	2.20%	2.41%	2.14%
Lodging - Guest Room	1.34%	1.31%	1.24%	1.20%	1.56%
Lodging - Common Area	1.11%	1.04%	1.02%	1.21%	1.20%
Manufacturing Facility - 1 Shift	2.62%	2.67%	2.71%	2.79%	2.56%
Manufacturing Facility - 2 Shift	1.57%	1.53%	1.53%	1.71%	1.52%
Manufacturing Facility - 3 Shift	0.37%	0.35%	0.35%	0.41%	0.37%
Multifamily Common Area	1.80%	1.71%	1.76%	2.10%	1.80%
Office - Low Rise	1.99%	1.98%	2.00%	2.21%	1.89%
Office - Mid Rise	1.99%	1.98%	2.00%	2.21%	1.89%
Religious Facility	2.01%	2.03%	2.07%	2.34%	2.11%
Restaurant - 1 Meal	1.92%	1.93%	2.01%	2.28%	2.15%
Restaurant - 2 Meal	1.52%	1.45%	1.51%	1.88%	1.80%
Restaurant - 3 Meal	0.99%	0.96%	0.94%	1.14%	1.02%
Retail Department Store	1.74%	1.70%	1.75%	2.09%	1.78%
Retail Strip Mall	1.74%	1.70%	1.75%	2.09%	1.78%
Warehouse	0.95%	0.88%	0.86%	1.01%	0.98%

[360] Savings factors were developed by RSG and used TMY3 weather data and ASHRAE 62.1 design standards to estimate the heating loads through 8760 hours. The model was run with no setback and setback temperatures of 1°F, 3°F, 5°F, 7°F, and 10°F. The percent savings as a function of setback temperature was found in the slope of the line using degrees of setback at the independent variables and the percent savings as the dependent variables. See workpaper entitled "New Measure_Nicor_CLEAResult_CI_PRGTSTAT_01-23-14.docx" for further details on the methodology and assumptions used. It is strongly recommended that future evaluation efforts are conducted to assess how reasonable these estimates are in predicting actual savings from installation of these measures.

For example, a programmable thermostat with 5°F of setback installed in Rockford on a 75,000 btu/hr furnace at a low rise office and installed by a contractor

$$\Delta\text{Therms} = 797 * 75{,}000 * 5 * 1.99\% / 100{,}000 \text{ Btu/Therm}$$
$$= 59 \text{ therms}$$

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-PROG-V01-140601

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_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_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 CO2 sensor estimated life. [361]

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[362].

Loadshape

Commercial ventilation C23

Coincidence Factor

[361] 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.

[362] Discussion with vendors

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS

ΔkWh = Condition Space/1000 * 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[363]

Building Type	Elect_Savings Factor (kWh/1000 sq ft)				
	Zone 1 (Rockford)	Zone 2 (Chicago)	Zone 3 (Springfield)	Zone 4 (Belleville)	Zone 5 (Marion)
Office - Low-rise	518	520	539	541	516
Office - Mid-rise	472	473	485	484	469
Office- High-rise	505	507	524	525	503
Religious Building	1039	1036	1235	1335	1036
Restaurant	773	791	899	949	791
Retail - Department Store	639	655	663	662	656
Retail - Strip Mall	252	246	188	435	435
Convenience Store	650	652	672	680	652
Elementary School	592	582	672	718	588
High School	579	570	660	706	576
College/University	604	639	725	736	648
Healthcare Clinic	521	521	586	618	521
Lodging	640	641	667	678	641
Manufacturing	525	524	535	535	519
Special Assembly Auditorium	759	780	928	987	784
De-fault	605	609	665	706	622

[363] 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 62.1[363] and 90.1[363], 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 office space in Chicago.

ΔkWh= 7,500 SqFt /1000 SqFt *520 kWh
= 3,900 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

TBD[364]

NATURAL GAS SAVINGS

Δtherms = Condition Space/1000 * Therm_Savings_Factor

Where:

Conditioned Space = actual square footage of conditioned space controlled by sensor

Therm _Savings_Factor= value in table below based on building type and weather zone[365]

Building Type	Therm_Savings Factor (kWh/1000 sq ft)				
	Zone 1 (Rockford)	Zone 2 (Chicago)	Zone 3 (Springfield)	Zone 4 (Belleville)	Zone 5 (Marion)
Office - Low-rise	30	26	14	22	55
Office - Mid-rise	20	17	10	15	37
Office- High-rise	27	23	13	20	49
Religious Building	191	169	147	143	354
Restaurant	135	122	74	104	251
Retail - Department Store	47	42	30	36	84
Retail - Strip Mall	31	27	25	24	57
Convenience Store	23	21	13	17	42
Elementary School	83	73	56	60	155
High School	81	71	54	59	152
College/University	161	141	72	120	292
Healthcare Clinic	57	50	43	42	106
Lodging	26	23	17	20	49
Manufacturing	21	19	12	15	40

[364] Need to discuss peak savings with tool developer before draft is finalized
[365] 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[365] and 90.1[365], 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 (kWh/1000 sq ft)				
	Zone 1 (Rockford)	Zone 2 (Chicago)	Zone 3 (Springfield)	Zone 4 (Belleville)	Zone 5 (Marion)
Special Assembly Auditorium	225	198	187	175	399
De-fault	77	68	51	58	141

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-DCV-V01-14060

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.[366] 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%[367] of the full fire input MBH for greater than 60%[368] of the operating hours.

Definition of Baseline Equipment

The baseline boiler utilizes a linkageless burner with a turndown ration 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.[369]

Deemed Measure Cost

The deemed installed measure cost including labor is approximately $2.53/MBtu/hr.[370]

Deemed O&M Cost Adjustments

N/A

Loadshape

N/A

[366] The standard turndown ratio for boilers is 6:1. Understanding Fuel Savings in the Boiler Room, ASHRAE Journal, David Eoff, December, 2008 p 38
[367] Focus on Energy Evaluation, Business Programs: Deemed Savings Manual V1.0, March 22, 2010. This factor implies that boilers are 30% oversized on average.
[368] FES Analysis of bin hours based upon a 30% oversizing factor.
[369] "Burner," Obtained from a nation-wide survey conducted by ASHRAE TC 1.8 (Akalin 1978). Data changed by TC 1.8 in 1986.
[370] FES review of PY2/PY3 costs for custom People's and North Shore high turndown burner projects. See High Turndown Costs.xlsx for details.

Coincidence Factor

N/A

Algorithm

Calculation of Savings

Electric Energy Savings

N/A

Summer Coincident Peak Demand Savings

N/A

Natural Gas Savings

Δtherms= Ngi * SF * EFLH / 100

Where:

Ngi = Boiler gas input size (kBtu/hr) = custom

SF = Savings Factor = Percentage of energy loss per hour

= (∑ ((EL_base – EL_eff) * H_cycling)) / H)*100

Where:

EL_base = Base Boiler Percentage of energy loss due to cycling at % of Base Boiler Load where BL_base ≤ TDR_base

= 0.003 * $(Cycles\_base)^2$ – 0.001 * Cycles_base [371]

Where:

Cycles_base = Number of Cycles/hour of base boiler

= 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.

[371] Release 3.0 Operations & Maintenance Best Practices A Guide to Achieving Operational Efficiency, August 2010, Federal Energy Management Program, US Department of Energy. The equation was determined by plotting the values in Table 9.2.1 – Boiler Cycling Energy Loss.

OSF = Oversizing Factor = 1.3[372] or custom

TDR_base = Turndown ratio = 0.33[373] or custom

EL_eff = Efficient Boiler Percentage of energy loss due to cycling at % of Efficient Boiler Load

$= 0.003 * (Cycles\_eff)^2 – 0.001 * Cycles\_eff$

Where:

Cycles_eff = Number of Cycles/hour

= TDR_eff / BL

Where:

TDR_eff = Turndown ratio = 0.10[374] or custom

H_cycling = Hours base boiler is cycling at % of base boiler load

= see table below or custom

H = Total Number of Hours in Heating Season

= 4,946 or custom

100 = convert to a percentage

SF = 69.1 / 4946 *100 = 1.4% or custom (see table below for summary of values)

Temperature	H_cycling	BL	EL_base	EL_eff	(EL_base-EL_eff)* Hours
50 to 55	601	6.0%	8.5%	0.7%	47.2
45 to 50	603	12.0%	2.0%	0.0%	12.0
40 to 45	455	18.0%	0.8%	0.0%	3.8
35 to 40	925	24.0%	0.4%	0.0%	4.0
30 to 35	814	30.0%	0.3%	0.0%	2.1
Total					69.1

EFLH = Equivalent Full Load Hours for heating are provided in section 4.4 HVAC End Use.

100 = convert kBtu to therms

372 PA Consulting, KEMA, Focus on Energy Evaluation, Business Programs: Deemed Savings Manual V1.0, March 22, 2010, Page 4-12.

373 Ibid.

374 10:1 ratio used to qualify for efficient equipment.

Water Impact Descriptions and Calculation

N/A

Deemed O&M Cost Adjustment Calculation

N/A

Measure Code: CI-HVAC-HTBC-V04-140601

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.[375]

DEEMED MEASURE COST

The deemed measure cost is estimated at $2.50/MBtu/hr burner input.[376]

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

N/A

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[375] Total number of hours for heating with a base temperature of 55°F for Chicago, IL as noted by National Climate Data Center

[377] 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

Coincidence Factor

N/A

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

Δtherms= Ngi * SF * EFLH / 100

Where:

Ngi = Boiler gas input size (kBtu/hr) = custom

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.[377] 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.[378] Therefore the nominal combustion efficiency increase is 57 / 15 * 1% = 3.8%.

= 3.8%

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

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[377] 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

[378] 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.

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-LBC-V04-140601

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.[379]

Deemed Measure Cost

The deemed measure cost is approximately $23,250.[380]

Loadshape

N/A

Coincidence Factor

N/A

[379] State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study Final Report: August 25, 2009, Table 1-2. Recommended Measure Life by WISeerts Group Description, pg. 1-4.

[380] 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

ΔTherms = Ngi * SF * EFLH / 100

Where:

Ngi = Boiler gas input size (kBtu/hr)

= Custom

SF = Savings factor

Note: Savings factor is the percentage reduction in gas consumption as a result of the addition of O2 trim controls. Linkageless controls have an excess air rate of 28% over the entire firing range.[381] O2 trim controls have an excess air rate of 15%.[382] The average difference is 13%. A 15% reduction in excess air is approximately a 1% increase in efficiency.[383] Therefore the nominal combustion efficiency increase is 13 / 15 * 1% = 0.87%.

= 0.87%

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

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

[381] Department of Energy (DOE). 2009. Energy Matters newsletter. Fall 2009- Vol. 1, Iss. 1. Washington, DC: U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Industrial Technologies Program.

[382] Ibid.

[384] 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.

Deemed O&M Cost Adjustment Calculation

The deemed annual Operations and Maintenance cost is $800.[384]

Measure Code: CI-HVC-O2TC-V01-140601

[384] 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.[385]

Deemed Measure Cost

The deemed measure cost for this approximately $1,500.[386]

Loadshape

N/A

Coincidence Factor

N/A

[385] State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study Final Report: August 25, 2009, Table 1-2. Recommended Measure Life by WISeerts Group Description, pg. 1-4.
[386] 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

Δtherms = Ngi * SF * EFLH / 100

Where:

Ngi = Boiler gas input size (kBtu/hr)

= Custom

SF = Savings factor

= 1%[387]

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.

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

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

The deemed annual Operations and Maintenance cost is $112.[388]

[387] Based on internet review of savings potential;
"Up to 4%": Use of Automatic Vent Dampers for New and Existing Boilers and Furnaces, Energy Innovators Initiative Technical Fact Sheet, Office of Energy Efficiency, Canada, 2002
"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", http://www.seai.ie/Your_Business/Technology/Buildings/Steam_Systems_Technical_Guide.pdf.
[388] CODES AND STANDARDS ENHANCEMENT INITIATIVE (CASE) PROCESS BOILERS, 2013 California Building Energy

MEASURE CODE: CI-HVC-SODP-V01-140601

Efficiency Standards, California Utilities Statewide Codes and Standards Team, October 2011, pg. 22

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.

Building Type	Fixture Annual Operating Hours[389]	Screw based bulb Annual Operating hours[390]	Waste Heat Cooling Energy WHFe[391]	Waste Heat Cooling Demand WHFd[392]	Coincidence Factor CF[393]	Waste Heat Gas Heating IFTherms[394]	Waste Heat Electric Resistance Heating IFkWh[395]	Waste Heat Electric Heat Pump Heating IFkWh
Office	4,439	3,088	1.25	1.30	0.66	0.016	0.366	0.183
Grocery	5,802	3,650	1.43	1.52	0.69	0.012	0.274	0.137
Healthcare Clinic	5,095	4,207	1.34	1.57	0.75	0.008	0.183	0.091
Hospital	6,038	4,207	1.35	1.69	0.75	0.011	0.251	0.126
Heavy Industry	5,041	2,629	1.03	1.06	0.89	0.008	0.183	0.091
Light Industry	5,360	2,629	1.03	1.06	0.92	0.008	0.183	0.091

389 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.

390 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.

391 The Waste Heat Factor for Energy is developed using EQuest models for various building types averaged across 5 climate zones for Illinois for the following building types: office, grocery, healthcare/clinic, manufacturing, motel, high school, hospital, elementary school, restaurant, retail, college and warehouse. Exterior and garage values are 1, miscellaneous is an average of all indoor spaces.

392 Waste Heat Factor for Demand is developed using EQuest models consistent with methodology for Waste Heat Factor for Energy.

393 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.

394 IF Therms value is developed using EQuest models consistent with methodology for Waste Heat Factor for Energy.

395 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%:
IFElectricHeat = IFTherms * 29.3 kWh/therm * 78% (Gas Heating Equipment Efficiency) / 100% (Electric Resistance Efficiency)

Building Type	Fixture Annual Operating Hours[389]	Screw based bulb Annual Operating hours[390]	Waste Heat Cooling Energy WHFe[391]	Waste Heat Cooling Demand WHFd[392]	Coincidence Factor CF[393]	Waste Heat Gas Heating IFTherms[394]	Waste Heat Electric Resistance Heating IFkWh[395]	Waste Heat Electric Heat Pump Heating IFkWh
Hotel/Motel Common Areas	5,311	4,542	1.15	1.51	0.21	0.022	0.503	0.251
Hotel/Motel Guest Rooms	777	777	1.15	1.51	0.21	0.022	0.503	0.251
High School/Middle School	4,311	2,327	1.23	0.74	0.22	0.017	0.389	0.194
Elementary School	2,422	2,118	1.21	1.33	0.22	0.019	0.434	0.217
Restaurant	3,673	4,784	1.34	1.65	0.80	0.023	0.526	0.263
Retail/Service	4,719	2,935	1.24	1.44	0.83	0.024	0.549	0.274
College/University	3,540	2,588	1.14	1.50	0.56	0.021	0.480	0.240
Warehouse	4,746	4,293	1.16	1.17	0.7	0.015	0.343	0.171
Garage	3,540	3,540	1.00	1.00	1.00	0.000	0.000	0.000
Garage, 24/7 lighting[396]	8,766	8,766	1.00	1.00	1.00	0.000	0.000	0.000
Exterior	4,903	4,903	1.00	1.00	0.00	0.000	0.000	0.000
Multi-family Common Areas	5,950	5,950	1.34	1.57	0.75	0.015	0.343	0.171
Religious Worship/Church [397]	1,664	1,664	1.24	1.46	0.66	0.014	0.320	0.160
Low-Use Small Business [398]	2,954	2,954	1.24	1.46	0.66	0.014	0.320	0.160

[396] As above except Heat Pump efficiency is assumed to be 200%.
[397] Religious worship/church hours are based on DOE 2003 Commercial Building Energy Survey (CBECS) assumption of 32 hours 52 weeks a year. Coincident factor is estimated based on assumption that system peak times (1-5pm M-F) are not likely to be heavy usage periods for religious buildings. Other assumptions are consistent with iscellaneous assumptions.
[398] Low-use small business hours are based on ComEd EPY4 Small Business Energy Savings Evaluation. Other assumptions are consistent with Miscellaneous assumptions.

Building Type	Fixture Annual Operating Hours[389]	Screw based bulb Annual Operating hours[390]	Waste Heat Cooling Energy WHFe[391]	Waste Heat Cooling Demand WHFd[392]	Coincidence Factor CF[393]	Waste Heat Gas Heating IFTherms[394]	Waste Heat Electric Resistance Heating IFkWh[395]	Waste Heat Electric Heat Pump Heating IFkWh
Miscellaneous[399]	4,576	3,198	1.24	1.46	0.66	0.014	0.320	0.160
Uncooled Building	Varies	varies	1.00	1.00	varies	varies	varies	varies
Refrigerated Cases	5,802	n/a	1.29	1.29	0.69	0	0.000	0.000
Freezer Cases	5,802	n/a	1.5	1.5	0.69	0	0.000	0.000

[399] Miscellaneous hours are based on an average of all other space types. Values for EIF, DIF and IFtherms are an average of the other values excluding garage, uncooled building and exterior. Coincident Diversity Factor is from DEER 2008

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 97% Residential and 3% Commercial assumptions should be used[400], and for Commercial targeted programs a deemed split of 17% Residential and 83% Commercial should be used[401].

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[402]) 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.

[400] RES v C&I split is based on a weighted (by sales volume) average of ComEd PY3, PY4 and PY5 and Ameren PY5 in store intercept survey results.
[401] Based upon weighted (by sales volume) average of the BILD program (ComEd's commercial lighting program) for PY 4 and PY5.
[402] 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.

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[403].

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

ΔkWh =((WattsBase-WattsEE)/1000) * ISR * Hours * WHFe

Where:

WattsBase = Actual (if retrofit measure) or based on lumens of CFL bulb and program year installed:

[403] Based upon pricing forecast developed by Applied Proactive Technologies Inc (APT) based on industry input and provided to 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%[404] if application form completed with sign off that equipment is not placed into storage

If sign off form not completed assume the following 3 year ISR assumptions:

Weigted Average 1st year In Service Rate (ISR)	2nd year Installations	3rd year Installations	Final Lifetime In Service Rate
75.5%[405]	12.1%	10.3%	98.0%[406]

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[407]. If unknown use the Miscellaneous value.

[404] 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.
[405] 1st 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.
[406]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.
[407] Based on ComEd analysis taking DEER 2008 values and averaging with PY1 and PY2 evaluation results.

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.

> For example, a 14W standard CFL is installed in an office in 2014 and sign off form provided:
>
> ΔkWh = (((43 - 14)/1000)* 1.0 * 3088 * 1.25
>
> = 111.9 kWh

HEATING PENALTY

If electrically heated building:

$$\Delta kWh_{heatpenalty}{}^{408} = (((WattsBase-WattsEE)/1000) * ISR * Hours * -IFkWh$$

Where:

IFkWh = 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:
>
> $\Delta kWh_{heatpenalty}$ = (((43 - 14)/1000)* 1.0*3088*-0.183
>
> = - 16.4 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.

[408] 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 kWh

$\Delta kWH_{2nd\ year\ installs}$ = ((43 - 14) / 1000) * 0.121 * 3198 * 1.06

= 11.9 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 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ((WattsBase-WattsEE)/1000) * ISR * WHFd * 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 unknown, use the Miscellaneous value..

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, a 14W standard CFLis installed in an office in 2014 and sign off form provided:

ΔkW = ((43 - 14)/1000)*1.0*1.3*0.66

= 0.025kW

NATURAL GAS ENERGY SAVINGS

Heating Penalty if fossil fuel heated building (or if heating fuel is unknown):

ΔTherms[409] = (((WattsBase-WattsEE)/1000) * ISR * Hours *- IFTherms

Where:

[409] Negative value because this is an increase in heating consumption due to the efficient lighting.

IFTherms = Lighting-HVAC Interation Factor for gas heating impacts; this factor represents the increased gas space heating requirements due to the reduction of waste heat rejected by the efficent lighting. Values are 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:

ΔTherms = (((43 - 14)/1000)* 1.0*3088*-0.016

= - 1.4 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[410].

	Std Inc.	EISA Compliant Halogen
2014	$0.34	$1.25
2015	$0.34	$0.90
2016	$0.34	$0.80
2017	$0.34	$0.70
2018	$0.34	$0.60
2019	$0.34	$0.60
2020 & after	$0.34	N/A

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:

[410] Based upon pricing forecast developed by Applied Proactive Technologies Inc (APT) based on industry input and provided to Ameren.

Location	Lumen Level	NPV of replacement costs for period			Levelized annual replacement cost savings		
		June 2014 - May 2015	June 2015 - May 2016	June 2016 - May 2017	June 2014 - May 2015	June 2015 - May 2016	June 2016 - May 2017
Commercial	Lumens <310 or >2600 (EISA exempt)	$2.83	$2.83	$2.83	$1.40	$1.40	$1.40
	Lumens ≥ 310 and ≤ 2600 (EISA compliant)	$8.60	$6.91	$6.08	$4.26	$3.43	$3.02

For halogen bulbs, we assume the same replacement cycle as incandescent bulbs.[411] 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-V03-140601

[411] 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[412].

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:

[412] Based on ComEd’s estimate of lamp type saturation.

Measure Category	Value	Source
8-Foot Lamp Removal	$16.00	ComEd/KEMA regression[413]
4-Foot Lamp Removal	$12.00	ICF Portfolio Plan
8-Foot Lamp Removal with reflector	$30.00	KEMA Assumption
4-Foot Lamp Removal with reflector	$25.00	KEMA Assumption
2-Foot or 3-Foot Removal	$12.35	KEMA Assumption
2-Foot or 3-Foot Removal with reflector	$25.70	KEMA Assumption

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.

[413] 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”

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

ΔkWh =((WattsBase-WattsEE)/1000) * ISR * Hours * WHFe

Where:

WattsBase = Assume wattage reduction of lamp removed

	Wattage of lamp removed[414]		Weighted average
	T8	T12	80% T12, 20% T8
8-ft T8	38.6	60.3	56.0
4-ft T8	19.4	33.7	30.8
3-ft T8	14.6	40.0	34.9
2-ft T8	9.8	28.0	24.4

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.

[414] Default wattage reducetion 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-9607-10A016D32D4B/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.

For example, delamping a 4 ft T8 fixture in an office building:

ΔkWh =((19.4 - 0)/1000) * 1.0 * 4439 * 1.25

= 107.6 kWh

HEATING PENALTY

If electrically heated building:

$\Delta kWh_{heatpenalty}$[415] = (((WattsBase-WattsEE)/1000) * ISR * Hours * -IFkWh

Where:

IFkWh = 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, delamping a 4 ft T8 fixture in a heat pump heated office building:

$\Delta kWh_{heatpenalty}$ =((19.4 - 0)/1000) * 1.0 * 4439 * -0.151

=-13.0 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW= ((WattsBase-WattsEE)/1000) * ISR * WHFd * 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 unknown, use the Miscellaneous value..

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

[415] 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:

ΔkWh =((19.4 - 0)/1000) * 1.0 * 1.3 * 0.66

= 0.017 kW

NATURAL GAS ENERGY SAVINGS

Heating Penalty if fossil fuel heated building (or if heating fuel is unknown):

ΔTherms[416] = (((WattsBase-WattsEE)/1000) * ISR * Hours *- IFTherms

Where:

IFTherms = Lighting-HVAC Interation Factor for gas heating impacts; this factor represents the increased gas space heating requirements due to the reduction of waste heat rejected by the efficent lighting. Values are 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:

ΔTherms =((19.4 - 0)/1000) * 1.0 * 4439 * -0.016

=-1.4 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-LTG-DLMP-V02-140601

[416] Negative value because this is an increase in heating consumption due to the efficient lighting.

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 98% Commercial and 2% Residential should be used[417].

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

The measure applies to all commercial HPT8 installations excluding new construction and major renovation or change of use measures (see lighting power density measure). Lookup tables have been provided to account for the different types of installations. Whenever possible, actual costs and hours of use should be utilized for savings calculations. Default new and baseline assumptions have been provided in the reference tables. Default component costs and lifetimes have been provided for Operating and Maintenance Calculations. Please see the Definition Table to determine applicability for each program. HPT8 configurations not included in the TRM may be included in custom program design using the provided algorithms as long as energy savings is achieved. The following table defines the applicability for different programs

Time of Sale (TOS)	Retrofit (RF)
This measure relates to the installation of new equipment with efficiency that exceeds that of equipment that would have been installed following standard market practices. In general, the measure will include qualifying high efficiency low ballast factor ballasts paired with high efficiency long life lamps as detailed in the attached tables. High-bay applications use this system paired with qualifying high ballast factor ballasts and high performance 32 w lamps. Custom lighting designs can use qualifying low, normal or high ballast factor ballasts and qualifying lamps in lumen equivalent applications where total system wattage is reduced when calculated using the Calculation of Savings Algorithms.	This measure relates to the replacement of existing equipment with new equipment with efficiency that exceeds that of the existing equipment. In general, the retrofit will include qualifying high efficiency low ballast factor ballasts paired with high efficiency long life lamps as detailed in the attached tables. Custom lighting designs can use qualifying low, normal or high ballast factor ballasts and qualifying lamps in lumen equivalent applications where total system wattage is reduced when calculated using the Calculation of Savings Algorithms. 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

[417] Based on ComEd's BILD program data from PY5. 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)	Retrofit (RF)
	ballast factor ballasts, but qualifying low and normal ballast factor ballasts may be used when appropriate light levels are provided and overall wattage is reduced.

DEFINITION OF EFFICIENT EQUIPMENT

The definition of efficient equipment varies based on the program and is defined below:

Time of Sale (TOS)	Retrofit (RF)
In order for this characterization to apply, new lamps and ballasts must be listed on the CEE website on the qualifying High Performance T8 lamps and ballasts list (http://www.cee1.org/com/com-lt/com-lt-main.php3)..	In order for this characterization to apply, new lamps and ballasts must be listed on the CEE website on the qualifying High Performance T8 lamps and ballasts list (http://www.cee1.org/com/com-lt/com-lt-main.php3).
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 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 must have fixture efficiencies of 85% or greater.	High bay fixtures will 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. (http://library.cee1.org/content/commercial-lighting-qualifying-products-lists). 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.	RWT8: in order for this characterization to apply, new 4' and U-tube lamps must be listed on the CEE website on the qualifying Reduced Wattage High Performance T8 lamps list. (http://library.cee1.org/content/commercial-lighting-qualifying-products-lists). 2', 3' and 8' lamps must meet the wattage requirements specified in the RWT8 new and baseline assumptions table.

DEFINITION OF BASELINE EQUIPMENT

The definition of baseline equipment varies based on the program and is defined below:

Time of Sale (TOS)	Retrofit (RF)
The baseline is standard efficiency T8 systems that would have been installed. The baseline for high-bay fixtures is pulse start metal halide fixtures, the baseline for a 2 lamp high efficiency troffer is a 3 lamp standard efficency troffer.	The baseline is the existing system. Due to new federal standards for linear fluorescent lamps, manufacturers of T12 lamps will not be permitted to manufacture most varieties of T12 lamps for sale in the United States after July 2012. All remaining stock and previously manufactured product may be sold after the July 2012 effective date. If a customer relamps an existing T12 fixture the day the standard takes effect, an assumption can be made that they would likely need to upgrade to, at a minimum, 800-series T8s in less than 5 years' time. This assumes the T12s installed have a typical rated life of 20,000 hours and are operated for 4500 hours annually (average miscellaneous hours 4576/year). Certainly, it is not realistic that everyone would wait until the final moment to relamp with T12s. Also, the exempted T12 lamps greater than 87 CRI will continue to be available to purchase, although they will be expensive. Therefore the more likely scenario would be a gradual shift to T8s over the 4 year timeframe. In other words, we can expect that for each year between 2012 and 2016, ~20% of the existing T12 lighting will change over to T8 lamps that comply with the federal standard. To simplify this assumption, we recommend assuming that standard T8s become the baseline for all T12 linear fluorescent retrofit January 1, 2016. There will be a baseline shift applied to all measures installed before 2016. See table C-1.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The deemed lifetime of efficient equipment varies based on the program and is defined below:

Time of Sale (TOS)	Retrofit (RF)
Fixture lifetime is 15 years[418]. Fixture retrofits which utilize RWT8 lamps have a lifetime equivalent to the life of the lamp, capped at 15 years. There is no guarantee that a reduced wattage lamp will be installed at time of burnout, but if one is, savings will be captured in the RWT8 measure below. 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.[419]	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.

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

[418] 15 years from GDS Measure Life Report, June 2007
[419] ibid

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$\Delta kWh = ((Watts_{base} - Watts_{EE})/1000) * Hours * WHF_e * ISR$

Where:

$Watts_{base}$ = Input wattage of the existing system which depends on the baseline fixture configuration (number and type of lamp) and number of fixtures. Value can be selected from the appropriate reference table as shown below, of a custom value can be entered if the configurations in the tables is not representative of the exisitng system.

Program	Reference Table
Time of Sale	A-1: HPT8 New and Baseline Assumptions
Retrofit	A-2: HPT8 New and Baseline Assumptions
Reduced Wattage T8, time of sale or retrofit	A-3: RWT8 New and Baseline Assumptions

$Watts_{EE}$ = New Input wattage of EE fixture which depends on new fixture configuration (number of lamps) and ballast factor and number of fixtures. Value can be selected from the appropriate reference table as shown below, of a custom value can be entered if the configurations in the tables is not representative of the exisitng system.

Program	Reference Table
Time of Sale	A-1: HPT8 New and Baseline Assumptions
Retrofit	A-2: HPT8 New and Baseline Assumptions
Reduced Wattage T8, time of sale or retrofit	A-3: RWT8 New and Baseline Assumptions

Hours = Average hours of use per year as provided by the customer or selected from the Reference Table in Section 4.5, Fixture annual operating hours. If hours or building type are unknown, use the Miscellaneous value.

WHF_e = Waste heat factor for energy to account for cooling energy savings from efficient lighting is selected from the Reference Table in Section 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%[420] if application form completed with sign off that equipment is not placed into storage

If sign off form not completed assume the following 3 year ISR assumptions:

Weigted Average 1st year In Service Rate (ISR)	2nd year Installations	3rd year Installations	Final Lifetime In Service Rate
96%[421]	1.1%	0.9%	98.0%[422]

HEATING PENALTY

If electrically heated building:

$$\Delta kWh_{heatpenalty}{}^{423} = (((WattsBase-WattsEE)/1000) * ISR * Hours * -IFkWh$$

Where:

IFkWh = 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.

SUMMER COINCIDENT DEMAND SAVINGS

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

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 WHFd is 1.

[420] 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.
[421] 1st 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
[422] 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.
[423] 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 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

ΔTherms[424] = (((WattsBase-WattsEE)/1000) * ISR * Hours *- IFTherms

Where:

IFTherms = Lighting-HVAC Integration Factor for gas heating impacts; this factor represents the increased gas space heating requirements due to the reduction of waste heat rejected by the efficient lighting. Please select from the Reference Table in Section 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

Program	Reference Table
Time of Sale	B-1: HPT8 Component Costs and Lifetime
Retrofit	B-2: HPT8 Component Costs and Lifetime
Reduced Wattage T8, time of sale or retrofit	B-3: HPT8 Component Costs and Lifetime

REFERENCE TABLES

See following page

[424] Negative value because this is an increase in heating consumption due to the efficient lighting.

A-1: Time of Sale: HPT8 New and Baseline Assumptions[425]

EE Measure Description	$Watts_{EE}$	Baseline Description	$Watts_{BASE}$	Measure Cost	$Watts_{SAVE}$
4-Lamp HPT8 w/ High-BF Ballast High-Bay	146	200 Watt Pulse Start Metal-Halide	232	$75	86
6-Lamp HPT8 w/ High-BF Ballast High-Bay	221	320 Watt Pulse Start Metal-Halide	350	$75	129
8-Lamp HPT8 w/ High-BF Ballast High-Bay	280	Proportionally Adjusted according to 6-Lamp HPT8 Equivalent to 320 PSMH	455	$75	175
1-Lamp HPT8-high performance 32 w lamp	25	1-Lamp Standard F32T8 w/ Elec. Ballast	32	$15	7
1-Lamp HPT8-high performance 28 w lamp	22	1-Lamp Standard F32T8 w/ Elec. Ballast	32	$15	10
1-Lamp HPT8-high performance 25 w lamp	19	1-Lamp Standard F32T8 w/ Elec. Ballast	32	$15	13
2-Lamp HPT8 -high performance 32 w lamp	49	2-Lamp Standard F32T8 w/ Elec. Ballast	59	$18	10
2-Lamp HPT8-high performance 28 w lamp	43	2-Lamp Standard F32T8 w/ Elec. Ballast	59	$18	16
2-Lamp HPT8-high performance 25 w lamp	35	2-Lamp Standard F32T8 w/ Elec. Ballast	59	$18	24
3-Lamp HPT8-high performance 32 w lamp	72	3-Lamp Standard F32T8 w/ Elec. Ballast	88	$20	16
3-Lamp HPT8-high performance 28 w lamp	65	3-Lamp Standard F32T8 w/ Elec. Ballast	88	$20	23
3-Lamp HPT8-high performance 25 w lamp	58	3-Lamp Standard F32T8 w/ Elec. Ballast	88	$20	30
4-Lamp HPT8 -high performance 32 w lamp	94	4-Lamp Standard F32T8 w/ Elec. Ballast	114	$23	20
4-Lamp HPT8-high performance 28 w lamp	86	4-Lamp Standard F32T8 w/ Elec. Ballast	114	$23	28
4-Lamp HPT8-high performance 25 w lamp	77	4-Lamp Standard F32T8 w/ Elec. Ballast	114	$23	37
2-lamp High-Performance HPT8 Troffer	49	3-Lamp F32T8 w/ Elec. Ballast	88	$100	39

Table developed using a constant ballast factor of .77. Input wattages are an average of manufacturer inputs that account for ballast efficacy

[425] Adapted from Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, October 26, 2011.

A-2: Retrofit HPT8 New and Baseline Assumptions[426] (Note see definiton for validity after 2016)

EE Measure Description	$Watts_{EE}$	Baseline Description	$Watts_{BASE}$	Incremental cost	$Watts_{SAVE}$
4-Lamp HPT8 w/ High-BF Ballast High-Bay	146	200 Watt Pulse Start Metal-Halide	232	$200	86
4-Lamp HPT8 w/ High-BF Ballast High-Bay	146	250 Watt Metal Halide	295	$200	149
6-Lamp HPT8 w/ High-BF Ballast High-Bay	206	320 Watt Pulse Start Metal-Halide	350	$225	144
6-Lamp HPT8 w/ High-BF Ballast High-Bay	206	400 Watt Metal Halide	455	$225	249
8-Lamp HPT8 w/ High-BF Ballast High-Bay	280	Proportionally Adjusted according to 6-Lamp HPT8 Equivalent to 320 PSMH	476	$250	196
8-Lamp HPT8 w/ High-BF Ballast High-Bay	280	Proportionally Adjusted according to 6-Lamp HPT8 Equivalent to 400 W Metal halide	618	$250	338
1-Lamp Relamp/Reballast T12 to HPT8	25	1-Lamp F34T12 w/ EEMag Ballast	40	$50	15
2-Lamp Relamp/Reballast T12 to HPT8	49	2-Lamp F34T12 w/ EEMag Ballast	68	$55	19
3-Lamp Relamp/Reballast T12 to HPT8	72	3-Lamp F34T12 w/ EEMag Ballast	110	$60	38
4-Lamp Relamp/Reballast T12 to HPT8	94	4-Lamp F34T12 w/ EEMag Ballast	139	$65	45
1-Lamp Relamp/Reballast T12 to HPT8	25	1-Lamp F40T12 w/ EEMag Ballast	48	$50	23
2-Lamp Relamp/Reballast T12 to HPT8	49	2-Lamp F40T12 w/ EEMag Ballast	82	$55	33
3-Lamp Relamp/Reballast T12 to HPT8	72	3-Lamp F40T12 w/ EEMag Ballast	122	$60	50
4-Lamp Relamp/Reballast T12 to HPT8	94	4-Lamp F40T12 w/ EEMag Ballast	164	$65	70
1-Lamp Relamp/Reballast T12 to HPT8	25	1-Lamp F40T12 w/ Mag Ballast	57	$50	32
2-Lamp Relamp/Reballast T12 to HPT8	49	2-Lamp F40T12 w/ Mag Ballast	94	$55	45
3-Lamp Relamp/Reballast T12 to HPT8	72	3-Lamp F40T12 w/ Mag Ballast	147	$60	75
4-Lamp Relamp/Reballast T12 to HPT8	94	4-Lamp F40T12 w/ Mag Ballast	182	$65	88
1-Lamp Relamp/Reballast T8 to HPT8	25	1-Lamp F32T8 w/ Elec. Ballast	32	$50	7
2-Lamp Relamp/Reballast T8 to HPT8	49	2-Lamp F32T8 w/ Elec. Ballast	59	$55	10
3-Lamp Relamp/Reballast T8 to HPT8	72	3-Lamp F32T8 w/ Elec. Ballast	88	$60	16
4-Lamp Relamp/Reballast T8 to HPT8	94	4-Lamp F32T8 w/ Elec. Ballast	114	$65	20
2-lamp High-Performance HPT8 Troffer or high efficiency retrofit troffer	49	3-Lamp F32T8 w/ Elec. Ballast	88	$100	39

426 Adapted from Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, October 26, 2011.

A– 3: RWT8 New and Baseline Assumptions

EE Measure Description	EE Cost	System WattsEE	Baseline Description	Base Cost	System Watts Base	Measure Cost	WattsSAVE
RWT8 - F28T8 Lamp	$4.50	25	F32T8 Standard Lamp	$2.50	28	$2.00	4
RWT8 - F28T8 Extra Life Lamp	$4.50	25	F32T8 Standard Lamp	$2.50	28	$2.00	4
RWT8 - F32/25W T8 Lamp	$4.50	22	F32T8 Standard Lamp	$2.50	28	$2.00	6
RWT8 - F32/25W T8 Lamp Extra Life	$4.50	22	F32T8 Standard Lamp	$2.50	28	$2.00	6
RWT8 - F17T8 Lamp - 2 Foot	$4.80	14	F17T8 Standard Lamp - 2 foot	$2.80	16	$2.00	2
RWT8 - F25T8 Lamp - 3 Foot	$5.10	20	F25T8 Standard Lamp - 3 foot	$3.10	23	$2.00	3
RWT8 - F30T8 Lamp - 6" Utube	$11.31	26	F32T8 Standard Utube Lamp	$9.31	28	$2.00	2
RWT8 - F29T8 Lamp - Utube	$11.31	26	F32T8 Standard Utube Lamp	$9.31	28	$2.00	3
RWT8 - F96T8 Lamp - 8 Foot	$9.00	57	F96T8 Standard Lamp - 8 foot	$7.00	62	$2.00	5
Notes: Wattage assumptions for Reduced-Wattage T8 based on Existing 0.88 Normal Ballast Factor.							

B-1: Time of Sale T8 Component Costs and Lifetime[427]

EE Measure Description	EE Lamp Cost	EE Lamp Life (hrs)	EE Lamp Rep. Labor Cost per lamp	EE Ballast Cost	EE Ballast Life (hrs)	EE Ballast Rep. Labor Cost	Baseline Description	Base Lamp Cost	Base Lamp Life (hrs)	Base Lamp Rep. Labor Cost	Base Ballast Cost	Base Ballast Life (hrs)	Base Ballast Rep. Labor Cost
4-Lamp HPT8 w/ High-BF Ballast High-Bay	$5.00	24000	$6.67	$32.50	70000	$15.00	200 Watt Pulse Start Metal-Halide	$21.00	10000	$6.67	$88	40000	$22.50
6-Lamp HPT8 w/ High-BF Ballast High-Bay	$5.00	24000	$6.67	$32.50	70000	$15.00	320 Watt Pulse Start Metal-Halide	$21.00	20000	$6.67	$109	40000	$22.50
8-Lamp HPT8 w/ High-BF Ballast High-Bay	$5.00	24000	$6.67	$32.50	70000	$15.00	Lamp HPT8 Equivalent to 320 PSMH	$21.00	20000	$6.67	$109	40000	$22.50
1-Lamp HPT8 - all qualifying lamps	$5.00	24000	$2.67	$32.50	70000	$15.00	1-Lamp Standard F32T8 w/ Elec. Ballast	$2.50	20000	$2.67	$15	70000	$15.00
2-Lamp HPT8 - all qualifying lamps	$5.00	24000	$2.67	$32.50	70000	$15.00	2-Lamp Standard F32T8 w/ Elec. Ballast	$2.50	20000	$2.67	$15	70000	$15.00
3-Lamp HPT8 - all qualifying lamps	$5.00	24000	$2.67	$32.50	70000	$15.00	3-Lamp Standard F32T8 w/ Elec. Ballast	$2.50	20000	$2.67	$15	70000	$15.00
4-Lamp HPT8 - all qualifying lamps	$5.00	24000	$2.67	$32.50	70000	$15.00	4-Lamp Standard F32T8 w/ Elec. Ballast	$2.50	20000	$2.67	$15	70000	$15.00
2-lamp High-Performance HPT8 Troffer	$5.00	24000	$2.67	$32.50	70000	$15.00	3-Lamp F32T8 w/ Elec. Ballast	$2.50	20000	$2.67	$15	70000	$15.00

[427] Ibid.

B-2: T8 Retrofit Component Costs and Lifetime[428]

EE Measure Description	EE Lamp Cost	EE Lamp Life (hrs)	EE Lamp Rep. Labor Cost per lamp	EE Ballast Cost	EE Ballast Life (hrs)	EE Ballast Rep. Labor Cost	Baseline Description	Base Lamp Cost	Base Lamp Life (hrs)	Base Lamp Rep. Labor Cost	Base Ballast Cost	Base Ballast Life (hrs)	Base Ballast Rep. Labor Cost
4-Lamp HPT8 w/ High-BF Ballast High-Bay	$5.00	24000	$6.67	$32.50	70000	$15.00	200 Watt Pulse Start Metal-Halide	$29.00	12000	$6.67	$88	40000	$22.50
							250 Watt Metal Halide	$21.00	10000	$6.67	$92	40000	$22.50
6-Lamp HPT8 w/ High-BF Ballast High-Bay	$5.00	24000	$6.67	$32.50	70000	$15.00	320 Watt Pulse Start Metal-Halide	$72.00	20000	$6.67	$109	40000	$22.50
							400 Watt Metal Halide	$17.00	20000	$6.67	$114	40000	$22.50
8-Lamp HPT8 w/ High-BF Ballast High-Bay	$5.00	24000	$6.67	$32.50	70000	$15.00	Proportionally Adjusted according to 6-Lamp HPT8 Equivalent to 320 PSMH	$72.00	20000	$6.67	$109	40000	$22.50
							Proportionally Adjusted according to 6-Lamp HPT8 Equivalent to 400 Watt Metal Halide	$17.00	20000	$6.67	$114	40000	$22.50
1-Lamp Relamp/Reballast T12 to HPT8 (all lamp/ballst combinations)	$5.00	24000	$2.67	$32.50	70000	$15.00	1-Lamp T12 all lamp/ballast combinations	$2.70	20000	$2.67	$20	40000	$15.00
2-Lamp Relamp/Reballast T12 to HPT8 (all lamp/ballast combinations)	$5.00	24000	$2.67	$32.50	70000	$15.00	2-Lamp T12 all lamp/ballast combinations	$2.70	20000	$2.67	$20	40000	$15.00
3-Lamp Relamp/Reballast T12 to HPT8 (all lamp/ballast combinations)	$5.00	24000	$2.67	$32.50	70000	$15.00	3-Lamp T12 all lamp/ballast combinations	$2.70	20000	$2.67	$20	40000	$15.00
4-Lamp Relamp/Reballast T12 to HPT8 (all lamp/ballast combinations)	$5.00	24000	$2.67	$32.50	70000	$15.00	3-Lamp T12 all lamp/ballast combinations	$2.70	20000	$2.67	$20	40000	$15.00
1-Lamp Relamp/Reballast T8 to HPT8	$5.00	24000	$2.67	$32.50	70000	$15.00	1-Lamp F32T8 w/ Elec. Ballast	$2.70	20000	$2.67	$20	70000	$15.00
2-Lamp Relamp/Reballast T8 to HPT8	$5.00	24000	$2.67	$32.50	70000	$15.00	2-Lamp F32T8 w/ Elec. Ballast	$2.70	20000	$2.67	$20	70000	$15.00
3-Lamp Relamp/Reballast T8 to HPT8	$5.00	24000	$2.67	$32.50	70000	$15.00	3-Lamp F32T8 w/ Elec. Ballast	$2.70	20000	$2.67	$20	70000	$15.00
4-Lamp Relamp/Reballast T8 to HPT8	$5.00	24000	$2.67	$32.50	70000	$15.00	4-Lamp F32T8 w/ Elec. Ballast	$2.70	20000	$2.67	$20	70000	$15.00
2-lamp High-Performance HPT8 Troffer or high efficiency retrofit reflective troffer	$5.00	24000	$2.67	$32.50	70000	$15.00	3-Lamp F32T8 w/ Elec. Ballast	$2.50	20000	$2.67	$15	70000	$15.00

B-3: Reduced Wattage T8 Component Costs and Lifetime[429]

[428] Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, January 2012.
[429] Adapted from EVT Technical Resource Manual, 2012-75, page 85.

EE Measure Description	EE Lamp Cost	EE Lamp Life (hrs)	Baseline Description	Base Lamp Cost	Base Lamp Life (hrs)	Base Lamp Rep. Labor Cost
RWT8 - F28T8 Lamp	$4.50	30000	F32T8 Standard Lamp	$2.50	15000	$2.67
RWT8 - F28T8 Extra Life Lamp	$4.50	36000	F32T8 Standard Lamp	$2.50	15000	$2.67
RWT8 - F32/25W T8 Lamp	$4.50	30000	F32T8 Standard Lamp	$2.50	15000	$2.67
RWT8 - F32/25W T8 Lamp Extra Life	$4.50	36000	F32T8 Standard Lamp	$2.50	15000	$2.67
RWT8 - F17T8 Lamp - 2 Foot	$4.80	18000	F17T8 Standard Lamp - 2 foot	$2.80	15000	$2.67
RWT8 - F25T8 Lamp - 3 Foot	$5.10	18000	F25T8 Standard Lamp - 3 foot	$3.10	15000	$2.67
RWT8 - F30T8 Lamp - 6" Utube	$11.31	24000	F32T8 Standard Utube Lamp	$9.31	15000	$2.67
RWT8 - F29T8 Lamp - Utube	$11.31	24000	F32T8 Standard Utube Lamp	$9.31	15000	$2.67
RWT8 - F96T8 Lamp - 8 Foot	$9.00	24000	F96T8 Standard Lamp - 8 foot	$7.00	15000	$2.67

C-1: T12 Baseline Adjustment:

For measures installed in 2012 through 2015, the full savings (as calculated above in the Algorithm section) will be claimed through 2015. A savings adjustment will be applied to the annual savings for the remainder of the measure life. The adjustment to be applied for each measure is listed in the reference table below.

Savings Adjustment Factors

EE Measure Description	Savings Adjustment T12 EEmag ballast and 34 w lamps to HPT8	Savings Adjustment T12 EEmag ballast and 40 w lamps to HPT8	Savings Adjustment T12 mag ballast and 40 w lamps to HPT8
1-Lamp Relamp/Reballast T12 to HPT8	47%	30%	20%
2-Lamp Relamp/Reballast T12 to HPT8	53%	30%	22%
3-Lamp Relamp/Reballast T12 to HPT8	42%	38%	21%
4-Lamp Relamp/Reballast T12 to HPT8	44%	29%	23%

Measures installed in 2012 will claim full savings for four years, 2013 for three years, 2014 two years and 2015 one year. Savings adjustment factors will be applied to the full savings for savings starting in 2016 and for the remainder of the measure life. The savings adjustment is equal to the ratio between wattage reduction from T8 baseline to HPT8 and wattage reduction from T12 EE ballast with 40 w lamp baseline from the table 'T8 New and Baseline Assumptions'.[430]

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-V02-140601

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[430] Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, October 26, 2011

EPE Program Downloads. Web accessed http://www.epelectricefficiency.com/downloads.asp?section=ci download Copy of LSF_2012_v4.04_250rows.xls.

Kuiken et al, Focus on Energy Evaluation. Business Programs: Deemed Savings Manual v1.0, Kema, march 22, 2010 available at http://www.focusonenergy.com/files/Document_Management_System/Evaluation/bpdeemedsavingsmanuav10_evaluationreport.pdf Based on ComEd's BILD program data from PY4 and PY5. 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.

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 83% Commercial and 17% Residential should be used[431].

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

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[431] Based on ComEd's BILD program data from PY4 and PY5. 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 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

$$\Delta kWh = ((Watts_{base} - Watts_{EE})/1000) * Hours * WHF_e * ISR$$

Where:

$Watts_{base}$ = Input wattage of the existing system. Reference the "LED New and Baseline Assumptions" table for default values.

$Watts_{EE}$ = New Input wattage of EE fixture. See the "LED New and Baseline Assumptions" table. For ENERGY STAR rated lamps the following lumen equivalence tables should be used:

Minimum Lumens	Maximum Lumens	Lumens used to calculate LED Wattage (midpoint)	LED Wattage[432] (WattsEE)	Baseline 2014-2019 (WattsBase)	Delta Watts 2014-2019 (WattsEE)	Baseline Post EISA 2020 requirement[433] (WattsBase)	Delta Watts Post 2020 (WattsEE)
5280	6209	5745	104.4	300.0	195.6	300.0	195.6
3000	5279	4140	75.3	200.0	124.7	200.0	124.7
2601	2999	2800	50.9	150.0	99.1	150.0	99.1
1490	2600	2045	37.2	72.0	34.8	45.4	8.3
1050	1489	1270	23.1	53.0	29.9	28.2	5.1
750	1049	900	16.4	43.0	26.6	20.0	3.6
310	749	530	9.6	29.0	19.4	11.8	2.1
250	309	280	5.6	25.0	19.4	25.0	19.4

Minimum Lumens	Maximum Lumens	Lumens used to calculate LED Wattage (midpoint)	LED Wattage[434] (WattsEE)	Baseline 2014-2019 (WattsBase)	Delta Watts 2014-2019 (WattsEE)	Baseline Post EISA 2020 requirement[435] (WattsBase)	Delta Watts Post 2020 (WattsEE)
5280	6209	5745	104.4	300.0	195.6	300.0	195.6
3000	5279	4140	75.3	200.0	124.7	200.0	124.7
2601	2999	2800	50.9	150.0	99.1	150.0	99.1
1490	2600	2045	37.2	72.0	34.8	45.4	8.3
1050	1489	1270	23.1	53.0	29.9	28.2	5.1
750	1049	900	16.4	43.0	26.6	20.0	3.6
310	749	530	9.6	29.0	19.4	11.8	2.1
250	309	280	5.6	25.0	19.4	25.0	19.4

Decorative Lamps - ENERGY STAR Minimum Luminous Efficacy = 40Lm/W for all lamps

[432] 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.
[433] Calculated as 45lm/W for all EISA non-exempt bulbs.
[434] 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.
[435] Calculated as 45lm/W for all EISA non-exempt bulbs.

Nominal wattage of lamp to be replaced ($Watts_{base}$)	Minimum initial light output of LED lamp (lumens)	LED Wattage ($Watts_{EE}$)	Delta Watts
10	70	1.75	8.25
15	90	2.25	12.75
25	150	3.75	21.25
40	300	7.5	32.5
60	500	12.5	47.5

Decorative lamps are exempt from EISA regulations.

Directional Lamps - ENERGY STAR Minimum Luminous Efficacy = 40Lm/W for lamp diameter <= 20/8 inch (PAR 20 and smaller) and 45 Lm/W for lamp diameter > 20/8 inch (greater than PAR20).

Bulb Type	Lower Lumen Range	Upper Lumen Range	Lumens used to calculate LED Wattage (midpoint)	LED Wattage ($Watts_{EE}$)	WattsBase	Delta Watts
Reflector with medium screw bases w/ diameter <=2.25"	400	449	425	10.6	40	29.4
	450	499	475	11.9	45	33.1
	500	649	575	14.4	50	35.6
	650	1199	925	23.1	65	41.9
R, PAR, ER, BR, BPAR or similar bulb shapes with medium screw bases w/ diameter >2.5" (*see exceptions below)	640	739	690	15.3	40	24.7
	740	849	795	17.7	45	27.3
	850	1179	1015	22.5	50	27.5
	1180	1419	1300	28.9	65	36.1
	1420	1789	1605	35.7	75	39.3
	1790	2049	1920	42.7	90	47.3
	2050	2579	2315	51.4	100	48.6
	2580	3429	3005	66.8	120	53.2
	3430	4270	3850	85.6	150	64.4
R, PAR, ER, BR, BPAR or similar bulb shapes with medium screw bases w/ diameter > 2.26'' and ≤ 2.5" (*see exceptions	540	629	585	14.6	40	25.4
	630	719	675	16.9	45	28.1
	720	999	860	21.5	50	28.5
	1000	1199	1100	27.5	65	37.5
	1200	1519	1360	34.0	75	41.0
	1520	1729	1625	40.6	90	49.4

Bulb Type	Lower Lumen Range	Upper Lumen Range	Lumens used to calculate LED Wattage (midpoint)	LED Wattage ($Watts_{EE}$)	WattsBase	Delta Watts
below)	1730	2189	1960	49.0	100	51.0
	2190	2899	2545	63.6	120	56.4
	2900	3850	3375	84.4	150	65.6
*ER30, BR30, BR40, or ER40	400	449	425	10.6	40	29.4
	450	499	475	11.9	45	33.1
	500	649	575	14.4	50	35.6
*BR30, BR40, or ER40	650	1419	1035	23.0	65	42.0
*R20	400	449	425	10.6	40	29.4
	450	719	585	14.6	45	30.4
*All reflector lamps below lumen ranges specified above	200	299	250	6.2	20	13.8
	300	399	350	8.7	30	21.3

Directional lamps are exempt from EISA regulations.

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 Referecne Table in Section 4.5. If unknown, use the Miscellaneous value.

ISR = In service Rate -the percentage of units rebated that actually get installed.

= 91%[436]

HEATING PENALTY

If electrically heated building:

$\Delta kWh_{heatpenalty}$[437] = (((WattsBase-WattsEE)/1000) * ISR * Hours * -IFkWh

Where:

IFkWh = Lighting-HVAC Interation Factor for electric heating impacts; this factor represents the

[436] Based on ComEd's BILD program data from PY5.

[437] Negative value because this is an increase in heating consumption due to the efficient lighting.

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, For example, a 9W LED lamp, 450 lumens, is installed in a heat pump heated office in 2014 and sign off form provided:

$\Delta kWh_{heatpenalty}$ = ((29-9/1000)*1.0*3088* -0.151

= - 9.3 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW =(($Watts_{base}$-$Watts_{EE}$)/1000) * ISR * WHF_d * CF

Where:

WHFd = Waste Heat Factor for Demand to account for cooling savings from efficient lighting in cooled buildings is provided in Referecne Table in Section 4.5. If unknown, use the Miscellaneous value.

CF = Summer Peak Coincidence Factor for measure is provided in the Referecne 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:

ΔkW = ((29-9/1000)* 1.0*1.3*0.66

= 0.002 kW

NATURAL GAS ENERGY SAVINGS

Heating Penalty if fossil fuel heated building (or if heating fuel is unknown):

ΔTherms = (((WattsBase-WattsEE)/1000) * ISR * Hours * - IFTherms

Where:

IFTherms = Lighting-HVAC Integration Factor for gas heating impacts; this factor represents the increased gas space heating requirements due to the reduction of waste heat rejected by the efficient lighting. Values are provided in the Referecne Table in Section 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:

ΔTherms = ((29-9/1000)*1.0*3088* -0.016

= - 0.99 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[438].

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[439]:

	Std Inc.	EISA Compliant Halogen	CFL
2014	$0.34	$1.25	N/A
2015	$0.34	$0.90	N/A
2016	$0.34	$0.80	N/A
2017	$0.34	$0.70	N/A
2018	$0.34	$0.60	N/A
2019	$0.34	$0.60	N/A
2020 & after	$0.34	N/A	$2.50

[438] See "LED reference tables.xls" for breakdown of component cost assumptions.
[439] Based upon pricing forecast developed by Applied Proactive Technologies Inc (APT) based on industry input and provided to Ameren.

The NPV for replacement lamps and annual levelized replacement costs using the statewide real discount rate of 5.23% are presented below:

Location	Lumen Level	NPV of replacement costs for period			Levelized annual replacement cost savings		
		June 2014 - May 2015	June 2015 - May 2016	June 2016 - May 2017	June 2014 - May 2015	June 2015 - May 2016	June 2016 - May 2017
Commercial	Lumens <310 or >2600 (EISA exempt)	$6.94	$6.94	$6.94	$1.49	$1.49	$1.49
	Lumens ≥ 310 and ≤ 2600 (EISA compliant)	$16.86	$13.90	$11.51	$3.63	$2.99	$2.48

For halogen bulbs, we assume the same replacement cycle as incandescent bulbs.[440] 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.

[440] 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[441]

LED Measure Description	WattsEE	Baseline Description	WattsBASE	Basis for Watt Assumptions	LED Lamp Cost	Baseline Cost (EISA 2012-2014, EISA 2020)	Incremental Cost (EISA 2012-2014, EISA 2020)	LED Minimum Lamp Life (hrs)
LED Screw and Pin-based Bulbs, Omnidirectional, < 10W	See tables above				$30.00	$0.34 ($1.25, $2.50)	$29.66 ($28.75, $27.50)	25,000
LED Screw and Pin-based Bulbs, Omnidirectional, >= 10W					$40.00	$0.34 ($1.25, $2.50)	$39.66 ($38.75, $37.50)	25,000
LED Screw and Pin-based Bulbs, Decorative					$30.00	$1.00	$29.00	25,000
LED Screw-based Bulbs, Directional, < 15W					$45.00	$5.00	$40.00	35,000
LED Screw-based Bulbs, Directional, >= 15W					$55.00	$5.00	$50.00	35,000
LED Recessed, Surface, Pendant Downlights	17.6	Baseline LED Recessed, Surface, Pendant Downlights	54.3	2008-2010 EVT Historical Data of 947 Measures	50,000		$50.00	
LED Track Lighting	12.2	Baseline LED Track Lighting	60.4	2008-2010 EVT Historical Data of 242 Measures	50,000		$100.00	

[441] Data is based on Efficiency Vermont derived cost and actual installed wattage information.

LED Wall-Wash Fixtures	8.3	Baseline LED Wall-Wash Fixtures	17.7	2008-2010 EVT Historical Data of 220 Measures	50,000		$80.00	
LED Portable Desk/Task Light Fixtures	7.1	Baseline LED Portable Desk/Task Light Fixtures	36.2	2008-2010 EVT Historical Data of 21 Measures	50,000		$50.00	
LED Undercabinet Shelf-Mounted Task Light Fixtures (per foot)	7.1	Baseline LED Undercabinet Shelf-Mounted Task Light Fixtures	36.2	2008-2010 EVT Historical Data of 21 Measures	50,000		$25.00	
LED Refrigerated Case Light, Horizontal or Vertical (per foot of light bar)	7.6	Baseline LED Refrigerated Case Light, Horizontal or Vertical (per foot of light bar)	15.2	PG&E Refrigerated Case Study[442] normalized to per foot of light bar.	50,000		$50.00	
LED Freezer Case Light, Horizontal or Vertical (per foot)	7.7	Baseline LED Freezer Case Light, Horizontal or Vertical (per foot)	18.7	PG&E Refrigerated Case Study normalized to per foot.	50,000		$50.00	
LED Display Case Light Fixture (per foot)	7.1	Baseline LED Display Case Light Fixture	36.2	Modeled after LED Undercabinet Shelf-Mounted Task Light Fixtures (per foot)	35,000		$25.00	
LED 2x2 Recessed Light Fixture	44.9	T8 U-Tube 2L-FB32 w/ Elec - 2'	61.0	Based on average watts of DLC qualified products as of 11/21/11	35,000		$75.00	
LED 2x4 Recessed Light Fixture	53.6	T8 3L-F32 w/ Elec - 4'	88.0	Based on average watts of DLC qualified products as of 11/21/11	35,000		$125.00	

[442] LED Refrigeration Case Ltg Workpaper 053007 rev1, May 30, 2007

LED 1x4 Recessed Light Fixture	32.2	T8 2L-F32 w/ Elec - 4'	59.0	Based on average watts of DLC qualified products as of 11/21/11	35,000		$100.00	
LED High- and Low-Bay Fixtures	160.2	MH 250 W CWA Pulse Start	295.0	Based on average watts of DLC qualified products as of 11/21/11	35,000		$200.00	
LED Outdoor Pole/Arm Mounted Parking/Roadway, < 30W	18.6	Baseline LED Outdoor Pole/Arm Mounted Parking/Roadway, < 30W	124.3	2008-2010 EVT Historical Data of 2,813 Measures	50,000		$125.00	
LED Outdoor Pole/Arm Mounted Parking/Roadway, 30W - 75W	52.5	Baseline LED Outdoor Pole/Arm Mounted Parking/Roadway, 30W - 75W	182.9	2008-2010 EVT Historical Data of 1,081 Measures	50,000		$250.00	
LED Outdoor Pole/Arm Mounted Parking/Roadway, >= 75W	116.8	Baseline LED Outdoor Pole/Arm Mounted Parking/Roadway, >= 75W	361.4	2008-2010 EVT Historical Data of 806 Measures	50,000		$375.00	
LED Outdoor Pole/Arm Mounted Decorative Parking/Roadway, < 30W	18.6	Baseline LED Outdoor Pole/Arm Mounted Decorative Parking/Roadway, < 30W	124.3	2008-2010 EVT Historical Data of 2,813 Measures	50,000		$125.00	
LED Outdoor Pole/Arm Mounted Decorative Parking/Roadway, 30W - 75W	52.5	Baseline LED Outdoor Pole/Arm Mounted Decorative Parking/Roadway, 30W - 75W	182.9	2008-2010 EVT Historical Data of 1,081 Measures	50,000		$250.00	
LED Outdoor Pole/Arm Mounted Decorative Parking/Roadway, >= 75W	116.8	Baseline LED Outdoor Pole/Arm Mounted Decorative Parking/Roadway, >= 75W	361.4	2008-2010 EVT Historical Data of 806 Measures	50,000		$375.00	

LED Parking Garage/Canopy, < 30W	18.6	Baseline LED Parking Garage/Canopy, < 30W	124.3	2008-2010 EVT Historical Data of 2,813 Measures	50,000		$125.00	
LED Parking Garage/Canopy, 30W - 75W	52.5	Baseline LED Parking Garage/Canopy, 30W - 75W	182.9	2008-2010 EVT Historical Data of 1,081 Measures	50,000		$250.00	
LED Parking Garage/Canopy, >= 75W	116.8	Baseline LED Parking Garage/Canopy, >= 75W	361.4	2008-2010 EVT Historical Data of 806 Measures	50,000		$375.00	
LED Wall-Mounted Area Lights, < 30W	18.6	Baseline LED Wall-Mounted Area Lights, < 30W	124.3	2008-2010 EVT Historical Data of 2,813 Measures	50,000		$125.00	
LED Wall-Mounted Area Lights, 30W - 75W	52.5	Baseline LED Wall-Mounted Area Lights, 30W - 75W	182.9	2008-2010 EVT Historical Data of 1,081 Measures	50,000		$250.00	
LED Wall-Mounted Area Lights, >= 75W	116.8	Baseline LED Wall-Mounted Area Lights, >= 75W	361.4	2008-2010 EVT Historical Data of 806 Measures	50,000		$375.00	
LED Bollard, < 30W	13.9	Baseline LED Bollard, < 30W	54.3	2008-2010 EVT Historical Data of 33 Measures	50,000		$150.00	
LED Bollard, >= 30W	41.0	Baseline LED Bollard, >= 30W	78.0	2008-2010 EVT Historical Data of 15 Measures	50,000		$250.00	
LED Flood Light, < 15W	8.7	Baseline LED Flood Light, < 15W	51.7	Consistent with LED Screw-base Directional	50,000		$35.00	

LED Flood Light, >= 15W	16.2	Baseline LED Flood Light, >= 15W	64.4	Consistent with LED Screw-base Directional	50,000		$45.00	

LED Component Costs & Lifetime[443]

LED Component Costs and Lifetimes													
LED Measure Description	LED Minimum Lamp Life (hrs)	LED Lamp Cost Total	LED Driver Life (hrs)	LED Driver Cost Total	Baseline Technology (1)	Lamp (1) Life (hrs)	Lamp (1) Total Cost	Ballast (1) Life (hrs)	Ballast (1) Total Cost	Baseline Technology (2)	Lamp (2) Life (hrs)	Lamp (2) Total Cost
LED Screw and Pin-based Bulbs, Decorative	25,000	N/A	N/A	N/A	53W EISA Halogen	2,000	$4.67	N/A	N/A	N/A	N/A	N/A
LED Screw-based Bulbs, Directional, < 15W	35,000	N/A	N/A	N/A	15% CFL 18W Pin Base	10,000	$11.62	40,000	$36.00	85% Halogen PAR20	2,500	$12.67
LED Screw-based Bulbs, Directional, >= 15W	35,000	N/A	N/A	N/A	15% CFL 26W Pin Base	10,000	$12.62	40,000	$36.00	85% Halogen PAR30/38	2,500	$12.67
LED Recessed, Surface, Pendant Downlights	50,000	$47.50	70,000	$47.50	40% CFL 26W Pin Base	10,000	$12.62	40,000	$36.00	60% Halogen PAR30/38	2,500	$12.67
LED Track Lighting	50,000	$47.50	70,000	$47.50	10% CMH PAR38	12,000	$62.92	40,000	$110.00	90% Halogen PAR38	2,500	$12.67

[443] Note some measures have blended baselines. All values are provided to enable calculation of appropriate O&M impacts. Total costs include lamp, labor and disposal cost assumptions where applicable, see "LED reference tables.xls" for more information.

LED Wall-Wash Fixtures	50,000	$47.50	70,000	$47.50	40% CFL 42W Pin Base	10,000	$15.72	40,000	$67.50	60% Halogen PAR38	2,500	$12.67
LED Portable Desk/Task Light Fixtures	50,000	$47.50	70,000	$47.50	50% 13W CFL Pin Base	10,000	$5.52	40,000	$25.00	50% 50W Halogen	2,500	$12.67
LED Undercabinet Shelf-Mounted Task Light Fixtures (per foot)	50,000	$47.50	70,000	$47.50	50% 2' T5 Linear	7,500	$9.92	40,000	$45.00	50% 50W Halogen	2,500	$12.67
LED Refrigerated Case Light, Horizontal or Vertical (per foot)	50,000	$9.50	70,000	$9.50	5' T8	15,000	$2.77	40,000	$9.50	N/A	N/A	N/A
LED Freezer Case Light, Horizontal or Vertical (per foot)	50,000	$8.75	70,000	$7.92	6' T12HO	12,000	$11.03	40,000	$59.58	N/A	N/A	N/A
LED Display Case Light Fixture (per foot)	35,000	$47.50	70,000	$28.75	50% 2' T5 Linear	7,500	$9.92	40,000	$45.00	50% 50W Halogen	2,500	$12.67
LED 2x2 Recessed Light Fixture	35,000	$47.50	70,000	$47.50	T8 U-Tube 2L-FB32 w/ Elec - 2'	15,000	$24.95	40,000	$52.00	N/A	N/A	N/A
LED 2x4 Recessed Light Fixture	35,000	$72.50	70,000	$47.50	T8 3L-F32 w/ Elec - 4'	15,000	$17.00	40,000	$35.00	N/A	N/A	N/A
LED 1x4 Recessed Light Fixture	35,000	$47.50	70,000	$47.50	T8 2L-F32 w/ Elec - 4'	15,000	$11.33	40,000	$35.00	N/A	N/A	N/A
LED High- and Low-Bay Fixtures	35,000	$112.50	70,000	$62.50	250W MH	10,000	$41.25	40,000	$130.25	N/A	N/A	N/A
LED Outdoor Pole/Arm Mounted	50,000	$62.50	70,000	$62.50	100W MH	10,000	$54.25	40,000	$166.70	N/A	N/A	N/A

Parking/Roadway, < 30W												
LED Outdoor Pole/Arm Mounted Parking/Roadway, 30W - 75W	50,000	$87.50	70,000	$62.50	175W MH	10,000	$48.25	40,000	$110.00	N/A	N/A	N/A
LED Outdoor Pole/Arm Mounted Parking/Roadway, >= 75W	50,000	$112.50	70,000	$62.50	250W MH	10,000	$41.25	40,000	$130.25	N/A	N/A	N/A
LED Outdoor Pole/Arm Mounted Decorative Parking/Roadway, < 30W	50,000	$62.50	70,000	$62.50	100W MH	10,000	$54.25	40,000	$166.70	N/A	N/A	N/A
LED Outdoor Pole/Arm Mounted Decorative Parking/Roadway, 30W - 75W	50,000	$87.50	70,000	$62.50	175W MH	10,000	$48.25	40,000	$110.00	N/A	N/A	N/A
LED Outdoor Pole/Arm Mounted Decorative Parking/Roadway, >= 75W	50,000	$112.50	70,000	$62.50	250W MH	10,000	$41.25	40,000	$130.25	N/A	N/A	N/A
LED Parking Garage/Canopy, < 30W	50,000	$47.50	70,000	$47.50	100W MH	10,000	$36.92	40,000	$151.70	N/A	N/A	N/A
LED Parking Garage/Canopy, 30W - 75W	50,000	$72.50	70,000	$47.50	175W MH	10,000	$30.92	40,000	$95.00	N/A	N/A	N/A
LED Parking Garage/Canopy, >= 75W	50,000	$97.50	70,000	$47.50	250W MH	10,000	$23.92	40,000	$115.25	N/A	N/A	N/A
LED Wall-Mounted Area	50,000	$47.50	70,000	$47.50	100W MH	10,000	$36.92	40,000	$151.70	N/A	N/A	N/A

Lights, < 30W												
LED Wall-Mounted Area Lights, 30W - 75W	50,000	$72.50	70,000	$47.50	175W MH	10,000	$30.92	40,000	$95.00	N/A	N/A	N/A
LED Wall-Mounted Area Lights, >= 75W	50,000	$97.50	70,000	$47.50	250W MH	10,000	$23.92	40,000	$115.25	N/A	N/A	N/A
LED Bollard, < 30W	50,000	$47.50	70,000	$47.50	50W MH	10,000	$36.92	40,000	$135.50	N/A	N/A	N/A
LED Bollard, >= 30W	50,000	$72.50	70,000	$47.50	70W MH	10,000	$36.92	40,000	$142.50	N/A	N/A	N/A
LED Flood Light, < 15W	50,000	$47.50	70,000	$47.50	25% 50W MH	10,000	$36.92	40,000	$135.50	75% Halogen PAR20	2,500	$12.67
LED Flood Light, >= 15W	50,000	$47.50	70,000	$47.50	50% 50W MH	10,000	$36.92	40,000	$135.50	50% Halogen PAR30/38	2,500	$12.67

MEASURE CODE: CI-LTG-LEDB-V02-140601

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[444].

DEEMED MEASURE COST

The incremental cost for this measure is assumed to be $30[445].

LOADSHAPE

Loadshape C53 - Flat

COINCIDENCE FACTOR

The summer peak coincidence factor for this measure is assumed to be 100%[446].

[444] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Effective/Remaining Useful Life Values", California Public Utilities Commission, December 16, 2008.
[445] NYSERDA Deemed Savings Database, Labor cost assumes 25 minutes @ $18/hr.
[446] 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

$$\Delta kWh = ((WattsBase - WattsEE) / 1000) * HOURS * WHF_e$$

Where:

WattsBase = Actual wattage if known, if unknown assume the following:

Baseline Type	WattsBase
Incandescent	35W[447]
Fluorescent	11W[448]
Unknown (e.g. time of sale)	23W[449]

WattsEE = Actual wattage if known, if unknown assume 2W[450]

HOURS = Annual operating hours

= 8766

WHF_e = Waste heat factor for energy to account for cooling energy savings from efficient lighting are provided for each building type in the Referecne Table in Section 4.5. If unknown, use the Miscellaneous value.

For example, replacing incandescent fixture in an office

ΔkWH = (35 – 2)/1000 * 8766 * 1.25

= 362 kWh

For example, replacing fluorescent fixture in a hospital

ΔkWH = (11 – 2)/1000 * 8766 * 1.35

= 106.5 kWh

447 Based on review of available product.
448 Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010
449 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)
450 Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010

HEATING PENALTY

If electrically heated building:

$\Delta kWh_{heatpenalty}$[451] = (((WattsBase-WattsEE)/1000) * Hours * -IFkWh

Where:

IFkWh = 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, replacing incandescent fixture in a heat pump heated office

$\Delta kWh_{heatpenalty}$ = (35 – 2)/1000 * 8760 * -0.151

= -43.7 kWh

For example, replacing fluorescent fixture in a heat pump heated hospital

$\Delta kWh_{heatpenalty}$ = (11 – 2)/1000 * 8760 * -0.104

= 8.2 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ((WattsBase - WattsEE) / 1000) * WHF_d * 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

[451] Negative value because this is an increase in heating consumption due to the efficient lighting.

For example, replacing incandescent fixture in an office

ΔkW = (35 – 2)/1000 * 1.3 * 1.0

= 0.043 kW

For example, replacing fluorescent fixture in a hospital

ΔkW = (11 – 2)/1000 * 1.69 * 1.0

= 0.015 kW

Natural Gas Savings

Heating Penalty if natural gas heated building (or if heating fuel is unknown):

Δtherms = (((WattsBase-WattsEE)/1000) * Hours *- IFTherms

Where:

IFTherms = Lighting-HVAC Integration Factor for gas heating impacts; this factor represents the increased gas space heating requirements due to the reduction of waste heat rejected by the efficient lighting. Values are provided in the Referecne Table in Section 4.5. If unknown, use the Miscellaneous value.

For example, replacing incandescent fixture in an office

ΔTherms = (35 – 2)/1000 * 8760 * -0.016

= -4.63 Therms

For example, replacing fluorescent fixture in a hospital

ΔTherms = (11 – 2)/1000 * 8760 * -0.011

= 0.87 Therms

Water Impact Descriptions and Calculation

N/A

Deemed O&M Cost Adjustment Calculation

The annual O&M Cost Adjustment savings should be calculated using the following component costs and lifetimes.

	Baseline Measures	
Component	Cost	Life (yrs)

Lamp	\$7.00[452]	1.37 years[453]

MEASURE CODE: CI-LTG-LEDE-V02-140601

[452] 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).
[453] 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.[454] 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

[454] ACEEE, (1998) A Market Transformation Opportunity Assessment for LED Traffic Signals, http://www.cee1.org/gov/led/led-ace3/ace3led.pdf

Loadshape C32 - Traffic Signal - “Man” Walk Signal

Loadshape C33 - Traffic Signal - Bi-Modal Walk/Don’t Walk

COINCIDENCE FACTOR[455]

The summer peak coincidence factor (CF) for this measure is dependent on lamp type as below:

Lamp Type	CF
Red Round, always changing or flashing	0.55
Red Arrows	0.90
Green Arrows	0.10
Yellow Arrows	0.03
Green Round, always changing or flashing	0.43
Flashing Yellow	0.50
Yellow Round, always changing	0.02
“Hand” Don’t Walk Signal	0.75
“Man” Walk Signal	0.21

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$\Delta kWh = (W_{base} - W_{eff}) \times HOURS / 1000$

Where:

Wbase =The connected load of the baseline equipment

= see Table ‘Traffic Signals Technology Equivalencies’

Weff =The connected load of the baseline equipment

= see Table ‘Traffic Signals Technology Equivalencies’

[455] Ibid

EFLH = annual operating hours of the lamp

= see Table 'Traffic Signals Technology Equivalencies'

1000 = conversion factor (W/kW)

EXAMPLE

For example, an 8 inch red, round signal:

ΔkWh = ((69 - 7) x 4818) / 1000
= 299 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = (Wbase– Weff) x CF / 1000

Where:

Wbase =The connected load of the baseline equipment

= see Table 'Traffic Signals Technology Equivalencies'

Weff =The connected load of the efficient equipment

= see Table 'Traffic Signals Technology Equivalencies'

CF = Summer Peak Coincidence Factor for measure

EXAMPLE

For example, an 8 inch red, round signal:

ΔkW = ((69 – 7) x 0.55) / 1000

= 0.0341 kW

NATURAL GAS ENERGY SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

REFERENCE TABLES

Traffic Signals Technology Equivalencies[456]

Traffic Fixture Type	Fixture Size and Color	Efficient Lamps	Baseline Lamps	HOURS	Efficient Fixture Wattage	Baseline Fixture Wattage	Energy Savings (in kWh)
Round Signals	8” Red	LED	Incandescent	4818	7	69	299
Round Signals	12” Red	LED	Incandescent	4818	6	150	694
Flashing Signal[457]	8” Red	LED	Incandescent	4380	7	69	272
Flashing Signal	12” Red	LED	Incandescent	4380	6	150	631
Flashing Signal	8” Yellow	LED	Incandescent	4380	10	69	258
Flashing Signal	12” Yellow	LED	Incandescent	4380	13	150	600
Round Signals	8” Yellow	LED	Incandescent	175	10	69	10
Round Signals	12” Yellow	LED	Incandescent	175	13	150	24
Round Signals	8” Green	LED	Incandescent	3767	9	69	266
Round Signals	12” Green	LED	Incandescent	3767	12	150	520
Turn Arrows	8” Yellow	LED	Incandescent	701	7	116	76
Turn Arrows	12” Yellow	LED	Incandescent	701	9	116	75

[456] Technical Reference Manual for Pennsylvania Act 129 Energy Efficiency and Conservation Program and Act 213 Alternative Energy Portfolio Standards. Pennsylvania Public Utility Commission. May 2009
[457] Technical Reference Manual for Ohio, August 6, 2010

Traffic Fixture Type	Fixture Size and Color	Efficient Lamps	Baseline Lamps	HOURS	Efficient Fixture Wattage	Baseline Fixture Wattage	Energy Savings (in kWh)
Turn Arrows	8” Green	LED	Incandescent	701	7	116	76
Turn Arrows	12” Green	LED	Incandescent	701	7	116	76
Pedestrian Sign	12” Hand/Man	LED	Incandescent	8760	8	116	946

Reference specifications for above traffic signal wattages are from the following manufacturers:

1. 8” Incandescent traffic signal bulb: General Electric Traffic Signal Model 17325-69A21/TS
2. 12” Incandescent traffic signal bulb: General Electric Signal Model 35327-150PAR46/TS
3. Incandescent Arrows & Hand/Man Pedestrian Signs: General Electric Traffic Signal Model 19010-116A21/TS
4. 8” and 12” LED traffic signals: Leotek Models TSL-ES08 and TSL-ES12
5. 8” LED Yellow Arrow: General Electric Model DR4-YTA2-01A
6. 8” LED Green Arrow: General Electric Model DR4-GCA2-01A
7. 12” LED Yellow Arrow: Dialight Model 431-3334-001X
8. 12: LED Green Arrow: Dialight Model 432-2324-001X
9. LED Hand/Man Pedestrian Sign: Dialight 430-6450-001X

MEASURE CODE: CI-LTG-LEDT-V01-120601

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[458]. 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 = ΔkWh = (WSFbase-WSFeffic)/1000* SF* Hours * WHF_e

Summer Coincident Peak kW Savings = ΔkW = (WSFbase-WSFeffic)/1000* SF* CF * WHF_d

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 15 years[459]

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.

[458] 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).
[459] Measure Life Report, Residential and Commercial/Industrial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007.

LOADSHAPE

Loadshape C06 - Commercial Indoor Lighting
Loadshape C07 - Grocery/Conv. Store Indoor Lighting
Loadshape C08 - Hospital Indoor Lighting
Loadshape C09 - Office Indoor Lighting
Loadshape C10 - Restaurant Indoor Lighting
Loadshape C11 - Retail Indoor Lighting
Loadshape C12 - Warehouse Indoor Lighting
Loadshape C13 - K-12 School Indoor Lighting
Loadshape C14 - Indust. 1-shift (8/5) (e.g., comp. air, lights)
Loadshape C15 - Indust. 2-shift (16/5) (e.g., comp. air, lights)
Loadshape C16 - Indust. 3-shift (24/5) (e.g., comp. air, lights)
Loadshape C17 - Indust. 4-shift (24/7) (e.g., comp. air, lights)
Loadshape C18 - Industrial Indoor Lighting
Loadshape C19 - Industrial Outdoor Lighting
Loadshape C20 - Commercial Outdoor Lighting

COINCIDENCE FACTOR

The summer peak coincidence factor for this measure is dependent on the building type.

Algorithm

CALCULATION OF SAVINGS

ENERGY SAVINGS

$$\Delta kWh = (WSF_{base} - WSF_{effic})/1000 * SF * Hours * WHF_e$$

Where:

WSF_{base} = Baseline lighting watts per square foot or linear foot as determined by building or space type. Whole building analysis values are presented in the Reference Tables below.[460]

WSF_{effic} = The actual installed lighting watts per square foot or linear foot.

SF = Provided by customer based on square footage of the building area applicable to the lighting design for new building.

Hours = Annual site-specific hours of operation of the lighting equipment collected from the customer. If not available, use building area type as provided in the Reference Table in Section 4.5, Fixture annual operating hours.

[460] IECC 2012 - Reference Code documentation for additional information.

WHF_e = Waste Heat Factor for Energy to account for cooling savings from efficient lighting is as provided in the Reference Table in Section 4.5 by buidling type. If building is not cooled WHF_e is 1.

HEATING PENALTY

If electrically heated building:

$$\Delta kWh_{heatpenalty}{}^{461} = (WSF_{base}-WSF_{effic})/1000 * SF * Hours * -IFkWh$$

Where:

IFkWh = 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.

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = (WSF_{base}-WSF_{effic})/1000 * SF * CF * WHF_d$$

Where:

WHF_d = Waste Heat Factor for Demand to account for cooling savings from efficient lighting in cooled buildings is as provided in the Reference Table in Section 4.5 by buidling type. If building is not cooled WHFd is 1.

CF = Summer Peak Coincidence Factor for measure is as provided in the Reference Table in Section 4.5 by buidling type. If the building type is unknown, use the Miscellaneous value of 0.66.

Other factors as defined above

NATURAL GAS ENERGY SAVINGS

$$\Delta Therms = (WSF_{base}-WSF_{effic})/1000 * SF * Hours * - IFTherms$$

Where:

IFTherms = Lighting-HVAC Integration Factor for gas heating impacts; this factor represents the increased gas space heating requirements due to the reduction of waste heat rejected by the efficient lighting. This value is provided in the Reference Table in Section 4.5 by buidling type.

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

[461] Negative value because this is an increase in heating consumption due to the efficient lighting.

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

REFERENCE TABLES

Lighting Power Density Values from IECC 2012 for Interior Commercial New Construction and Substantial Renovation Building Area Method:

Building Area Type [462]	Lighting Power Density (w/ft^2)
Automotive Facility	0.9
Convention Center	1.2
Court House	1.2
Dining: Bar Lounge/Leisure	1.3
Dining: Cafeteria/Fast Food	1.4
Dining: Family	1.6
Dormitory	1.0
Exercise Center	1.0
Fire station	0.8
Gymnasium	1.1
Healthcare – clinic	1.0
Hospital	1.2
Hotel	1.0
Library	1.3
Manufacturing Facility	1.3
Motel	1.0
Motion Picture Theater	1.2
Multifamily	0.7
Museum	1.1
Office	0.9
Parking Garage	0.3
Penitentiary	1.0
Performing Arts Theater	1.6
Police Station	1.0
Post Office	1.1
Religious Building	1.3
Retail[463]	1.4

[462] 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.

[463] 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.

Building Area Type [462]	Lighting Power Density (w/ft^2)
School/University	1.2
Sports Arena	1.1
Town Hall	1.1
Transportation	1.0
Warehouse	0.6
Workshop	1.4

Lighting Power Density Values from IECC 2012 for Interior Commercial New Construction and Substantial Renovation Space by Space Method:

TABLE C405.5.2(2)
INTERIOR LIGHTING POWER ALLOWANCES: SPACE-BY-SPACE METHOD

COMMON SPACE-BY-SPACE TYPES	LPD (w/ft²)
Atrium – First 40 feet in height	0.03 per ft. ht.
Atrium – Above 40 feet in height	0.02 per ft. ht.
Audience/seating area – permanent	
For auditorium	0.9
For performing arts theater	2.6
For motion picture theater	1.2
Classroom/lecture/training	1.30
Conference/meeting/multipurpose	1.2
Corridor/transition	0.7
Dining area	
Bar/lounge/leisure dining	1.40
Family dining area	1.40
Dressing/fitting room performing arts theater	1.1
Electrical/mechanical	1.10
Food preparation	1.20
Laboratory for classrooms	1.3
Laboratory for medical/industrial/research	1.8
Lobby	1.10
Lobby for performing arts theater	3.3
Lobby for motion picture theater	1.0
Locker room	0.80
Lounge recreation	0.8
Office – enclosed	1.1
Office – open plan	1.0
Restroom	1.0
Sales area	1.6[a]
Stairway	0.70
Storage	0.8
Workshop	1.60
Courthouse/police station/penetentiary	
Courtroom	1.90
Confinement cells	1.1
Judge chambers	1.30
Penitentiary audience seating	0.5
Penitentiary classroom	1.3
Penitentiary dining	1.1
BUILDING SPECIFIC SPACE-BY-SPACE TYPES	
Automotive – service/repair	0.70
Bank/office – banking activity area	1.5
Dormitory living quarters	1.10
Gymnasium/fitness center	
Fitness area	0.9
Gymnasium audience/seating	0.40
Playing area	1.40

(continued)

TABLE C405.5.2(2)—continued
INTERIOR LIGHTING POWER ALLOWANCES: SPACE-BY-SPACE METHOD

COMMON SPACE-BY-SPACE TYPES	LPD (w/ft²)
Healthcare clinic/hospital	
Corridors/transition	1.00
Exam/treatment	1.70
Emergency	2.70
Public and staff lounge	0.80
Medical supplies	1.40
Nursery	0.9
Nurse station	1.00
Physical therapy	0.90
Patient room	0.70
Pharmacy	1.20
Radiology/imaging	1.3
Operating room	2.20
Recovery	1.2
Lounge/recreation	0.8
Laundry – washing	0.60
Hotel	
Dining area	1.30
Guest rooms	1.10
Hotel lobby	2.10
Highway lodging dining	1.20
Highway lodging guest rooms	1.10
Library	
Stacks	1.70
Card file and cataloguing	1.10
Reading area	1.20
Manufacturing	
Corridors/transition	0.40
Detailed manufacturing	1.3
Equipment room	1.0
Extra high bay (> 50-foot floor-ceiling height)	1.1
High bay (25- – 50-foot floor-ceiling height)	1.20
Low bay (< 25-foot floor-ceiling height)	1.2
Museum	
General exhibition	1.00
Restoration	1.70
Parking garage – garage areas	0.2
Convention center	
Exhibit space	1.50
Audience/seating area	0.90
Fire stations	
Engine room	0.80
Sleeping quarters	0.30
Post office	
Sorting area	0.9
Religious building	
Fellowship hall	0.60
Audience seating	2.40
Worship pulpit/choir	2.40
Retail	
Dressing/fitting area	0.9
Mall concourse	1.6
Sales area	1.6[a]

(continued)

TABLE C405.5.2(2)—continued
INTERIOR LIGHTING POWER ALLOWANCES:
SPACE-BY-SPACE METHOD

BUILDING SPECIFIC SPACE-BY-SPACE TYPES	LPD (w/ft²)
Sports arena	
Audience seating	0.4
Court sports area – Class 4	0.7
Court sports area – Class 3	1.2
Court sports area – Class 2	1.9
Court sports area – Class 1	3.0
Ring sports area	2.7
Transportation	
Air/train/bus baggage area	1.00
Airport concourse	0.60
Terminal – ticket counter	1.50
Warehouse	
Fine material storage	1.40
Medium/bulky material	0.60

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

LIGHTING ZONE	DESCRIPTION
1	Developed areas of national parks, state parks, forest land, and rural areas
2	Areas predominantly consisting of residential zoning, neighborhood business districts, light industrial with limited nighttime use and residential mixed use areas
3	All other areas
4	High-activity commercial districts in major metropolitan areas as designated by the local land use planning authority

The lighting power density savings will be based on reductions below the allowable design levels as specified in IECC 2012 Table 405.6.2(2) which follows.

TABLE C405.6.2(2)
INDIVIDUAL LIGHTING POWER ALLOWANCES FOR BUILDING EXTERIORS

		LIGHTING ZONES			
		Zone 1	Zone 2	Zone 3	Zone 4
Base Site Allowance (Base allowance is usable in tradable or nontradable surfaces.)		500 W	600 W	750 W	1300 W
Tradable Surfaces (Lighting power densities for uncovered parking areas, building grounds, building entrances and exits, canopies and overhangs and outdoor sales areas are tradable.)	**Uncovered Parking Areas**				
	Parking areas and drives	0.04 W/ft^2	0.06 W/ft^2	0.10 W/ft^2	0.13 W/ft^2
	Building Grounds				
	Walkways less than 10 feet wide	0.7 W/linear foot	0.7 W/linear foot	0.8 W/linear foot	1.0 W/linear foot
	Walkways 10 feet wide or greater, plaza areas special feature areas	0.14 W/ft^2	0.14 W/ft^2	0.16 W/ft^2	0.2 W/ft^2
	Stairways	0.75 W/ft^2	1.0 W/ft^2	1.0 W/ft^2	1.0 W/ft^2
	Pedestrian tunnels	0.15 W/ft^2	0.15 W/ft^2	0.2 W/ft^2	0.3 W/ft^2
	Building Entrances and Exits				
	Main entries	20 W/linear foot of door width	20 W/linear foot of door width	30 W/linear foot of door width	30 W/linear foot of door width
	Other doors	20 W/linear foot of door width	20 W/linear foot of door width	20 W/linear foot of door width	20 W/linear foot of door width
	Entry canopies	0.25 W/ft^2	0.25 W/ft^2	0.4 W/ft^2	0.4 W/ft^2
	Sales Canopies				
	Free-standing and attached	0.6 W/ft^2	0.6 W/ft^2	0.8 W/ft^2	1.0 W/ft^2
	Outdoor Sales				
	Open areas (including vehicle sales lots)	0.25 W/ft^2	0.25 W/ft^2	0.5 W/ft^2	0.7 W/ft^2
	Street frontage for vehicle sales lots in addition to "open area" allowance	No allowance	10 W/linear foot	10 W/linear foot	30 W/linear foot
Nontradable Surfaces (Lighting power density calculations for the following applications can be used only for the specific application and cannot be traded between surfaces or with other exterior lighting. The following allowances are in addition to any allowance otherwise permitted in the "Tradable Surfaces" section of this table.)	Building facades	No allowance	0.1 W/ft^2 for each illuminated wall or surface or 2.5 W/linear foot for each illuminated wall or surface length	0.15 W/ft^2 for each illuminated wall or surface or 3.75 W/linear foot for each illuminated wall or surface length	0.2 W/ft^2 for each illuminated wall or surface or 5.0 W/linear foot for each illuminated wall or surface length
	Automated teller machines and night depositories	270 W per location plus 90 W per additional ATM per location	270 W per location plus 90 W per additional ATM per location	270 W per location plus 90 W per additional ATM per location	270 W per location plus 90 W per additional ATM per location
	Entrances and gatehouse inspection stations at guarded facilities	0.75 W/ft^2 of covered and uncovered area	0.75 W/ft^2 of covered and uncovered area	0.75 W/ft^2 of covered and uncovered area	0.75 W/ft^2 of covered and uncovered area
	Loading areas for law enforcement, fire, ambulance and other emergency service vehicles	0.5 W/ft^2 of covered and uncovered area	0.5 W/ft^2 of covered and uncovered area	0.5 W/ft^2 of covered and uncovered area	0.5 W/ft^2 of covered and uncovered area
	Drive-up windows/doors	400 W per drive-through	400 W per drive-through	400 W per drive-through	400 W per drive-through
	Parking near 24-hour retail entrances	800 W per main entry	800 W per main entry	800 W per main entry	800 W per main entry

For SI: 1 foot = 304.8 mm, 1 watt per square foot = W/0.0929 m^2.

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 years[464].

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)

[464] 15 years from GDS Measure Life Report, June 2007

Miscellaneous Commercial/Industrial Lighting

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

$\Delta kWh = ((Watts_{base} - Watts_{EE})/1000) * Hours * WHF_e * ISR$

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

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%[465] if application form completed with sign off that equipment is not

[465] Illinois evaluation of PY1 through PY3 has not found that fixtures or lamps placed into storage to be a significant enough

placed into storage

If sign off form not completed assume the following 3 year ISR assumptions:

Weigted Average 1st year In Service Rate (ISR)	2nd year Installations	3rd year Installations	Final Lifetime In Service Rate
75.5%[466]	12.1%	10.3%	98.0%[467]

HEATING PENALTY

If electrically heated building:

$$\Delta kWh_{heatpenalty}{}^{468} = (((WattsBase-WattsEE)/1000) * ISR * Hours * -IFkWh$$

Where:

IFkWh = 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.

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.

issue to warrant including an "In-Service Rate" when commercial customers complete an application form.

466 1st 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.

467 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.

468 Negative value because this is an increase in heating consumption due to the efficient lighting.

The NTG factor for the Purchase Year should be applied.

SUMMER COINCIDENT DEMAND SAVINGS

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

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 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

ΔTherms[469] = (((WattsBase-WattsEE)/1000) * ISR * Hours * - IFTherms

Where:

IFTherms = Lighting-HVAC Integration Factor for gas heating impacts; this factor represents the increased gas space heating requirements due to the reduction of waste heat rejected by the efficient lighting. This value is selected from the Reference Table in Section 6.5 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

[469] 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[470].

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[471].

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)

[470] Consistent with Occupancy Sensor control measure.
[471] Goldberg et al, State of Wisconsin Public Service Commission of Wisconsin, Focus on Energy Evaluation, Business Programs: Incremental Cost Study, KEMA, October 28, 2009.

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

$\Delta kWh = KW_{Controlled} * Hours * ESF * WHF_e$

Where:

$KW_{Controlled}$ = Total lighting load connected to the control in kilowatts.

= Actual

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 buidling type, use the Miscellaneous value.

ESF = Energy Savings factor (represents the percentage reduction to the KWcontrolled due to the use of multi-level switching).

= Dependent on building type[472]:

Building Type	Energy Savings Factor (ESF)
Private Office	21.6%
Open Office	16.0%
Retail	14.8%
Classrooms	8.3%
Unknown, average	15%

[472] Based on results from "Lighting Controls Effectiveness Assessment: Final Report on Bi-Level Lighting Study" published by the California Public Utilities Commission (CPUC), prepared by ADM Associates. http://lightingcontrolsassociation.org/bi-level-switching-study-demonstrates-energy-savings/

WHF_e = 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:

$\Delta kWh_{heatpenalty}$[473] = $KW_{Controlled}$ * Hours * ESF * -IFkWh

Where:

IFkWh = 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.

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$\Delta kW = KW_{controlled} * ESF * WHF_d * CF$

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 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[474].

NATURAL GAS ENERGY SAVINGS

$\Delta therms = KW_{Controlled}$ * Hours * ESF * - IFTherms

Where:

IFTherms = Lighting-HVAC Integration Factor for gas heating impacts; this factor represents the increased gas space heating requirements due to the reduction of waste heat rejected by the efficient lighting and provided in the Reference Table in Section 4.5 by buidling type.

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

[473]Negative value because this is an increase in heating consumption due to the efficient lighting.

[474] 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.

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[475].

Deemed Measure Cost

When available, the actual cost of the measure shall be used. When not available, the following default values are provided:

Lighting control type	Cost
Full cost of wall mounted occupancy sensor	$42[476]
Full cost mounted occupancy sensor	$66[477]

[475] DEER 2008
[476] Goldberg et al, State of Wisconsin, Public Service Commission of Wisconsin, Focus on Energy Evaluation Business programs Incremental Cost Study, KEMA, October 28, 2009
[477] Ibid

Full cost of fixture-mounted occupancy sensor	$125[478]

LOADSHAPE

Loadshape C06 - Commercial Indoor Lighting
Loadshape C07 - Grocery/Conv. Store Indoor Lighting
Loadshape C08 - Hospital Indoor Lighting
Loadshape C09 - Office Indoor Lighting
Loadshape C10 - Restaurant Indoor Lighting
Loadshape C11 - Retail Indoor Lighting
Loadshape C12 - Warehouse Indoor Lighting
Loadshape C13 - K-12 School Indoor Lighting
Loadshape C14 - Indust. 1-shift (8/5) (e.g., comp. air, lights)
Loadshape C15 - Indust. 2-shift (16/5) (e.g., comp. air, lights)
Loadshape C16 - Indust. 3-shift (24/5) (e.g., comp. air, lights)
Loadshape C17 - Indust. 4-shift (24/7) (e.g., comp. air, lights)
Loadshape C18 - Industrial Indoor Lighting
Loadshape C19 - Industrial Outdoor Lighting
Loadshape C20 - Commercial Outdoor Lighting

COINCIDENCE FACTOR

The summer peak coincidence factor for this measure is dependent on location.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$\Delta kWh = KW_{Controlled} * Hours * ESF * WHF_e$

Where:

$Kw_{Controlled}$ = Total lighting load connected to the control in kilowatts. Savings is per control. The total connected load per control should be collected from the customer or the default values presented below used;

Lighting Control Type	Default kw controlled
Wall mounted occupancy sensor	0.350[479]

[478] Efficiency Vermont TRM, October 26, 2011.
[479] Goldberg et al, State of Wisconsin Public Service Commission of Wisconsin, Focus on Energy Evaluation, Business Programs, Incremental Cost Study, KEMA, October 28, 2009

Remote mounted occupancy sensor	0.587[480]
Fixture mounted sensor	0.073[481]

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 buidling type, use the Miscellaneous value.

ESF = Energy Savings factor (represents the percentage reduction to the operating Hours from the non-controlled baseline lighting system).

Lighting Control Type	Energy Savings Factor[482]
Wall or Ceiling-Mounted Occupancy Sensors	41% or custom
Fixture Mounted Occupancy Sensors	30% or custom
Wall-Mounted Occupancy Sensors Configured as “Vacancy Sensors”	53% or custom[483]

WHF_e = 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:

$$\Delta kWh_{heatpenalty}{}^{484} = KW_{Controlled} * Hours * ESF * -IFkWh$$

Where:

IFkWh = 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.

480 Ibid

481 Efficiency Vermont TRM 2/19/2010

482 Kuiken, Tammy eta al, State of Wisconsin/Public Service Commission of Wisconsin, Focus on Energy Evaluation, Business Programs, Deemed Savings Manual V1.0, PA Consulting Group and KEMA, March 22, 2010 pp 4-192-194.

483 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%..

484 Negative value because this is an increase in heating consumption due to the efficient lighting.

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$\Delta kW = KW_{controlled} * WHF_d *(CFbaseline - CFos)$

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 the building is un-cooled WHFd is 1.

CFbaseline = 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

CFos = Retrofit Summer Peak Coincidence Factor the lighting system with Occupancy Sensors installed is 0.15 regardless of building type.[485]

NATURAL GAS ENERGY SAVINGS

$\Delta therms = KW_{Controlled} * Hours * ESF * - IFTherms$

Where:

IFTherms = Lighting-HVAC Integration Factor for gas heating impacts; this factor represents the increased gas space heating requirements due to the reduction of waste heat rejected by the efficient lighting and provided in the Reference Table in Section 4.5 by buidling type.

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-LTG-OSLC-V02-140601

[485] 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[486].

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[2].

Loadshape

Loadshape C14 - Indust. 1-shift (8/5) (e.g., comp. air, lights)[487]

Coincidence Factor

The summer peak coincidence factor for this measure is dependent on location.

[486] Equal to the manufacturers standard warranty
[487] 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

$\Delta kWh = kW_f * HOURS * WHFe$

Where:

kW_f = Connected load of the fixture the solar tube replaces

Size of Tube	Average Lumen output for Chicago Illinois (minimum)[488]	Equivalent fixture	kW
21”	9,775 (4,179)	50% 3 x 2 32W lamp CFL (207W, 9915 lumens) 50% 4 lamp F32 w/Elec 4’ T8 (114W, 8895 lumens)	0.161
14”	4,392 (1,887)	50% 2 42W lamp CFL (94W, 4406 lumens) 50% 2 lamp F32 w/Elec 4’ T8 (59W, 4448 lumens)	0.077
10”	2,157 (911)	50% 1 42W lamp CFL (46W, 2203 lumens) 50% 1 lamp F32 w/Elec 4’ T8 (32W, 2224 lumens)	0.039
		AVERAGE	**0.092**

HOURS = Equivalent full load hours

= 2400 [489]

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.

Heating Penalty

If electrically heated building:

$\Delta kWh_{heatpenalty}$[490] $= kW_f * HOURS * -IFkWh$

Where:

IFkWh = 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

488 Solatube Test Report (2005). http://www.mainegreenbuilding.com/files/file/solatube/stb_lumens_datasheet.pdf

489 Ibid. The lumen values presented in the kW table represent the average of the lightest 2400 hours.

490 Negative value because this is an increase in heating consumption due to the efficient lighting.

Miscellaneous value.

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = \Delta kW_f * WHFd * CF$$

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

ΔTherms[491] = ΔkW_f * HOURS *- IFTherms

Where:

IFTherms = Lighting-HVAC Integration Factor for gas heating impacts; this factor represents the increased gas space heating requirements due to the reduction of waste heat rejected by the efficient lighting. Please select from the Reference Table in Section 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

[491] 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 98% Commercial and 2% Residential should be used[492].

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

The measure applies to all commercial T5 installations excluding new construction and substantial renovation or change of use measures (see lighting power density measure). Lookup tables have been provided to account for various installations. Actual existing equipment wattages should be compared to new fixture wattages whenever possible while maintaining lumen equivalent designs. Default new and baseline assumptions are provided if existing equipment cannot be determined. Actual costs and hours of use should be utilized when available. Default component costs and lifetimes have been provided for Operating and Maintenance Calculations. Please see the Definition Table to determine applicability for each program. Configurations not included in the TRM may be included in custom program design using the provided algorithms as long as energy savings is achieved. The following table defines the applicability for different programs:

Time of Sale (TOS)	RETROFIT (RF)
This program applies to installations where customer and location of equipment is not known, or at time of burnout of existing equipment. T5 Lamp/ballast systems have higher lumens per watt than a standard T8 system. The smaller lamp diameter allows for better optical systems, and more precise control of lighting. These characteristics result in light fixtures that produce equal or greater light than standard T8 fixtures, while using fewer watts.	For installations that upgrade installations before the end of their useful life. T5 Lamp/ballast systems have higher lumens per watt than a standard T8 or T12 system. The smaller lamp diameter allows for better optical systems, and more precise control of lighting. These characteristics result in light fixtures that produce equal or greater light than standard T8 or T12 fixtures, while using fewer watts and having longer life.

Definition of Efficient Equipment

The definition of efficient equipment varies based on the program and is defined below:

[492] Based on ComEd's BILD program data from PY5. 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)	Retrofit (RF)
4' fixtures must use a T5 lamp and ballast configuration. 1' and 3' lamps are not eligible. High Performance Troffers must be 85% efficient or greater. T5 HO high bay fixtures must be 3, 4 or 6 lamps and 90% efficient or better.	4' fixtures must use a T5 lamp and ballast configuration. 1' and 3' lamps are not eligible. High Performance Troffers must be 85% efficient or greater. T5 HO high bay fixtures must be 3, 4 or 6 lamps and 90% efficient or better.

DEFINITION OF BASELINE EQUIPMENT

The definition of baseline equipment varies based on the program and is defined below:

Time of Sale (TOS)	Retrofit (RF)
The baseline is T8 with equivalent lumen output. In high-bay applications, the baseline is pulse start metal halide systems.	The baseline is the existing system. For T12 systems, the baseline becomes standard T8 in 2016. Retrofits to T12 systems installed before 2016 have a baseline adjustment applied in 2016 for the remainder of the measure life. Due to new federal standards for linear fluorescent lamps, manufacturers of T12 lamps will not be permitted to manufacture most varieties of T12 lamps for sale in the United States after July 2012. All remaining stock and previously manufactured product may be sold after the July 2012 effective date. If a customer relamps an existing T12 fixture the day the standard takes effect, an assumption can be made that they would likely need to upgrade to, at a minimum, 800-series T8s in less than 5 years' time. This assumes the T12s installed have a typical rated life of 20,000 hours and are operated for 4500 hours annually (average miscellaneous hours 4576/year). Certainly, it is not realistic that everyone would wait until the final moment to relamp with T12s. Also, the exempted T12 lamps greater than 87 CRI will continue to be available to purchase, although they will be expensive. Therefore the more likely scenario would be a gradual shift to T8s over the 4 year timeframe. In other words, we can expect that for each year between 2012 and 2016, ~20% of the existing T12 lighting will change over to T8 lamps that comply with the federal standard. To simplify this assumption, we recommend assuming that standard T8s become the baseline for all T12 linear fluorescent retrofit January 1, 2016. There will be a baseline shift applied to all measures installed before 2016 in 2016 in years remaining in the measure life.. See table C-1.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The deemed lifetime of the efficient equipment fixture, regardless of program type is Fixture lifetime is 15 years[493].

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

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$\Delta kWh = ((Watts_{base} - Watts_{EE})/1000) * Hours * WHF_e * ISR$

Where:

Program	Reference Table
Time of Sale	A-1: T5 New and Baseline Assumptions
Retrofit	A-2: T5 New and Baseline Assumptions

493 15 years from GDS Measure Life Report, June 2007

$Watts_{base}$ = Input wattage of the existing system which depends on the baseline fixture configuration (number and type of lamp) and number of fixtures. Value can be selected from the appropriate reference table as shown below, of a custom value can be entered if the configurations in the tables is not representative of the exisitng system.

$Watts_{EE}$ = New Input wattage of EE fixture which depends on new fixture configuration (number of lamps) and ballast factor and number of fixtures. Value can be selected from the appropriate reference table as shown below, of a custom value can be entered if the configurations in the tables is not representative of the exisitng system.

Program	Reference Table
Time of Sale	A-1: T5 New and Baseline Assumptions
Retrofit	A-2: T5 New and Baseline Assumptions

Hours = Average hours of use per year as provided by the customer or selected from the Reference Table in Section 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%[494] 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:

[494] 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.

Weigted Average 1st year In Service Rate (ISR)	2nd year Installations	3rd year Installations	Final Lifetime In Service Rate
96%[495]	1.1%	0.9%	98.0%[496]

HEATING PENALTY

If electrically heated building:

$$\Delta kWh_{heatpenalty}{}^{497} = (((WattsBase-WattsEE)/1000) * ISR * Hours * -IFkWh$$

Where:

IFkWh = 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.

SUMMER COINCIDENT DEMAND SAVINGS

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

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.

[495] 1st 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

[496] 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.

[497] Negative value because this is an increase in heating consumption due to the efficient lighting.

NATURAL GAS ENERGY SAVINGS

ΔTherms[498] = (((WattsBase-WattsEE)/1000) * ISR * Hours *- IFTherms

Where:

IFTherms = Lighting-HVAC Integration Factor for gas heating impacts; this factor represents the increased gas space heating requirements due to the reduction of waste heat rejected by the efficient lighting. This value is selected from the Reference Table in Section 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

Program	Reference Table
Time of Sale	B-1: T5 Component Costs and Lifetime
Retrofit	B-2: T5 Component Costs and Lifetime

REFERENCE TABLES

See following page

[498] Negative value because this is an increase in heating consumption due to the efficient lighting.

A-1: Time of Sale: T5 New and Baseline Assumptions[499]

EE Measure Description	EE Cost	$Watts_{EE}$	Baseline Description	Base Cost	$Watts_{BASE}$	Measure Cost	$Watts_{SAVE}$
2-Lamp T5 High-Bay	$200.00	180	200 Watt Pulse Start Metal-Halide	$100.00	232	$100.00	52
3-Lamp T5 High-Bay	$200.00	180	200 Watt Pulse Start Metal-Halide	$100.00	232	$100.00	52
4-Lamp T5 High-Bay	$225.00	240	320 Watt Pulse Start Metal-Halide	$125.00	350	$100.00	110
6-Lamp T5 High-Bay	$250.00	360	Proportionally Adjusted according to 6-Lamp HPT8 Equivalent to 320 PSMH	$150.00	476	$100.00	116
1-Lamp T5 Troffer/Wrap	$100.00	32	Proportionally adjusted according to 2-Lamp T5 Equivalent to 3-Lamp T8	$60.00	44	$40.00	12
2-Lamp T5 Troffer/Wrap	$100.00	64	3-Lamp F32T8 Equivalent w/ Elec. Ballast	$60.00	88	$40.00	24
1-Lamp T5 Industrial/Strip	$70.00	32	Proportionally adjusted according to 2-Lamp T5 Equivalent to 3-Lamp T8	$40.00	44	$30.00	12
2-Lamp T5 Industrial/Strip	$70.00	64	3-Lamp F32T8 Equivalent w/ Elec. Ballast	$40.00	88	$30.00	24
3-Lamp T5 Industrial/Strip	$70.00	96	Proportionally adjusted according to 2-Lamp T5 Equivalent to 3-Lamp T8	$40.00	132	$30.00	36
4-Lamp T5 Industrial/Strip	$70.00	128	Proportionally adjusted according to 2-Lamp T5 Equivalent to 3-Lamp T8	$40.00	178	$30.00	50
1-Lamp T5 Indirect	$175.00	32	Proportionally adjusted according to 2-Lamp T5 Equivalent to 3-Lamp T8	$145.00	44	$30.00	12
2-Lamp T5 Indirect	$175.00	64	3-Lamp F32T8 Equivalent w/ Elec. Ballast	$145.00	88	$30.00	24

[499] Adapted from Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, October 26, 2011.

A-2: Retrofit T5 New and Baseline Assumptions[500]

EE Measure Description	EE Cost	$Watts_{EE}$
3-Lamp T5 High-Bay	$ 200	180
4-Lamp T5 High-Bay	$ 225	240
6-Lamp T5 High-Bay	$ 250	360
1-Lamp T5 Troffer/Wrap	$ 100	32
2-Lamp T5 Troffer/Wrap	$ 100	64
1-Lamp T5 Industrial/Strip	$ 70	32
2-Lamp T5 Industrial/Strip	$ 70	64
3-Lamp T5 Industrial/Strip	$ 70	96
4-Lamp T5 Industrial/Strip	$ 70	128
1-Lamp T5 Indirect	$ 175	32
2-Lamp T5 Indirect	$ 175	64

Baseline Description	$Watts_{BASE}$
200 Watt Pulse Start Metal-Halide	232
250 Watt Metal-Halide	295
320 Watt Pulse Start Metal-Halide	350
400 Watt Metal halide	455
400 Watt Pulse Start Metal-halide	476
1-Lamp F34T12 w/ EEMag Ballast	40
2-Lamp F34T12 w/ EEMag Ballast	68
3-Lamp F34T12 w/ EEMag Ballast	110
4-Lamp F34T12 w/ EEMag Ballast	139
1-Lamp F40T12 w/ EEMag Ballast	48
2-Lamp F40T12 w/ EEMag Ballast	82
3-Lamp F40T12 w/ EEMag Ballast	122
4-Lamp F40T12 w/ EEMag Ballast	164
1-Lamp F40T12 w/ Mag Ballast	57
2-Lamp F40T12 w/ Mag Ballast	94
3-Lamp F40T12 w/ Mag Ballast	147
4-Lamp F40T12 w/ Mag Ballast	182
1-Lamp F32 T8	32
2-Lamp F32 T8	59
3-Lamp F32 T18	88
4-Lamp F32 T8	114

[500] Ibid.

B-1: Time of Sale T5 Component Costs and Lifetime[501]

EE Measure Description	EE Lamp Cost	EE Lamp Life (hrs)	EE Lamp Rep. Labor Cost per lamp	EE Ballast Cost	EE Ballast Life (hrs)	EE Ballast Rep. Labor Cost	Baseline Description	# Base Lamps	Base Lamp Cost	Base Lamp Life (hrs)	Base Lamp Rep. Labor Cost	# Base Ballasts	Base Ballast Cost	Base Ballast Life (hrs)	Base Ballast Rep. Labor Cost
3-Lamp T5 High-Bay	$12.00	20000	$6.67	$52.00	70000	$22.50	200 Watt Pulse Start Metal-Halide	1.00	$21.00	10000	$6.67	1.00	$87.75	40000	$22.50
4-Lamp T5 High-Bay	$12.00	20000	$6.67	$52.00	70000	$22.50	320 Watt Pulse Start Metal-Halide	1.00	$21.00	20000	$6.67	1.00	$109.35	40000	$22.50
6-Lamp T5 High-Bay	$12.00	20000	$6.67	$52.00	70000	$22.50	Adjusted according to 6-Lamp HPT8 Equivalent to 320	1.36	$21.00	20000	$6.67	1.50	$109.35	40000	$22.50
1-Lamp T5 Troffer/Wrap	$12.00	20000	$2.67	$52.00	70000	$15.00	Proportionally adjusted according to 2-Lamp T5 Equivalent to 3-Lamp T8	1.50	$2.50	20000	$2.67	0.50	$15.00	70000	$15.00
2-Lamp T5 Troffer/Wrap	$12.00	20000	$2.67	$52.00	70000	$15.00	3-Lamp F32T8 Equivalent w/ Elec. Ballast	3.00	$2.50	20000	$2.67	1.00	$15.00	70000	$15.00
1-Lamp T5 Industrial/Strip	$12.00	20000	$2.67	$52.00	70000	$15.00	Proportionally adjusted according to 2-Lamp T5 Equivalent to 3-Lamp T8	1.50	$2.50	20000	$2.67	0.50	$15.00	70000	$15.00
2-Lamp T5 Industrial/Strip	$12.00	20000	$2.67	$52.00	70000	$15.00	3-Lamp F32T8 Equivalent w/ Elec. Ballast	3.00	$2.50	20000	$2.67	1.00	$15.00	70000	$15.00
3-Lamp T5 Industrial/Strip	$12.00	20000	$2.67	$52.00	70000	$15.00	Proportionally adjusted according to 2-Lamp T5 Equivalent	4.50	$2.50	20000	$2.67	1.50	$15.00	70000	$15.00
4-Lamp T5 Industrial/Strip	$12.00	20000	$2.67	$52.00	70000	$15.00	Proportionally adjusted according to 2-Lamp T5 Equivalent to 3-Lamp T8	6.00	$2.50	20000	$2.67	2.00	$15.00	70000	$15.00
1-Lamp T5 Indirect	$12.00	20000	$2.67	$52.00	70000	$15.00	Proportionally adjusted according to 2-Lamp T5 Equivalent to 3-Lamp T8	1.50	$2.50	20000	$2.67	0.50	$15.00	70000	$15.00
2-Lamp T5 Indirect	$12.00	20000	$2.67	$52.00	70000	$15.00	3-Lamp F32T8 Equivalent w/ Elec. Ballast	3.00	$2.50	20000	$2.67	1.00	$15.00	70000	$15.00

[501] Adapted from Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, October 26, 2011.

B-2: T5 Retrofit Component Costs and Lifetime[502]

EE Measure Description	EE Lamp Cost	EE Lamp Life (hrs)	EE Lamp Rep. Labor Cost per lamp	EE Ballast Cost	EE Ballast Life (hrs)	EE Ballast Rep. Labor Cost	Baseline Description	# Base Lamps	Base Lamp Cost	Base Lamp Life (hrs)	Base Lamp Rep. Labor Cost	# Base Ballasts	Base Ballast Cost	Base Ballast Life (hrs)	Base Ballast Rep. Labor Cost
3-Lamp T5 High-Bay	$12.00	20000	$6.67	$52.00	70000	$22.50	200 Watt Pulse Start Metal-Halide	1.00	$21.00	10000	$6.67	1.00	$ 88	40000	$22.50
							250 Watt Metal Halide	1.00	$21.00	10000	$6.67	1.00	$ 92	40000	$22.50
4-Lamp T5 High-Bay	$12.00	20000	$6.67	$52.00	70000	$22.50	320 Watt Pulse Start Metal-Halide	1.00	$72.00	20000	$6.67	1.00	$ 109	40000	$22.50
							400 Watt Metal Halide	1.00	$17.00	20000	$6.67	1.00	$ 114	40000	$22.50
6-Lamp T5 High-Bay	$12.00	20000	$6.67	$52.00	70000	$22.50	Proportionally Adjusted according to 6-Lamp HPT8 Equivalent to 320 PSMH	1.36	$72.00	20000	$6.67	1.50	$ 109	40000	$22.50
1-Lamp T5 Troffer/Wrap	$12.00	20000	$2.67	$52.00	70000	$15.00	Proportionally adjusted according to 2-Lamp T5 Equivalent to 3-Lamp T8	1.50	$2.50	20000	$2.67	0.50	$ 15	70000	$15.00
2-Lamp T5 Troffer/Wrap	$12.00	20000	$2.67	$52.00	70000	$15.00	3-Lamp F32T8 Equivalent w/ Elec. Ballast	3.00	$2.50	20000	$2.67	1.00	$ 15	70000	$15.00
1-Lamp T5 Industrial/Strip	$12.00	20000	$2.67	$52.00	70000	$15.00	Proportionally adjusted according to 2-Lamp T5 Equivalent to 3-Lamp T8	1.50	$2.50	20000	$2.67	0.50	$ 15	70000	$15.00
2-Lamp T5 Industrial/Strip	$12.00	20000	$2.67	$52.00	70000	$15.00	3-Lamp F32T8 Equivalent w/ Elec. Ballast	3.00	$2.50	20000	$2.67	1.00	$ 15	70000	$15.00
3-Lamp T5 Industrial/Strip	$12.00	20000	$2.67	$52.00	70000	$15.00	Proportionally adjusted according to 2-Lamp T5 Equivalent to 3-Lamp T8	4.50	$2.50	20000	$2.67	1.50	$ 15	70000	$15.00
4-Lamp T5 Industrial/Strip	$12.00	20000	$2.67	$52.00	70000	$15.00	Proportionally adjusted according to 2-Lamp T5 Equivalent to 3-Lamp T8	6.00	$2.50	20000	$2.67	2.00	$ 15	70000	$15.00
1-Lamp T5 Indirect	$12.00	20000	$2.67	$52.00	70000	$15.00	Proportionally adjusted according to 2-Lamp T5 Equivalent to 3-Lamp T8	1.50	$2.50	20000	$2.67	0.50	$ 15	70000	$15.00
2-Lamp T5 Indirect	$12.00	20000	$2.67	$52.00	70000	$15.00	3-Lamp F32T8 Equivalent w/ Elec. Ballast	3.00	$2.50	20000	$2.67	1.00	$ 15	70000	$15.00

502 Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, October 26, 2011
EPE Program Downloads. Web accessed http://www.epelectricefficiency.com/downloads.asp?section=ci download Copy of LSF_2012_v4.04_250rows.xls.
Kuiken et al, Focus on Energy Evaluation. Business Programs: Deemed Savings Manual v1.0, Kema, march 22, 2010 available at http://www.focusonenergy.com/files/Document_Management_System/Evaluation/bpdeemedsavingsmanuav10_evaluationreport.pdf

C-1: T12 Baseline Adjustment:

Savings Adjustment Factors

	watts	Equivalent T12 watts adjusted for lumen equivalency-34 w and 40 w with EEMag ballast	Equivalent T12 watts adjusted for lumen equivalency-40 w with EEMag ballast	Equivalent T12 watts adjusted for lumen equivalency-40 w with Mag ballast	Prportionally Adjusted for Lumens wattage for T8 equivalent
1-Lamp T5 Industrial/Strip	32	61	73	82	44
2-Lamp T5 Industrial/Strip	64	103	125	135	88
3-Lamp T5 Industrial/Strip	96	167	185	211	132
4-Lamp T5 Industrial/Strip	128	211	249	226	178
		Savings Factor Adjustment to the T8 baseline	Savings Factor Adjustment to the T8 baseline	Savings Factor Adjustment to the T8 baseline	
1-Lamp T5 Industrial/Strip		42%	29%	24%	
2-Lamp T5 Industrial/Strip		61%	40%	34%	
3-Lamp T5 Industrial/Strip		51%	40%	31%	
4-Lamp T5 Industrial/Strip		60%	41%	51%	

Measures installed in 2012 will claim full savings for four years, 2013 for three years, 2014 two years and 2015 one year. Savings adjustment factors based on a T8 baseline will be applied to the full savings for savings starting in 2016 and for the remainder of the measure life. The adjustment to be applied for each measure is listed in the reference table above and is based on equivalent lumens.

MEASURE CODE: CI-LTG-T5FX-V02-140601

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[503].

Deemed Measure Cost

When available, the actual cost of the measure shall be used. When not available, the assumed measure cost is $274[504].

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)

[503] DEER 2008.
[504] Consistent with the Multi-level Fixture measure with reference to Goldberg et al, State of Wisconsin Public Service Commission of Wisconsin, Focus on Energy Evaluation, Business Programs: Incremental Cost Study, KEMA, October 28, 2009. Also consistent with field experience of about $250 per fixture and $25 install labor.

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

$$\Delta kWh = (KW_{Baseline} - (KW_{Controlled} * (1 - ESF))) * Hours * WHF_e$$

Where:

$KW_{Baseline}$ = Total baseline lighting load of the existing/baseline fixture

= Actual

Note that if the existing fixture is only being retrofit with bi-level occpuancy controls and not being replaced $KW_{Baseline}$ will equal $KW_{Controlled}$.

$KW_{Controlled}$ = Total contolled lighting load at full light output of the new bi-level fixture

= Actual

Hours = Number of hours lighting is on. This measure is limited to 24/7 operation.

= 8,766

ESF = Energy Savings factor (represents the percentage reduction to the $KW_{Controlled}$ due to the occupancy control).

= % Standby Mode * (1 - % Full Light at Standby Mode)

% Standby Mode = Represents the percentage of the time the fixture is operating in standby (i.e. low-wattage) mode.

% Full Light at Standby Mode = 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.

= 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:

Application	% Standby Mode	% Full Light at Standby Mode	Energy Savings Factor (ESF)
Stairwells	78.5%[505]	50%	39.3%
		33%	52.6%
		10%	70.7%
		5%	74.6%
Corridors	50.0%[506]	50%	25.0%
		33%	33.5%
		10%	45.0%
		5%	47.5%
Other 24/7 Space Type	50.0%[507]	50%	25.0%
		33%	33.5%
		10%	45.0%
		5%	47.5%

WHF_e = 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:

$$\Delta kWh_{heatpenalty}{}^{508} = (KW_{Baseline} - (KW_{Controlled} * (1 - ESF))) * Hours * -IFkWh$$

Where:

IFkWh = 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.

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = (KW_{Baseline} - (KW_{Controlled} * (1 - ESF))) * WHF_d * (CF_{baseline} - CF_{os})$$

[505] 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

[506] Value determined from the Pacific Gas and Electric Company: Bi-Level Lighting Control Credits study for Interior Corridors of Hotels, Motels and High Rise Residential. http://www.energy.ca.gov/title24/2005standards/archive/documents/2002-07-18_workshop/2002-07-18_BILEVEL_LIGHTING.PDF

[507] Conservative estimate.

[508] Negative value because this is an increase in heating consumption due to the efficient lighting.

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 the building is un-cooled WHFd is 1.

$CF_{baseline}$ = 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_{os} = Retrofit Summer Peak Coincidence Factor the lighting system with Occupancy Sensors installed is 0.15 regardless of building type.[509]

NATURAL GAS HEATING PENALTY

If natural gas heating:

$$\Delta therms = (KW_{Baseline} - (KW_{Controlled} * (1 - ESF))) * Hours * - IFTherms$$

Where:

IFTherms = Lighting-HVAC Integration Factor for gas heating impacts; this factor represents the increased gas space heating requirements due to the reduction of waste heat rejected by the efficient lighting and provided in the Reference Table in Section 4.5 by buidling type.

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-LTG-OCBL-V01-140601

[509] 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.

4.6 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.[510]

Deemed Measure Cost

The deem measure cost is $156.82 for a walk-in cooler or freezer.[511]

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

[510] Source: DEER 2008
[511] Ibid.

Cooler or Freezer Doors. Savings are averaged across all California climate zones and vintages[512].

Annual Savings	kWh
Walk in Cooler	943 kWh
Walk in Freezer	2307 kWh

Summer Coincident Peak Demand Savings

Annual Savings	kW
Walk in Cooler	0.137 kW
Walk in Freezer	0.309 kW

Natural Gas Energy Savings

N/A

Water Impact Descriptions and Calculation

N/A

Deemed O&M Cost Adjustment Calculation

N/A

Measure Code: CI-RFG-ATDC-V01-120601

[512] Measure savings from ComEd TRM developed by KEMA. June 1, 2010

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 [513].

Deemed Measure Cost

The actual measure installation cost should be used (including material and labor), but the following can be assumed for analysis purposes[514]:

Refrigerated Vending Machine and Glass Front Cooler: $180.00

Non-Refrigerated Vending Machine: $80.00

Loadshape

Loadshape C52 - Beverage and Snack Machine Controls

[513] Measure Life Study, prepared for the Massachusetts Joint Utilities, Energy & Resource Solutions, November 2005.
[514] ComEd workpapers, 8—15-11.pdf

Coincidence Factor

The summer peak coincidence factor for this measure is assumed to be 0[515].

Algorithm

Calculation of Savings

Electric Energy Savings

ΔkWh = WATTSbase / 1000 * HOURS * ESF

Where:

WATTSbase = connected W of the controlled equipment; see table below for default values by connected equipment type:

Equipment Type	WATTSbase[516]
Refrigerated Beverage Vending Machines	400
Non-Refrigerated Snack Vending Machines	85
Glass Front Refrigerated Coolers	460

1000 = conversion factor (W/kW)

HOURS = operating hours of the connected equipment; assumed that the equipment operates 24 hours per day, 365.25 days per year

= 8766

ESF = Energy Savings Factor; represents the percent reduction in annual kWh consumption of the equipment controlled; see table below for default values:

Equipment Type	Energy Savings Factor (ESF)[517]
Refrigerated Beverage Vending Machines	46%
Non-Refrigerated Snack Vending Machines	46%
Glass Front Refrigerated Coolers	30%

515 Assumed that the peak period is coincident with periods of high traffic diminishing the demand reduction potential of occupancy based controls.
516 USA Technologies Energy Management Product Sheets, July 2006; cited September 2009. <http:// http://www.usatech.com/energy_management/energy_productsheets.php>
517 Ibid.

EXAMPLE

For example, adding controls to a refrigerated beverage vending machine:

$$\Delta kWh = WATTSbase / 1000 * HOURS * ESF$$

$$=400/1000* 8766* .46 = 1.6 \text{ kWh}$$

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: CI-RFG-BEVM-V01-120601

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 [518].

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[519].

Loadshape

Loadshape C51 - Door Heater Control

Coincidence Factor[520]

The summer peak coincidence factor for this measure is assumed to be 0%[521].

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[518] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Effective/Remaining Useful Life Values", California Public Utilities Commission, December 16, 2008.
[519] Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010
[520] Source partial list from DEER 2008
[521] Based on the assumption that humidity levels will most likely be relatively high during the peak period, reducing

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

ΔkWH = kWbase * NUMdoors * ESF * BF *8760

Where:

kWbase[522] = 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[523] = 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[524] = 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.

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the likelihood of demand savings from door heater controls.

[522] 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.

[523] 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.

[524] Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010

Definition	Representative Evaporator Temperature Range, °F[525]	Typical Uses	BF
Low	-35 to 0	Freezers for times such as frozen pizza, ice cream, etc.	1.36
Medium	0 – 20	Coolers for items such as meat, milk, dairy, etc	1.22
High	20 – 45	Coolers for items such as floral, produce and meat preperation rooms	1.15

8760 = annual hours of operation

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

[525] Energy Efficiency Supermarket Refrigeration, Wisconsin Electric Power Company, July 23, 1993

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[526]

Deemed Measure Cost

The measure cost is assumed to be $50 for a walk in cooler and walk in freezer. [527]

Loadshape

Loadshape C22 - Commercial Refrigeration

Coincidence Factor

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

Algorithm

Calculation of Savings [528]

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

[526] DEER
[527] Act on Energy Commercial Technical Reference Manual No. 2010-4
[528] "Efficient Evaporator Fan Motors (Shaded Pole to ECM)," Workpaper WPSCNRRN0011. Southern California Edison Company. 2007.

into consideration temperature, compressor efficiency, and various loads involved for both walk-in and reach-in refrigerators. Details on cooling load calculations, including refrigeration conditions, can be found in the SCE workpaper. The baseline for this measure assumes that the refrigeration unit has a shaded-pole motor. The following tables are values calculated within the SCE workpaper.

Table 156 SCE Restaurant Savings Walk-In

	Restaurant			
SCE Workpaper Values	Cooler		Freezer	
Northern California Climate Zones	kWh Savings Per Motor	Peak kW Savings Per Motor	kWh Savings Per Motor	Peak kW Savings Per Motor
1	318	0.0286	507	0.03
2	253	0.033	263	0.037
3	364	0.0315	649	0.034
4	365	0.0313	652	0.034
5	350	0.0305	605	0.033
11	410	0.0351	780	0.04
12	399	0.034	748	0.039
13	407	0.0342	771	0.039
16	354	0.0315	620	0.034
Average	358	0.0322	622	0.036

Table 157: SCE Grocery Savings Walk-In

	Grocery			
SCE Workpaper Values	Cooler		Freezer	
Northern California Climate Zones	kWh Savings Per Motor	Peak kW Savings Per Motor	kWh Savings Per Motor	Peak kW Savings Per Motor
1	318	0.0284	438	0.03
2	252	0.0534	263	0.064
3	364	0.0486	552	0.056
4	365	0.048	553	0.055
5	349	0.0452	516	0.051
11	410	0.0601	656	0.074
12	398	0.0566	631	0.069
13	406	0.0574	649	0.07
16	354	0.0486	528	0.056
Average	357	0.0496	532	0.058

Table 158: SCE Grocery Savings Reach-In

	Grocery			
SCE Workpaper Values	Cooler		Freezer	
Northern California Climate Zones	kWh Savings Per Motor	Peak kW Savings Per Motor	kWh Savings Per Motor	Peak kW Savings Per Motor
1	306	0.031	362	0.031
2	269	0.033	273	0.035
3	331	0.032	421	0.034
4	332	0.032	422	0.034
5	323	0.032	402	0.033
11	357	0.034	476	0.037
12	350	0.034	462	0.036
13	355	0.034	472	0.037
16	325	0.032	409	0.034
Average	328	0.033	411	0.035

Savings values in the following table are an average of walk-in cooler (80 percent) and freezer (20 percent) applications. The workpapers for the 2006-2008 program years include this distribution of coolers and freezers in their refrigeration measure savings analyses.

Electric Energy Savings

The following table provides the kWh savings.

Building type	kWh Savings/ft
Restaurant	411
Grocery	392
Average	401

Summer Coincident Peak Demand Savings

The following table provides the kW savings

Building Type	Peak kW Savings/motor
Restaurant	0.033
Grocery	0.051
Average	0.042

NATURAL GAS ENERGY SAVINGS

N/A

Water Impact Descriptions and Calculation

N/A

Deemed O&M Cost Adjustment Calculation

N/A

Measure Code: CI-RFG-ECMF-V01-120601

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[529]

Deemed Measure Cost

The incremental cost of this measure is $500[530]

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.

[529] ENERGY STAR
[530] ENERGY STAR

ELECTRIC ENERGY SAVINGS

ENERGY STAR Vending Machine Savings[531]

Vending Machine Capacity (cans)	kWh Savings Per Machine w/o software	kWh Savings Per Machine w/ software
<500	1,099	1,659
500	1,754	2,231
699	1,242	1,751
799	1,741	2,283
800+	713	1,288
Average	1,310	1,842

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-RFG-ESVE-V01-120601

[531] Savings from Vending Machine Calculator: http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=VMC

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[532]

DEEMED MEASURE COST

The measure cost is assumed to be $291[533]

LOADSHAPE

Loadshape C46 - Evaporator Fan Control

COINCIDENCE FACTOR

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

[532] Source: DEER
[533] Source: DEER

Algorithm

CALCULATION OF SAVINGS

Savings for this measure were obtained from the DEER database and are summarized in the following table. The baseline is assumed to be evaporator fans that run continuously with either a permanent split capacitor or shaded-pole motors. In the energy-efficient case the fan is still assumed to operate even with the evaporator inactive[534].

ELECTRIC ENERGY SAVINGS

DEER provides savings numbers for building vintages and grocery only. The numbers above are averages of these vintages. We are assuming that this measure will be applicable for all building types

The following table provides the kWh savings

Northern California Climate Zones	kWh Savings Per Motor
1	480
2	476
3	479
4	475
5	477
11	476
12	476
13	476
16	483
Average	478

[534] 2005 Database for Energy Efficiency Resources (DEER) Update Study Final Report

Summer Coincident Peak Demand Savings

The following table provides the kW savings

Northern California Climate Zones	Peak kW Savings Per Motor
1	0.057
2	0.064
3	0.062
4	0.061
5	0.056
11	0.058
12	0.065
13	0.061
16	0.061
Average	0.06

NATURAL GAS ENERGY SAVINGS

N/A

Water Impact Descriptions and Calculation

N/A

Deemed O&M Cost Adjustment Calculation

N/A

Measure Code: CI-RFG-EVPF-V01-120601

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[535].

Deemed Measure Cost

The incremental capital cost for this measure is $286.16 [536]

Loadshape

Loadshape C22 - Commercial Refrigeration

Coincidence Factor

The summer peak coincidence factor for this measure is 100%[537].

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[535] M. Goldberg, J. Ryan Barry, B. Dunn, M. Ackley, J. Robinson, and D. Deangelo-Woolsey, KEMA. "Focus on Energy: Business Programs – Measure Life Study", August 2009.

[536] 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

[537] 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.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS[538]

ΔkWh = 2,974 per freezer with curtains installed

= 422 per cooler with curtains installed

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ΔkWh / 8760 * CF

= 0.35 for freezers

= 0.05 for coolers

Where:

8766 = hours per year

CF = Summer Peak Coincidence Factor for the measure

= 1.0

NATURAL GAS ENERGY SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-RFG-CRTN-V02-130601

[538] 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 measures 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[539].

DEEMED MEASURE COST

The installation cost for an economizer is $2,558.[540]

LOADSHAPE

Loadshape C22 - Commercial Refrigeration

COINCIDENCE FACTOR

The summer peak coincidence factor for this measure is assumed to be 0%[541].

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS

Electric energy savings is calculated based on whether evaporator fans run all

[539] Estimated life from Efficiency Vermont TRM
[540] Based on average of costs from Freeaire, Natural Cool, and Cooltrol economizer systems.
[541] Based on the assumption that humidity levels will most likely be relatively high during the peak period, reducing the likelihood of demand savings.

With Fan Control Installed

ΔkWh = [HP x kWhCond] + [((kWEvap x nFans) – kWCirc) x Hours x DCComp x BF] – [kWEcon x DCEcon x Hours]

Without Fan Control Installed

ΔkWh = [HP x kWhCond] – [kWEcon x DCEcon x Hours]

Where:

HP = Horsepower of Compressor
= actual installed

kWhCond = Condensing unit savings, per hp. (value from savings table) [542]

	Hermetic/ Semi-Hermetic	Scroll	Discus
kWh / HP	1,256	1,108	1,051

Hours = Number of annual hours that economizer operates [543].

Region (city)	Hours
1 (Rockford)	2,376
2 (Chicago/O'Hare)	1,968
3 (Springfield)	1,728
4 (Belleview)	1,488
5 (Marion)	1,224

DCComp = Duty cycle of the compressor
= 50% [544]

kWEvap = Connected load kW of each evaporator fan,
= If known, actual installed. Otherwise assume 0.123 kW[545]

kWCirc = Connected load kW of the circulating fan

[542] 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

[543] 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).

[544] 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)

[545] Based on an a weighted average of 80% shaded pole motors at 132 watts and 20% PSC motors at 88 watts

= If known, actual installed. Otherwise assume 0.035 kW[546]

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%[547]

BF = Bonus factor for reduced cooling load from running the evaporator fan less or (1.3)[548]

kWEcon = Connected load kW of the economizer fan
= If known, actual installed. Otherwise assume 0.227 kW.[549]

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:

ΔkWh = [HP * kWhCond] + [((kWEvap ´*nFans)) * Hours ´*DCComp * BF] – [kWEcon * DCEcon * Hours]

= [5 * 1256] + [((0.123 ´*3)) * 2376 ´*0.5 * 1.3] – [0.227 * .63 * 2376]

= 6510 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ΔkWh / Hours

NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-RFG-ECON-V04-140601

[546] 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
[547] Average of two manufacturer estimates of 50% and 75%.
[548] 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
[549] 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).

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

$IncrementalCost (\$) = (127 \times hp_{compressor}) + 1446$

Where:

127 and 1446[550] = compressor motor nominal hp to incremental cost conversion factor and offset

$hp_{compressor}$ = compressor motor nominal

DEEMED O&M COST ADJUSTMENTS

N/A

[550] Conversion factor and offset based on a linear regression analysis of the relationship between air compressor motor nominal horsepower and incremental cost. Several Vermont vendors were surveyed to determine the cost of equipment. See "Compressed Air Analysis.xls" and "Compiled Data ReQuest Results.xls" for incremental cost details.

LOADSHAPE

Loadshape C35 - Industrial Process

COINCIDENCE FACTOR

The coincidence factor equals 0.95

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$\Delta kWh = 0.9 \times hp_{compressor} \times HOURS \times (CF_b - CF_e)$

Where:

ΔkWh = gross customer annual kWh savings for the measure

$hp_{compressor}$ = compressor motor nominal hp

0.9[551] = compressor motor nominal hp to full load kW conversion factor

HOURS = compressor total hours of operation below depending on shift

Shift	Hours
Single shift (8/5)	1976 hours 7 AM – 3 PM, weekdays, minus some holidays and scheduled down time
2-shift (16/5)	3952 hours 7AM – 11 PM, weekdays, minus some holidays and scheduled down time
3-shift (24/5)	5928 hours 24 hours per day, weekdays, minus some holidays and scheduled down time
4-shift (24/7)	8320 hours 24 hours per day, 7 days a week minus some holidays and scheduled down time

CF_b = baseline compressor factor[552]

[551] 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".
[552] Compressor factors were developed using DOE part load data for different compressor control types as well as load profiles from 50 facilities employing air compressors less than or equal to 40 hp. "See "BHP Weighted Compressed Air Load Profiles.xls" for source data and calculations (The "variable speed drive" compressor factor

=0.890

CF_e = efficient compressor [553]

=0.705

EXAMPLE

For example a VFD compressor with 10 HP operating in a 1 shift facility would save

ΔkWh = 0.9 x 10 x 1976 x (0.890 – 0.705)

= 3290 kWh

Summer Coincident Peak Demand Savings

ΔkW = ΔkWh / HOURS * CF

EXAMPLE

For example a VFD compressor with 10 HP operating in a 1 shift facility would save

ΔkW = 3290/1976*.95

= 1.58 kW

Natural Gas Energy Savings

N/A

Water Impact Descriptions and Calculation

N/A

Deemed O&M Cost Adjustment Calculation

N/A

Measure Code: CI-MSC-VSDA-V01-120601

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).

[553] Ibid.

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[554]

Loadshape

Loadshape C35 - Industrial Process

Coincidence Factor

The coincidence factor equals 0.95

Algorithm

Calculation of Savings

Electric Energy Savings

$\Delta kWh = (kW_{typical} \times \Delta P \times SF \times Hours / HP_{typical}) \times HP_{real}$

Where:

$kW_{typical}$ = Adjusted compressor power (kW) based on typical compressor loading and operating profile.

[554] Incremental cost research found in LPDF Costs. xlsx

Use Use actual compressor control type if known:

Compressor $kW_{typical}$

Control Type	$kW_{typical}$ [555]
Reciprocating - On/off Control	70.2
Reciprocating - Load/Unload	74.8
Screw - Load/Unload	82.3
Screw - Inlet Modulation	82.5
Screw - Inlet Modulation w/ Unloading	82.5
Screw - Variable Displacement	73.2
Screw - VFD	70.8

= If the actual compressor control type is not known, then use a weighted average based on the following market assumptions:

Control Type	Share %	$kW_{typical}$ [556]
Market share estimation for load/unload control compressors	40%	74.8
Market share estimation for modulation w/unloading control compressors	40%	82.5
Market share estimation for variable displacement control compressors	20%	73.2
	Weighted Average	77.6

ΔP = Reduced filter loss (psi) =2 psi[557]

SF =1% 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[558]

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 (7AM – 11 PM, weekdays, minus some holidays and scheduled down time) + 500 hrs maintenance = 4452 hrs

555 See "Industrial System Standard Deemed Saving Analysis.xls"
556 See "Industrial System Standard Deemed Saving Analysis.xls"
557 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
558 "Optimizing pneumatic systems for extra savings," 10, 2010, http://www.compressedairchallenge.org/library/articles/2010-10-CABP.pdf

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)

$HP_{typical}$ = Nominal HP for typical compressor = 100 hp[559]

HP_{real} = Total HP of real compressors distibuting air through filter. This should include the total horsepower of the compressors that normally run through the filter, but not backup compressors

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ΔkWh / HOURS * 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

559 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 [560]

Loadshape

Loadshape C35 - Industrial Process

Coincidence Factor

The coincidence factor equals 0.95

Algorithm

Calculation of Savings

Electric Energy Savings

$\Delta kWh = CFM_{reduced} \times kW_{CFM} \times Hours$

Where:

[560] Based on empirical project data from ComEd Comprehensive Compressed Air Study program and VEIC review of pricing data found in CAS Cost Data.xls

$CFM_{reduced}$ = Reduced air consumption (CFM) per drain = 3 CFM[561]

kW_{CFM}= System power reduction per reduced air demand (kw/CFM) depending on the type of compressor control:

System Power Reduction per Reduced Air Demand[562]

Control Type	kW / CFM
Reciprocating - On/off Control	0.184
Reciprocating - Load/Unload	0.136
Screw - Load/Unload	0.152
Screw - Inlet Modulation	0.055
Screw - Inlet Modulation w/ Unloading	0.055
Screw - Variable Displacement	0.153
Screw - VFD	0.178

Or if compressor control type is unknow, then a weighted average based on market share can be used:

Control Type	Share %	*kW / CFM*
Market share estimation for load/unload control compressors	40%	*0.136*
Market share estimation for modulation w/unloading control compressors	40%	*0.055*
Market share estimation for variable displacement control compressors	20%	*0.153*
Weighted Average		*0.107*

Hours = Compressed air system pressurized hours =6136 hours[563]

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ΔkWh / HOURS * CF

NATURAL GAS ENERGY SAVINGS

N/A

561 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”

562 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”

563 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

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[564] 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[565].

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure life is assumed to be 9 years[566].

DEEMED MEASURE COST

The incremental cost for this measure is $70.[567]

---

[564] Measured according to the latest ANSI/AHAM AC-1 (AC-1) Standard

[565] 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.

[566] ENERGY STAR Qualified Room Air Cleaner Calculator, http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorRoomAirCleaner.xls?8ed7-275b.

Loadshape

Loadshape C53 - Flat

Coincidence Factor

The summer peak coincidence factor for this measure is assumed to be 100 % (the unit is assumed to be always on).

Algorithm

Calculation of Savings

Electric Energy Savings

$$\Delta kWh = kWh_{Base} - kWh_{ESTAR}$$

Where:

kWh_{BASE} = Baseline kWh consumption per year[568]

= see table below

kWh_{ESTAR} = ENERGY STAR kWh consumption per year[569]

= see table below

Clean Air Delivery Rate	Baseline Unit Energy Consumption (kWh/year)	ENERGY STAR Unit Energy Consumption (kWh/year)	ΔkWH
CADR 51-100	596	329	268
CADR 101-150	1,072	548	525
CADR 151-200	1,480	767	714
CADR 201-250	1,887	986	902
CADR Over 250	1,641	1205	437

Summer Coincident Peak Demand Savings

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

[567] Ibid

[568] ENERGY STAR Qualified Room Air Cleaner Calculator, http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorRoomAirCleaner.xls?8ed7-275b

[569] Ibid.

Where:

ΔkWh = Gross customer annual kWh savings for the measure

Hours = Average hours of use per year

= 8766 hours[570]

CF = Summer Peak Coincidence Factor for measure

= 1.0

Clean Air Delivery Rate	ΔkW
CADR 51-100	0.031
CADR 101-150	0.060
CADR 151-200	0.081
CADR 201-250	0.103
CADR Over 250	0.050

NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

There are no operation and maintenance cost adjustments for this measure.[571]

MEASURE CODE: RS-APL-ESAP-V01-120601

[570] Consistent with ENERGY STAR Qualified Room Air Cleaner Calculator.
[571] 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 CEE Tier 2 and 3 Clothes Washers

Description

This measure relates to the installation of a clothes washer meeting the Energy Star, or CEE Tier 2 or Tier 3 minimum qualifications. Note if the DHW and dryer fuels of the installations are unknown (for example through a retail program) savings should be based on a weighted blend using RECS data (the resultant values (kWh, therms and gallons of water) are provided). The algorithms can also be used to calculate site specific savings where DHW and dryer fuels are known.

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

Definition of Efficient Equipment

Clothes washer must meet the ENERGY STAR or CEE Tier 2 or 3 minimum qualifications, as required by the program.

Definition of Baseline Equipment

The baseline condition is a clothes washer meeting the minimum federal baseline.

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 14 years[572].

Deemed Measure Cost

The incremental cost for an Energy Star unit is assumed to be $210, for a CEE Tier 2 unit is $360 and for a CEE Tier 3 unit it is $458[573].

Deemed O&M Cost Adjustments

N/A

Loadshape

Loadshape R01 - Residential Clothes Washer

[572] 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

[573] Cost estimates are based on Navigant analysis for the Department of Energy (see CW Analysis.xls). This analysis looked at incremental cost and shipment data from manufacturers and the Association of Home Appliance Manufacturers and attempts to find the costs associated only with the efficiency improvements.

COINCIDENCE FACTOR

The coincidence factor for this measure is 3.8%[574].

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

1. Calculate clothes washer savings based on Modified Energy Factor (MEF).

   The Modified Energy Factor (MEF) includes unit operation, water heating and drying energy use: *"MEF is the quotient of the capacity of the clothes container, C, divided by the total clothes washer energy consumption per cycle, with such energy consumption expressed as the sum of the machine electrical energy consumption, M, the hot water energy consumption, E, and the energy required for removal of the remaining moisture in the wash load, D"* [575].

   The hot water and dryer savings calculated here assumes electric DHW and Dryer (this will be separated in Step 2).

   MEFsavings[576] = Capacity * (1/MEFbase - 1/MEFeff) * Ncycles

Where

Capacity = Clothes Washer capacity (cubic feet)

= Actual. If capacity is unknown assume 3.9 cubic feet [577]

MEFbase = Modified Energy Factor of baseline unit

= 1.42[578]

MEFeff = Modified Energy Factor of efficient unit

= Actual. If unknown assume average values provided below.

Ncycles = Number of Cycles per year

= 295[579]

574 Calculated from Itron eShapes, 8760 hourly data by end use for Missouri, as provided by Ameren.
575 Definition provided on the Energy star website.
576 Tsavings represents total kWh only when water heating and drying are 100% electric.
577 Based on the average clothes washer volume of all units added to the California Energy Commission (CEC) database of Clothes Washer products after 1/1/2011. 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.
578 Average MEF of non-ENERGY STAR units from the California Energy Commission (CEC) database of Clothes Washer products added after 1/1/2011.

MEFsavings is provided below based on deemed values[580]:

Efficiency Level	MEF	MEFSavings (kWh)
Federal Standard	1.42	0.0
Energy Star	2.08	251
CEE Tier 2	2.28	299
CEE Tier 3	2.79	391

2. Break out savings calculated in Step 1 for electric DHW and electric dryer

ΔkWh = [(Capacity * 1/MEFbase * Ncycles) * (%CWbase + (%DHWbase * %Electric_DHW) + (%Dryerbase * %Electric_Dryer)] - [(Capacity * 1/MEFeff * Ncycles) * (%CWeff + (%DHWeff * %Electric_DHW) + (%Dryereff * %Electric_Dryer)]

Where:

%CW = Percentage of total energy consumption for Clothes Washer operation (different for baseline and efficient unit – see table below)

%DHW = Percentage of total energy consumption used for water heating (different for baseline and efficient unit – see table below)

%Dryer = Percentage of total energy consumption for dryer operation (different for baseline and efficient unit – see table below)

	Percentage of Total Energy Consumption[581]		
	%CW	%DHW	%Dryer
Baseline	7%	33%	59%
Non-CEE Energy Star Units	6%	31%	62%
CEE 2	8%	24%	68%
CEE 3	10%	16%	74%

[579] 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/
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.

[580] MEF values are the average of the from the California Energy Commission (CEC) database of Clothes Washer products. See “CW Analysis.xls” for the calculation.

[581] The percentage of total energy consumption that is used for the machine, heating the hot water or by the dryer is different depending on the efficiency of the unit. Values are based on a sales weighted average of top loading and front loading units based on data from Life-Cycle Cost and Payback Period Excel-based analytical tool, available online at: http://www1.eere.energy.gov/buildings/appliance_standards/residential/clothes_washers_support_stakeholder_negotiations.html. See “CW Analysis.xls” for the calculation.

%Electric_DHW = Percentage of DHW savings assumed to be electric

DHW fuel	%Electric_DHW
Electric	100%
Natural Gas	0%
Unknown	16%[582]

%Electric_Dryer = Percentage of dryer savings assumed to be electric

Dryer fuel	%Electric_DHW
Electric	100%
Natural Gas	0%
Unknown	27%[583]

In summation, the complete algorithm is as follows:

ΔkWH = [(Capacity * 1/MEFbase * Ncycles) * (%CWbase + (%DHWbase * %Electric_DHW) + (%Dryerbase * %Electric_Dryer)] - [(Capacity * 1/MEFeff * Ncycles) * (%CWeff + (%DHWeff * %Electric_DHW) + (%Dryereff * %Electric_Dryer)]

Using the default assumptions provided above, the prescriptive savings for each configuration are presented below:

	ΔkWH			
	Electric DHW Electric Dryer	Gas DHW Electric Dryer	Electric DHW Gas Dryer	Gas DHW Gas Dryer
Non-CEE Energy Star Units	250.6	155.2	121.0	25.6
CEE 2	298.9	153.0	166.9	20.9
CEE 3	390.7	189.4	219.6	18.3

If the DHW and dryer fuel is unknown the prescriptive kWH savings based on defaults provided above should be:

	ΔkWH
Non-CEE Energy Star Units	75.84
CEE 2	79.94
CEE 3	96.68

582 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

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

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ΔkWh/Hours * CF

Where:

ΔkWh = Energy Savings as calculated above

Hours = Assumed Run hours of Clothes Washer

= 295 hours[584]

CF = Summer Peak Coincidence Factor for measure.

= 0.038[585]

Using the default assumptions provided above, the prescriptive savings for each configuration are presented below:

	ΔkW			
	Electric DHW Electric Dryer	Gas DHW Electric Dryer	Electric DHW Gas Dryer	Gas DHW Gas Dryer
Non-CEE Energy Star Units	0.032	0.020	0.016	0.003
CEE 2	0.038	0.020	0.021	0.003
CEE 3	0.050	0.024	0.028	0.002

If the DHW and dryer fuel is unknown the prescriptive kW savings should be:

	ΔkW
Non-CEE Energy Star Units	0.010
CEE 2	0.010
CEE 3	0.012

NATURAL GAS SAVINGS

Break out savings calculated in Step 1 of electric energy savings (MEF savings) and extract Natural Gas DHW and Natural Gas dryer savings from total savings:

ΔTherm = [(Capacity * 1/MEFbase * Ncycles) * ((%DHWbase * %Natural Gas_DHW * R_eff) + (%Dryerbase

[584] 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/)

[585] Calculated from Itron eShapes, 8760 hourly data by end use for Missouri, as provided by Ameren.

* %Gas _Dryer)] - [(Capacity * 1/MEFeff * Ncycles) * ((%DHWeff * %Natural Gas_DHW * R_eff) + (%Dryereff * %Gas_Dryer)] * Therm_convert

Where:

Therm_convert = Convertion factor from kWh to Therm

= 0.03413

R_eff = Recovery efficiency factor

= 1.26[586]

%Natural Gas_DHW = Percentage of DHW savings assumed to be Natural Gas

DHW fuel	%Natural Gas_DHW
Electric	0%
Natural Gas	100%
Unknown	84%[587]

%Gas_Dryer = Percentage of dryer savings assumed to be Natural Gas

Dryer fuel	%Gas_Dryer
Electric	100%
Natural Gas	0%
Unknown	44%[588]

Other factors as defined above

Using the default assumptions provided above, the prescriptive savings for each configuration are presented below:

	ΔTherms			
	Electric DHW Electric Dryer	Gas DHW Electric Dryer	Electric DHW Gas Dryer	Gas DHW Gas Dryer
Non-CEE Energy Star Units	0.00	4.1	4.4	8.5
CEE 2	0.00	6.3	4.5	10.8
CEE 3	0.00	8.7	5.8	14.5

[586] To account for the different efficiency of electric and Natural Gas hot water heaters (gas water heater: recovery efficiencies ranging from 0.74 to 0.85 (0.78 used), and electric water heater with 0.98 recovery efficiency (http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/Waste_Water_Heat_Recovery_Guidelines.pdf). Therefore a factor of 0.98/0.78 (1.26) is applied.
[587] 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
[588] Ibid.

If the DHW and dryer fuel is unknown the prescriptive Therm savings should be:

	ΔTherms
Non-CEE Energy Star Units	5.39
CEE 2	7.25
CEE 3	9.84

WATER IMPACT DESCRIPTIONS AND CALCULATION

ΔWater (gallons) = (Capacity * (WFbase - WFeff)) * Ncycles

Where

WFbase = Water Factor of baseline clothes washer

= 8.86[589]

WFeff = Water Factor of efficient clothes washer

= Actual. If unknown assume average values provided below.

Using the default assumptions provided above, the prescriptive water savings for each efficiency level are presented below:

Efficiency Level	WF[590]	ΔWater (gallons per year)
Federal Standard	8.86	0.0
Energy Star	5.42	3913
CEE Tier 2	4.07	5447
CEE Tier 3	3.41	6202

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-APL-ESCL-V02-140601

589 Average MEF of non-ENERGY STAR units.

590 Water Factor is the number of gallons required for each cubic foot of laundry. WF values are the average of the CEC data set. See “CW Analysis.xls” for the calculation.

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)[591] is purchased and installed in a residential setting in place of a unit that meets the minimum federal standard efficiency.

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

Definition of Efficient Equipment

To qualify for this measure, the new dehumidifier must meet the ENERGY STAR standards as defined below:

Until 9/30/2012:

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

After 10/1/2012[592]:

Capacity (pints/day)	ENERGY STAR Criteria (L/kWh)
<75	≥1.85
75 to ≤185	≥2.80

Qualifying units shall be equipped with an adjustable humidistat control or shall require a remote humidistat control to operate.

Definition of Baseline Equipment

The baseline for this measure is defined as a new dehumidifier that meets the Federal Standard efficiency standards. The Federal Standard for Dehumidifiers changed as of October 2012 as defined below:

[591] Energy Star Version 3.0 will become effective 10/1/12
[592] http://www.energystar.gov/ia/partners/prod_development/revisions/downloads/dehumid/ES_Dehumidifiers_Final_V3.0_Eligibility_Criteria.pdf?d70c-99b0

Until 9/30/2012:

Capacity (pints/day)	Federal Standard Criteria (L/kWh)
≤25	≥1.0
> 25 to ≤35	≥1.20
> 35 to ≤45	≥1.30
> 45 to ≤ 54	≥1.30
> 54 to ≤ 75	≥1.50
> 75 to ≤ 185	≥2.25

Post 10/1/2013

Capacity (pints/day)	Federal Standard Criteria (L/kWh) [593]
Up to 35	≥1.35
> 35 to ≤45	≥1.50
> 45 to ≤ 54	≥1.60
> 54 to ≤ 75	≥1.70
> 75 to ≤ 185	≥2.50

Deemed Lifetime of Efficient Equipment

The assumed lifetime of the measure is 12 years[594].

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[595].

Loadshape

Loadshape R12 - Residential - Dehumidifier

[593] The Federal Standard for Dehumidifiers changed as of October 2012; https://www.federalregister.gov/articles/2010/12/02/2010-29756/energy-conservation-program-for-consumer-products-test-procedures-for-residential-dishwashers#h-11

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

[595] Based on extrapolating available data from the Department of Energy's Life Cycle Cost analysis spreadsheet and weighting based on volume of units available: http://www1.eere.energy.gov/buildings/appliance_standards/residential/docs/lcc_dehumidifier.xls See 'DOE life cycle cost_dehumidifier.xls' for calculation.

Coincidence Factor

The coincidence factor is assumed to be 37% [596].

Algorithm

Calculation of Savings

Electric Energy Savings

ΔkWh = (((Avg Capacity * 0.473) / 24) * Hours) * (1 / (L/kWh_Base) – 1 / (L/kWh_Eff))

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 [597]

L/kWh = Liters of water per kWh consumed, as provided in tables above

Annual kWh results for each capacity class are presented below:

Until 9/30/2012 (V 2.1):

Capacity (pints/day) Range	Capacity Used	Federal Standard Criteria (≥ L/kWh)	ENERGY STAR Criteria (≥ L/kWh)	Annual kWh Federal Standard	Annual kWh ENERGY STAR	Annual kWh Savings
≤25	20	1.0	1.2	643	536	107
> 25 to ≤35	30	1.2	1.4	804	689	115
> 35 to ≤45	40	1.3	1.5	990	858	132
> 45 to ≤ 54	50	1.3	1.6	1237	1005	232
> 54 to ≤ 75	65	1.5	1.8	1394	1161	232
> 75 to ≤ 185	130	2.25	2.5	1858	1673	186
Average	46	1.31	1.55	1129	953	176

[596] 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%
[597] ENERGY STAR Dehumidifier Calculator http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDehumidifier.xls

After 10/1/2012 (V 3.0):

Capacity (pints/day) Range	Capacity Used	Federal Standard Criteria (≥ L/kWh)	ENERGY STAR Criteria (≥ L/kWh)	Annual kWh Federal Standard	Annual kWh ENERGY STAR	Annual kWh Savings
≤25	20	1.35	1.85	477	348	129
> 25 to ≤35	30	1.35	1.85	715	522	193
> 35 to ≤45	40	1.5	1.85	858	695	162
> 45 to ≤ 54	50	1.6	1.85	1005	869	136
> 54 to ≤ 75	65	1.7	1.85	1230	1130	100
> 75 to ≤ 185	130	2.5	2.8	1673	1493	179
Average	46	1.51	1.85	983	800	183

Summer Coincident Peak Demand Savings

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

Where:

Hours = Annual operating hours

= 1632 hours [598]

CF = Summer Peak Coincidence Factor for measure

= 0.37 [599]

[598] 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

[599] 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%

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

Until 9/30/2012 (V 2.1):

Capacity (pints/day) Range	Annual Summer peak kW Savings
≤25	0.024
> 25 to ≤35	0.026
> 35 to ≤45	0.030
> 45 to ≤ 54	0.053
> 54 to ≤ 75	0.053
> 75 to ≤ 185	0.042
Average	0.040

After 10/1/2012 (V 3.0):

Capacity (pints/day) Range	Annual Summer peak kW Savings
≤25	0.029
> 25 to ≤35	0.044
> 35 to ≤45	0.037
> 45 to ≤ 54	0.031
> 54 to ≤ 75	0.023
> 75 to ≤ 185	0.041
Average	0.042

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[600]). The Energy Star standard is presented in the table below:

Dishwasher Type	Maximum kWh/year	Maximum gallons/cycle
Standard	295	4.25

DEFINITION OF BASELINE EQUIPMENT

The Baseline reflects the minimum federal efficiency standards for dishwashers effective May 30, 2013, as presented in the table below[601].

Dishwasher Type	Maximum kWh/year	Maximum gallons/cycle
Standard	307	5.0

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The assumed lifetime of the measure is 13 years[602].

DEEMED MEASURE COST

The incremental cost for this measure is $50[603].

LOADSHAPE

Loadshape R02 - Residential Dish Washer

[600] As of May 30, 2013 the Federal Baseline specification for compact units is equal to the ENERGY STAR specification.
[601] http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/67
[602] Koomey, Jonathan et al. (Lawrence Berkeley National Lab), Projected Regional Impacts of Appliance Efficiency Standards for the U.S. Residential Sector, February 1998.
[603] Estimate based on review of Energy Star stakeholder documents

COINCIDENCE FACTOR

The coincidence factor is assumed to be 2.6%[604].

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh^{605} = ((kWh_{Base} - kWh_{ESTAR}) * (\%kWh\_op + (\%kWh\_heat * \%Electric\_DHW)))$$

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%[606]

= 44%

%kWh_heat = Percentage of dishwasher energy consumption used for water heating

= 56%[607]

%Electric_DHW = Percentage of DHW savings assumed to be electric

DHW fuel	%Electric_DHW
Electric	100%
Natural Gas	0%
Unknown	16%[608]

[604] Calculated from Itron eShapes, 8760 hourly data by end use for Missouri, as provided by Ameren.
[605] 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.
[606] ENERGY STAR Dishwasher Calculator (http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDishwasher.xls)
[607] Ibid.
[608] 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.

An Energy Star standard dishwasher installed in place of a baseline unit with unknown DHW fuel:

ΔkWh = ((307 - 295) * (0.44 + (0.56*0.16)))

= 6.4 kWh

An Energy Star standard dishwasher installed in place of a baseline unit with electric DHW:

ΔkWh = ((307 - 295) * (0.44 + (0.56*1.0)))

= 12 kWh

Summer Coincident Peak Demand Savings

ΔkW = ΔkWh/Hours * CF

Where:

Hours = Annual operating hours[609]

= 252 hours

CF = Summer Peak Coincidence Factor

= 2.6% [610]

An Energy Star standard dishwasher installed in place of a baseline unit with unknown DHW fuel:

ΔkWh = 6.4/252 * 0.026

= 0.0007 kW

An Energy Star standard dishwasher installed in place of a baseline unit with electric DHW:

ΔkWh = 12/252 * 0.026

= 0.001 kWh

NATURAL GAS SAVINGS

Δ Therm = (kWh_{Base} - kWh_{ESTAR}) * %kWh_heat * %Natural Gas_DHW * R_eff * 0.03413

Where

%kWh_heat = % of dishwasher energy used for water heating

[609] 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/

[610] End use data from Ameren representing the average DW load during peak hours/peak load.

= 56%

%Natural Gas_DHW = Percentage of DHW savings assumed to be Natural Gas

DHW fuel	%Natural Gas_DHW
Electric	0%
Natural Gas	100%
Unknown	84%[611]

R_eff = Recovery efficiency factor

= 1.26[612]

0.03413 = factor to convert from kWh to Therm

An Energy Star standard dishwasher installed in place of a baseline unit with unknown DHW fuel:

Δ Therm = (307 - 295) * 0.56 * 0.84* 1.26 * 0.03413

= 0.24 therm

An Energy Star standard dishwasher installed in place of a baseline unit with gas DHW:

Δ Therm = (307 - 295) * 0.56 * 1.0* 1.26 * 0.03413

= 0.29 Therm

WATER IMPACT DESCRIPTIONS AND CALCULATION

$\Delta Water = Water_{Base} - Water_{EFF}$

Where

$Water_{Base}$ = water consumption of conventional unit

= 840 gallons[613]

[611] 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.

[612] To account for the different efficiency of electric and Natural Gas hot water heaters (gas water heater: recovery efficiencies ranging from 0.74 to 0.85 (0.78 used), and electric water heater with 0.98 recovery efficiency (http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/Waste_Water_Heat_Recovery_Guidelines.pdf). Therefore a factor of 0.98/0.78 (1.26) is applied.

[613] 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;

$Water_{EFF}$ = annual water consumption of efficient unit:

= 714 gallons[614]

Δ Water = 840 – 714

= 126 gallons

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-APL-ESDI-V02-130601

http://205.254.135.7/consumption/residential/data/2009/

[614] 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/

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):

Product Category	Volume (cubic feet)	Assumptions up to September 2014		Assumptions after September 2014	
		Federal Baseline Maximum Energy Usage in kWh/year[615]	ENERGY STAR Maximum Energy Usage in kWh/year[616]	Federal Baseline Maximum Energy Usage in kWh/year[617]	ENERGY STAR Maximum Energy Usage in kWh/year[618]
Upright Freezers with Manual Defrost	7.75 or greater	7.55*AV+258.3	6.795*AV+232.47	5.57*AV + 193.7	5.01*AV + 174.3
Upright Freezers with Automatic Defrost	7.75 or greater	12.43*AV+326.1	11.187*AV+293.49	8.62*AV + 228.3	7.76*AV + 205.5
Chest Freezers and all other Freezers except Compact Freezers	7.75 or greater	9.88*AV+143.7	8.892*AV+129.33	7.29*AV + 107.8	6.56*AV + 97.0
Compact Upright Freezers with Manual Defrost	< 7.75 and 36 inches or less in height	9.78*AV+250.8	7.824*AV+200.64	8.65*AV + 225.7	7.79*AV + 203.1
Compact Upright Freezers with Automatic Defrost	< 7.75 and 36 inches or less in height	11.40*AV+391	9.12*AV+312.8	10.17*AV + 351.9	9.15*AV + 316.7
Compact Chest Freezers	<7.75 and 36 inches or less in height	10.45*AV+152	8.36*AV+121.6	9.25*AV + 136.8	8.33*AV + 123.1

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:

615 http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/43
616 http://www.energystar.gov/ia/products/appliances/refrig/NAECA_calculation.xls?c827-f746
617 http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/43
618 http://www.energystar.gov/products/specs/sites/products/files/ENERGY%20STAR%20Final%20Version%205.0%20Residential%20Refrigerators%20and%20Freezers%20Specification.pdf

Equipment	Volume	Criteria
Full Size Freezer	7.75 cubic feet or greater	At least 10% more energy efficient than the minimum federal government standard (NAECA).
Compact Freezer	Less than 7.75 cubic feet and 36 inches or less in height	At least 20% more energy efficient than the minimum federal government standard (NAECA).

Definition of Baseline Equipment

The baseline equipment is assumed to be a model that meets the federal minimum standard for energy efficiency. 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[619].

Deemed Measure Cost

The incremental cost for this measure is $35[620].

Loadshape

Loadshape R04 - Residential Freezer

Coincidence Factor

The summer peak coincidence factor for this measure is assumed to be 95%[621].

Algorithm

Calculation of Savings

Electric Energy Savings:

$$\Delta kWh = kWh_{Base} - kWh_{ESTAR}$$

Where:

kWh_{BASE} = Baseline kWh consumption per year as calculated in algorithm provided in table above.

619 Energy Star Freezer Calculator; http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Consumer_Residential_Freezer_Sav_Calc.xls?570a-f000

620 Based on review of data from the Northeast Regional ENERGY STAR Consumer Products Initiative; "2009 ENERGY STAR Appliances Practices Report", submitted by Lockheed Martin, December 2009.

621 Based on eShapes Residential Freezer load data as provided by Ameren.

kWh_{ESTAR} = ENERGY STAR kWh consumption per year as calculated in algorithm provided in table above.

For example for a 7.75 cubic foot Upright Freezers with Manual Defrost purchased after September 2014:

ΔkWh =(5.57*(7.75* 1.73)+193.7) – (5.01*(7.75* 1.73)+174.3)

= 268.4 – 241.5

= 26.9 kWh

If volume is unknown, use the following default values:

Product Category	Volume Used[622]	Assumptions up to September 2014			Assumptions after September 2014		
		kWh_{BASE}	kWh_{ESTAR}	kWh Savings	kWh_{BASE}	kWh_{ESTAR}	kWh Savings
Upright Freezers with Manual Defrost	27.9	469.1	422.2	46.9	349.2	314.2	35.0
Upright Freezers with Automatic Defrost	27.9	673.2	605.9	67.3	469.0	422.2	46.8
Chest Freezers and all other Freezers except Compact Freezers	27.9	419.6	377.6	42.0	311.4	280.2	31.2
Compact Upright Freezers with Manual Defrost	10.4	352.3	281.9	70.5	467.2	420.6	46.6
Compact Upright Freezers with Automatic Defrost	10.4	509.3	407.5	101.9	635.9	572.2	63.7
Compact Chest Freezers	10.4	260.5	208.4	52.1	395.1	355.7	39.4

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ΔkWh/ Hours * CF

Where:

ΔkWh = Gross customer annual kWh savings for the measure

Hours = Full Load hours per year

622 Volume is based on ENERGY STAR Calculator assumption of 16.14 ft^3 average volume, converted to Adjusted volume by multiplying by 1.73.

= 5890[623]

CF = Summer Peak Coincident Factor

= 0.95 [624].

For example for a 7.75 cubic foot Upright Freezers with Manual Defrost:

ΔkW = 26.9/5890 * 0.95

= 0.0043 kW

If volume is unknown, use the following default values:

Product Category	Assumptions up to September 2014	Assumptions after September 2014
	kW Savings	kW Savings
Upright Freezers with Manual Defrost	0.0076	0.0057
Upright Freezers with Automatic Defrost	0.0109	0.0076
Chest Freezers and all other Freezers except Compact Freezers	0.0068	0.0050
Compact Upright Freezers with Manual Defrost	0.0114	0.0075
Compact Upright Freezers with Automatic Defrost	0.0164	0.0103
Compact Chest Freezers	0.0084	0.0064

NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

[623] Calculated from eShapes Residential Freezer load data as provided by Ameren by dividing total annual load by the maximum kW in any one hour.
[624] Based on eShapes Residential Freezer load data as provided by Ameren.

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):

Product Category	Existing Unit	Assumptions up to September 2014		Assumptions after September 2014	
	Based on Refrigerator Recycling algorithm	Federal Baseline Maximum Energy Usage in kWh/year[625]	ENERGY STAR Maximum Energy Usage in kWh/year[626]	Federal Baseline Maximum Energy Usage in kWh/year[627]	ENERGY STAR Maximum Energy Usage in kWh/year[628]
1. Refrigerators and Refrigerator-freezers with manual defrost	Use Algorithm in 5.1.8 Refrigerator and Freezer Recycling measure to estimate existing unit consumption	8.82*AV+248.4	7.056*AV+198.72	6.79AV + 193.6	6.11 * AV + 174.2
2. Refrigerator-Freezer--partial automatic defrost		8.82*AV+248.4	7.056*AV+198.72	7.99AV + 225.0	7.19 * AV + 202.5
3. Refrigerator-Freezers--automatic defrost with top-mounted freezer without through-the-door ice service and all-refrigerators--automatic defrost		9.80*AV+276	7.84*AV+220.8	8.07AV + 233.7	7.26 * AV + 210.3
4. Refrigerator-Freezers--automatic defrost with side-mounted freezer		4.91*AV+507.5	3.928*AV+406	8.51AV + 297.8	7.66 * AV + 268.0

[625] http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/43
[626] http://www.energystar.gov/ia/products/appliances/refrig/NAECA_calculation.xls?c827-f746
[627] http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/43
[628] http://www.energystar.gov/products/specs/sites/products/files/ENERGY%20STAR%20Final%20Version%205.0%20Residential%20Refrigerators%20and%20Freezers%20Specification.pdf

Product Category	Existing Unit	Assumptions up to September 2014		Assumptions after September 2014	
	Based on Refrigerator Recycling algorithm	Federal Baseline Maximum Energy Usage in kWh/year[625]	ENERGY STAR Maximum Energy Usage in kWh/year[626]	Federal Baseline Maximum Energy Usage in kWh/year[627]	ENERGY STAR Maximum Energy Usage in kWh/year[628]
without through-the-door ice service					
5. Refrigerator-Freezers--automatic defrost with bottom-mounted freezer without through-the-door ice service		4.60*AV+459	3.68*AV+367.2	8.85AV + 317.0	7.97 * AV + 285.3
5A Refrigerator-freezer—automatic defrost with bottom-mounted freezer with through-the-door ice service		N/A	N/A	9.25AV + 475.4	8.33 * AV * 436.3
6. Refrigerator-Freezers--automatic defrost with top-mounted freezer with through-the-door ice service		10.20*AV+356	8.16*AV+284.8	8.40AV + 385.4	7.56 * AV + 355.3
7. Refrigerator-Freezers--automatic defrost with side-mounted freezer with through-the-door ice service		10.10*AV+406	8.08*AV+324.8	8.54AV + 432.8	7.69 * AV + 397.9

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.[629]

Remaining life of existing equipment is assumed to be 4 years[630]

DEEMED MEASURE COST

Time of Sale: The incremental cost for this measure is assumed to be $40[631] for an ENERGY STAR unit and $140[632] 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[633].

The avoided replacement cost (after 4 years) of a baseline replacement refrigerator is $390[634].

LOADSHAPE

Loadshape R05 - Residential Refrigerator

COINCIDENCE FACTOR

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

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[629] From ENERGY STAR calculator: http://www.energystar.gov/buildings/sites/default/uploads/files/appliance_calculator.xlsx?7224-046c=&7224-__046ceiling_fan_calculator_xlsx=&f7d8-39dd&f7d8-39dd

[630] Standard assumption of one third of effective useful life.

[631] From ENERGY STAR calculator linked above.

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

[633] 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.

[634] Calculated using incremental cost from Time of Sale measure.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS:

Time of Sale: $\Delta kWh = UEC_{BASE} - UEC_{EE}$

Early Replacement:

ΔkWh for remaining life of existing unit (1st 4 years) $= UEC_{EXIST} - UEC_{EE}$

ΔkWh for remaining measure life (next 8 years) $= UEC_{BASE} - UEC_{EE}$

Where:

UEC_{EXIST} = Annual Unit Energy Consumption of existing unit as calculated in algorithm from 5.1.8 Refrigerator and Freezer Recycling measure.

UEC_{BASE} = Annual Unit Energy Consumption of baseline unit as calculated in algorithm provided in table above.

UEC_{EE} = Annual Unit Energy Consumption of ENERGY STAR unit as calculated in algorithm provided in table above.

For CEE Tier 2, unit consumption is calculated as 25% lower than baseline.

If volume is unknown, use the following defaults, based on an assumed Adjusted Volume of 25.8 :

<u>Assumptions prior to standard changes on September 1st, 2014:</u>

Product Category	Existing Unit UEC_{EXIST} [636]	New Baseline UEC_{BASE}	New Efficient UEC_{EE}		Early Replacement (1st 4 years) ΔkWh		Time of Sale and Early Replacement (last 8 years) ΔkWh	
			ENERGY STAR	CEE T2	ENERGY STAR	CEE T2	ENERGY STAR	CEE T2
1. Refrigerators and Refrigerator-freezers with manual defrost	1027.7	475.7	380.5	356.8	647.2	671.0	95.1	118.9

[635] Volume is based on the ENERGY STAR calculator average assumption of 14.75 ft^3 fresh volume and 6.76 ft^3 freezer volume.

[636] 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 ft3 (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.

Product Category	Existing Unit UEC_{EXIST} 636	New Baseline UEC_{BASE}	New Efficient UEC_{EE}		Early Replacement (1st 4 years) ΔkWh		Time of Sale and Early Replacement (last 8 years) ΔkWh	
			ENERGY STAR	CEE T2	ENERGY STAR	CEE T2	ENERGY STAR	CEE T2
2. Refrigerator-Freezer--partial automatic defrost	1027.7	475.7	380.5	356.8	647.2	671.0	95.1	118.9
3. Refrigerator-Freezers--automatic defrost with top-mounted freezer without through-the-door ice service and all-refrigerators--automatic defrost	814.5	528.5	422.8	396.4	391.7	418.1	105.7	132.1
4. Refrigerator-Freezers--automatic defrost with side-mounted freezer without through-the-door ice service	1241.0	634.0	507.2	475.5	733.7	765.4	126.8	158.5
5. Refrigerator-Freezers--automatic defrost with bottom-mounted freezer without through-the-door ice service	814.5	577.5	462.0	433.2	352.5	381.4	115.5	144.4
6. Refrigerator-Freezers--automatic defrost with top-mounted freezer with through-the-door ice service	814.5	618.8	495.1	464.1	319.5	350.4	123.8	154.7
7. Refrigerator-Freezers--automatic defrost with side-mounted freezer with through-the-door ice service	1241.0	666.3	533.0	499.7	707.9	741.3	133.3	166.6

Assumptions after standard changes on September 1st, 2014:

Product Category	Existing Unit UEC_{EXIST} [637]	New Baseline UEC_{BASE}	New Efficient UEC_{EE}		Early Replacement (1st 4 years) ΔkWh		Time of Sale and Early Replacement (last 8 years) ΔkWh	
			ENERGY STAR	CEE T2	ENERGY STAR	CEE T2	ENERGY STAR	CEE T2
1. Refrigerators and Refrigerator-freezers with manual defrost	1027.7	368.6	331.6	276.4	696.1	751.3	36.9	92.1
2. Refrigerator-Freezer--partial automatic defrost	1027.7	430.9	387.8	323.2	640.0	704.6	43.1	107.7
3. Refrigerator-Freezers--automatic defrost with top-mounted freezer without through-the-door ice service and all-refrigerators--automatic defrost	814.5	441.7	397.4	331.2	417.2	483.3	44.3	110.4
4. Refrigerator-Freezers--automatic defrost with side-mounted freezer without through-the-door ice service	1241.0	517.1	465.4	387.8	775.6	853.1	51.7	129.3
5. Refrigerator-Freezers--automatic defrost with bottom-mounted freezer without through-the-door ice service	814.5	545.1	490.7	408.8	323.9	405.8	54.4	136.3
5A Refrigerator-freezer—automatic defrost with bottom-mounted freezer with through-the-door ice service	814.5	713.8	651.0	535.3	163.6	279.2	62.8	178.4
6. Refrigerator-Freezers--automatic defrost with top-mounted freezer with through-the-door ice service	814.5	601.9	550.1	451.4	264.4	363.2	51.7	150.5
7. Refrigerator-Freezers--automatic defrost with side-mounted freezer with through-the-door ice service	1241.0	652.9	596.1	489.6	644.9	751.3	56.8	163.2

[637] 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 ft3 (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.

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = (ΔkWh/8766) * TAF * LSAF

Where:

TAF = Temperature Adjustment Factor

= 1.25[638]

LSAF = Load Shape Adjustment Factor

= 1.057 [639]

[638] 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 central cooling (CAC saturation: "Table HC7.9 Air Conditioning in Homes in Midwest Region, Divisions, and States, 2009 from Energy Information Administration", 2009 Residential Energy Consumption Survey; http://www.eia.gov/consumption/residential/data/2009/xls/HC7.9%20Air%20Conditioning%20in%20Midwest%20Region.xls)

[639] Daily load shape adjustment factor (average load in peak period /average daily load) also based on Blasnik, Michael, "Measurement and Verification of Residential Refrigerator Energy Use, Final Report, 2003-2004 Metering Study", July 29, 2004 (p. 48, using the average Existing Units Summer Profile for hours 13 through 17)

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			
	Early Replacement (1st 4 years)		Time of Sale and Early Replacement (last 8 years)		Early Replacement (1st 4 years)		Time of Sale and Early Replacement (last 8 years)	
	ENERGY STAR	CEE T2	ENERGY STAR	CEE T2	ENERGY STAR	CEE T2	ENERGY STAR	CEE T2
1. Refrigerators and Refrigerator-freezers with manual defrost	0.098	0.101	0.014	0.018	0.105	0.113	0.006	0.014
2. Refrigerator-Freezer--partial automatic defrost	0.098	0.101	0.014	0.018	0.096	0.106	0.006	0.016
3. Refrigerator-Freezers--automatic defrost with top-mounted freezer without through-the-door ice service and all-refrigerators--automatic defrost	0.059	0.063	0.016	0.020	0.063	0.073	0.007	0.017
4. Refrigerator-Freezers--automatic defrost with side-mounted freezer without through-the-door ice service	0.111	0.115	0.019	0.024	0.117	0.129	0.008	0.019
5. Refrigerator-Freezers--automatic defrost with bottom-mounted freezer without through-the-door ice service	0.053	0.057	0.017	0.022	0.049	0.061	0.008	0.021
5A Refrigerator-freezer—automatic defrost with bottom-mounted freezer with through-the-door ice service	n/a	n/a	n/a	n/a	0.025	0.042	0.009	0.027
6. Refrigerator-Freezers--automatic defrost with top-mounted freezer with through-the-door ice service	0.048	0.053	0.019	0.023	0.040	0.055	0.008	0.023
7. Refrigerator-Freezers--automatic defrost with side-mounted freezer with through-the-door ice service	0.107	0.112	0.020	0.025	0.097	0.113	0.009	0.025

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%[640] in 2010 to 62%[641] 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.

Product Type and Class (Btu/hr)		ENERGY STAR v2.0 with louvered sides (EER)[642]	ENERGY STAR v2.0 without louvered sides (EER)	ENERGY STAR v3.0 / CEE Tier 1 with louvered sides (EER)[643]	ENERGY STAR v3.0 / CEE Tier 1 without louvered sides (EER)	CEE TIER 2 (EER)[644]
Without Reverse Cycle	< 8,000	10.7	9.9	11.2	10.4	11.6
	8,000 to 10,999	10.8	9.9	11.3	9.8	11.8
	11,000 to 13,999	10.8	9.4	11.3	9.8	11.8
	14,000 to 19,999	10.7	9.4	11.2	9.8	11.6
	20,000 to 24,999	9.4	9.4	9.8	9.8	10.2
	>=25,000	9.4	9.4	9.8	9.8	10.2
With Reverse Cycle	<14,000	9.9	9.4	10.4	9.8	11.8
	14,000 to 19,999	9.9	8.8	10.4	9.2	11.6
	>=20,000	9.4	8.8	9.8	9.2	10.2
Casement only		9.6		10.0		
Casement-Slider		10.5		10.9		

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.

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[640] http://www.energystar.gov/ia/partners/downloads/unit_shipment_data/2010_USD_Summary_Report.pdf?3193-51e7

[641] http://www.energystar.gov/ia/partners/downloads/unit_shipment_data/2011_USD_Summary_Report.pdf?3193-51e7

[642] http://www.energystar.gov/ia/partners/prod_development/revisions/downloads/roomac/RAC_ProgramRequirements_1105.pdf?c2df-6034

[643] http://www.energystar.gov/index.cfm?c=roomac.pr_crit_room_ac

[644] http://library.cee1.org/sites/default/files/library/9296/CEE_ResApp_RoomAirConditionerSpecification_2003_Updated.pdf

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[645].

Remaining life of existing equipment is assumed to be 4 years[646]

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[647].

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[648].

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645 Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007.
http://neep.org/uploads/EMV%20Forum/EMV%20Studies/measure_life_GDS%5B1%5D.pdf

646 Standard assumption of one third of effective useful life.

647 CEE Tier 1 based on field study conducted by Efficiency Vermont and Tier 2 based on professional judgement.

648 Based on IL PHA Efficient Living Prgroam Data for 810 replaced units showing $416 per unit plus $32 average recycling/removal cost.

The avoided replacement cost (after 4 years) of a baseline replacement refrigerator is $376.[649]

LOADSHAPE

Loadshape R08 - Residential Cooling

COINCIDENCE FACTOR

The coincidence factor for this measure is assumed to be 0.3[650].

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

Time of Sale: ΔkWh = $(FLH_{RoomAC} * Btu/H * (1/EERbase - 1/EERee))/1000$

Early Replacment:

ΔkWh for remaining life of existing unit (1^{st} 4 years) = $(FLH_{RoomAC} * Btu/H * (1/EERexist - 1/EERee))/1000$

ΔkWh for remaining measure life (next 8 years) = $(FLH_{RoomAC} * Btu/H * (1/EERbase - 1/EERee))/1000$

Where:

FLH_{RoomAC} = Full Load Hours of room air conditioning unit

= dependent on location[651]:

Climate Zone (City based upon)	FLH_{RoomAC}
1 (Rockford)	220

[649] Estimate based upon Time of Sale incremental costs.

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

[651] Full load hours for room AC is significantly lower than for central AC. The average ratio of FLH for Room AC (provided in RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008: http://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/117_RLW_CF%20Res%20RAC.pdf) to FLH for Central Cooling for the same location (provided by AHRI: http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_CAC.xls) is 31%. This ratio is applied to those IL cities that have FLH for Central Cooling provided in the Energy Star calculator. For other cities this is extrapolated using the FLH assumptions VEIC have developed for Central AC. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

2 (Chicago)	210
3 (Springfield)	319
4 (Belleville)	428
5 (Marion)	374
Weighted Average[652]	248

Btu/H = Size of rebated unit

= Actual. If unknown assume 8500 Btu/hr[653]

EERexist = Efficiency of existing unit

= Actual. If unknown assume 7.7[654]

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

[652] Weighted based on number of residential occupied housing units in each zone.
[653] Based on maximum capacity average from the RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008
[654] Based on Nexus Market Research Inc, RLW Analytics, December 2005; "Impact, Process, and Market Study of the Connecticut Appliance Retirement Program: Overall Report."

Time of Sale:

For example for an 8,500 Btu/H capacity unit, with louvered sides, in an unknown location:

$\Delta kWH_{CEE\ TIER\ 1}$ = (248 * 8500 * (1/10.8 – 1/11.3)) / 1000

= 8.6 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:

ΔkWh for remaining life of existing unit (1^{st} 4 years) = (319 * 9000 * (1/7.7 - 1/11.3))/1000

= 118.8 kWh

ΔkWh for remaining measure life (next 8 years) = (319 * 9000 * (1/10.8 - 1/11.3))/1000

= 11.8 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = Btu/H * ((1/EERbase - 1/EERee))/1000) * CF

Where:

CF = Summer Peak Coincidence Factor for measure

= 0.3[655]

Other variable as defined above

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

Time of Sale:

For example for an 8,500 Btu/H capacity unit, with louvered sides, for an unknown location:

$\Delta kW_{CEE\ TIER\ 1}$ = (8500 * (1/10.8 – 1/11.3)) / 1000 * 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:

ΔkW for remaining life of existing unit (1st 4 years) = (9000 * (1/7.7 - 1/11.3))/1000 * 0.3

= 0.11 kW

ΔkW for remaining measure life (next 8 years) = (9000 * (1/10.8 - 1/11.3))/1000 * 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 [656].

Deemed Measure Cost

Measure cost includes the cost of pickup and recycling of the refrigerator and should be based on actual costs of

[656] KEMA "Residential refrigerator recycling ninth year retention study", 2004

running the program. If unknown assume $120[657] per unit.

LOADSHAPE

Loadshape R05 - Residential Refrigerator

COINCIDENCE FACTOR

The coincidence factor is assumed to be 0.00012.

Algorithm

CALCULATION OF SAVINGS

ENERGY SAVINGS[658]

Refrigerators:

Energy savings for refrigerators are based upon a linear regression model using the following coefficients[659]:

Independent Variable Description	Estimate Coefficient
Intercept	116.843
Age (years)	10.895
Pre-1990 (=1 if manufactured pre-1990)	431.788
Size (cubic feet)	19.424
Dummy: Single Door (=1 if single door)	-795.368
Dummy: Side-by-Side (= 1 if side-by-side)	426.407
Dummy: Primary Usage Type (in absence of the program) (= 1 if primary unit)	170.984
Interaction: Located in Unconditioned Space x CDD/365.25	17.342
Interaction: Located in Unconditioned Space x HDD/365.25	-11.776

ΔkWh = [116.84 + (Age * 10.90) + (Pre-1990 * 431.79) + (Size * 19.42) + (Single-Door * -795.37)

[657] Based on similar Efficiency Vermont program.

[658] 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.

[659] 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".

+ (Side-by-side * 426.41) + (Proportion of Primary Appliances * 170.98) + (CDD/365.25 * unconditioned * 17.34) + (HDD/365.25 *unconditioned *-11.78)] * 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

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[660]:

Climate Zone (City based upon)	CDD 65	CDD/365.25
1 (Rockford)	820	2.25
2 (Chicago)	842	2.31
3 (Springfield)	1,108	3.03
4 (Belleville)	1,570	4.30
5 (Marion)	1,370	3.75

[660] National Climatic Data Center, calculated from 1981-2010 climate normals with a base temp of 65°F.

Interaction: Located in Unconditioned Space x HDD/365.25

(=1 * HDD/365.25 if in unconditioned space)

HDD = Heating Degree Days

= Dependent on location:[661]

Climate Zone (City based upon)	HDD 65	HDD/365.25
1 (Rockford)	6,569	17.98
2 (Chicago)	6,339	17.36
3 (Springfield)	5,497	15.05
4 (Belleville)	4,379	11.99
5 (Marion)	4,476	12.25

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[662]. For illustration purposes, this example uses 0.93.[663]

For example, the program averages for AIC's ARP in PY4 produce the following equation:

ΔkWh = [116.84+ (22.81 * 10.90) + (0.45 * 431.79) + (18.82 * 19.42) + (0.1 * -795.37) + (0.17 * 426.41) + (0.34 * 170.98) + (1.29 * 17.34) + (6.49 * -11.78)] * 0.876

= 920 * 0.93

= 856 kWh

Freezers:

Energy savings for freezers are based upon a linear regression model using the following coefficients[664]:

[661] National Climatic Data Center, calculated from 1981-2010 climate normals with a base temp of 65°F.

[662] 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.

[663] Most recent refrigerator part-use factor from Ameren Illinois PY5 evaluation.

[664] 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".

Independent Variable Description	Estimate Coefficient
Intercept	132.122
Age (years)	12.130
Pre-1990 (=1 if manufactured pre-1990)	156.181
Size (cubic feet)	31.839
Chest Freezer Configuration (=1 if chest freezer)	-19.709
Interaction: Located in Unconditioned Space x CDD/365.25	-12.755
Interaction: Located in Unconditioned Space x HDD/365.25	9.778

ΔkWh = [132.12 + (Age * 12.13) + (Pre-1990 * 156.18) + (Size * 31.84) + (Chest Freezer * -19.71) + (CDDs* unconditioned *9.78) + (HDDs*unconditioned *-12.75)] * 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)

Interaction: Located in Unconditioned Space x CDD/365.25

(=1 * CDD/365.25 if in unconditioned space)

CDD = Cooling Degree Days (see table above)

Interaction: Located in Unconditioned Space x HDD/365.25

(=1 * HDD/365.25 if in unconditioned space)

HDD = 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[665]. . For illustration purposes, the example uses 0.85.[666]

[665] 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.

[666] Most recent freezer part-use factor from Ameren Illnois Company PY5 evaluation.

The program averages for AIC's ARP PY4 program are used as an example.

ΔkWh = [132.12 + (26.92 * 12.13) + (0.6 * 156.18) + (15.9 * 31.84) + (0.48 * -19.71) + (6.61 * 9.78) + (1.3 * -12.75)] * 0.825

= 977 * 0.825

= 905 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = kWh/8760 * CF

Where:

kWh = Savings provided in algorithm above

CF = Coincident factor defined as summer kW/average kW

= 1.081 for Refrigerators

= 1.028 for Freezers[667]

For example, the program averages for AIC's ARP in PY4 produce the following equation:

ΔkW = 806/8760 * 1.081

= 0.099 kW

NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-APL-RFRC-V03-140601

[667] Cadmus memo, February 12, 2013; "Appliance Recycling Update"

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[668].

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%[669].

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

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$\Delta kWh = ((FLH_{RoomAC} * Btu/hr * (1/EERexist))/1000)$

Where:

FLH_{RoomAC} = Full Load Hours of room air conditioning unit

= dependent on location[670]:

Climate Zone (City based upon)	FLH_{RoomAC}
1 (Rockford)	220
2 (Chicago)	210
3 (Springfield)	319
4 (Belleville)	428
5 (Marion)	374
Weighted Average[671]	248

Btu/H = Size of retired unit

= Actual. If unknown assume 8500 Btu/hr [672]

EERexist = Efficiency of existing unit

= 7.7[673]

[670] The average ratio of FLH for Room AC (provided in RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008: http://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/117_RLW_CF%20Res%20RAC.pdf) to FLH for Central Cooling for the same location (provided by AHRI: http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_CAC.xls) is 31%. This ratio is applied to those IL cities that have FLH for Central Cooling provided in the Energy Star calculator. For other cities this is extrapolated using the FLH assumptions VEIC have developed for Central AC. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

[671] Weighted based on number of residential occupied housing units in each zone.

[672] Based on maximum capacity average from the RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008

[673] Based on Nexus Market Research Inc, RLW Analytics, December 2005; “Impact, Process, and Market Study of the Connecticut Appliance Retirement Program: Overall Report.”

For example for an 8500 Btu/h unit in Springfield:

ΔkWh = ((319 * 8500 * (1/7.7)) / 1000)

= 352 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = (Btu/hr * (1/EERexist))/1000) * CF

Where:

CF = Summer Peak Coincidence Factor for measure

= 0.3[674]

For example an 8500 Btu/h unit:

ΔkW = (8500 * (1/7.7)) / 1000) * 0.3

= 0.33 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

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

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 years[675].

DEEMED MEASURE COST

The incremental cost of a smart strip over a standard power strip with surge protection is assumed to be $16 for a 5-plug and $26 for a 7-plug[676].

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%[677].

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[675] David Rogers, Power Smart Engineering, October 2008; "Smart Strip electrical savings and usability", p22.
[676] Price survey performed in NYSERDA Measure Characterization for Advanced Power Strips, p4
[677] Efficiency Vermont coincidence factor for smart strip measure –in the absence of empirical evaluation data, this

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$\Delta kWh_{5\text{-}Plug}$ = 56.5 kWh [678]

$\Delta kWh_{7\text{-}Plug}$ = 103 kWh [679]

SUMMER COINCIDENT PEAK DEMAND SAVINGS

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

Where:

Hours = Annual number of hours during which the controlled standby loads are turned off by the Smart Strip.

= 7,129 [680]

CF = Summer Peak Coincidence Factor for measure

= 0.8 [681]

$\Delta kW_{5\text{-}Plug}$ = 56.5 / 7129 * 0.8

= 0.00634 kW

was based on assumptions of the typical run pattern for televisions and computers in homes.

[678] NYSERDA Measure Characterization for Advanced Power Strips. Study based on review of:

I. Smart Strip Electrical Savings and Usability, Power Smart Engineering, October 27, 2008.
II. Final Field Research Report, Ecos Consulting, October 31, 2006. Prepared for California Energy Commission's PIER Program.
III. Developing and Testing Low Power Mode Measurement Methods, Lawrence Berkeley National Laboratory (LBNL), September 2004. Prepared for California Energy Commission's Public Interest Energy Research (PIER) Program.
IV. 2005 Intrusive Residential Standby Survey Report, Energy Efficient Strategies, March, 2006.
V. Smart Strip Portfolio of the Future, Navigant Consulting for San Diego G&E, March 31, 2009.

[679] Ibid.

[680] Average of hours for controlled TV and computer from; NYSERDA Measure Characterization for Advanced Power Strips

[681] 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.

$\Delta kW_{7\text{-}Plug}$ = 102.8 / 7129 * 0.8

= 0.0115 kW

NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-CEL-SSTR-V01-120601

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.

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.

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; 13 SEER and 7.7HSPF.

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[682] for the remainder of the measure life.

[682] Baseline SEER and EER should be updated when new minimum federal standards become effective.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 18 years[683].

Remaining life of existing equipment is assumed to be 6 years[684].

DEEMED MEASURE COST

Time of sale: The incremental capital cost for this measure is dependent on the efficiency and capacity of the new unit[685]. Note these costs are per ton of unit capacity:

Efficiency (SEER)	Incremental Cost per Ton of Capacity ($/ton)
14	$137
15	$274
16	$411
17	$548
18	$685

Early replacement: The capital 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)[686]:

Efficiency (SEER)	Full Retrofit Cost (including labor) per Ton of Capacity ($/ton)
14	$1,381
15	$1,518
16	$1,655
17	$1,792
18	$1,929

Assumed deferred cost (after 6 years) of replacing existing equipment with new baseline unit is assumed to be $1,244 per ton of capacity[687]. This cost should be discounted to present value using the utilities discount rate.

[683] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007,
http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf
[684] Assumed to be one third of effective useful life
[685] Based on costs derived from DEER 2008 Database Technology and Measure Cost Data (www.deeresources.com).
[686] Ibid. See 'ASHP_Revised DEER Measure Cost Summary.xls' for calculation.
[687] Ibid.

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.

CF_{SSP} = Summer System Peak Coincidence Factor for Heat Pumps (during utility peak hour)
= 72%%[688]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Heat Pumps (average during PJM peak period)
= 46.6%[689]

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

Time of sale:

ΔkWh = ((FLH_cooling * Capacity_cooling * (1/SEER_base - 1/SEER_ee)) / 1000) + ((FLH_heat * Capacity_heating * (1/HSPF_base - 1/HSFP_ee)) / 1000)

Early replacement[690]:

ΔkWH for remaining life of existing unit (1st 6 years):

= ((FLH_cooling * Capacity_cooling * (1/SEER_exist - 1/SEER_ee)) / 1000) + ((FLH_heat * Capacity_heating * (1/HSPF_exist - 1/HSFP_ee)) / 1000)

ΔkWH for remaining measure life (next 12 years):

= ((FLH_cooling * Capacity_cooling * (1/SEER_base - 1/SEER_ee)) / 1000) + ((FLH_heat *

[688] 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)'.

[689] 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.

[690] 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).

Capacity_heating * (1/HSPF_base - 1/HSFP_ee)) / 1000)

Where:

FLH_cooling = Full load hours of air conditioning

= dependent on location[691]:

Climate Zone (City based upon)	FLH_cooling (single family)	FLH_cooling (multi family)
1 (Rockford)	512	467
2 (Chicago)	570	506
3 (Springfield)	730	663
4 (Belleville)	1,035	940
5 (Marion)	903	820
Weighted Average[692]	629	564

Capacity_cooling = Cooling Capacity of Air Source Heat Pump (Btu/hr)

= Actual (1 ton = 12,000Btu/hr)

SEER_exist = Seasonal Energy Efficiency Ratio of existing cooling system (kBtu/kWh)

= Use actual SEER rating where it is possible to measure or reasonably estimate.

Existing Cooling System	SEER_exist[693]
Air Source Heat Pump	9.12
Central AC	8.60
No central cooling[694]	Make '1/SEER_exist' = 0

SEER_base = Seasonal Energy Efficiency Ratio of baseline Air Source Heat Pump (kBtu/kWh)

691 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.

692 Weighted based on number of occupied residential housing units in each zone.

693 Average nameplate efficiencies of all Early Replacement qualifying equipment in Ameren PY3-PY4.

694 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.

= 13 [695]

SEER_ee = Seasonal Energy Efficiency Ratio of efficient Air Source Heat Pump (kBtu/kWh)

= Actual

FLH_heat = Full load hours of heating

= Dependent on location[696]:

Climate Zone (City based upon)	FLH_heat
1 (Rockford)	1,969
2 (Chicago)	1,840
3 (Springfield)	1,754
4 (Belleville)	1,266
5 (Marion)	1,288
Weighted Average[697]	1,821

Capacity_heating = Heating Capacity of Air Source Heat Pump (Btu/hr)

= Actual (1 ton = 12,000Btu/hr)

HSPF_exist =Heating System Performance Factor[698] of existing heating system (kBtu/kWh)

= Use actual HSPF rating where it is possible to measure or reasonably estimate. If not available use:

[695] Based on Minimum Federal Standard; http://www1.eere.energy.gov/buildings/appliance_standards/residential/residential_cac_hp.html.

[696] 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.

[697] Weighted based on number of occupied residential housing units in each zone.

[698] 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

Existing Heating System	HSPF_exist
Air Source Heat Pump	5.44 [699]
Electric Resistance	3.41[700]

HSPF_base =Heating System Performance Factor of baseline Air Source Heat Pump (kBtu/kWh)

= 7.7 [701]

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:

ΔkWh = ((903 * 36,000 * (1/13 - 1/15)) / 1000) + ((1,288 * 36,000 * (1/7.7 - 1/9)) / 1000)

= 1,203 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:

ΔkWH for remaining life of existing unit (1st 6 years):

= ((903 * 36,000 * (1/9.12 - 1/15)) / 1000) + ((1,288 * 36,000 * (1/5.44 - 1/9)) / 1000)

= 4769 kWh

ΔkWH for remaining measure life (next 12 years):

= ((903 * 36,000 * (1/13 - 1/15)) / 1000) + ((1,288 * 36,000 * (1/7.7 - 1/9)) / 1000)

= 1,203 kWh

[699] 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.
[700] Electric resistance has a COP of 1.0 which equals 1/0.293 = 3.41 HSPF.
[701] Based on Minimum Federal Standard; http://www1.eere.energy.gov/buildings/appliance_standards/residential/residential_cac_hp.html.

SUMMER COINCIDENT PEAK DEMAND SAVINGS

Time of sale:

ΔkW = (Capacity_cooling * (1/EER_base - 1/EER_ee)) / 1000) * CF

Early replacement[702]:

ΔkW for remaining life of existing unit (1st 6 years):

= ((Capacity_cooling * (1/EERexist - 1/EERee))/1000 * CF);

ΔkW for remaining measure life (next 12 years):

= ((Capacity_cooling * (1/EERbase - 1/EERee))/1000 * CF)

Where:

EER_exist = Energy Efficiency Ratio of existing cooling system (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:

$EER\_base = (-0.02 * SEER\_base^2) + (1.12 * SEER)$ [703]

If SEER rating unavailable use:

Existing Cooling System	EER_exist[704]
Air Source Heat Pump	8.55
Central AC	8.15
No central cooling[705]	Make '1/EER_exist' = 0

EER_base = Energy Efficiency Ratio of baseline Air Source Heat Pump (kBtu/hr / kW)

= 11.2 [706]

[702] 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).

[703] From Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder.

[704] Average nameplate efficiencies of all Early Replacement qualifying equipment in Ameren PY3-PY4.

[705] 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.

[706] The Federal Standard does not include an EER requirement, so it is approximated with this formula: (-0.02 *

EER_ee = Energy Efficiency Ratio of baseline Air Source Heat Pump (kBtu/hr / kW)

= Actual, If not provided convert SEER to EER using this formula:[707]

$= (-0.02 * SEER^2) + (1.12 * SEER)$

CF_{SSP} = Summer System Peak Coincidence Factor for Heat Pumps (during system peak hour)

= 72%%[708]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Heat Pumps (average during peak period)

= 46.6%[709]

SEER2) + (1.12 * SEER) Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder. Note this is appropriate for single speed units only.

[707] Based on Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder. Note this is appropriate for single speed units only.

[708] 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)'.

[709] 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:

ΔkW_{SSP} = ((36,000 * (1/11.2 – 1/12)) / 1000) * 0.72

= 0.154 kW

ΔkW_{PJM} = ((36,000 * (1/11.2 – 1/12)) / 1000) * 0.466

= 0.100 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:

ΔkW_{SSP} for remaining life of existing unit (1st 6 years):

= ((36,000 * (1/8.55 - 1/12)) / 1000) * 0.72

= 0.872 kW

ΔkW_{SSP} for remaining measure life (next 12 years):

= ((36,000 * (1/11.2 – 1/12)) / 1000) * 0.72

= 0.154 kW

ΔkW_{PJM} for remaining life of existing unit (1st 6 years):

= ((36,000 * (1/8.55 - 1/12)) / 1000) * 0.466

= 0.564 kW

ΔkW_{PJM} for remaining measure life (next 12 years):

= ((36,000 * (1/11.2 – 1/12)) / 1000) * 0.466

= 0.100 kW

NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HVC-ASHP-V03-140601

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[710].

Deemed Measure Cost

The measure cost including material and installation is assumed to be $3 per linear foot[711].

Loadshape

N/A

Coincidence Factor

N/A

Algorithm

Calculation of Savings

Electric Energy Savings

N/A

[710] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007.
http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf
[711] Consistent with DEER 2008 Database Technology and Measure Cost Data (www.deeresources.com).

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS SAVINGS

ΔTherm = $(((1/R_{exist} * C_{exist}) – (1/R_{new} * C_{new})) * FLH\_heat * L * \Delta T) / \eta Boiler / 100{,}000$

Where:

R_{exist} = Pipe heat loss coefficient of uninsulated pipe (existing) [(hr-°F-ft^2)/Btu]

= 0.5[712]

R_{new} = Pipe heat loss coefficient of insulated pipe (new) [(hr-°F-ft^2)/Btu]

= Actual (0.5 + R value of insulation)

FLH_heat = Full load hours of heating

= Dependent on location[713]:

Climate Zone (City based upon)	FLH_heat
1 (Rockford)	1,969
2 (Chicago)	1,840
3 (Springfield)	1,754
4 (Belleville)	1,266
5 (Marion)	1,288
Weighted Average[714]	1,821

L = Length of boiler pipe in unconditioned space covered by pipe wrap (ft)

= Actual

[712] 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.

[713] 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.

[714] Weighted based on number of occupied residential housing units in each zone.

C_{exist} = Circumference of bare pipe (ft) (Diameter (in) * π/12)

= Actual (0.5" pipe = 0.131ft, 0.75" pipe = 0.196ft)

C_{new} = Circumference of pipe with insulation (ft) (Diameter (in) * π/12)

= Actual

ΔT = Average temperature difference between circulated heated water and unconditioned space air temperature (°F) [715]

Pipes in unconditioned basement:

Outdoor reset controls	ΔT (°F)
Boiler without reset control	110
Boiler with reset control	70

Pipes in crawl space:

Climate Zone (City based upon)	ΔT (°F)	
	Boiler without reset control	Boiler with reset control
1 (Rockford)	127	87
2 (Chicago)	126	86
3 (Springfield)	122	82
4 (Belleville)	120	80
5 (Marion)	120	80
Weighted Average[716]	125	85

ηBoiler = Efficiency of boiler

= 0.819 [717]

[715] Assumes 160°F water temp for a boiler without reset control, 120°F for a boiler with reset control, and 50°F air temperature 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).

[716] Weighted based on number of occupied residential housing units in each zone.

[717] Average efficiency of boiler units found in Ameren PY3-PY4 data.

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:

ΔTherm = (((1/0.5 * 0.196) – (1/3.5 * 0.589)) * 10 * 120 * 1288) / 0.819 / 100,000

= 4.2 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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.

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

Definition of Efficient Equipment

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

Definition of Baseline Equipment

The baseline for the Time of Sale measure is based on the current Federal Standard efficiency level; 13 SEER and 11 EER.

The baseline for the early replacement measure is the efficiency of the existing equipment for the assumed remaining useful life of the unit and the new baseline as defined above[718] for the remainder of the measure life.

[718] Baseline SEER and EER should be updated when new minimum federal standards become effective.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 18 years [719].

Remaining life of existing equipment is assumed to be 6 years[720].

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[721]:

Efficiency Level	Cost per Ton
SEER 14	$119
SEER 15	$238
SEER 16	$357
SEER 17	$476
SEER 18	$596
SEER 19	$715
SEER 20	$834
SEER 21	$908
Average	$530

Early replacement: The incremental capital cost for this measure is the actual cost of removing the existing unit and installing the new one. If this is unknown, assume $3,413[722].

Assumed deferred cost (after 6 years) of replacing existing equipment with new baseline unit is assumed to be $2,857[723]. This cost should be discounted to present value using the utilities discount rate.

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719 Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007.
http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf
The "lifespan" of a central air conditioner is about 15 to 20 years (US DOE: http://www.energysavers.gov/your_home/space_heating_cooling/index.cfm/mytopic=12440).

720 Assumed to be one third of effective useful life

721 DEER 2008 Database Technology and Measure Cost Data (www.deeresources.com)

722 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).

723 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.

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} = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)

= 68%[724]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)

= 46.6%[725]

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

Time of sale:

ΔkWH = (FLHcool * Btu/hr * (1/SEERbase - 1/SEERee))/1000

Early replacement[726]:

ΔkWH for remaining life of existing unit (1st 6 years):

=((FLHcool * Capacity * (1/SEERexist - 1/SEERee))/1000);

ΔkWH for remaining measure life (next 12 years):

= ((FLHcool * Capacity * (1/SEERbase - 1/SEERee))/1000)

724 Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.

725 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.

726 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:

FLHcool = Full load cooling hours

= dependent on location and building type[727]:

Climate Zone (City based upon)	FLHcool (single family)	FLHcool (multi family)
1 (Rockford)	512	467
2 (Chicago)	570	506
3 (Springfield)	730	663
4 (Belleville)	1035	940
5 (Marion)	903	820
Weighted Average[728]	629	564

Capacity = Size of new equipment in Btu/hr (note 1 ton = 12,000Btu/hr)

= Actual installed, or if actual size unknown 33,600Btu/hr for single-family buildings[729]

SEERbase = Seasonal Energy Efficiency Ratio of baseline unit (kBtu/kWh)

= 13[730]

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[731].

SEERee = Seasonal Energy Efficiency Ratio of ENERGY STAR unit (kBtu/kWh)

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727 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.

728 Weighted based on number of residential occupied housing units in each zone.

729 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.

730 Based on Minimum Federal Standard; http://www1.eere.energy.gov/buildings/appliance_standards/residential/residential_cac_hp.html.

731 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.

= Actual installed or 14.5 if unknown

> Time of sale example: a 3 ton unit with SEER rating of 14.5, in unknown location:
>
> ΔkWH = (629 * 36,000 * (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:
>
> ΔkWH(for first 6 years) = (629 * 36,000 * (1/10 – 1/14.5)) / 1000
>
> = 702 kWh
>
> ΔkWH(for next 12 years) = (629 * 36,000 * (1/13 – 1/14.5)) / 1000
>
> = 180 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

Time of sale:

ΔkW = (Capacity * (1/EERbase - 1/EERee))/1000 * CF

Early replacement[732]:

ΔkW for remaining life of existing unit (1st 6 years):

= ((Capacity * (1/EERexist - 1/EERee))/1000 * CF);

ΔkW for remaining measure life (next 12 years):

= ((Capacity * (1/EERbase - 1/EERee))/1000 * CF)

Where:

EERbase = EER Efficiency of baseline unit

= 11.2 [733]

[732] 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).

[733] The federal Standard does not currently include an EER component. The value is approximated based on the SEER standard (13) and equals EER 11.2. To perform this calculation we are using this formula: (-0.02 * SEER2) + (1.12 * SEER) (from Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat

EERexist = EER Efficiency of existing unit

= Actual EER of unit should be used, if EER is unknown, use 9.2[734]

EERee = EER Efficiency of ENERGY STAR unit

= Actual installed or 12 if unknown

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)

= 68%[735]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)

= 46.6%[736]

Time of sale example: a 3 ton unit with EER rating of 12:

ΔkW_{SSP} = (36,000 * (1/11.2– 1/12)) / 1000 * 0.68

= 0.146 kW

ΔkW_{PJM} = (36,000 * (1/11.2– 1/12)) / 1000 * 0.466

= 0.100 kW

Early replacement example: a 3 ton unit with EER rating of 12 replaces an existing unit:

ΔkW_{SSP} (for first 6 years) = (36,000 * (1/9.2– 1/12)) / 1000 * 0.68

= 0.621 kW

ΔkW_{SSP} (for next 12 years) = (36,000 * (1/11.2– 1/12)) / 1000 * 0.68

= 0.146 kW

ΔkW_{PJM} (for first 6 years) = (36,000 * (1/9.2– 1/12)) / 1000 * 0.466

= 0.425 kW

ΔkW_{PJM} (for next 12 years) = (36,000 * (1/11.2– 1/12)) / 1000 * 0.466

= 0.100 kW

Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder).

[734] Based on SEER of 10,0, using formula above to give 9.2 EER.

[735] Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.

[736] 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

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HVC-CAC1-V03-140601

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.

1. **Modified Blower Door Subtraction** – this technique is described in detail on p.44 of the Energy Conservatory Blower Door Manual; http://www.energyconservatory.com/download/bdmanual.pdf

2. **Evaluation of Distribution Efficiency** – this methodology requires the evaluation of three duct characteristics below, and use of the Building Performance Institutes 'Distribution Efficiency Look-Up Table';

   http://www.bpi.org/files/pdf/DistributionEfficiencyTable-BlueSheet.pdf

   a. Percentage of duct work found within the conditioned space

   b. Duct leakage evaluation

   c. Duct insulation evaluation

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

Definition of Efficient Equipment

The efficient condition is sealed duct work throughout the unconditioned space in the home.

Definition of Baseline Equipment

The existing baseline condition is leaky duct work within the unconditioned space in the home.

Deemed Lifetime of Efficient Equipment

The assumed lifetime of this measure is 20 years[737].

Deemed Measure Cost

The actual duct sealing measure cost should be used.

[737] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007.
http://neep.org/uploads/EMV%20Forum/EMV%20Studies/measure_life_GDS%5B1%5D.pdf

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} = Summer System Peak Coincidence Factor for Central A/C (during utility peak hour)

= 68%[738]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)

= 46.6%[739]

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

Methodology 1: Modified Blower Door Subtraction

a) Determine Duct Leakage rate before and after performing duct sealing:

Duct Leakage ($CFM50_{DL}$) = ($CFM50_{Whole\ House}$ – $CFM50_{Envelope\ Only}$) * SCF

Where:

$CFM50_{Whole\ House}$ = Standard Blower Door test result finding Cubic Feet per Minute at 50 Pascal pressure differential

$CFM50_{Envelope\ Only}$ = Blower Door test result finding Cubic Feet per Minute at 50 Pascal pressure differential with all supply and return registers sealed.

SCF = Subtraction Correction Factor to account for underestimation of duct leakage due to connections between the duct system and the home. Determined by measuring pressure in duct system with registers sealed and using look up table

[738] Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.

[739] 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.

provided by Energy Conservatory.

b) Calculate duct leakage reduction, convert to $CFM25_{DL}$ and factor in Supply and Return Loss Factors

Duct Leakage Reduction ($\Delta CFM25_{DL}$) = (Pre $CFM50_{DL}$ – Post $CFM50_{DL}$) * 0.64 * (SLF + RLF)

Where:

0.64 = Converts CFM50 to CFM25[740]

SLF = Supply Loss Factor

= % leaks sealed located in Supply ducts * 1 [741]

Default = 0.5[742]

RLF = Return Loss Factor

= % leaks sealed located in Return ducts * 0.5[743]

Default = 0.25[744]

c) Calculate Energy Savings:

$\Delta kWh_{cooling}$ = (($\Delta CFM25_{DL}$)/ ((CapacityCool/12,000) * 400)) * FLHcool * CapacityCool) / 1000 / ηCool

Where:

$\Delta CFM25_{DL}$ = Duct leakage reduction in CFM25

= calculated above

[740] 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).

[741] 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

[742] Assumes 50% of leaks are in supply ducts.

[743] 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

[744] 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)

FLHcool = Full load cooling hours

= Dependent on location as below[745]:

Climate Zone (City based upon)	FLHcool Single Family	FLHcool Multifamily
1 (Rockford)	512	467
2 (Chicago)	570	506
3 (Springfield)	730	663
4 (Belleville)	1,035	940
5 (Marion)	903	820
Weighted Average[746]	629	564

1000 = Converts Btu to kBtu

ηCool = Efficiency (SEER) of Air Conditioning equipment (kBtu/kWh)

= Actual. If unknown assume the following[747]:

Age of Equipment	SEER Estimate
Before 2006	10
After 2006	13

[745] 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.

[746] Weighted based on number of occupied residential housing units in each zone.

[747] These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Central AC was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate.

For example, duct sealing in a single family house in Springfield with a 36,000 Btu/H, SEER 11 central air conditioning and the following blower door test results:

Before: $CFM50_{Whole\ House}$ = 4800 CFM50

$CFM50_{Envelope\ Only}$ = 4500 CFM50

House to duct pressure of 45 Pascals. = 1.29 SCF (Energy Conservatory look up table)

After: $CFM50_{Whole\ House}$ = 4600 CFM50

$CFM50_{Envelope\ Only}$ = 4500 CFM50

House to duct pressure of 43 Pascals = 1.39 SCF (Energy Conservatory look up table)

Duct Leakage:

$CFM50_{DL\ before}$ = (4800 – 4500) * 1.29

= 387 CFM

$CFM50_{DL\ after}$ = (4600 – 4500) * 1.39

= 139 CFM

Duct Leakage reduction at CFM25:

$\Delta CFM25_{DL}$ = (387 – 139) * 0.64 * (0.5 + 0.25)

= 119 CFM25

Energy Savings:

$\Delta kWh_{cooling}$ = ((119 / ((36,000/12,000) * 400)) * 730 * 36,000) / 1000 / 11

= 237 kWh

Heating savings for homes with electric heat (Heat Pump):

$\Delta kWh_{heating}$ = ((($\Delta CFM25_{DL}$ /((CapacityHeat/12,000) * 400)) * FLHheat * CapacityHeat) / ηHeat / 3412

Where:

CapacityHeat = Heating input capacity (Btu/hr)

=Actual

FLHheat = Full load heating hours

= Dependent on location as below[748]:

Climate Zone (City based upon)	FLH_heat
1 (Rockford)	1,969
2 (Chicago)	1,840
3 (Springfield)	1,754
4 (Belleville)	1,266
5 (Marion)	1,288
Weighted Average[749]	1,821

ηHeat = Efficiency in COP of Heating equipment

= Actual. If not available use[750]:

System Type	Age of Equipment	HSPF Estimate	COP Estimate
Heat Pump	Before 2006	6.8	2.00
	After 2006	7.7	2.26
Resistance	N/A	N/A	1.00

3412 = Converts Btu to kWh

For example, duct sealing in a 36,000 Btu/H 2.5 COP heat pump heated single family house in Springfield with the blower door results described above:

$\Delta kWh_{heating}$ = (((119 / ((36,000/12,000) * 400)) * 1,754 * 36,000) / 2.5 / 3412

= 734 kWh

Methodology 2: Evaluation of Distribution Efficiency

Determine Distribution Efficiency by evaluating duct system before and after duct sealing using Building Performance Institute "Distribution Efficiency Look-Up Table"

$\Delta kWh_{cooling}$ = $((DE_{after} - DE_{before}) / DE_{after})) * FLHcool * CapacityCool)/1000 / \eta Cool$

[748] 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.
[749] Weighted based on number of occupied residential housing units in each zone.
[750] These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Heat Pumps was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate.

Where:

DE_{after} = Distribution Efficiency after duct sealing

DE_{before} = Distribution Efficiency before duct sealing

FLHcool = Full load cooling hours

= Dependent on location as below[751]:

Climate Zone (City based upon)	FLHcool Single Family	FLHcool Multifamily
1 (Rockford)	512	467
2 (Chicago)	570	506
3 (Springfield)	730	663
4 (Belleville)	1,035	940
5 (Marion)	903	820
Weighted Average[752]	629	564

CapacityCool = Capacity of Air Cooling system (Btu/hr)

=Actual

1000 = Converts Btu to kBtu

ηCool = Efficiency (SEER) of Air Conditioning equipment (kBtu/kWh)

= Actual. If unknown assume[753]:

Age of Equipment	SEER Estimate
Before 2006	10
After 2006	13

[751] 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.
[752] Weighted based on number of occupied residential housing units in each zone.
[753] These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Central AC was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate.

For example, duct sealing in a single family house in Springfield, with 36,000 Btu/H SEER 11 central air conditioning and the following duct evaluation results:

DE_{before} = 0.85

DE_{after} = 0.92

Energy Savings:

$\Delta kWh_{cooling}$ = ((0.92 – 0.85)/0.92) * 730 * 36,000) / 1000 / 11

= 182 kWh

<u>Heating savings for homes with electric heat (Heat Pump or resistance):</u>

$\Delta kWh_{heating}$ = $((DE_{after} – DE_{before})/ DE_{after}))$ * FLHheat * CapacityHeat) / ηHeat / 3412

Where:

CapacityHeat = Heating input capacity (Btu/hr)

=Actual

FLHheat = Full load heating hours

= Dependent on location as below[754]:

Climate Zone (City based upon)	FLH_heat
1 (Rockford)	1,969
2 (Chicago)	1,840
3 (Springfield)	1,754
4 (Belleville)	1,266
5 (Marion)	1,288
Weighted Average[755]	1,821

[754] 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.
[755] Weighted based on number of occupied residential housing units in each zone.

COP = Coefficient of Performance of electric heating system[756]

= Actual. If not available use[757]:

System Type	Age of Equipment	HSPF Estimate	COP Estimate
Heat Pump	Before 2006	6.8	2.00
	After 2006	7.7	2.26
Resistance	N/A	N/A	1.00

For example, duct sealing in a 36,000 Btu/H, 2.5 COP heat pump heated single family house in Springfield with the following duct evaluation results:

DE_{after} = 0.92

DE_{before} = 0.85

Energy Savings:

$\Delta kWh_{heating}$ = ((0.92 – 0.85)/0.92) * 1,967 * 36,000) / 2.5) / 3412

= 632 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$\Delta kW = \Delta kWh_{cooling} / FLHcool * CF$

Where:

FLHcool = Full load cooling hours:

= Dependent on location as below[758]:

[756] Note that the HSPF of a heat pump is equal to the COP * 3.413.

[757] 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.

[758] 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.

Climate Zone (City based upon)	FLHcool Single Family	FLHcool Multifamily
1 (Rockford)	512	467
2 (Chicago)	570	506
3 (Springfield)	730	663
4 (Belleville)	1,035	940
5 (Marion)	903	820
Weighted Average[759]	629	564

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)

= 68%[760]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)

= 46.6%[761]

NATURAL GAS SAVINGS

<u>For homes with Natural Gas Heating:</u>

Methodology 1: Modified Blower Door Subtraction

ΔTherm = (((ΔCFM25$_{DL}$ / (CapacityHeat * 0.0123)) * FLHheat * CapacityHeat) / 100,000 / ηHeat

Where:

ΔCFM25$_{DL}$ = Duct leakage reduction in CFM25

CapacityHeat = Heating input capacity (Btu/hr)

=Actual

0.0123 = Conversion of Capacity to CFM (0.0123CFM / Btu/hr)[762]

FLHheat = Full load heating hours

---

759 Weighted based on number of occupied residential housing units in each zone.

760 Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.

761 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.

762 Based on Natural Draft Furnaces requiring 100 CFM per 10,000 Btu, Induced Draft Furnaces requiring 130CFM per 10,000Btu and Condensing Furnaces requiring 150 CFM per 10,000 Btu (rule of thumb from http://contractingbusiness.com/enewsletters/cb_imp_43580/). Data provided by GAMA during the federal rule-making process for furnace efficiency standards, suggested that in 2000, 24% of furnaces purchased in Illinois were condensing units. Therefore a weighted average required airflow rate is calculated assuming a 50:50 split of natural v induced draft non-condensing furnaces, as 123 per 10,000Btu or 0.0123/Btu.

=Dependent on location as below[763]:

Climate Zone (City based upon)	FLH_heat
1 (Rockford)	1,969
2 (Chicago)	1,840
3 (Springfield)	1,754
4 (Belleville)	1,266
5 (Marion)	1,288
Weighted Average[764]	1,821

100,000 = Converts Btu to therms

ηHeat = Average Net Heating System Efficiency (Equipment Efficiency * Distribution Efficiency)[765]

= Actual. If not available use 70%[766].

[763] 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.
[764] Weighted based on number of occupied residential housing units in each zone.
[765] The System Efficiency can be obtained either by recording the AFUE of the unit, or performing a steady state efficiency test. The Distribution Efficiency can be estimated via a visual inspection and by referring to a look up table such as that provided by the Building Performance Institute: (http://www.bpi.org/files/pdf/DistributionEfficiencyTable-BlueSheet.pdf) or by performing duct blaster testing.
If there are more than one heating systems, the weighted (by consumption) average efficiency should be used.
If the heating system or distribution is being upgraded within a package of measures together with the insulation upgrade, the new average heating system efficiency should be used.
[766] This has been estimated assuming that natural gas central furnace heating is typical for Illinois residences (66% of Illinois homes have a Natural Gas Furnace (based on Energy Information Administration, 2009 Residential Energy Consumption Survey: http://www.eia.gov/consumption/residential/data/2009/xls/HC6.9%20Space%20Heating%20in%20Midwest%20Region.xls))
In 2000, 24% of furnaces purchased in Illinois were condensing (based on data from GAMA, provided to Department of Energy during the federal standard setting process for residential heating equipment - see Furnace Penetration.xls). Furnaces tend to last up to 20 years and so units purchased 10 years ago provide a reasonable proxy for the current mix of furnaces in the State. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows:
(0.24*0.92) + (0.76*0.8) * (1-0.15) = 0.70

For example, duct sealing in a house in Springfield with an 80% AFUE, 105,000 Btu/H natural gas furnace and the following blower door test results:

Before: $CFM50_{Whole\ House}$ = 4800 CFM50

$CFM50_{Envelope\ Only}$ = 4500CFM50

House to duct pressure of 45 Pascals = 1.29 SCF (Energy Conservatory look up table)

After: $CFM50_{Whole\ House}$ = 4600 CFM50

$CFM50_{Envelope\ Only}$ = 4500CFM50

House to duct pressure of 43 Pascals = 1.39 SCF (Energy Conservatory look up table)

Duct Leakage:

$CFM50_{DL\ before}$ = (4800 – 4500) * 1.29

= 387 CFM

$CFM50_{DL\ after}$ = (4600 – 4500) * 1.39

= 119 CFM

Duct Leakage reduction at CFM25:

$\Delta CFM25_{DL}$ = (387 – 139) * 0.64 * (0.5 + 0.25)

= 119 CFM25

Energy Savings:

ΔTherm = ((119/ (105,000 * 0.0123)) * 1,754 * 105,000) / 100,000 / 0.80

= 212 therms

Methodology 2: Evaluation of Distribution Efficiency

$$\Delta Therm = ((DE_{after} - DE_{before}) / DE_{after})) * FLHheat * CapacityHeat) / 100,000 / \eta Heat$$

Where:

DE_{after} = Distribution Efficiency after duct sealing

DE_{before} = Distribution Efficiency before duct sealing

Other variables as defined above

For example, duct sealing in a house in Springfield an 80% AFUE, 105,000 Btu/H natural gas furnace and the following duct evaluation results:

DE_{after} = 0.92

DE_{before} = 0.85

Energy Savings:

$$\Delta Therm = ((0.92 - 0.85)/0.92) * 1{,}754 * 105{,}000) / 100{,}000 / 0.80$$

$$= 175 \text{ therm}$$

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HVC-DINS-V02-140601

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[767].

Deemed Measure Cost

The capital cost for this measure is assumed to be $97[768].

Loadshape

Loadshape R08 - Residential Cooling
Loadshape R09 - Residential Electric Space Heat
Loadshape R10 - Residential Electric Heating and Cooling

[767] Consistent with assumed life of a new gas furnace. Table 8.3.3 The Technical support documents for federal residential appliance standards:
http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/fb_fr_tsd/chapter_8.pdf
[768] Adapted from Tables 8.2.3 and 8.2.13 in
http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/hvac_ch_08_lcc_2011-06-24.pdf

Coincidence Factor

The summer peak coincidence factor for cooling is provided in two different ways below. The first is used to estimate peak savings during the utility peak hour and is most indicative of actual peak benefits, and the second represents the *average* savings over the defined summer peak period, and is presented so that savings can be bid into PJM's Forward Capacity Market.

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during utility peak hour)
= 68%[769]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)
= 46.6%[770]

Algorithm

Calculation of Savings

Electric Energy Savings

ΔkWh = Heating Savings + Cooling Savings + Shoulder Season Savings

Where:

Heating Savings = Blower motor savings during heating season

= 418 kWh[771]

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[772]

[769] Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.
[770] 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.
[771] 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.
[772] 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

Shoulder Season Savings = Blower motor savings during shoulder seasons

= 51 kWh

For example, a blower motor in a home where Central AC presence is unknown:

ΔkWh = Heating Savings + Cooling Savings + Shoulder Season Savings

= 418 +251 + 51

= 721 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = Cooling Savings / FLH_cooling * CF

Where:

FLH_cooling = Full load hours of air conditioning

= Dependent on location[773]:

Climate Zone (City based upon)	FLH_cooling
1 (Rockford)	512
2 (Chicago)	570
3 (Springfield)	730
4 (Belleville)	1,035
5 (Marion)	903
Weighted Average[774]	629

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)

= 68%[775]

overlap to a large extent (like the 95% in the FOE study above).

[773] 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.

[774] Weighted based on number of occupied residential housing units in each zone.

[775] Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)

= 46.6%[776]

> For example, a blower motor in a home of unknown location where Central AC prevalence is unknown:
>
> ΔkW_{SSP} = 251 / 629 * 0.68
>
> = 0.271 kW
>
> ΔkW_{SSP} = 251 / 629 * 0.466
>
> = 0.186 kW

NATURAL GAS SAVINGS

Δtherms[777] = - Heating Savings * 0.03412 therms/kWh

= - (418 * 0.03412)

= - 14.3 therms[778]

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HVC-FBMT-V02-140601

[776] 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.

[777] The blower fan is in the heating duct so all, or very nearly all, of its waste heat is delivered to the conditioned space.

[778] Negative value since this measure will increase the heating load due to reduced waste heat.

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.

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% 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:

Program Year	AFUE
June 2012 – May 2013[779]	80%
June 2013 on	82%

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[780].

Early replacement: Remaining life of existing equipment is assumed to be 8 years[781].

Deemed Measure Cost

Time of sale: The incremental install cost for this measure is dependent on tier[782]:

		Incremental Install Cost	Incremental Install Cost
Measure Type	Installation Cost	(June 2012 – May 2013)	(June 2013 on)
AFUE 80%	$3334	n/a	
AFUE 82%	$3543		
AFUE 85% (Energy Star Minimum)	$4268	$934	$725
AFUE 90%	$4815	$1,481	$1,272
AFUE 95%	$5328	$1,994	$1,785

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

[779] There will be some delay to the baseline shift while existing stocks of lower efficiency equipment is sold.
[780] 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
[781] Assumed to be one third of effective useful life
[782] 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.

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:

ΔTherms = Gas_Boiler_Load * (1/AFUE(base) - 1/AFUE(eff))

Early replacement[783]:

ΔTherms for remaining life of existing unit (1st 8 years):

= Gas_Boiler_Load * (1/AFUE(exist) - 1/AFUE(eff)))

ΔTherms for remaining measure life (next 17 years):

= Gas_Boiler_Load * (1/AFUE(base) - 1/AFUE(eff)))

Where:

Gas_Boiler_Load[784]

= Estimate of annual household Load for gas boiler heated single-family homes. If location is unknown, assume the average below[785].

[783] 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).

[784] 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)

[785] Values are based on household heating consumption values and inferred average AFUE results from Table 3-4,

= or Actual if informed by site-specific load calculations, ACCA Manual J or equivalent[786].

Climate Zone (City based upon)	Gas_Boiler Load (therms)
1 (Rockford)	1275
2 (Chicago)	1218
3 (Springfield)	1043
4 (Belleville)	805
5 (Marion)	819
Average	1158

AFUE(exist) = Existing Boiler Annual Fuel Utilization Efficiency Rating

= Use actual AFUE rating where it is possible to measure or reasonably estimate.

If unknown, assume 61.6 AFUE% [787].

AFUE(base) = Baseline Boiler Annual Fuel Utilization Efficiency Rating

= Dependent on year as listed below:

Program Year	AFUE(base)
June 2012 – May 2013	80%
June 2013 on	82%

AFUE(eff) = Efficent Boiler Annual Fuel Utilization Efficiency Rating

= Actual. If unknown, use defaults dependent[788] on tier as listed below:

Measure Type	AFUE(eff)
ENERGY STAR®	87.5%
AFUE 90%	92.5%
AFUE 95%	95%

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.

[786] 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.

[787] Average nameplate efficiencies of all Early Replacement qualifying equipment in Ameren PY3-PY4.

[788] 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.

Time of Sale:

For example, a default sized ENERGY STAR boiler purchased and installed near Springfield in the year 2012

ΔTherms = (1043) * (1/0.8) - 1/0.875)

= 112 Therms

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.

ΔTherms for remaining life of existing unit (1st 8 years):

= 1043 * (1/0.616 – 1/0.875)

= 501 Therms

ΔTherms for remaining measure life (next 17 years):

= (1043) * (1/0.82 - 1/0.875)

= 80.0 Therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HVC-GHEB-V02-130601

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:

b) 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.

c) 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.

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[789].

For early replacement: Remaining life of existing equipment is assumed to be 6 years[790].

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[791]:

AFUE	Installed Cost	Incremental Installed Cost
80%	$2011	n/a
90%	$2641	$630
91%	$2727	$716
92%	$2813	$802
93%	$3025	$1014
94%	$3237	$1226
95%	$3449	$1438
96%	$3661	$1650

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

[789] 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

[790] Assumed to be one third of effective useful life

[791] 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.

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:

ΔTherms = Gas_Furnace_Heating_Load * (1/AFUE(base) - 1/AFUE(eff))

Early replacement[792]:

ΔTherms for remaining life of existing unit (1st 6 years):

= Gas_Furnace_Heating_Load * (1/AFUE(exist) - 1/AFUE(eff)))

ΔTherms for remaining measure life (next 14 years):

= Gas_Furnace_Heating_Load * (1/AFUE(base) - 1/AFUE(eff)))

Where:

Gas_Furnace_Heating_Load

= Estimate of annual household heating load [793] for gas furnace heated single-family homes. If location is unknown, assume the average below[794].

= Actual if informed by site-specific load calculations, ACCA Manual J or equivalent[795].

[792] 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).

[793] Heating load is used to describe the household heating need, which is equal to (gas consumption * AFUE)

[794] 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.

[795] 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.

Climate Zone (City based upon)	Gas_Furnace_Heating_Load (therms)
1 (Rockford)	873
2 (Chicago)	834
3 (Springfield)	714
4 (Belleville)	551
5 (Marion)	561
Average	793

HF = Household factor, to adjust heating consumption for non-single-family households.

Household Type	HF
Single-Family	100%
Multi-Family	65%[796]
Actual	Custom[797]

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% .

AFUE(base) = Baseline Furnace Annual Fuel Utilization Efficiency Rating

= Dependent on program type as listed below[799]:

Program Year	AFUE(base)
Time of Sale	80%
Early Replacement	90%

AFUE(eff) = Efficent Furnace Annual Fuel Utilization Efficiency Rating

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.

[796] 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

[797] Program-specific household factors may be utilized on the basis of sufficiently validated program evaluations.

[798] Average nameplate efficiencies of all Early Replacement qualifying equipment in Ameren PY3-PY4.

[799] 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.

= Actual. If unknown, assume 95%[800]

Time of Sale:

For example, a 95% AFUE furnace near Rockford and purchased in the year 2014

ΔTherms = 873 * (1/0.8 - 1/0.95)

=172 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.

ΔTherms for remaining life of existing unit (1st 6 years):

= 873 * (1/0.644 – 1/0.95)

= 437 therms

ΔTherms for remaining measure life (next 14 years):

= 873 * (1/0.9 - 1/0.95)

=51.1 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HVC-GHEF-V03-140601

[800] Minimum ENERGY STAR efficiency after 2.1.2012.

5.3.8 Ground Source Heat Pump

DESCRIPTION

This measure characterizes:

a) Time of sale:
   a. The installation of a new residential sized Ground Source Heat Pump 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 functioning electric heating and cooling (SEER 10 or under if present) systems from service, prior to the natural end of life, and replacement with a new high efficiency Ground Source Heat Pump system. 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.

The ENERGY STAR efficiency standards are presented below.

ENERGY STAR Requirements (Effective January 1, 2012)

Product Type	EER	COP
Water-to-air		
Closed Loop	17.1	3.6
Open Loop	21.1	4.1
Water-to-Water		
Closed Loop	16.1	3.1
Open Loop	20.1	3.5
DGX	16	3.6

This measure was developed to be applicable to the following program types: TOS, NC, 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

Time of Sale: The baseline equipment is assumed to be an Air Source Heat Pump meeting the Federal Standard efficiency level; 13 SEER, 7.7 HSPF and 11 EER.

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 18 years[801].

Remaining life of existing equipment is assumed to be 6 years[802].

Deemed Measure Cost

The actual installed cost of the Ground Source Heat Pump should be used, minus the assumed installation cost of a 3 ton standard baseline Air Source Heat Pump of $3,609[803].

Early Replacement: The full installation cost of the Ground Source Heat Pump should be used. The assumed deferred cost (after 6 years) of replacing existing equipment with a new baseline unit is assumed to be $3609 (corresponding to a new baseline Air Source Heat Pump). 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.

CF_{SSP} = Summer System Peak Coincidence Factor for Heat Pumps (during utility peak hour)

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[801] Lifetime for an air source heat pump. The ground loop has a much longer life, but the compressor and other mechanical components are the same as an ASHP. The more moderate operating conditions for a GSHP may extend the life of these components beyond the life of an ASHP. Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007. http://neep.org/uploads/EMV%20Forum/EMV%20Studies/measure_life_GDS%5B1%5D.pdf

[802] Assumed to be one third of effective useful life

[803] Based on DEER 2008 Database Technology and Measure Cost Data (www.deeresources.com). Material cost of 13 SEER AC is $796 per ton, and labor cost of $407 per ton. For a 3 ton unit this would be (796+407) *3 = $3609.

= 72%%[804]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Heat Pumps (average during PJM peak period)
= 46.6%[805]

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

Time of sale:

ΔkWh = (FLHcool * Capacity_cooling * (1/SEERbase – (1/(EERee * 1.02))/1000 + (FLHheat * Capacity_heating * (1/HSPFbase – (1/COPee * 3.412))/1000

Early replacement[806]:

ΔkWH for remaining life of existing unit (1st 6 years):

= (FLHcool * Capacity_cooling * (1/SEERexist – (1/(EERee * 1.02))/1000 + (FLHheat * Capacity_heating * (1/HSPFexist – (1/COPee * 3.412))/1000

ΔkWH for remaining measure life (next 12 years):

= (FLHcool * Capacity_cooling * (1/SEERbase – (1/(EERee * 1.02))/1000 + (FLHheat * Capacity_heating * (1/HSPFbase – (1/COPee * 3.412))/1000

Where:

FLHcool = Full load cooling hours

Dependent on location as below[807]:

[804] 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)'.

[805] 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.

[806] 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).

[807] 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.

Climate Zone (City based upon)	FLHcool Single Family	FLHcool Multifamily
1 (Rockford)	512	467
2 (Chicago)	570	506
3 (Springfield)	730	663
4 (Belleville)	1,035	940
5 (Marion)	903	820
Weighted Average[808]	629	564

Capacity_cooling = Cooling Capacity of Ground Source Heat Pump (Btu/hr)

= Actual (1 ton = 12,000Btu/hr)

SEERexist = SEER Efficiency of existing cooling unit

= Use actual SEER rating where it is possible to measure or reasonably estimate.

Existing Cooling System	SEER_exist[809]
Air Source Heat Pump	9.12
Central AC	8.60
No central cooling[810]	Make '1/SEER_exist' = 0

SEERbase = SEER Efficiency of baseline ASHP unit

= 13 [811]

EERee = EER Efficiency of efficient GSHP unit

= Actual installed

1.02 = Constant used to estimate the equivalent air conditioning SEER based on the GSHP unit's EER[812].

FLHheat = Full load heating hours

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[808] Weighted based on number of occupied residential housing units in each zone.

[809] Average nameplate efficiencies of all Early Replacement qualifying equipment in Ameren PY3-PY4.

[810] 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.

[811] Minimum Federal Standard; Federal Register, Vol. 66, No. 14, Monday, January 22, 2001/Rules and Regulations, p. 7170-7200.

[812] Note that EERs of GSHPs are measured differently than EERs of air source heat pumps (focusing on entering water temperatures rather than ambient air temperatures). The equivalent SEER of a GSHP can be estimated by multiplying EER by 1.02, based on VEIC extrapolation of manufacture data.

Dependent on location as below[813]:

Climate Zone (City based upon)	FLH_heat
1 (Rockford)	1,969
2 (Chicago)	1,840
3 (Springfield)	1,754
4 (Belleville)	1,266
5 (Marion)	1,288
Weighted Average[814]	1,821

Capacity_heating = Heating Capacity of Ground Source Heat Pump (Btu/hr)

= Actual (1 ton = 12,000Btu/hr)

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.

Existing Cooling System	HSPF_exist
Air Source Heat Pump	5.44
Electric Resistance	3.41[816]

HSPFbase =Heating Season Performance Factor for baseline unit

=7.7 [817]

COPee = Coefficient of Performance of efficient unit

= Actual Installed

3.412 = Constant to convert the COP of the unit to the Heating Season Performance Factor (HSPF).

[813] Heating EFLH based on ENERGY Star EFLH for Rockford, Chicago, and Springfield and on NCDC/NOAA HDD for the other two cities. In all cases, the hours were adjusted based on average natural gas heating consumption in IL. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

[814] Weighted based on number of occupied residential housing units in each zone.

[815] 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.

[816] Electric resistance has a COP of 1.0 which equals 1/0.293 = 3.41 HSPF.

[817] Minimum Federal Standard; Federal Register, Vol. 66, No. 14, Monday, January 22, 2001/Rules and Regulations, p. 7170-7200.

Time of Sale:

For example, a 3 ton unit with EER rating of 16 and COP of 3.5 in single family house in Springfield:

ΔkWh = (FLHcool * Btu/H * (1/SEERbase – (1/(EERee * 1.02))/1000+ (FLHheat * Btu/H * (1/HSPFbase – (1/COPee * 3.412))/1000

ΔkWh = (730 * 36,000 * (1/13 – 1/ (16*1.02))) / 1000 + (1967 * 36,000 * (1/7.7 – 1/ (3.5*3.412)) / 1000

= 3680 kWh

Early Replacement:

For example, a 3 ton unit with EER rating of 16 and COP of 3.5 in single family house in Springfield replaces an existing working Air Source Heat Pump with unknown efficiency ratings:

ΔkWH for remaining life of existing unit (1st 6 years):

= (730* 36,000 * (1/9.12 - 1/(16*1.02))) / 1000) + ((1,967 * 36,000 * (1/5.44 - 1/(3.5 * 3.412))) / 1000)

= 8359 kWh

ΔkWH for remaining measure life (next 12 years):

= (730 * 36,000 * (1/13 – 1/ (16*1.02))) / 1000 + (1967 * 36,000 * (1/7.7 – 1/ (3.5*3.412)) / 1000

= 1,203 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

Time of sale:

$$\Delta kW = (Capacity\_cooling * (1/EERbase - 1/EERee_{AC\ equivalent}))/1000) * CF$$

Early replacement[818]:

ΔkW for remaining life of existing unit (1st 6 years):

$$= (Capacity\_cooling * (1/EERexist - 1/EERee_{AC\ equivalent}))/1000) * CF$$

ΔkW for remaining measure life (next 12 years):

[818] 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).

= (Capacity_cooling * (1/EERexist - 1/$EERee_{AC\ equivalent}$))/1000) * CF

Where:

EERexist = 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_base = (-0.02 * SEER_base^2) + (1.12 * SEER) [819]

If SEER rating unavailable use:

Existing Cooling System	EER_exist[820]
Air Source Heat Pump	8.55
Central AC	8.15
No central cooling[821]	Make '1/EER_exist' = 0

EERbase = EER Efficiency of baseline ASHP unit

= 11 [822]

$EERee_{AC\ equivalent}$ = Equivalent Air Conditioning EER Efficiency of ENERGY STAR GSHP unit[823]

To calculate this, the actual EER of the GSHP is converted to an air conditioning SEER equivalent by multiplying by 1.02 [824]

This is then converted to the air conditioning EER equivalent resulting in the following algorithm:

$EERee_{AC\ equivalent}$= (-0.02 * (EERee * 1.02)^2 + (1.12 * (EERee * 1.02)) [825]

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)

= 72%%[826]

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[819] From Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder.
[820] Average nameplate efficiencies of all Early Replacement qualifying equipment in Ameren PY3-PY4.
[821] 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.
[822] Minimum Federal Standard; as above.
[823] EERs of GSHPs are measured differently than EERs of air source heat pumps (focusing on entering water temperatures rather than ambient air temperatures).
[824] Based on VEIC extrapolation of manufacturer data.
[825] Air conditioning SEER to EER algorithm based on Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder. Note this is appropriate for single speed units only.

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)

= 46.6%[827]

[826] 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)'.

[827] 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 3 ton unit with EER rating of 16:

$$\Delta kW_{SSP} = ((36{,}000 * (1/11 – 1/(-0.02 * (16 * 1.02)^2 + (1.12 * (16 * 1.02))))/1000) * 0.72$$

$$= 0.355 \text{ kW}$$

$$\Delta kW_{PJM} = ((36{,}000 * (1/11 – 1/(-0.02 * (16 * 1.02)^2 + (1.12 * (16 * 1.02))))/1000) * 0.466$$

$$= 0.230 \text{ kW}$$

Early Replacement:

For example, a 3 ton 16 EER replaces an existing working Air Source Heat Pump with unknown efficiency ratings in Marion:

ΔkW_{SSP} for remaining life of existing unit (1st 6 years):

$$= ((36{,}000 * (1/8.55 – 1/(-0.02 * (16 * 1.02)^2 + (1.12 * (16 * 1.02))))/1000) * 0.72$$

$$= 1.03 \text{ kW}$$

ΔkW_{SSP} for remaining measure life (next 12 years):

$$= ((36{,}000 * (1/11 – 1/(-0.02 * (16 * 1.02)^2 + (1.12 * (16 * 1.02))))/1000) * 0.72$$

$$= 0.355 \text{ kW}$$

ΔkW_{PJM} for remaining life of existing unit (1st 6 years):

$$= ((36{,}000 * (1/8.55 – 1/(-0.02 * (16 * 1.02)^2 + (1.12 * (16 * 1.02))))/1000) * 0.466$$

$$= 1.01 \text{ kW}$$

ΔkW_{PJM} for remaining measure life (next 12 years):

$$= ((36{,}000 * (1/11 – 1/(-0.02 * (16 * 1.02)^2 + (1.12 * (16 * 1.02))))/1000) * 0.466$$

$$= 0.230 \text{ kW}$$

NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HVC-GSHP-V03-140601

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 [828]) exhaust-only ventilation fan, quiet (< 2.0 sones) Continuous operation in accordance with recommended ventilation rate indicated by ASHRAE 62.2[829]

DEFINITION OF BASELINE EQUIPMENT

New standard efficiency (average CFM/Watt of 3.1[830]) exhaust-only ventilation fan, quiet (< 2.0 sones) operating in accordance with recommended ventilation rate indicated by ASHRAE 62.2 [831]

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 19 years[832].

DEEMED MEASURE COST

Incremental cost per installed fan is $43.50 for quiet, efficient fans[833].

LOADSHAPE

Loadshape R11 - Residential Ventilation

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[828] 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.
[829] Bi-level controls may be used by efficient fans larger than 50 CFM
[830] 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.
[831] On/off cycling controls may be required of baseline fans larger than 50CFM.
[832] 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.
[833] VEIC analysis using cost data collected from wholesale vendor; http://www.westsidewholesale.com/ .

Coincidence Factor

The summer Peak Coincidence Factor is assumed to be 100% because the fan runs continuously.

Algorithm

Calculation of Savings

Electric Energy Savings

$\Delta kWh = (CFM * (1/\eta_{,BASELINE} - 1/\eta_{EFFICIENT})/1000) * Hours$

Where:

CFM = Nominal Capacity of the exhaust fan

= 50 CFM[834]

$\eta_{BASELINE}$ = Average efficacy for baseline fan

= 3.1 CFM/Watt[835]

$\eta_{EFFCIENT}$ = Average efficacy for efficient fan

= 8.3 CFM/Watt[836]

Hours = assumed annual run hours,

= 8766 for continuous ventilation.

$\Delta kWh = (50 * (1/3.1 – 1/8.3)/1000) * 8766$

= 88.6 kWh

Summer Coincident Peak Demand Savings

$\Delta kW = (CFM * (1/\eta_{BASELINE} - 1/\eta_{EFFICIENT})/1000) * CF$

[834] 50CFM is the closest available fan size to ASHRAE 62.2 Section 4.1 Whole House Ventilation rates based upon typical square footage and bedrooms.

[835] 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.

[836] 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.

Where:

CF = Summer Peak Coincidence Factor

= 1.0 (continuous operation)

Other variables as defined above

ΔkW = (50 * (1/3.1 – 1/8.3)/1000) * 1.0

= 0.0101 kW

NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HVC-BAFA-V01-120601

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[837].

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[838].

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} = Summer System Peak Coincidence Factor for Central A/C (during utility peak hour)

[837] Based on VEIC professional judgment.
[838] 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.

= 68%[839]

CF_{SSP} = Summer System Peak Coincidence Factor for Heat Pumps (during system peak hour)

= 72%%[840]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)

= 46.6%[841]

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

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

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

Where:

FLHcool = Full load cooling hours

Dependent on location as below:[842]

Climate Zone (City based upon)	FLHcool Single Family	FLHcool Multifamily
1 (Rockford)	512	467
2 (Chicago)	570	506
3 (Springfield)	730	663
4 (Belleville)	1,035	940
5 (Marion)	903	820
Weighted Average[843]	629	564

839 Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.
840 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)'.
841 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.
842 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.
843 Weighted based on number of occupied residential housing units in each zone.

Capacity_cooling = Cooling cpacity of equipment in Btu/hr (note 1 ton = 12,000 Btu/hr)

= Actual

$SEER_{CAC}$ = SEER Efficiency of existing central air conditioning unit receiving maintenence

= Actual. If unknown assume 10 SEER [844]

MFe = Maintenance energy savings factor

= 0.05[845]

$SEER_{ASHP}$ = SEER Efficiency of existing air source heat pump unit receiving maintenence

= Actual. If unknown assume 10 SEER [846]

FLHheat = Full load heating hours

Dependent on location:[847]

Climate Zone (City based upon)	FLHheat
1 (Rockford)	2208
2 (Chicago)	2064
3 (Springfield)	1967
4 (Belleville)	1420
5 (Marion)	1445
Weighted Average[848]	1821

[844] 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.
[845] Energy Center of Wisconsin, May 2008; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research."
[846] 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.
[847] 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.
[848] Weighted based on number of occupied residential housing units in each zone.

Capacity_heating = Heating cpacity of equipment in Btu/hr (note 1 ton = 12,000 Btu/hr)

= Actual

HSPFbase = Heating Season Performance Factor of existing air source heat pump unit receiving maintenence

= Actual. If unknown assume 6.8 HSPF [849]

For example, maintenance of a 3-ton, SEER 10 air conditioning unit in a single family house in Springfield:

ΔkWh_{CAC} = (730 * 36,000 * (1/10))/1000 * 0.05

= 131 kWh

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

ΔkWh_{ASHP} = ((730 * 36,000 * (1/10))/1000 * 0.05) + (1967 * 36,000 * (1/6.8))/1000 * 0.05)

= 652 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = Capacity_cooling * (1/EER)/1000 * MFd * CF

Where:

EER = EER Efficiency of existing unit receiving maintenance in Btu/H/Watts

= Calculate using Actual SEER

= $- 0.02*SEER^2 + 1.12*SEER$ [850]

MFd = Maintenance demand savings factor

= 0.02 [851]

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)

[849] 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.

[850] Based on Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder. Note this is appropriate for single speed units only.

[851] 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.

= 68%[852]

CF_{SSP} = Summer System Peak Coincidence Factor for Heat Pumps (during system peak hour)

= 72%%[853]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)

= 46.6%[854]

For example, maintenance of 3-ton, SEER 10 (equals EER 9.2) CAC unit:

ΔkW_{SSP} = 36,000 * 1/(9.2)/1000 * 0.02 * 0.68

= 0.0532 kW

ΔkW_{PJM} = 36,000 * 1/(9.2)/1000 * 0.02 * 0.466

= 0.0365 kW

NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

Conservatively not included.

MEASURE CODE: RS-HVC-TUNE-V02-140601

[852] Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.
[853] 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)'.
[854] 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.

5.3.11 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[855]. 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[856] based upon equipment life only[857]. For the purposes of claiming savings for a new programmable thermostat, this is reduced by a 50%

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[855] 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'.

[856] Table 1, HVAC Controls, Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007

[857] 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 persistence factor to give final measures life of 5 years. For reprogramming, this is reduced further to give a measure life of 2 years.

DEEMED MEASURE COST

Actual material and labor costs should be used if the implementation method allows. If unknown (e.g. through a retail program) the capital cost for the new installation measure is assumed to be $30[858]. 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

ΔkWh[859] = %ElectricHeat * Elec_Heating_Consumption * Heating_Reduction * HF * Eff_ISR + (ΔTherms * F_e * 29.3)

Where:

%ElectricHeat = Percentage of heating savings assumed to be electric

Heating fuel	%ElectricHeat
Electric	100%
Natural Gas	0%
Unknown	13%[860]

Elec_Heating_ Consumption

impacts of programmable thermostats, the longer term impacts should be assessed.

858 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.

859 Note the second part of the algorithm relates to furnace fan savings if the heating system is Natural Gas.

860 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.

= Estimate of annual household heating consumption for electrically heated single-family homes[861]. If location and heating type is unknown, assume 15,678 kWh[862]

Climate Zone (City based upon)	Electric Resistance Elec_Heating_ Consumption (kWh)	Electric Heat Pump Elec_Heating_ Consumption (kWh)
1 (Rockford)	21,741	12,789
2 (Chicago)	20,771	12,218
3 (Springfield)	17,789	10,464
4 (Belleville)	13,722	8,072
5 (Marion)	13,966	8,215
Average	**19,743**	**11,613**

Heating_Reduction = Assumed percentage reduction in total household heating energy consumption due to programmable thermostat

= 6.2%[863]

HF = Household factor, to adjust heating consumption for non-single-family households.

Household Type	HF
Single-Family	100%
Multi-Family	65%[864]
Actual	Custom[865]

[861] 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) 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.

[862] 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.

[863] 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.

[864] 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

Eff_ISR = Effective In-Service Rate, the percentage of thermostats installed and programmed effectively

Program Delivery	Eff_ISR
Direct Install	100%
Other, or unknown	56%[866]

ΔTherms = Therm savings if Natural Gas heating system

= See calculation in Natural Gas section below

F_e = Furnace Fan energy consumption as a percentage of annual fuel consumption

= 3.14%[867]

29.3 = kWh per therm

> For example, a programmable thermostat directly installed in an electric resistance heated, single-family home in Springfield:
>
> ΔkWH = 1 * 17,789 * 0.062 * 100% * 100% + (0 * 0.0314 * 29.3)
>
> = 1,103 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A due to no savings from cooling during the summer peak period.

NATURAL GAS ENERGY SAVINGS

ΔTherms = %FossilHeat * Gas_Heating_Consumption * Heating_Reduction * HF * Eff_ISR

Where:

%FossilHeat = Percentage of heating savings assumed to be Natural Gas

Heating fuel	%FossilHeat
Electric	0%

[865] Program-specific household factors may be utilized on the basis of sufficiently validated program evaluations.
[866]"Programmable Thermostats. Report to KeySpan Energy Delivery on Energy Savings and Cost Effectiveness," GDS Associates, Marietta, GA. 2002GDS
[867] 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	100%
Unknown	87%[868]

Gas_Heating_Consumption

= Estimate of annual household heating consumption for gas heated single-family homes. If location is unknown, assume the average below[869].

Climate Zone (City based upon)	Gas_Heating_ Consumption (therms)
1 (Rockford)	1,052
2 (Chicago)	1,005
3 (Springfield)	861
4 (Belleville)	664
5 (Marion)	676
Average	955

For example, a programmable thermostat directly-installed in a gas heated single-family home in Chicago:

ΔTherms = 1.0 * 1005 * 0.062 * 100% * 100%

= 62.3 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HVC-PROG-V03-140601

868 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.

869 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*0.92) + (0.76*0.8) = 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.[870]

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 requirements of IECC 2012, table C403.2.3(2).This means the unit must meet or exceed 7.7 HSPF (heating mode) and 13 SEER (cooling mode).

This measure only applies to the *first* ductless heat pump installed in a residence[871].

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.

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[870] 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 2F higher than any remaining existing system and the cooling setpoint for the ductless heat pump should be at least 2F 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.

[871] 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[872].

Deemed Measure Cost

The incremental cost for this measure is provided below:

Unit Size	Incremental Cost[873]
1-Ton	$3,000
1.5-Ton	$3750
2-Ton	$4,500

Loadshape

Loadshape R10 - Residential Electric Heating and Cooling

Coincidence Factor

The summer peak coincidence factor for cooling is provided in two different ways below. The first is used to estimate peak savings during the utility peak hour and is most indicative of actual peak benefits, and the second represents the *average* savings over the defined summer peak period, and is presented so that savings can be bid into PJM's Forward Capacity Market. Both values provided are based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren.

CF_{SSP} = Summer System Peak Coincidence Factor for ASHP (during utility peak hour)
= 72%%[874]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)
= 46.6%[875]

[872] Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, Inc., June 2007

[873] *Ductless Heat Pumps for Residential Customers in Connecticut*, Swift, Joseph R and Rebecca A. Meyer, The Connecticut Light & Power Company, 2010 ACEEE Summer Study on Energy Efficiency in Buildings (2-292)

[874] 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)'.

[875] 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.

ALGORITHMS

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

Electric savings

$\Delta kWh = \Delta kWh_{heat} + \Delta kWh_{cool}$

$\Delta kWh_{heat} = PLD*AHHL*HF*(1/HSPF_{exist}-1/HSPF_{ee})*3.413$

$\Delta kWh_{cool} = Capacity_{cool}*HF*(1/SEER_{exist}-1/SEER_{ee})*EFLH_{cool}$

Where:

PLD = Percent Load Displaced. The average total annual heating load displaced from the existing heating system and now provided by the ductless heat pump[876]

For a first DHP installed in a given home.

	PLD[5]		
Climate zone	1-ton unit	1.5-ton unit	2-ton unit
Rockford	26%	39%	39%
Chicago	27%	40%	42%
Springfield	31%	47%	48%
Belleville	30%	45%	48%
Marion	31%	46%	50%

AHHL = Anual Household Heating Load in kWh[877]

[876] 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.
Ecotope Study, prepared for Bonneville Power Administration, “Residential Ductless Mini-Split Heat Pump Retrofit Monitoring,” Monmouth, Oregon, June, 2009.
Ecotope Study, Prepared for Bonneville Power Administration, “Ductless Heat Pump Retrofits in Multifamily and Small Commercial Buildings,” December, 2012.
KEMA Study, Prepared for NSTAR Electric and Gas Corporation et al. “Ductless Mini Pilot Study,” Middletown, Connecticut, June, 2009

[877] 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. Values for individual cities are then calculated by comparing average HDD to the individual city’s HDD.

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%[878]
Actual	Custom[879]

$Capacity_{cool}$ = the cooling capacity of the ductless heat pump unit in kBtu/hr[880].

= Actual installed

$HSPF_{ee}$ = HSPF rating of new equipment

= Actual installed

$HSPF_{exist}$ = HSPF rating of existing equipment

Existing Equipment Type	$HSPF_{base}$
Electric resistance heating	3.41[881]
Air Source Heat Pump	5.44[882]

$SEER_{ee}$ = SEER rating of new equipment

= Actual installed[883]

878 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

879 Program-specific household factors may be utilized on the basis of sufficiently validated program evaluations.

880 1 Ton = 12 kBtu/hr

881 Electric resistance has a COP of 1.0 which equals 1/0.293 = 3.41 HSPF.

882 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.

$SEER_{exist}$ = SEER rating of existing equipment

= Use actual value. If unknown, see table below

Equipment Type	$SEER_{exist}$[884]
PTAC	7.4 SEER
PTHP	7.4 SEER
SPVAC < 65kBtu/hr	9.0 SEER
SPVHP < 65 kBtu/hr	9.0 SEER
Room AC	7.0 SEER
Ducted ASHP	13.0 SEER
No existing system	No cooling savings.

$EFLH_{cool}$ = Equivalent Full Load Hours for cooling. Depends on location. See table below[885].

Climate Zone (City based upon)	FLH_{RoomAC}
1 (Rockford)	220
2 (Chicago)	210
3 (Springfield)	319
4 (Belleville)	428
5 (Marion)	374
Weighted Average[886]	248

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:

ΔkWh_{heat} = 40% x 20,771kWh x 100% x (1/3.41 – 1/8) x 3.413 = 4,771kWh

ΔkWh_{cool} = 18 x 100% x (1/7 – 1/14) x 210 = 270kWh

ΔkWh = 4,771 + 270 = 5,041kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = (Capacity_cooling *HF* (1/EER_exist - 1/EER_ee)) / 1000) * CF

Where:

Where:

883 Note that if only an EER rating is available, a conversion factor of SEER=1.1*EER can be used

884 Converted from EER using formula EER = 1.1 SEER

885 Residential EFLH for room AC

886 Weighted based on number of residential occupied housing units in each zone.

EER_exist = Energy Efficiency Ratio of existing cooling system (kBtu/hr / kW)

= Use actual EER rating otherwise:

Equipment Type	EER_{exist}
PTAC	8.1EER[887]
PTHP	8.1EER[888]
SPVAC < 65kBtu/hr	9.9 EER [889]
SPVHP < 65 kBtu/hr	9.9 EER[890]
Room AC	7.7 EER[891]
Ducted ASHP	11.2 EER [892]
No existing system	

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:

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)

= 72%%[893]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)

= 46.6%[894]

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[887] Same EER as PTAC recycling. 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.

[888] Same method to calculate EER as PTAC recycling. 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.

[889] The quoted efficiency rating in the IECC was given in EER and was translated to SEER using a conversion factor of SEER=1.1*EER.

[890] Ibid.

[891] Same EER as Window AC recycling. Based on Nexus Market Research Inc, RLW Analytics, December 2005; "Impact, Process, and Market Study of the Connecticut Appliance Retirement Program: Overall Report."

[892] The Federal Standard does not include an EER requirement, so it is approximated with this formula: (-0.02 * SEER2) + (1.12 * SEER) Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder. Note this is appropriate for single speed units only.

[893] 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)'.

[894] 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

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

MEASURE CODE: RS-HVC-DHP-V01-140601

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[895].

DEEMED MEASURE COST

The measure cost including material and installation is assumed to be $3 per linear foot[896].

LOADSHAPE

Loadshape C53 - Flat

COINCIDENCE FACTOR

This measure assumes a flat loadshape since savings relate to reducing standby losses and as such the coincidence factor is 1.

Algorithm

[895] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007.
http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf
[896] Consistent with DEER 2008 Database Technology and Measure Cost Data (www.deeresources.com).

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

For electric DHW systems:

$$\Delta kWh = ((1/Rexist – 1/Rnew) * (L * C) * \Delta T * 8{,}766)/ \eta DHW / 3413$$

Where:

Rexist = Pipe heat loss coefficient of uninsulated pipe (existing) [(hr-°F-ft)/Btu]

= 1.0[897]

Rnew = Pipe heat loss coefficient of insulated pipe (new) [(hr-°F-ft)/Btu]

= Actual (1.0 + R value of insulation)

L = Length of pipe from water heating source covered by pipe wrap (ft)

= Actual

C = Circumference of pipe (ft) (Diameter (in) * π/12)

= Actual (0.5" pipe = 0.131ft, 0.75" pipe = 0.196ft)

ΔT = Average temperature difference between supplied water and outside air temperature (°F)

= 60°F [898]

8,766 = Hours per year

ηDHW = Recovery efficiency of electric hot water heater

= 0.98 [899]

3412 = Conversion from Btu to kWh

[897] Navigant Consulting Inc., April 2009; "Measures and Assumptions for Demand Side Management (DSM) Planning; Appendix C Substantiation Sheets", p77.

[898] Assumes 125°F water leaving the hot water tank and average temperature of basement of 65°F.

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

For example, insulating 5 feet of 0.75" pipe with R-5 wrap:

ΔkWh = ((1/Rexist – 1/Rnew) * (L * C) * ΔT * 8,766) / ηDHW / 3412

= ((1/1– 1/5) * (5 * 0.196) * 60 * 8766) / 0.98 /3412

= 123 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.

ΔkWh = ((1/Rexist – 1/Rnew) * (L * C) * ΔT * 8,766) / ηDHW / 3412

= ((1/1– 1/5) * (3 * 0.196) * 60 * 8766) / 0.98 /3412

= 74.0 kWh per 3ft length

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW **=** ΔkWh / 8766

Where:

ΔkWh = kWh savings from pipe wrap installation

8766 = Number of hours in a year (since savings are assumed to be constant over year).

For example, insulating 5 feet of 0.75" pipe with R-5 wrap:

ΔkW = 123/8766

= 0.014kW

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.

ΔkW = 73.9/8766

= 0.0084 kW

NATURAL GAS SAVINGS

For Natural Gas DHW systems:

ΔTherm = ((1/Rexist – 1/Rnew) * (L * C) * ΔT * 8,766) / ηDHW /100,000

Where:

ηDHW = Recovery efficiency of gas hot water heater

= 0.78 [900]

Other variables as defined above

For example, insulating 5 feet of 0.75" pipe with R-5 wrap: ΔTherm = ((1/1– 1/5) * (5 * 0.196) * 60 * 8766) / 0.78 / 100,000 = 5.29 therms

If inputs above are not available the following default per 3ft R-4 length can be used for up to 6ft length on the hot pipe and 3ft on the cold pipe.

ΔTherm = ((1/Rexist – 1/Rnew) * (L * C) * ΔT * 8,766) / ηDHW / 100,000

= ((1/1– 1/5) * (3 * 0.196) * 60 * 8766) / 0.78 /100,000

= 3.17 therms per 3ft length

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HWE-PINS-V01-120601

[900] 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%

5.4.2 Gas Water Heater

Description

This measure characterizes the purchase and installation of a new efficient gas-fired water heater, in place of a Federal Standard unit in a residential setting. Savings are provided for power-vented, condensing storage, and whole-house tankless units meeting specific EF criteria.

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

Definition of Efficient Equipment

To qualify for this measure the efficient equipment must be a water heater rated with the following minimum efficiency ratings:

Water heater Type	Minimum Energy Factor
Gas Storage	0.67
Condensing gas storage	0.80
Tankless whole-house unit	0.82

Definition of Baseline Equipment

The baseline condition is assumed to be a standard gas storage water heater of the same capacity as the efficient unit, rated at the federal minimum (0.67 – 0.0019 * storage size in gallons)[901]. For a 40-gallon storage water heater this would be 0.594 EF.

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 13 years.[902]

[901] Federal Standard as of January 2004, http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/water_heater_fr.pdf

[902] DOE, 2010 Residential Heating Products Final Rule Technical Support Document, Table 8.2.14 http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/htgp_finalrule_ch8.pdf Note: This source is used to support this category in aggregate. For all water heaters, life expectancy will depend on local variables such as water chemistry and homeowner maintenance. Some categories, including condensing storage and tankless water heaters do not yet have sufficient field data to support separate values. Preliminary data show lifetimes may exceed 20 years, though this has yet to be sufficiently demonstrated.

DEEMED MEASURE COST

The incremental capital cost for this measure is dependent on the type of water heater as listed below[903]:

Water heater Type	Incremental Cost
Gas Storage	$400
Condensing gas storage	$685
Tankless whole-house unit	$605

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

$\Delta Therms = (1/ EF_{BASE} - 1/EF_{EFFICIENT}) * (GPD * Household * 365.25 * \gamma Water * (T_{OUT} - T_{IN}) * 1.0)/100{,}000$

Where:

EF_Baseline = Energy Factor rating for baseline equipment

= (0.67 – 0.0019 * tank_size) [904]

[903] Source for cost info; DOE, 2010 Residential Heating Products Final Rule Technical Support Document, Table 8.2.14 (http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/htgp_finalrule_ch8.pdf)
[904] Algorithm based on current Federal Standard; http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/water_heater_fr.pdf
Note that changes to the Federal Standard will be applied from April 16, 2015, see link below for more details:

Tank_size (gallons)	EF_Baseline
40	0.594
50	0.575
60	0.556

= If tank size unknown assume 40 gallons and EF_Baseline of 0.594

EF_Efficient = Energy Factor Rating for efficient equipment

= Actual. If Tankless whole-house multiply rated efficiency by 0.91[905]. If unknown assume values in look up in table below

Water Heater Type	EF_Efficient
Condensing Gas Storage	0.80
Gas Storage	0.67
Tankless whole-house	0.82 * 0.91 = 0.75

GPD = Gallons Per Day of hot water use per person

= 45.5 gallons hot water per day per household/2.59 people per household[906]

= 17.6

Household = Average number of people per household

Household Unit Type	Household
Single-Family - Deemed	2.56[907]

http://www1.eere.energy.gov/buildings/appliance_standards/residential/heating_products_fr.html.

[905] 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.

[906] DeOreo, William B., Mayer, Peter W., Residential End Uses of Water Study Update, 2013. http://www.aquacraft.com/sites/default/files/img/REUWS2%20Project%20Report%2020131204.pdf

[907] ComEd Energy Efficiency/ Demand Response Plan: Plan Year 2 (6/1/2009-5/31/2010) Evaluation Report: All Electric Single Family Home Energy Performance Tune-Up Program citing 2006-2008 American Community Survey data from the US Census Bureau for Illinois cited on p. 17 of the PY2 Evaluation report. 2.75 * 93% evaluation adjustment

Multi-Family - Deemed	2.1[908]
Custom	Actual Occupancy or Number of Bedrooms[909]

365.25 = Days per year, on average

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[910]

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:

ΔTherms = (1/0.594 - 1/0.8) * (17.6 * 2.56 * 365.25* 8.33 * (125 – 54) * 1) / 100,000

= 42.2 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HWE-GWHT-V02-140601

[908] Navigant, ComEd PY3 Multi-Family Home Energy Savings Program Evaluation Report Final, May 16, 2012.
[909] 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.
[910] 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 standards.

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 13 years.[911]

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.[912]

Loadshape

Loadshape R03 - Residential Electric DHW

Coincidence Factor

The summer Peak Coincidence Factor is assumed to be 12%.[913]

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[911] DOE, 2010 Residential Heating Products Final Rule Technical Support Document, Page 8-52 http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/htgp_finalrule_ch8.pdf

[912] 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

[913] 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

$\Delta kWh = (((1/EF_{BASE} - 1/EF_{EFFICIENT}) * GPD * Household * 365.25 * \gamma Water * (T_{OUT} - T_{IN}) * 1.0) / 3412) + kWh\_cooling - kWh\_heating$

Where:

EF_{BASE} = Energy Factor (efficiency) of standard electric water heater according to federal standards:

= 0.93 – (0.00132 * rated volume in gallons)[914]

= 0.904 for a 50 gallon tank, the most common size for HPWH

$EF_{EFFICIENT}$ = Energy Factor (efficiency) of Heat Pump water heater

= Actual

GPD = Gallons Per Day of hot water use per person

= 45.5 gallons hot water per day per household/2.59 people per household[915]

= 17.6

Household = Average number of people per household

Household Unit Type	Household
Single-Family - Deemed	2.56[916]
Multi-Family - Deemed	2.1[917]
Custom	Actual Occupancy or Number of Bedrooms[918]

[914] Current Federal Standard EF, since 2004, for a 50-gal electric storage WH, Federal Register Vol. 66, No. 11/1/17/2001, page 4497, http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/water_heater_fr.pdf

[915] DeOreo, William B., Mayer, Peter W., Residential End Uses of Water Study Update, 2013. http://www.aquacraft.com/sites/default/files/img/REUWS2%20Project%20Report%2020131204.pdf

[916] ComEd Energy Efficiency/ Demand Response Plan: Plan Year 2 (6/1/2009-5/31/2010) Evaluation Report: All Electric Single Family Home Energy Performance Tune-Up Program citing 2006-2008 American Community Survey data from the US Census Bureau for Illinois cited on p. 17 of the PY2 Evaluation report. 2.75 * 93% evaluation adjustment

[917] Navigant, ComEd PY3 Multi-Family Home Energy Savings Program Evaluation Report Final, May 16, 2012.

[918] Bedrooms are suitable proxies for household occupancy, and may be preferable to actual occupancy due to

365.25 = Days per year

γWater = Specific weight of water

= 8.33 pounds per gallon

T_{OUT} = Tank temperature

= 125°F

T_{IN} = Incoming water temperature from well or municiple system

= 54°F[919]

1.0 = Heat Capacity of water (1 Btu/lb*°F)

3412 = Conversion from Btu to kWh

kWh_cooling[920] = Cooling savings from conversion of heat in home to water heat

=((([(GPD * Household * 365.25 * γWater * ($T_{OUT} – T_{IN}$) * 1.0) / 3412) – (GPD * Household * 365.25 * γWater * ($T_{OUT} – T_{IN}$) * 1.0) / 3412) / EF_{NEW}] * LF * 27%) / COP_{COOL}) * LM

Where:

LF = Location Factor

= 1.0 for HPWH installation in a conditioned space

= 0.5 for HPWH installation in an unknown location

= 0.0 for installation in an unconditioned space

27% = Portion of reduced waste heat that results in cooling savings[921]

COP_{COOL} = COP of central air conditioning

= Actual, if unknown, assume 3.08 (10.5 SEER / 3.412)

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turnover rates in residency and non-adult population impacts.

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

[920] 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.

[921] 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).

LM = Latent multiplier to account for latent cooling demand

= 1.33 [922]

kWh_heating = Heating cost from conversion of heat in home to water heat (dependent on heating fuel)

For Natural Gas heating, kWh_heating = 0

For electric heating:

$= ([(GPD * Household * 365.25 * \rho * (T_{OUT} – T_{IN}) * 1.0) / 3412) – (GPD * Household * 365.25 * \rho * (T_{OUT} – T_{IN}) * 1.0) / 3412) / EF_{NEW}] * LF * 49\%) / COP_{HEAT}$

Where:

49% = Portion of reduced waste heat that results in increased heating load[923]

COP_{HEAT} = COP of electric heating system

= actual. If not available use[924]:

System Type	Age of Equipment	HSPF Estimate	COP_{HEAT} (COP Estimate)
Heat Pump	Before 2006	6.8	2.00
	After 2006	7.7	2.26
Resistance	N/A	N/A	1.00

922 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

923 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).

924 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, 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:

ΔkWh = [(1 / 0.904 – 1 / 2.0) * 17.6 * 2.56 * 365.25* 8.33 * (125 – 54)] / 3412 + 185 - 0

= 1910 kWh

Summer Coincident Peak Demand Savings

ΔkW = ΔkWh / Hours * CF

Where:

Hours = Full load hours of water heater

= 2533 [925]

CF = Summer Peak Coincidence Factor for measure

= 0.12 [926]

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 = 1910 / 2533 * 0.12

= 0.0905 kW

Natural Gas Savings

ΔTherms = - ((((GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0) / 3412) – (((GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0) / 3412) / $EF_{EFFICIENT}$)) * LF * 49% * 0.03412) / (ηHeat * % Natural Gas)

Where:

ΔTherms = Heating cost from conversion of heat in home to water heat for homes with Natural Gas heat.[927]

[925] Full load hours assumption based on Efficiency Vermont analysis of Itron eShapes.

[926] 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 / 2533 hours) * 5 hours] = 0.12

[927] This is the additional energy consumption required to replace the heat removed from the home during the

0.03412 = conversion factor (therms per kWh)

ηHeat = Efficiency of heating system

= Actual.[928] If not available use 70%.[929]

% Natural Gas = Factor dependent on heating fuel:

Heating System	%Natural Gas
Electric resistance or heat pump	0%
Natural Gas	100%
Unknown heating fuel[930]	87%

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):

ΔTherms = -((((25.1 * 2.56 * 365.25* 8.33 * (125 – 54) * 1.0) / 3412) – (17.6 * 2.56 * 365.25* 8.33 * (125 – 54) * 1.0 / 3412 / 2.0)) * 1 * 0.49 * 0.03412) / (0.7 * 1)

= - 63.1 therms

heating season by the heat pump water heater. kWh_heating (electric resistance) is that additional heating energy for a home with electric resistance heat (COP 1.0). This formula converts the additional heating kWh for an electric resistance home to the MMBtu required in a Natural Gas heated home, applying the relative efficiencies.

[928] Ideally, the System Efficiency should be obtained either by recording the AFUE of the unit, or performing a steady state efficiency test. The Distribution Efficiency can be estimated via a visual inspection and by referring to a look up table such as that provided by the Building Performance Institute: (http://www.bpi.org/files/pdf/DistributionEfficiencyTable-BlueSheet.pdf) or by performing duct blaster testing.

[929] This has been estimated assuming that natural gas central furnace heating is typical for Illinois residences (66% of Illinois homes have a Natural Gas Furnace (based on Energy Information Administration, 2009 Residential Energy Consumption Survey: http://www.eia.gov/consumption/residential/data/2009/xls/HC6.9%20Space%20Heating%20in%20Midwest%20Region.xls))

In 2000, 24% of furnaces purchased in Illinois were condensing (based on data from GAMA, provided to Department of Energy during the federal standard setting process for residential heating equipment - see Furnace Penetration.xls). Furnaces tend to last up to 20 years and so units purchased 10 years ago provide a reasonable proxy for the current mix of furnaces in the State. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows:

(0.24*0.92) + (0.76*0.8) * (1-0.15) = 0.70

[930] 2010 American Community Survey.

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HWE-HPWH-V02-140601

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.[931]

Deemed Measure Cost

The incremental cost for this measure is $8[932] 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%.[933]

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[931] Table C-6, Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007.
"http://neep.org/uploads/EMV%20Forum/EMV%20Studies/measure_life_GDS%5B1%5D.pdf"
[932] 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)
[933] Calculated as follows: Assume 18% aerator use takes place during peak hours (based on:

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

NOTE THESE SAVINGS ARE *PER* FAUCET RETROFITTED[934] (UNLESS FAUCET TYPE IS UNKNOWN, THEN IT IS PER HOUSEHOLD).

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

Where:

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

DHW fuel	%ElectricDHW
Electric	100%
Natural Gas	0%
Unknown	16%[935]

GPM_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[936] or custom based on metering studies[937] or if measured during DI:

= Measured full throttle flow * 0.83 throttling factor[938]

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

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

[934] This algorithm calculates the amount of energy saved per aerator by determining the fraction of water consumption savings for the upgraded fixture.

[935] 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

[936] Table 56, DeOreo, William B., Mayer, Peter W., Residential End Uses of Water Study Update, 2013. http://www.aquacraft.com/sites/default/files/img/REUWS2%20Project%20Report%2020131204.pdf

[937] 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.

[938] 2008, Schultdt, Marc, and Debra Tachibana. Energy related Water Fixture Measurements: Securing the Baseline for Northwest Single Family Homes. 2008 ACEEE Summer Study on Energy Efficiency in Buildings. Page 1-265. www.seattle.gov/light/Conserve/Reports/paper_10.pdf

used”

= 0.94[939] or custom based on metering studies[940] or if measured during DI:

= Rated full throttle flow * 0.95 throttling factor[941]

L_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:

Faucet Type	L_base (min/person/day)
Kitchen	4.5[942]
Bathroom	1.6[943]
If location unknown (total for household): Single-Family	9.0[944]
If location unknown (total for household): Multi-Family	6.9[945]

L_low = Average retrofit daily length faucet use per capita for faucet of interest in minutes

= if available custom based on metering studies, if not use:

[939] 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.

[940] 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.

[941] 2008, Schultdt, Marc, and Debra Tachibana. Energy related Water Fixture Measurements: Securing the Baseline for Northwest Single Family Homes. 2008 ACEEE Summer Study on Energy Efficiency in Buildings. Page 1-265. www.seattle.gov/light/Conserve/Reports/paper_10.pdf

[942] 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.

[943] Ibid.

[944] One kitchen faucet plus 2.83 bathroom faucets. Based on findings from a 2009 ComEd residential survey of 140 sites, provided by Cadmus.

[945] One kitchen faucet plus 1.5 bathroom faucets. Based on findings from a 2009 ComEd residential survey of 140 sites, provided by Cadmus.

Faucet Type	L_low (min/person/day)
Kitchen	4.5[946]
Bathroom	1.6[947]
If location unknown (total for household): Single-Family	9.0[948]
If location unknown (total for household): Multi-Family	6.9[949]

Household = Average number of people per household

Household Unit Type	Household
Single-Family - Deemed	2.56[950]
Multi-Family - Deemed	2.1[951]
Custom	Actual Occupancy or Number of Bedrooms[952]

365.25 = Days in a year, on average.

DF = Drain Factor

Faucet Type	Drain Factor[953]
Kitchen	75%
Bath	90%
Unknown	79.5%

FPH = Faucets Per Household

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[946] Cadmus and Opinion Dynamics Showerhead and Faucet Aerator Meter Study Memorandum dated June 2013, directed to Michigan Evaluation Working Group.

[947] Ibid.

[948] One kitchen faucet plus 2.83 bathroom faucets. Based on findings from a 2009 ComEd residential survey of 140 sites, provided by Cadmus.

[949] One kitchen faucet plus 1.5 bathroom faucets. Based on findings from a 2009 ComEd residential survey of 140 sites, provided by Cadmus.

[950] ComEd Energy Efficiency/ Demand Response Plan: Plan Year 2 (6/1/2009-5/31/2010) Evaluation Report: All Electric Single Family Home Energy Performance Tune-Up Program citing 2006-2008 American Community Survey data from the US Census Bureau for Illinois cited on p. 17 of the PY2 Evaluation report. 2.75 * 93% evaluation adjustment

[951] Navigant, ComEd PY3 Multi-Family Home Energy Savings Program Evaluation Report Final, May 16, 2012.

[952] 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.

[953] 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.

Faucet Type	FPH
Kitchen Faucets Per Home (KFPH)	1
Bathroom Faucets Per Home (BFPH): Single-Family	2.83[954]
Bathroom Faucets Per Home (BFPH): Multi-Family	1.5[955]
If location unknown (total for household): Single-Family	3.83
If location unknown (total for household): Multi-Family	2.5

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

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

= (8.33 * 1.0 * (86 – 54.1)) / (0.98 * 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-°F)

WaterTemp = Assumed temperature of mixed water

= 86F for Bath, 93F for Kitchen 91F for Unknown[956]

SupplyTemp = Assumed temperature of water entering house

= 54.1F [957]

RE_electric = Recovery efficiency of electric water heater

= 98% [958]

3412 = Converts Btu to kWh (btu/kWh)

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[954]Based on findings from a 2009 ComEd residential survey of 140 sites, provided by Cadmus.

[955] Ibid.

[956] 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.

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

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

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

Selection	ISR
Direct Install - Single Family	0.95[959]
Direct Install – Multi Family Kitchen	0.91[960]
Direct Install – Multi Family Bathroom	0.95[961]
Efficiency Kits	To be determined through evaluation

For example, a direct installed kitchen low flow faucet aerator in a single-family electric DHW home:

ΔkWh = 1.0 * (((1.39 * 4.5 – 0.94 * 4.5) * 2.56 * 365.25 *0.75) / 1) * 0.0969 * 0.95

= 131 kWh

For example, a direct installed bath low flow faucet aerator in a multi-family electric DHW home:

ΔkWh = 1.0 * (((1.39 * 1.6 – 0.94 * 1.6) * 2.1 * 365.25 * 0.90) /1.5) * 0.0795 * 0.95

= 25.0 kWh

For example, a direct installed low flow faucet aerator in unknown faucet in a single-family electric DHW home:

ΔkWh = 1.0 * (((1.39 * 9.0 – 0.94 * 9.0) * 2.56 * 365.25 * 0.795) /3.83) * 0.0919 * 0.95

= 68.6 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ΔkWh / Hours * CF

[959] ComEd Energy Efficiency/ Demand Response Plan: Plan Year 2 (6/1/2009-5/31/2010) Evaluation Report: All Electric Single Family Home Energy Performance Tune-Up Program Table 3-8
[960] Navigant, ComEd-Nicor Gas EPY4/GPY1 Multi-Family Home Energy Savings Program Evaluation Report DRAFT 2013-01-28
[961] Ibid.

Where:

ΔkWh = calculated value above

Hours = Annual electric DHW recovery hours for faucet use per faucet

= ((GPM_base * L_base) * Household/FPH * 365.25 * DF) * 0.545[962] / GPH

Building Type	Faucet location	Calculation	Hours per faucet
Single Family	Kitchen	((1.39 * 4.5) * 2.56/1 * 365.25 * 0.75) * 0.545 / 25.5	94
	Bathroom	((1. 39 * 1.6) * 2.56/2.83 * 365.25 * 0.9) * 0.545 / 25.5	14
	Unknown	((1. 39 * 9.0) * 2.56/3.83 * 365.25 * 0.795) * 0.545 / 25.5	52
Multi Family	Kitchen	((1. 39 * 4.5) * 2.1/1 * 365.25 * 0.75) * 0.545 / 25.5	77
	Bathroom	((1. 39 * 1.6) * 2.1/1.5 * 365.25 * 0.9) * 0.545 / 25.5	22
	Unknown	((1. 39 * 6.9) * 2.1/2.5 * 365.25 * 0.795) * 0.545 / 25.5	50

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

= 0.022[963]

For example, a direct installed kitchen low flow faucet aerator in a single family electric DHW home:

ΔkW = 131/94 * 0.022

= 0.0306 kW

NATURAL GAS SAVINGS

ΔTherms = %FossilDHW * ((GPM_base * L_base - GPM_low * L_low) * Household * 365.25 *DF / FPH) * EPG_gas * ISR

Where:

[962] 54.5% is the proportion of hot 120F water mixed with 54.1F supply water to give 90F mixed faucet water.

[963] 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

%FossilDHW = proportion of water heating supplied by Natural Gas heating

DHW fuel	%Fossil_DHW
Electric	0%
Natural Gas	100%
Unknown	84%[964]

EPG_gas = Energy per gallon of Hot water supplied by gas

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

= 0.00341 Therm/gal for SF homes (Bath), 0.00415 Therm/gal for SF homes (Kitchen), 0.00394 Therm/gal for SF homes (Unknown)

= 0.00397 Therm/gal for MF homes (Bath), 0.00484 Therm/gal for MF homes (Kitchen), 0.00459 Therm/gal for MF homes (Unknown)

RE_gas = Recovery efficiency of gas water heater

= 78% For SF homes[965]

= 67% For MF homes[966]

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

Other variables as defined above.

[964] 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

[965] 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%.

[966] 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 kitchen low flow faucet aerator in a fuel DHW single-family home:

ΔTherms = 1.0 * (((1.39 * 4.5 – 0.94 * 4.5) * 2.56 * 365.25 *0.75) / 1) * 0.00415 * 0.95

= 5.60 Therms

For example, a direct installed bath low flow faucet aerator in a fuel DHW multi-family home:

ΔTherms = 1.0 * (((1.39 * 1.6 – 0.94 * 1.6) * 2.1 * 365.25 * 0.90) /1.5) * 0.003974 * 0.95

= 1.25 Therms

For example, a direct installed low flow faucet aerator in unknown faucet in a fuel DHW single-family home:

ΔTherms = 1.0 * (((1.39 * 6.1– 0.94 * 6.1) * 2.56 * 365.25 * 0.795) /3.83) * 0.00394 * 0.95

= 1.99 Therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

Δgallons = ((GPM_base * L_base - GPM_low * L_low) * Household * 365.25 *DF / FPH) * ISR

Variables as defined above

For example, a direct-installed kitchen low flow aerator in a single family home

Δgallons = (((1.39 * 4.5 – 0.94 * 4.5) * 2.56 * 365.25 *0.75) / 1) * 0.95

= 1350 gallons

For example, a direct installed bath low flow faucet aerator in a multi-family home:

Δgallons = (((1.39 * 1.6 – 0.94 * 1.6) * 2.1 * 365.25 * 0.90) /1.5) * 0.95

= 314 gallons

For example, a direct installed low flow faucet aerator in unknown faucet in a single-family home:

Δgallons = (((1.39 * 9.0 – 0.94 * 9.0) * 2.56 * 365.25 * 0.795) /3.83) * 0.95

= 747 gallons

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

SOURCES

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

MEASURE CODE: RS-HWE-LFFA-V03-140601

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.[967]

Deemed Measure Cost

The incremental cost for this measure is $12[968] 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

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

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

Coincidence Factor

The coincidence factor for this measure is assumed to be 2.78%.[969]

Algorithm

Calculation of Savings

Electric Energy Savings

Note these savings are per showerhead fixture

ΔkWh = %ElectricDHW * ((GPM_base * L_base - GPM_low * L_low) * Household * SPCD * 365.25 / SPH) * EPG_electric * ISR

Where:

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

DHW fuel	%ElectricDHW
Electric	100%
Natural Gas	0%
Unknown	16%[970]

GPM_base = Flow rate of the baseline showerhead

Program	GPM_base
Direct-install	2.67[971]
Retrofit or TOS	2.35[972]

[969] Calculated as follows: Assume 11% showers take place during peak hours (based on: http://www.aquacraft.com/sites/default/files/pub/DeOreo-%282001%29-Disaggregated-Hot-Water-Use-in-Single-Family-Homes-Using-Flow-Trace-Analysis.pdf). There are 65 days in the summer peak period, so the percentage of total annual aerator use in peak period is 0.11*65/365 = 1.96%. The number of hours of recovery during peak periods is therefore assumed to be 1.96% * 369 = 7.23 hours of recovery during peak period, where 369 equals the average annual electric DHW recovery hours for showerhead use including SF and MF homes with Direct Install and Retrofit/TOS measures. There are 260 hours in the peak period so the probability you will see savings during the peak period is 7.23/260 = 0.0278

[970] 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

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

[972] Representative value from sources 1, 2, 4, 5, 6 and 7 (See Source Table at end of measure section) adjusted slightly upward to account for program participation which is expected to target customers with existing higher flow devices rather than those with existing low flow devices.

GPM_low = As-used flow rate of the low-flow showerhead, which may, as a result of measurements of program evaulations deviate from rated flows, see table below:

Rated Flow
2.0 GPM
1.75 GPM
1.5 GPM
Custom or Actual[973]

L_base = Shower length in minutes with baseline showerhead

= 7.8 min[974]

L_low = Shower length in minutes with low-flow showerhead

= 7.8 min[975]

Household = Average number of people per household

Household Unit Type[976]	Household
Single-Family - Deemed	2.56[977]
Multi-Family - Deemed	2.1[978]
Custom	Actual Occupancy or Number of Bedrooms[979]

SPCD = Showers Per Capita Per Day

[973] 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.

[974] 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.

[975] Ibid.

[976] If household type is unknown, as may be the case for time of sale measures, then single family deemed value shall be used.

[977] ComEd Energy Efficiency/ Demand Response Plan: Plan Year 2 (6/1/2009-5/31/2010) Evaluation Report: All Electric Single Family Home Energy Performance Tune-Up Program citing 2006-2008 American Community Survey data from the US Census Bureau for Illinois cited on p. 17 of the PY2 Evaluation report. 2.75 * 93% evaluation adjustment

[978] ComEd PY3 Multi-Family Evaluation Report REVISED DRAFT v5 2011-12-08.docx

[979] 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.

= 0.6[980]

365.25 = Days per year, on average.

SPH = Showerheads Per Household so that per-showerhead savings fractions can be determined

Household Type	SPH
Single-Family	1.79[981]
Multi-Family	1.3[982]
Custom	Actual

EPG_electric = Energy per gallon of hot water supplied by electric

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

= (8.33 * 1.0 * (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-°)

ShowerTemp = Assumed temperature of water

= 101F [983]

SupplyTemp = Assumed temperature of water entering house

= 54.1F [984]

RE_electric = Recovery efficiency of electric water heater

= 98% [985]

980 Cadmus and Opinion Dynamics Showerhead and Faucet Aerator Meter Study Memorandum dated June 2013, directed to Michigan Evaluation Working Group.
981 Based on findings from a 2009 ComEd residential survey of 140 sites, provided by Cadmus.
982 Ibid.
983 Cadmus and Opinion Dynamics Showerhead and Faucet Aerator Meter Study Memorandum dated June 2013, directed to Michigan Evaluation Working Group.
984 US DOE Building America Program. Building America Analysis Spreadsheet. For Chicago, IL http://www1.eere.energy.gov/buildings/building_america/analysis_spreadsheets.html.
985 Electric water heaters have recovery efficiency of 98%:

3412 = Converts Btu to kWh (btu/kWh)

ISR = In service rate of showerhead

= Dependant on program delivery method as listed in table below

Selection	ISR
Direct Install - Single Family	0.98[986]
Direct Install – Multi Family	0.95[987]
Efficiency Kits	To be determined through evaluation

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:

ΔkWh = 1.0 * ((2.67 * 7.8 – 1.5 * 7.8) * 2.56 * 0.6 * 365.25 / 1.79) * 0.117 * 0.98

= 328 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ΔkWh/Hours * CF

Where:

ΔkWh = calculated value above

Hours = Annual electric DHW recovery hours for showerhead use

= ((GPM_base * L_base) * Household * SPCD * 365.25) * 0.712[988] / GPH

= 302 for SF Direct Install; 248 for MF Direct Install

= 266 for SF Retrofit and TOS; 218 for MF Retrofit and TOS

GPH = Gallons per hour recovery of electric water heater calculated for 65.9F temp rise (120-

http://www.ahridirectory.org/ahridirectory/pages/home.aspx

986 Deemed values are from ComEd Energy Efficiency/ Demand Response Plan: Plan Year 2 (6/1/2009-5/31/2010) Evaluation Report: All Electric Single Family Home Energy Performance Tune-Up Program Table 3-8. Alternative ISRs may be developed for program delivery methods based on evaluation results.

987 Navigant, ComEd-Nicor Gas EPY4/GPY1 Multi-Family Home Energy Savings Program Evaluation Report FINAL 2013-06-05

988 71.2% is the proportion of hot 120F water mixed with 54.1F supply water to give 101F shower water.

54.1), 98% recovery efficiency, and typical 4.5kW electric resistance storage tank.

= 27.51

CF = Coincidence Factor for electric load reduction

= 0.0278[989]

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:

ΔkW = 328/302 * 0.0278

= 0.0302 kW

NATURAL GAS SAVINGS

ΔTherms = %FossilDHW * ((GPM_base * L_base - GPM_low * L_low) * Household * SPCD * 365.25 / SPH) * EPG_gas * ISR

Where:

%FossilDHW = proportion of water heating supplied by Natural Gas heating

DHW fuel	%Fossil_DHW
Electric	0%
Natural Gas	100%
Unknown	84%[990]

EPG_gas = Energy per gallon of Hot water supplied by gas

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

= 0.00501 Therm/gal for SF homes

= 0.00583 Therm/gal for MF homes

[989] Calculated as follows: Assume 11% showers take place during peak hours (based on: http://www.aquacraft.com/sites/default/files/pub/DeOreo-%282001%29-Disaggregated-Hot-Water-Use-in-Single-Family-Homes-Using-Flow-Trace-Analysis.pdf). There are 65 days in the summer peak period, so the percentage of total annual aerator use in peak period is 0.11*65/365 = 1.96%. The number of hours of recovery during peak periods is therefore assumed to be 1.96% * 369 = 7.23 hours of recovery during peak period where 369 equals the average annual electric DHW recovery hours for showerhead use including SF and MF homes with Direct Install and Retrofit/TOS measures. There are 260 hours in the peak period so the probability you will see savings during the peak period is 7.23/260 = 0.0278

[990] 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

RE_gas = Recovery efficiency of gas water heater

= 78% For SF homes[991]

= 67% For MF homes[992]

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:

ΔTherms = 1.0 * ((2.67 * 7.8 – 1.5 * 7.8) * 2.56 * 0.6 * 365.25 / 1.79) * 0.00501 * 0.98

= 14.0 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

Δgallons = ((GPM_base * L_base - GPM_low * L_low) * Household * SPCD * 365.25 / SPH) * ISR

Variables as defined above

For example, a direct installed 1.5 GPM low flow showerhead in a single family home where the number of showers is not known:

Δgallons = ((2.67 * 7.8 – 1.5 * 7.8) * 2.56 * 0.6 * 365.25 / 1.79) * 0.98

= 2803 gallons

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

SOURCES

[991] 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%.

[992] 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.

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

MEASURE CODE: RS-HWE-LFSH-V03-140601

5.4.6 Water Heater Temperature Setback

DESCRIPTION

The thermostat setting of a hot water tank is lowered to no lower than 120 degrees. The savings are from the Connecticut TRM which considers that for some draws, the hot water flow will be increased to make up for the lower temperature, and that additional dishwasher's supplemental heating will be required.

This measure was developed to be applicable to the following program types: NC, RF, DI, 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, the default analysis assumes a 15 degree setback. 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:

ΔkWh = 86.4 kWh * (Tpre – Tpost) / 15

Where:

86.4 kWh = Estimate of savings derived in UL and CLP Program Savings Documentation, 2010.

Tpre = Actual hot water setpoint prior to adjustment

Tpost = Actual new hot water setpoint, which may not be lower than 120 degrees

Default Hot Water Temperature Inputs	
Tpre	135
Tpost	120

15 = Delta watts used to derive the UL and CLP Program Savings Documentation estimate.

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ΔkWh / Hours * CF

Where:

Hours = 8766

CF = Summer Peak Coincidence Factor for measure

= 1

ΔkW = (86.4 * (Tpre – Tpost) / 15) / 8766 * 1

ΔkW default = 0.00986 kW

NATURAL GAS SAVINGS

For homes with gas water heaters:

ΔTherms = 6.4 therms* (Tpre – Tpost) / 15

ΔkWh[993] = -34.2 kWh * (Tpre – Tpost) / 15

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HWE-TMPS-V03-140601

[993] The ΔkWh accounts for the increased use of dishwasher's supplemental heating.

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.[994]

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[995].

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.

Algorithm

[994] Visually determine whether it is insulated by foam (newer, rigid, and more effective) or fiberglass (older, gives to gently pressure, and not as effective)
[995] This estimate assumes the tank wrap is installed on an existing unit with 5 years remaining life.

Calculation of Savings

Electric Energy Savings

For electric DHW systems:

$$\Delta kWh = ((U_{base}A_{base} - U_{insul}A_{insul}) * \Delta T * Hours) / (3.412 * \eta DHW)$$

Where:

U_{base} = Overall heat transfer coefficient prior to adding tank wrap (Btu/Hr-°F-ft2).

U_{insul} = Overall heat transfer coefficient after addition of tank wrap (Btu/Hr-°F-ft2).

A_{base} = Surface area of storage tank prior to adding tank wrap (square feet)[996]

A_{insul} = Surface area of storage tank after addition of tank wrap (square feet)[997]

ΔT = Average temperature difference between tank water and outside air temperature (°F)

= 60°F [998]

Hours = Number of hours in a year (since savings are assumed to be constant over year).

= 8766

3412 = Conversion from Btu to kWh

ηDHW = Recovery efficiency of electric hot water heater

= 0.98 [999]

[996] Area includes tank sides and top to account for typical wrap coverage.
[997] Ibid.
[998] Assumes 125°F water leaving the hot water tank and average temperature of basement of 65°F.
[999] 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.

Capacity (gal)	Rbase	Rinsul	Abase (ft2)[1000]	Ainsul (ft2)[1001]	ΔkWh	ΔkW
30	8	16	19.16	20.94	171	0.0195
30	10	18	19.16	20.94	118	0.0135
30	12	20	19.16	20.94	86	0.0099
30	8	18	19.16	20.94	194	0.0221
30	10	20	19.16	20.94	137	0.0156
30	12	22	19.16	20.94	101	0.0116
40	8	16	23.18	25.31	207	0.0236
40	10	18	23.18	25.31	143	0.0164
40	12	20	23.18	25.31	105	0.0120
40	8	18	23.18	25.31	234	0.0268
40	10	20	23.18	25.31	165	0.0189
40	12	22	23.18	25.31	123	0.0140
50	8	16	24.99	27.06	225	0.0257
50	10	18	24.99	27.06	157	0.0179
50	12	20	24.99	27.06	115	0.0131
50	8	18	24.99	27.06	255	0.0291
50	10	20	24.99	27.06	180	0.0206
50	12	22	24.99	27.06	134	0.0153
80	8	16	31.84	34.14	290	0.0331
80	10	18	31.84	34.14	202	0.0231
80	12	20	31.84	34.14	149	0.0170
80	8	18	31.84	34.14	328	0.0374
80	10	20	31.84	34.14	232	0.0265
80	12	22	31.84	34.14	173	0.0198

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW **=** ΔkWh / 8766 * CF

Where:

ΔkWh = kWh savings from tank wrap installation

8766 = Number of hours in a year (since savings are assumed to be constant over year).

CF = Summer Coincidence Factor for this measure

= 1.0

[1000] 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.

[1001] Assumptions from PA TRM. A_{insul} was calculated by assuming that the water heater wrap is a 2" thick fiberglass material.

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-V01-120601

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 97% Residential and 3% Commercial assumptions should be used[1002].

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[1003]. 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

[1002] RES v C&I split is based on a weighted (by sales volume) average of ComEd PY3, PY4 and PY5 and Ameren PY5 in store intercept survey results.

[1003] 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.

year[1004].

Multi Family Common area bulbs: The expected measure life is 1.7 years[1005] for bulbs installed June 2012 –May 2017.

Exterior bulbs: The expected measure life is 4.4 years[1006] for bulbs installed June 2012 – May 2015. For bulbs installed June 2016-May 2017 this would be reduced to 4 years.

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[1007].

For the Direct Install measure, the full cost of $2.50 per bulb should be used, plus $5 labor cost[1008] 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.

LOADSHAPE

Loadshape R06 - Residential Indoor Lighting
Loadshape R07 - Residential Outdoor Lighting
Loadshape C06 - Commercial Indoor Lighting[1009]

COINCIDENCE FACTOR

The summer peak coincidence factor is assumed to be 9.5%[1010] for Residential and in-unit Multi Family bulbs and 75%[1011] for Multi Family common area bulbs.

[1004] 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.

[1005] Based on using 10,000 hour rated life assumption since significantly less switching with higher use. 10,000/5950 = 1.7years.

[1006] Based on using 8,000 hour rated life assumption since more switching and use outdoors. 8,000/1825 = 4.4years

[1007] Based upon pricing forecast developed by Applied Proactive Technologies Inc (APT) based on industry input and provided to Ameren.

[1008] Based on 15 minutes at $20 an hour. Includes some portion of travel time to site.

[1009] For Multi Family common area lighting.

[1010] Based on lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation. "ComEd Residential Energy Star Lighting Program Metering Study: Overview of Study Protocols" http://www.icc.illinois.gov/downloads/public/edocket/303835.pdf
"Memo RE: Lighting Logger Study Results – Version 2, Date: May 27, 2011, To: David Nichols and ComEd Residential Lighting Interested Parties, From: Amy Buege and Jeremy Eddy; Navigant Evaluation Team" http://www.icc.illinois.gov/downloads/public/edocket/303834.pdf

[1011] Coincidence factor is based on healthcare/clinic value (used as proxy for multi family common area lighting

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

ΔkWh = ((WattsBase - WattsEE) / 1000) * ISR * Hours * WHFe

Where:

WattsBase = Based on lumens of CFL bulb and program year installed:

Minimum Lumens	Maximum Lumens	Incandescent Equivalent Post-EISA 2007 ($Watts_{Base}$)
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 / installed

ISR = In Service Rate, the percentage of units rebated that are actually in service.

with similar hours of use) developed using Equest models for various building types averaged across 5 climate zones for Illinois.

Program	Weighted Average 1st year In Service Rate (ISR)	2nd year Installations	3rd year Installations	Final Lifetime In Service Rate
Retail (Time of Sale) or Efficiency Kits	72.2%[1012]	13.9%	11.9%	98.0%[1013]
Direct Install	96.9%[1014]			

Hours = Average hours of use per year

Installation Location	Hours
Residential and in-unit Multi Family	938 [1015]
Multi Family Common Areas	5,950 [1016]
Exterior	1,825 [1017]
Unknown	1,000 [1018]

WHFe = Waste heat factor for energy to account for cooling energy savings from efficient lighting

[1012] 1st year in service rate is based upon review of PY3-5 evaluations from ComEd and PY5 for Ameren (see 'IL RES Lighting ISR.xls' for more information. The average first year ISR for each utility was calculated weighted by the number of bulbs in the each year's survey. This was then weighted by annual sales to give a statewide assumption.

[1013] 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.

[1014] 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.

[1015] Based on lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation. http://www.icc.illinois.gov/downloads/public/edocket/323818.pdf

[1016] Multi family common area lighting assumption is 16.3 hours per day (5950 hours per year) based on Focus on Energy Evaluation, ACES Deemed Savings Desk Review, November 2010.

[1017] Based on secondary research conducted as part of the PY3 ComEd Residential Lighting Program evaluation. http://www.icc.illinois.gov/downloads/public/edocket/323818.pdf

[1018] Assumes 7% exterior lighting, based on lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation. http://www.icc.illinois.gov/downloads/public/edocket/323818.pdf

Bulb Location	WHFe
Interior single family or unknown location	1.06 [1019]
Multi family in unit	1.04 [1020]
Multi family common area	1.04 [1021]
Exterior or uncooled location	1.0

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.

[1019] 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)

[1020] 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

[1021] Ibid.

For example, for a 14W CFL (60W standard incandescent and 43W EISA qualified incandescent/halogen) purchased in 2014.

$\Delta kWH_{1st\ year\ installs}$ = ((43 - 14) / 1000) * 0.722 * 1000 * 1.06

= 22.2 kWh

$\Delta kWH_{2nd\ year\ installs}$ = ((43 - 14) / 1000) * 0.139 * 1000 * 1.06

= 4.3 kWh

Note: Here we assume no change in hours assumption. NTG value from Purchase year applied.

$\Delta kWH_{3rd\ year\ installs}$ = ((43 - 14) / 1000) * 0.119 * 1000 * 1.06

= 3.7 kWh

HEATING PENALTY

If electric heated home (if heating fuel is unknown assume gas, see Natural Gas section):

ΔkWh[1022] = - (((WattsBase - WattsEE) / 1000) * ISR * Hours * HF) / ηHeat

Where:

HF = Heating Factor or percentage of light savings that must be heated

= 49%[1023] for interior or unknown location

= 0% for exterior or unheated location

ηHeat = Efficiency in COP of Heating equipment

= actual. If not available use[1024]:

System Type	Age of Equipment	HSPF Estimate	ηHeat (COP Estimate)
Heat Pump	Before 2006	6.8	2.00
	After 2006	7.7	2.26
Resistance	N/A	N/A	1.00

[1022] Negative value because this is an increase in heating consumption due to the efficient lighting.
[1023] 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.
[1024] 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, a 14W standard CFL is purchased in 2014 and installed in home with 2.0 COP Heat Pump:

$\Delta kWh_{1st\ year}$ = - (((43 - 14) / 1000) * 0.722 * 938 * 0.49) / 2.0

= - 4.8 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

ΔkW = ((WattsBase - WattsEE) / 1 000) * ISR * WHFd * CF

Where:

WHFd = Waste heat factor for demand to account for cooling savings from efficient lighting.

Bulb Location	WHFd
Interior single family or unknown location	1.11[1025]
Multi family in unit	1.07[1026]
Multi family common area	1.07 [1027]
Exterior or uncooled location	1.0

CF = Summer Peak Coincidence Factor for measure.

[1025] 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.

[1026] 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.

[1027] Ibid

Bulb Location	CF
Interior single family or unknown location	9.5% [1028]
Multi family in unit	9.5% [1029]
Multi family common area	75% [1030]

Other factors as defined above

For example, a 14W standard CFL is purchased and installed in a single family interior location in 2014:

ΔkW = ((43 - 14) / 1000) * 0.722 * 1.11 * 0.095

= 0.0022 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

Heating Penalty if Natural Gas heated home (or if heating fuel is unknown):

ΔTherms[1031] = - (((WattsBase - WattsEE) / 1000) * ISR * Hours * HF * 0.03412) / ηHeat

Where:

HF = Heating Factor or percentage of light savings that must be heated

= 49%[1032] for interior or unknown location

= 0% for exterior or unheated location

0.03412 =Converts kWh to Therms

ηHeat = Efficiency of heating system

[1028] Based on lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation. "ComEd Residential Energy Star Lighting Program Metering Study: Overview of Study Protocols" http://www.icc.illinois.gov/downloads/public/edocket/303835.pdf
"Memo RE: Lighting Logger Study Results – Version 2, Date: May 27, 2011, To: David Nichols and ComEd Residential Lighting Interested Parties, From: Amy Buege and Jeremy Eddy; Navigant Evaluation Team" http://www.icc.illinois.gov/downloads/public/edocket/303834.pdf

[1029] Ibid.

[1030] Coincidence factor is based on healthcare/clinic value (used as proxy for multi family common area lighting with similar hours of use) developed using Equest models for various building types averaged across 5 climate zones for Illinois for the following building types.

[1031] Negative value because this is an increase in heating consumption due to the efficient lighting.

[1032] 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.

=70%[1033]

For example, a14 standard CFL is purchased and installed in a home in 2014:

ΔTherms = - (((43 - 14) / 1000) * 0.722 * 938 * 0.49 * 0.03412) / 0.7

= - 0.47 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[1034].

	Std Inc.	EISA Compliant Halogen
2014	$0.34	$1.25
2015	$0.34	$0.90
2016	$0.34	$0.80
2017	$0.34	$0.70
2018	$0.34	$0.60
2019	$0.34	$0.60
2020 & after	$0.34	N/A

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

[1033] This has been estimated assuming that natural gas central furnace heating is typical for Illinois residences (66% of Illinois homes have a Natural Gas Furnace (based on Energy Information Administration, 2009 Residential Energy Consumption Survey: http://www.eia.gov/consumption/residential/data/2009/xls/HC6.9%20Space%20Heating%20in%20Midwest%20Region.xls))
In 2000, 24% of furnaces purchased in Illinois were condensing (based on data from GAMA, provided to Department of Energy during the federal standard setting process for residential heating equipment - see Furnace Penetration.xls). Furnaces tend to last up to 20 years and so units purchased 10 years ago provide a reasonable proxy for the current mix of furnaces in the State. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows:
(0.24*0.92) + (0.76*0.8) * (1-0.15) = 0.70

[1034] Based upon pricing forecast developed by Applied Proactive Technologies Inc (APT) based on industry input and provided to Ameren.

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:

Location	Lumen Level	NPV of replacement costs for period			Levelized annual replacement cost savings		
		June 2014 - May 2015	June 2015 - May 2016	June 2016 - May 2017	June 2014 - May 2015	June 2015 - May 2016	June 2016 - May 2017
Residential and in-unit Multi Family	Lumens <310 or >2600 (EISA exempt)	$1.12	$1.07	$0.82	$0.25	$0.25	$0.23
	Lumens ≥ 310 and ≤ 2600 (EISA compliant)	$2.46	$2.14	$1.53	$0.55	$0.50	$0.44
Multi Family Common Areas	Lumens <310 or >2600 (EISA exempt)	$2.88	$2.88	$2.88	$1.81	$1.81	$1.81
	Lumens ≥ 310 and ≤ 2600 (EISA compliant)	$9.27	$7.24	$6.40	$5.84	$4.56	$4.03
Exterior	Lumens <310 or >2600 (EISA exempt)	$2.06	$2.06	$1.87	$0.54	$0.54	$0.53
	Lumens ≥ 310 and ≤ 2600 (EISA compliant)	$5.10	$4.35	$3.61	$1.33	$1.13	$1.02
Unknown	Lumens <310 or >2600 (EISA exempt)	$1.19	$1.14	$0.88	$0.27	$0.26	$0.25
	Lumens ≥ 310 and ≤ 2600 (EISA compliant)	$2.62	$2.28	$1.64	$0.59	$0.53	$0.46

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.[1035] 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-V03-140601

[1035] 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 97% Residential and 3% Commercial assumptions should be used[1036].

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

Energy Star qualified specialty CFL bulb 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).

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[1037].

Multi Family Common area bulbs: The expected measure life is 1.7 years[1038] for bulbs installed June 2012 –May 2017.

Exterior bulbs: The expected measure life is 4.4 years[1039] for bulbs installed June 2012 – May 2015. For bulbs installed June 2016-May 2017 this would be reduced to 4 years.

[1036] RES v C&I split is based on a weighted (by sales volume) average of ComEd PY3, PY4 and PY5 and Ameren PY5 in store intercept survey results.

[1037] 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).

[1038] Based on using 10,000 hour rated life assumption since significantly less switching with higher use. 10,000/5950 = 1.7years.

[1039] Based on using 8,000 hour rated life assumption since more switching and use ourdoors. 8,000/1825 = 4.4years

Deemed Measure Cost

For the Retail (Time of Sale) measure, the incremental capital cost for this measure is $5[1040].

For the Direct Install measure, the full cost of $8.50 should be used plus $5 labor[1041] 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..

Loadshape

Loadshape R06 - Residential Indoor Lighting
Loadshape R07 - Residential Outdoor Lighting
Loadshape C06 - Commercial Indoor Lighting[1042]

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[1043]

Bulb Type	Peak CF
Three-way	0.081
Dimmable	0.081
Interior reflector (incl. dimmable)	0.095
Exterior reflector	0.184
Candelabra base and candle medium and intermediate base	0.122
Bug light	0.184
Post light (>100W)	0.184
Daylight	0.095
Plant light	0.095
Globe	0.116
Vibration or shatterproof	0.095
Standard spirals >= 2601 lumens	0.095
Specialty - Generic	0.095

[1040] NEEP Residential Lighting Survey, 2011
[1041] Based on 15 minutes at $20 per hour.
[1042] For Multi Family common area lighting.
[1043] Lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation, results were used to calculate the average coincident peak factor in the rooms where the specialty bulbs are most likely to be installed. http://www.icc.illinois.gov/downloads/public/edocket/303834.pdf

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

ΔkWh = ((WattsBase - WattsEE) / 1000) * ISR * Hours * WHFe

Where:

WattsBase = Actual wattage equivalent of incandescent specialty bulb, use the tables below to obtain the incandescent bulb equivalent wattage[1044]; use 60W if unknown[1045]

EISA exempt bulb types:

Bulb Type	Lower Lumen Range	Upper Lumen Range	WattsBase
Standard Spirals >=2601	2601	2999	150
	3000	5279	200
	5280	6209	300
3-Way	250	449	25
	450	799	40
	800	1099	60
	1100	1599	75
	1600	1999	100
	2000	2549	125
	2550	2999	150
Globe (medium and intermediate bases less than 750 lumens)	90	179	10
	180	249	15
	250	349	25
	350	749	40
Decorative	70	89	10

[1044] 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.

[1045] A 2006-2008 California Upstream Lighting Evaluation found an average incandescent wattage of 61.7 Watts (KEMA, Inc, The Cadmus Group, Itron, Inc, PA Consulting Group, Jai J. Mitchell Analytics, Draft Evaluation Report: Upstream Lighting Program. Prepared for the California Public Utilities Commission, Energy Division. December 10, 2009)

Bulb Type	Lower Lumen Range	Upper Lumen Range	WattsBase
(Shapes B, BA, C, CA, DC, F, G, medium and intermediate bases less than 750 lumens)	90	149	15
	150	299	25
	300	749	40
Globe (candelabra bases less than 1050 lumens)	90	179	10
	180	249	15
	250	349	25
	350	499	40
	500	1049	60
Decorative (Shapes B, BA, C, CA, DC, F, G, candelabra bases less than 1050 lumens)	70	89	10
	90	149	15
	150	299	25
	300	499	40
	500	1049	60
Reflector with medium screw bases w/ diameter <=2.25"	400	449	40
	450	499	45
	500	649	50
	650	1199	65
R, PAR, ER, BR, BPAR or similar bulb shapes with medium screw bases w/ diameter >2.5" (*see exceptions below)	640	739	40
	740	849	45
	850	1179	50
	1180	1419	65
	1420	1789	75
	1790	2049	90
	2050	2579	100
	2580	3429	120
	3430	4270	150
R, PAR, ER, BR, BPAR or similar bulb shapes with medium screw bases w/ diameter > 2.26'' and ≤ 2.5" (*see exceptions below)	540	629	40
	630	719	45
	720	999	50
	1000	1199	65
	1200	1519	75
	1520	1729	90
	1730	2189	100
	2190	2899	120
	2900	3850	150
***ER30, BR30, BR40, or ER40**	400	449	40
	450	499	45

Bulb Type	Lower Lumen Range	Upper Lumen Range	WattsBase
	500	649-1179[1046]	50
***BR30, BR40, or ER40**	650	1419	65
***R20**	400	449	40
	450	719	45
***All reflector lamps below lumen ranges specified above**	200	299	20
	300	399-639[1047]	30

EISA non-exempt bulb types:

Bulb Type	Lower Lumen Range	Upper Lumen Range	Incandescent Equivalent Post-EISA 2007 (WattsBase)
Dimmable Twist, Globe (less than 5" in diameter and > 749 lumens), candle (shapes B, BA, CA > 749 lumens), Candelabra Base Lamps (>1049 lumens), Intermediate Base Lamps (>749 lumens)	310	749	29
	750	1049	43
	1050	1489	53
	1490	2600	72

WattsEE = Actual wattage of energy efficient specialty bulb purchased, use 15W if unknown[1048]

ISR = In Service Rate, the percentage of units rebated that are actually in service.

[1046] The upper bounds for these categories depends on the lower bound of the next higher wattage, which varies by bulb type.

[1047] As above.

[1048] An evaluation (Energy Efficiency / Demand Response Plan: Plan Year 2 (6/1/2009-5/31/2010) Evaluation Report: Residential Energy Star ® Lighting http://ilsag.org/yahoo_site_admin/assets/docs/ComEd_Res_Lighting_PY2_Evaluation_Report_2010-12-21_Final.12113928.pdf) reported 13-17W as the most common specialty CFL wattage (69% of program bulbs). 2009 California data also reported an average CFL wattage of 15.5 Watts (KEMA, Inc, The Cadmus Group, Itron, Inc, PA Consulting Group, Jai J. Mitchell Analytics, Draft Evaluation Report: Upstream Lighting Program, Prepared for the California Public Utilities Commission, Energy Division. December 10, 2009).

Program	Weighted Average 1st year In Service Rate (ISR)	2nd year Installations	3rd year Installations	Final Lifetime In Service Rate
Retail (Time of Sale) or Efficiency Kits	82.3%[1049]	8.5%	7.2%	98.0%[1050]
Direct Install	96.9%[1051]			

Hours = Average hours of use per year, varies by bulb type as presented below:[1052]

Bulb Type	Annual hours of use (HOU)
Three-way	897
Dimmable	897
Interior reflector (incl. dimmable)	938
Exterior reflector	1825
Candelabra base and candle medium and intermediate base	1328
Bug light	1825
Post light (>100W)	1825
Daylight	938
Plant light	938
Globe	847
Vibration or shatterproof	938
Standard Spiral >2601 lumens, Residential, Multi Family in-unit or unknown	938
Standard Spiral >2601 lumens, Multi Family Common area	5950

1049 1st year in service rate is based upon review of PY3-5 evaluations from ComEd and PY5 from Ameren (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.

1050 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.

1051 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.

1052 Hours of use by specialty bulb type calculated using the average hours of use in locations or rooms where each type of specialty bulb is most commonly found. Annual hours of use by location in the home from Docket No. 10-0520, ICC Staff Exhibit 1.4, RE: Lighting Logger Study Results – Version 2, Navigant, May 27, 2011. http://www.icc.illinois.gov/downloads/public/edocket/303834.pdf

Standard Spiral >2601 lumens, Exterior	1825
Specialty - Generic	938

WHFe = Waste heat factor for energy to account for cooling savings from efficient lighting

Bulb Location	WHFe
Interior single family or unknown location	1.06 [1053]
Multi family in unit	1.04 [1054]
Exterior or uncooled location	1.0

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.

[1053] 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)

[1054] 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

For example, for a 13W dimmable CFL impacted by EISA 2007 (60W standard incandescent and 43W EISA qualified incandescent/halogen) purchased in 2013.

$\Delta kWH_{1st\ year\ installs}$ = ((60 - 13) / 1000) * 0.823 * 897 * 1.06

= 36.8 kWh

$\Delta kWH_{2nd\ year\ installs}$ = ((43 - 13) / 1000) * 0.085 * 897 * 1.06

= 2.4 kWh

Note: Here we assume no change in hours assumption. NTG value from Purchase year applied.

$\Delta kWH_{3rd\ year\ installs}$ = ((43 - 13) / 1000) * 0.072 * 897 * 1.06

= 2.1 kWh

HEATING PENALTY

If electric heated home (if heating fuel is unknown assume gas, see Natural Gas section):

ΔkWh[1055] = - (((WattsBase - WattsEE) / 1000) * ISR * Hours * HF) / ηHeat

Where:

HF = Heating Factor or percentage of light savings that must be heated

= 49%[1056] for interior or unknown location

= 0% for exterior location

ηHeat = Efficiency in COP of Heating equipment

= actual. If not available use[1057]:

System Type	Age of Equipment	HSPF Estimate	ηHeat (COP Estimate)
Heat Pump	Before 2006	6.8	2.00
	After 2006	7.7	2.26
Resistance	N/A	N/A	1.00

[1055] Negative value because this is an increase in heating consumption due to the efficient lighting.
[1056] 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.
[1057] 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, a 15W specialty CFL replacing a 60W incandescent specialty bulb installed in home with 2.0 COP Heat Pump:

$\Delta kWh_{1st\ year}$ = - (((60 - 15) / 1000) * 0.823 * 938 * 0.49) / 2.0

= - 8.5 kWh

Second and third year savings should be calculated using the appropriate ISR.

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW =((WattsBase - WattsEE) / 1000) * ISR * WHFd * CF

Where:

WHFd = Waste heat factor for demand to account for cooling savings from efficient lighting.

Bulb Location	WHFd
Interior single family or unknown location	1.11[1058]
Multi family in unit	1.07[1059]
Exterior or uncooled location	1.0

CF = Summer Peak Coincidence Factor for measure. Coincidence factors by bulb types are presented below[1060]

Bulb Type	Peak CF
Three-way	0.081
Dimmable	0.081
Interior reflector (incl. dimmable)	0.095
Exterior reflector	0.184
Candelabra base and candle medium and intermediate base	0.122
Bug light	0.184
Post light (>100W)	0.184
Daylight	0.095
Plant light	0.095
Globe	0.116
Vibration or shatterproof	0.095
Standard Spiral >=2601 lumens	0.095
Specialty - Generic	0.095

[1058] 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.

[1059] 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); http://205.254.135.7/consumption/residential/data/2009/xls/HC7.1%20Air%20Conditioning%20by%20Housing%20Unit%20Type.xls.

[1060] Lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation, results were used to calculate the average coincident peak factor in the rooms where the specialty bulbs are most likely to be installed.

Other factors as defined above

For example, a 15W specialty CFL replacing a 60W incandescent specialty bulb:

$\Delta kW_{1st\ year}$ = ((60 - 15) / 1000) * 0.823 * 1.11 * 0.095

= 0.004 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):

ΔTherms[1061] = - (((WattsBase - WattsEE) / 1000) * ISR * Hours * HF * 0.03412) / ηHeat

Where:

HF = Heating Factor or percentage of light savings that must be heated

= 49%[1062] for interior or unknown location

= 0% for exterior location

0.03412 =Converts kWh to therms

ηHeat = Efficiency of heating system

=70%[1063]

[1061] Negative value because this is an increase in heating consumption due to the efficient lighting.

[1062] 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.

[1063] 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

For example, a 15W specialty CFL replacing a 60W incandescent specialty bulb:

ΔTherms = - (((60 - 15) / 1000) * 0. 823 * 938 * 0.49 * 0.03412) / 0.7

= - 0.83 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 1.07 year[1064]; baseline replacement cost is assumed to be $3.5[1065].

For non-exempt EISA bulb types defined above, in order to account for the shift in baseline due to the Energy Independence and Security Act of 2007, an equivalent annual levelized baseline replacement cost over the lifetime of the CFL is calculated (see RES Specialty CFL O&M calc.xls) for each CFL lumen range and installation year and using the statewide real discount rate of 5.23%. The key assumptions used in this calculation are documented below:

	Standard Incandescent	EISA Qualified Incandescent/Halogen
Replacement Cost	$3.50	$5.00
Component Rated Life (hrs)	1000	1000

The Net Present Value of the baseline replacement costs[1066]:

Lumen Range	NPV of baseline replacement costs		
	June 2014 - May 2015	June 2015 - May 2016	June 2016 - May 2017
1490-2600	$21.08	$17.28	$13.29
1050-1489	$21.08	$17.28	$13.29
750-1049	$21.08	$17.28	$13.29
310-749	$21.08	$17.28	$13.29

The annual levelized baseline replacement costs:

Lumen Range	Levelized annual replacement cost savings

[1064] Assuming 1000 hour rated life for incandescent bulb: 1000/938 = 1.07
[1065] NEEP Residential Lighting Survey, 2011
[1066] See 'RES Specialty CFL O&M calc.xls' for more details.

	June 2014 - May 2015	June 2015 - May 2016	June 2016 - May 2017
1490-2600	$3.76	$3.09	$2.37
1050-1489	$3.76	$3.09	$2.37
750-1049	$3.76	$3.09	$2.37
310-749	$3.76	$3.09	$2.37

MEASURE CODE: RS-LTG-ESCC-V03-140601

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[1067].

Deemed Measure Cost

The incremental cost for this measure is assumed to be $5[1068].

Loadshape

Loadshape R06 - Residential Indoor Lighting
Loadshape R07 - Residential Outdoor Lighting
Loadshape C06 - Commercial Indoor Lighting[1069]

Coincidence Factor

The summer peak coincidence factor for this measure is 9.5%[1070] for Residential and in-unit Multi Family bulbs and

[1067] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007.
[1068] DEER 2008 Database Technology and Measure Cost Data (www.deeresources.com) and consistent with Efficiency Vermont TRM.
[1069] For Multi Family common area lighting.
[1070] Based on lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation. "ComEd Residential Energy Star Lighting Program Metering Study: Overview of Study Protocols" http://www.icc.illinois.gov/downloads/public/edocket/303835.pdf
"Memo RE: Lighting Logger Study Results – Version 2, Date: May 27, 2011, To: David Nichols and ComEd Residential Lighting Interested Parties, From: Amy Buege and Jeremy Eddy; Navigant Evaluation Team" http://www.icc.illinois.gov/downloads/public/edocket/303834.pdf

75%[1071] for Multi Family common area bulbs.

Algorithm

Calculation of Savings

Electric Energy Savings

ΔkWh = ((ΔWatts) /1000) * ISR * HOURS * WHFe

Where:

ΔWatts = Average delta watts per purchased ENERGY STAR torchiere

= 115.8 [1072]

ISR = In Service Rate or percentage of units rebated that get installed.

= 0.86 [1073]

HOURS = Average hours of use per year

Installation Location	Hours
Residential and in-unit Multi Family	1095 (3.0 hrs per day)[1074]
Multi Family Common Areas	5950[1075]

WHFe = Waste Heat Factor for Energy to account for cooling savings from efficient lighting.

[1071] Coincidence factor is based on healthcare/clinic value (used as proxy for multi family common area lighting with similar hours of use) developed using Equest models for various building types averaged across 5 climate zones for Illinois for the following building types.
[1072] 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)
[1073] 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
[1074] 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)
[1075] Multi family common area lighting assumption is 16.3 hours per day (5950 hours per year) based on Focus on Energy Evaluation, ACES Deemed Savings Desk Review, November 2010.

Bulb Location	WHFe
Interior single family or unknown location	1.06 [1076]
Multi family in unit	1.04 [1077]
Multi family common area	1.04 [1078]
Exterior or uncooled location	1.0

For single family buildings:

ΔkWh = (115.8 /1000) * 0.86 * 1095 * 1.06

= 116 kWh

For multi family in unit:

ΔkWh = (115.8 /1000) * 0.86 * 1095 * 1.04

= 113 kWh

For multi family common area:

ΔkWh = (115.8 /1000) * 0.86 * 5950 * 1.04

= 616 kWh

HEATING PENALTY

If electric heated home (if heating fuel is unknown assume gas, see Natural Gas section):

ΔkWh[1079] = - ((ΔWatts) /1000) * ISR * HOURS * HF) / ηHeat

[1076] 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)

[1077] 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

[1078] Ibid.

Where:

HF = Heating Factor or percentage of light savings that must be heated

= 49%[1080] for interior or unknown location

ηHeat = Efficiency in COP of Heating equipment

= Actual. If not available use defaults provided below[1081]:

System Type	Age of Equipment	HSPF Estimate	ηHeat (COP Estimate)
Heat Pump	Before 2006	6.8	2.00
	After 2006	7.7	2.26
Resistance	N/A	N/A	1.00

For example, an ES torchiere installed in a house with a newer heat pump:

ΔkWh = - ((115.8) / 1000) * 0.86 * 1095 * 0.49) / 2.26

= - 23.6 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ((ΔWatts) /1000) * ISR * WHFd * CF

Where:

WHFd = Waste Heat Factor for Demand to account for cooling savings from efficient lighting

Bulb Location	WHFd
Interior single family or unknown location	1.11[1082]
Multi family in unit	1.07[1083]

[1079] Negative value because this is an increase in heating consumption due to the efficient lighting.
[1080] 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.
[1081] 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.
[1082] 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.
[1083] 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);

Multi family common area	1.07 [1084]
Exterior or uncooled location	1.0

CF = Summer Peak Coincidence Factor for measure

Bulb Location	CF
Interior single family or unknown location	9.5% [1085]
Multi family in unit	9.5% [1086]
Multi family common area	75% [1087]

For single family buildings:

ΔkW = (115.8 / 1000) * 0.86 * 1.11 * 0.095

= 0.011kW

For multi family in unit:

ΔkW = (115.8 / 1000) * 0.86 * 1.07 * 0.095

= 0.010 kW

For multi family common area:

ΔkW = (115.8 / 1000) * 0.86 * 1.07 * 0.75

= 0.080 kW

NATURAL GAS SAVINGS

Heating penalty if Natural Gas heated home, or if heating fuel is unknown.

$\Delta Therms_{WH}$ = - (((ΔWatts) /1000) * ISR * HOURS * 0.03412 * HF) / ηHeat

Where:

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http://205.254.135.7/consumption/residential/data/2009/xls/HC7.1%20Air%20Conditioning%20by%20Housing%20Unit%20Type.xls.

1084 Ibid

1085 Based on lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation. "ComEd Residential Energy Star Lighting Program Metering Study: Overview of Study Protocols" http://www.icc.illinois.gov/downloads/public/edocket/303835.pdf
"Memo RE: Lighting Logger Study Results – Version 2, Date: May 27, 2011, To: David Nichols and ComEd Residential Lighting Interested Parties, From: Amy Buege and Jeremy Eddy; Navigant Evaluation Team" http://www.icc.illinois.gov/downloads/public/edocket/303834.pdf

1086 Ibid.

1087 Coincidence factor is based on healthcare/clinic value (used as proxy for multi family common area lighting with similar hours of use) developed using Equest models for various building types averaged across 5 climate zones for Illinois for the following building types.

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

0.03412 = conversion from kWh to therms

HF = Heating Factor or percentage of light savings that must be heated

= 49% [1088]

ηHeat = average heating system efficiency

= 70% [1089]

$\Delta Therms_{WH}$ = - ((115.8 / 1000) * 0.86 * 1095 * 0.03412 * 0.49) / 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[1090] for residential and multifamily in unit and 0.34 years[1091] for multifamily common area. Baseline bulb cost replacement is assumed to be $6.[1092]

MEASURE CODE: RS-LTG-ESTO-V01-120601

[1088] 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.

[1089] This has been estimated assuming that natural gas central furnace heating is typical for Illinois residences (66% of Illinois homes have a Natural Gas Furnace (based on Energy Information Administration, 2009 Residential Energy Consumption Survey: www.eia.gov/consumption/residential/data/2009/xls/HC6.9%20Space%20Heating%20in%20Midwest%20Region.xls) In 2000, 24% of furnaces purchased in Illinois were condensing (based on data from GAMA, provided to Department of Energy during the federal standard setting process for residential heating equipment - see Furnace Penetration.xls). Furnaces tend to last up to 20 years and so units purchased 10 years ago provide a reasonable proxy for the current mix of furnaces in the State. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows:
(0.24*0.92) + (0.76*0.8) * (1-0.15) = 0.70

[1090] Based on VEIC assumption of baseline bulb (mix of incandescent and halogen) average rated life of 2000 hours, 2000/1095 = 1.83 years.

[1091] 2000/5950 = 0.34 years

[1092] 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[1093]. 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[1094].

[1093] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007 (http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf) gives 20 years for an interior fluorescent fixture.

[1094] 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.

Deemed Measure Cost

The incremental cost for an exterior fixture is assumed to be $32[1095].

Loadshape

Loadshape R07 - Residential Outdoor Lighting

Coincidence Factor

The summer peak coincidence factor is assumed to be 0.4%[1096].

Algorithm

Calculation of Savings

Electric Energy Savings

ΔkWh =((WattsBase - WattsEE) / 1000) * ISR * Hours

Where:

WattsBase = Based on lumens of CFL bulb and program year purchased:

Minimum Lumens	Maximum Lumens	Incandescent Equivalent Post-EISA 2007 ($Watts_{Base}$)
5280	6209	300
3000	5279	200
2601	2999	150
1490	2600	72
1050	1489	53
750	1049	43
310	749	29
250	309	25

1095 ENERGY STAR Qualified Lighting Savings Calculator default incremental cost input for exterior fixture (http://www.energystar.gov/buildings/sites/default/uploads/files/light_fixture_ceiling_fan_calculator.xlsx?4349-303e=&b6b3-3efd&b6b3-3efd)

1096 Estimated based on Commercial Outdoor Lighting coincidence factor calculation from analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. Residential Outdoor Lighting is not provided in this data set.

WattsEE = Actual wattage of CFL purchased

ISR = In Service Rate or the percentage of units rebated that get installed.

Program	Weighted Average 1st year In Service Rate (ISR)	2nd year Installations	3rd year Installations	Final Lifetime In Service Rate
Retail (Time of Sale)	87.5%[1097]	5.7%	4.8%	98.0%[1098]
Direct Install	96.9[1099]			

Hours = Average hours of use per year

=1643 (4.5 hrs per day)[1100]

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.

1097 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.

1098 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.

1099 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.

1100 Updated results from above study, presented in 2005 memo; http://publicservice.vermont.gov/energy/ee_files/efficiency/eval/marivtfinalresultsmemodelivered.pdf

For example, for a 2 x 14W pin based CFL fixture (43W EISA qualified incandescent/halogen) purchased in 2014.

$\Delta kWH_{1st\ year\ installs}$ = ((86 - 28) / 1000) * 0.875 * 1643

= 83.4 kWh

$\Delta kWH_{2nd\ year\ installs}$ = ((86 - 28) / 1000) * 0.057 * 1643

= 5.4 kWh

Note: Here we assume no change in hours assumption. NTG value from Purchase year applied.

$\Delta kWH_{3rd\ year\ installs}$ = ((86 - 28) / 1000) * 0.048 * 1643

= 4.6 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ((WattsBase - WattsEE) / 1 000) * ISR * CF

Where:

CF = Summer Peak Coincidence Factor for measure.

= 0.4%[1101]

Other factors as defined above

For example, a 2 x 14W pin-based CFL fixture is purchased in 2013:

$\Delta kW_{1st\ year}$ = ((86 - 28) / 1000) * 0.875 * 0.004

= 0.0002 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

[1101] Estimated based on Commercial Outdoor Lighting coincidence factor calculation from analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. Residential Outdoor Lighting is not provided in this data set.

DEEMED O&M COST ADJUSTMENT CALCULATION

Bulb replacement costs assumed in the O&M calculations are provided below[1102].

	Std Inc.	EISA Compliant Halogen
2014	$0.34	$1.25
2015	$0.34	$0.90
2016	$0.34	$0.80
2017	$0.34	$0.70
2018	$0.34	$0.60
2019	$0.34	$0.60
2020 & after	$0.34	N/A

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:

Location	Lumen Level	NPV of replacement costs for period			Levelized annual replacement cost savings		
		June 2014 - May 2015	June 2015 - May 2016	June 2016 - May 2017	June 2014 - May 2015	June 2015 - May 2016	June 2016 - May 2017
Exterior	Lumens <310 or >2600 (non-EISA compliant)	$2.49	$2.08	$1.65	$0.49	$0.48	$0.47
	Lumens ≥ 310 and ≤ 2600 (EISA compliant)	$5.66	$4.29	$3.18	$1.12	$1.00	$0.90
	Efficient bulb CFL	$0.42	$0.04	$0 - No replacement bulb within measure life	$0.08	$0.01	$0 - No replacement bulb within measure life

For halogen bulbs, we assume the same replacement cycle as incandescent bulbs.[1103] The replacement cycle is

[1102] Based upon pricing forecast developed by Applied Proactive Technologies Inc (APT) based on industry input and provided to Ameren.

[1103] 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.

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 leads to longer lamp life).

MEASURE CODE: RS-LTG-EFIX-V03-140601

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 table provided in the Electric Energy Savings section.

Deemed Lifetime of Efficient Equipment

The expected life of an interior fixture is 20 years[1104]. 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[1105].

[1104] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007 (http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf) gives 20 years for an interior fluorescent fixture.

[1105] 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.

DEEMED MEASURE COST

The incremental cost for an interior fixture is assumed to be $32[1106].

LOADSHAPE

Loadshape R06 - Residential Indoor Lighting
Loadshape C06 - Commercial Indoor Lighting[1107]

COINCIDENCE FACTOR

The summer peak coincidence factor is assumed to be 9.5%[1108] for Residential and in-unit Multi Family bulbs and 75%[1109] for Multi Family common area bulbs.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

ΔkWh = ((WattsBase - WattsEE) / 1000) * ISR * Hours * WHFe

Where:

WattsBase = Based on lumens of CFL bulb and program year purchased:

[1106] ENERGY STAR Qualified Lighting Savings Calculator default incremental cost input for interior fixture (http://www.energystar.gov/buildings/sites/default/uploads/files/light_fixture_ceiling_fan_calculator.xlsx?4349-303e=&b6b3-3efd&b6b3-3efd)
[1107] For Multi Family common area lighting.
[1108] Based on lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation. “ComEd Residential Energy Star Lighting Program Metering Study: Overview of Study Protocols” http://www.icc.illinois.gov/downloads/public/edocket/303835.pdf
“Memo RE: Lighting Logger Study Results – Version 2, Date: May 27, 2011, To: David Nichols and ComEd Residential Lighting Interested Parties, From: Amy Buege and Jeremy Eddy; Navigant Evaluation Team” http://www.icc.illinois.gov/downloads/public/edocket/303834.pdf
[1109] Coincidence factor is based on healthcare/clinic value (used as proxy for multi family common area lighting with similar hours of use) developed using Equest models for various building types averaged across 5 climate zones for Illinois for the following building types.

Minimum Lumens	Maximum Lumens	Incandescent Equivalent Post-EISA 2007 ($Watts_{Base}$)
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

ISR = In Service Rate or the percentage of units rebated that get installed.

Program	Weighted Average 1st year In Service Rate (ISR)	2nd year Installations	3rd year Installations	Final Lifetime In Service Rate
Retail (Time of Sale)	87.5%[1110]	5.7%	4.8%	98.0%[1111]
Direct Install	96.9[1112]			

[1110] 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.

[1111] 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.

[1112] 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.

Hours = Average hours of use per year

Installation Location	Hours
Residential and in-unit Multi Family	938 [1113]
Multi Family Common Areas	5950[1114]

WHFe = Waste heat factor for energy to account for cooling energy savings from efficient lighting

Bulb Location	WHFe
Interior single family or unknown location	1.06 [1115]
Multi family in unit	1.04 [1116]
Multi family common area	1.04 [1117]

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.

[1113] Based on lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation.
[1114] Multi family common area lighting assumption is 16.3 hours per day (5950 hours per year) based on Focus on Energy Evaluation, ACES Deemed Savings Desk Review, November 2010.
[1115] 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)
[1116] 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
[1117] Ibid.

For example, for a 2 x 14W pin based CFL fixture (43W EISA qualified incandescent/halogen) purchased in 2013.

$\Delta kWH_{1st\ year\ installs}$ = ((86 - 28) / 1000) * 0.875 * 938 * 1.06

= 50.5 kWh

$\Delta kWH_{2nd\ year\ installs}$ = ((86 - 28) / 1000) * 0.057 * 938 * 1.06

= 3.3 kWh

Note: Here we assume no change in hours assumption. NTG value from Purchase year applied.

$\Delta kWH_{3rd\ year\ installs}$ = ((86 - 28) / 1000) * 0.048 * 938 * 1.06

= 2.8 kWh

HEATING PENALTY

If electric heated building:

ΔkWh[1118] = - (((WattsBase - WattsEE) / 1000) * ISR * Hours * HF) / ηHeat

Where:

HF = Heating Factor or percentage of light savings that must be heated

= 49%[1119] for interior or unknown location

= 0% for unheated location

ηHeat = Efficiency in COP of Heating equipment

= actual. If not available use[1120]:

System Type	Age of Equipment	HSPF Estimate	ηHeat (COP Estimate)
Heat Pump	Before 2006	6.8	2.00
	After 2006	7.7	2.26
Resistance	N/A	N/A	1.00

[1118] Negative value because this is an increase in heating consumption due to the efficient lighting.
[1119] 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.
[1120] 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, a 2 x 14W pin-based CFL fixture is purchased in 2013 and installed in home with 2.0 COP Heat Pump:

$\Delta kWh_{1st\ year}$ = - (((86 – 28) / 1000) * 0.875 * 938 * 0.49) / 2.0

= - 11.7 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

ΔkW = ((WattsBase - WattsEE) / 1 000) * ISR * WHFd * CF

Where:

WHFd = Waste heat factor for demand to account for cooling savings from efficient lighting.

Bulb Location	WHFd
Interior single family or unknown location	1.11[1121]
Multi family in unit	1.07[1122]
Multi family common area	1.07 [1123]
Exterior or uncooled location	1.0

CF = Summer Peak Coincidence Factor for measure.

Bulb Location	CF
Interior single family or unknown location	9.5% [1124]
Multi family in unit	9.5% [1125]
Multi family common area	75% [1126]

[1121] 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.

[1122] 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 .

[1123] Ibid

[1124] Based on lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation. "ComEd Residential Energy Star Lighting Program Metering Study: Overview of Study Protocols" http://www.icc.illinois.gov/downloads/public/edocket/303835.pdf
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[1125] Ibid.

[1126] Coincidence factor is based on healthcare/clinic value (used as proxy for multi family common area lighting

Other factors as defined above

For example, a 14W pin-based CFL fixture is purchased in 2013:

$\Delta kW_{1st\ year}$ = ((86- 28) / 1000) * 0.875 * 1.11 * 0.095

= 0.0054 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

ΔTherms[1127] = - (((WattsBase - WattsEE) / 1000) * ISR * Hours * HF * 0.03412) / ηHeat

Where:

HF = Heating Factor or percentage of light savings that must be heated

= 49%[1128] for interior or unknown location

= 0% for unheated location

0.03412 =Converts kWh to Therms

ηHeat = Efficiency of heating system

=70%[1129]

with similar hours of use) developed using Equest models for various building types averaged across 5 climate zones for Illinois for the following building types.

[1127] Negative value because this is an increase in heating consumption due to the efficient lighting.

[1128] 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.

[1129] This has been estimated assuming that natural gas central furnace heating is typical for Illinois residences (66% of Illinois homes have a Natural Gas Furnace (based on Energy Information Administration, 2009 Residential Energy Consumption Survey: http://www.eia.gov/consumption/residential/data/2009/xls/HC6.9%20Space%20Heating%20in%20Midwest%20Region.xls))

In 2000, 24% of furnaces purchased in Illinois were condensing (based on data from GAMA, provided to Department of Energy during the federal standard setting process for residential heating equipment - see Furnace Penetration.xls). Furnaces tend to last up to 20 years and so units purchased 10 years ago provide a reasonable proxy for the current mix of furnaces in the State. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows:

(0.24*0.92) + (0.76*0.8) * (1-0.15) = 0.70

For example, a 2 x 14W pin-based CFL fixture is purchased in 2013 and installed in home with gas heat at 70% efficiency:

$$\Delta Therms_{1st\ year} = -((86 - 28) / 1000) * 0.875 * 938 * 0.49 * 0.03412) / 0.7$$

$$= - 1.1\ Therms$$

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[1130].

	Std Inc.	EISA Compliant Halogen
2014	$0.34	$1.25
2015	$0.34	$0.90
2016	$0.34	$0.80
2017	$0.34	$0.70
2018	$0.34	$0.60
2019	$0.34	$0.60
2020 & after	$0.34	N/A

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:

[1130] Based upon pricing forecast developed by Applied Proactive Technologies Inc (APT) based on industry input and provided to Ameren.

Location	Lumen Level	NPV of replacement costs for period			Levelized annual replacement cost savings		
		June 2014 - May 2015	June 2015 - May 2016	June 2016 - May 2017	June 2014 - May 2015	June 2015 - May 2016	June 2016 - May 2017
Residential and in-unit Multi Family	Lumens <310 or >2600 (non-EISA compliant)	$1.30	$1.07	$0.82	$0.26	$0.25	$0.23
	Lumens ≥ 310 and ≤ 2600 (EISA compliant)	$2.79	$2.14	$1.53	$0.55	$0.50	$0.44
	Efficient bulb CFL	$0 - No replacement bulb within measure life			$0 - No replacement bulb within measure life		
Multi Family Common Areas	Lumens <310 or >2600 (non-EISA compliant)	$9.87	$8.38	$6.81	$1.96	$1.95	$1.93
	Lumens ≥ 310 and ≤ 2600 (EISA compliant)	$23.59	$17.78	$13.50	$4.68	$4.13	$3.83
	Efficient bulb CFL	$5.68	$4.58	$3.43	$1.13	$1.13	$1.07

For halogen bulbs, we assume the same replacement cycle as incandescent bulbs.[1131] 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 and multi family common areas assume 10,000 (longer run hours and less switching leads to longer lamp life).

MEASURE CODE: RS-LTG-IFIX-V03-140601

[1131] 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.[1132]

Bulb Type	Measure Life (yr)
PAR20, PAR30, PAR38 screw-in lamps	10
MR16/PAR16 pin-based lamps	10
Recessed downlight luminaries	15
Track lights	15

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[1133]:

Bulb Type	Baseline Cost	LED Cost	Incremental Cost
PAR20, PAR30, PAR38 screw-in lamps	$4.00	$44.00	$40.00
MR16/PAR16 pin-based lamps	$3.00	$28.00	$25.00
Recessed downlight luminaries	$4.00	$94.00	$90.00
Track lights	$4.00	$60.00	$56.00

[1132] Limited by persistence. NEEP EMV Emerging Technologies Research Report (December 2011)
[1133] 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.

LOADSHAPE

Loadshape R06 - Residential Indoor Lighting

Loadshape R07 - Residential Outdoor Lighting

Loadshape C06 - Commercial Indoor Lighting[1134]

COINCIDENCE FACTOR

The summer Peak Coincidence Factor is assumed to be 9.5%[1135] for Residential and in-unit Multi Family bulbs and 75%[1136] for Multi Family common area bulbs.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

ΔkWh = ((WattsBase - WattsEE) / 1000) * ISR * Hours * WHFe

Where:

WattsBase = Baseline lamp wattage of equivalent lumens

[1134] For Multi Family common area lighting.

[1135] Based on lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation. "ComEd Residential Energy Star Lighting Program Metering Study: Overview of Study Protocols" http://www.icc.illinois.gov/downloads/public/edocket/303835.pdf

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[1136] Coincidence factor is based on healthcare/clinic value (used as proxy for multi family common area lighting with similar hours of use) developed using Equest models for various building types averaged across 5 climate zones for Illinois for the following building types.

Bulb Type	Lower Lumen Range	Upper Lumen Range	WattsBase
Reflector with medium screw bases w/ diameter <=2.25"	400	449	40
	450	499	45
	500	649	50
	650	1199	65
R, PAR, ER, BR, BPAR or similar bulb shapes with medium screw bases w/ diameter >2.5" (*see exceptions below)	640	739	40
	740	849	45
	850	1179	50
	1180	1419	65
	1420	1789	75
	1790	2049	90
	2050	2579	100
	2580	3429	120
	3430	4270	150
R, PAR, ER, BR, BPAR or similar bulb shapes with medium screw bases w/ diameter > 2.26'' and ≤ 2.5" (*see exceptions below)	540	629	40
	630	719	45
	720	999	50
	1000	1199	65
	1200	1519	75
	1520	1729	90
	1730	2189	100
	2190	2899	120
	2900	3850	150
*ER30, BR30, BR40, or ER40	400	449	40
	450	499	45
*BR30, BR40, or ER40	650	1419	65
	500	649	50
*R20	400	449	40
	450	719	45
*All reflector lamps below lumen ranges specified above	200	299	20
	300	399	30

WattsEE = Actual wattage of energy efficient LED lamp purchased

ISR = In Service Rate or the percentage of units rebated that get installed[1137]

[1137] NEEP EMV Emerging Technologies Research Report (December 2011)

Bulb Type	ISR
PAR20, PAR30, PAR38 screw-in lamps	0.95
MR16/PAR16 pin-based lamps	0.95
Recessed downlight luminaries	1.0
Track lights	1.0

Hours = Average hours of use per year

Installation Location	Hours
Residential and in-unit Multi Family	1,010 [1138]
Multi Family Common Areas	5950[1139]

WHFe = Waste heat factor for energy to account for cooling savings from efficient lighting

Bulb Location	WHFe
Interior single family or unknown location	1.06 [1140]
Multi family in unit	1.04 [1141]
Multi family common area	1.04 [1142]
Exterior or uncooled location	1.0

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:

ΔkWh = ((45 - 13) / 1000) * 0.95 * 1010 * 1.06

= 32.5 kWh

[1138] NEEP EMV Emerging Technologies Research Report (December 2011)

[1139] Multifamily common area lighting assumption is 16.3 hours per day (5950 hours per year) based on Focus on Energy Evaluation, ACES Deemed Savings Desk Review, November 2010.

[1140] 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)

[1141] 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

[1142] Ibid.

HEATING PENALTY

If electric heated home (if heating fuel is unknown assume gas, see Natural Gas section):

ΔkWh[1143] = - (((WattsBase - WattsEE) / 1000) * ISR * Hours * HF) / ηHeat

Where:

HF = Heating Factor or percentage of light savings that must be heated

= 49%[1144] for interior or unknown location

= 0% for exterior location

ηHeat = Efficiency in COP of Heating equipment

= Actual. If not available use:[1145]

System Type	Age of Equipment	HSPF Estimate	ηHeat (COP Estimate)
Heat Pump	Before 2006	6.8	2.00
	After 2006	7.7	2.26
Resistance	N/A	N/A	1.00

For example, a 13W PAR20 LED is installed in place of a 750 lumen PAR20 incandescent screw-in lamp with medium screw base, diameter >2.5",installed in single family interior location:

ΔkWh = - ((45 - 13) / 1000) * 0.95 * 1010 * 0.49) / 2.26

= - 6.66 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ((WattsBase - WattsEE) / 1000) * ISR * WHFd * CF

Where:

WHFd = Waste heat factor for demand to account for cooling savings from efficient lighting.

[1143] Negative value because this is an increase in heating consumption due to the efficient lighting.
[1144] 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.
[1145] 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.

Bulb Location	WHFd
Interior single family or unknown location	1.11[1146]
Multi family in unit	1.07[1147]
Multi family common area	1.07 [1148]
Exterior or uncooled location	1.0

CF = Summer Peak Coincidence Factor for measure, see above for values.

Bulb Location	CF
Interior single family or unknown location	9.5% [1149]
Multi family in unit	9.5% [1150]
Multi family common area	75% [1151]

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:

ΔkW = ((45 - 13) / 1000) * 0.95 * 1.11* 0.095

= 0.0032 kW

NATURAL GAS SAVINGS

Heating penalty if Natural Gas heated home, or if heating fuel is unknown.

Δtherms = - (((WattsBase - WattsEE) / 1000) * ISR * Hours * HF * 0.03412) / ηHeat

[1146] 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.

[1147] 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.

[1148] Ibid

[1149] Based on lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation. "ComEd Residential Energy Star Lighting Program Metering Study: Overview of Study Protocols" http://www.icc.illinois.gov/downloads/public/edocket/303835.pdf

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[1150] Ibid.

[1151] Coincidence factor is based on healthcare/clinic value (used as proxy for multi family common area lighting with similar hours of use) developed using Equest models for various building types averaged across 5 climate zones for Illinois for the following building types.

Where:

HF = Heating factor, or percentage of lighting savings that must be replaced by heating system.

= 49% [1152] for interior or unknown location

= 0% for exterior location

0.03412 = Converts kWh to Therms

ηHeat = Average heating system efficiency.

= 0.70 [1153]

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:

Δtherms = - (((45 - 13) / 1000) * 0.95 * 1010 * 0.49* 0.03412) / 0.70

= - 0.73 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:

[1152] Average result from REMRate modeling of several different configurations and IL locations of homes

[1153] This has been estimated assuming that natural gas central furnace heating is typical for Illinois residences (66% of Illinois homes have a Natural Gas Furnace (based on Energy Information Administration, 2009 Residential Energy Consumption Survey:
http://www.eia.gov/consumption/residential/data/2009/xls/HC6.9%20Space%20Heating%20in%20Midwest%20Region.xls))
In 2000, 24% of furnaces purchased in Illinois were condensing (based on data from GAMA, provided to Department of Energy during the federal standard setting process for residential heating equipment - see Furnace Penetration.xls). Furnaces tend to last up to 20 years and so units purchased 10 years ago provide a reasonable proxy for the current mix of furnaces in the State. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows:
(0.24*0.92) + (0.76*0.8) * (1-0.15) = 0.70

Lamp Type	Baseline Lamp Life (hours)	Baseline Life (Single Family and in unit Multifamily - 1010 hours)	Baseline Life (Common Area Multifamily - 5950 hours)	Baseline Replacement Cost
PAR20, PAR30, PAR38 screw-in lamps	2000	2.0	0.3	$4.00
MR16/PAR16 pin-based lamps	2000	2.0	0.3	$3.00
Recessed downlight luminaries	2000	2.0	0.3	$4.00
Track lights	2000	2.0	0.3	$4.00

MEASURE CODE: RS-LTG-LEDD-V02-140601

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[1154].

Deemed Measure Cost

The incremental cost for this measure is assumed to be $30[1155].

Loadshape

Loadshape C53 - Flat

Coincidence Factor

The summer peak coincidence factor for this measure is assumed to be 100%[1156].

[1154] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Effective/Remaining Useful Life Values", California Public Utilities Commission, December 16, 2008.
[1155] NYSERDA Deemed Savings Database, Labor cost assumes 25 minutes @ $18/hr.
[1156] 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

$$\Delta kWh = ((WattsBase - WattsEE) / 1000) * HOURS * WHF_e$$

Where:

WattsBase = Actual wattage if known, if unknown assume the following:

Baseline Type	WattsBase
Incandescent	35W[1157]
Fluorescent	11W[1158]
Unknown (e.g. time of sale)	11W

WattsEE = Actual wattage if known, if unknown assume 2W[1159]

HOURS = Annual operating hours

= 8766

WHF_e = Waste heat factor for energy; accounts for cooling savings from efficient lighting.

= 1.04[1160] for multi family buildings

Default if replacing incandescent fixture

ΔkWH = (35 – 2)/1000 * 8766 * 1.04

[1157] Based on review of available product.

[1158] Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010

[1159] Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010

[1160] The value is estimated at 1.04 (calculated as 1 + (0.45*(0.27 / 2.8)). Based on cooling loads decreasing by 27% of the lighting savings (average result from REMRate modeling of several different configurations and IL locations of homes), assuming typical cooling system operating efficiency of 3.1 COP (starting from standard assumption of SEER 10.5 central AC unit, converted to 9.5 EER using algorithm (-0.02 * SEER2) + (1.12 * SEER) (from Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder), converted to COP = EER/3.412 = 2.8COP) and estimate of 45% of multi family buildings in Illinois having central cooling (based on data from “Table HC7.1 Air Conditioning in U.S. Homes, By Housing Unit Type, 2009” which is for the whole of the US, scaled to IL air conditioning prevalence compared to US average); http://205.254.135.7/consumption/residential/data/2009/xls/HC7.1%20Air%20Conditioning%20by%20Housing%20Unit%20Type.xls

= 301 kWh

Default if replacing fluorescent fixture

ΔkWH = (11 – 2)/1000 * 8766 * 1.04

= 82 kWh

HEATING PENALTY

If electric heated building (if heating fuel is unknown assume gas, see Natural Gas section):

ΔkWh[1161] = - (((WattsBase - WattsEE) / 1000) * Hours * HF) / ηHeat

Where:

HF = Heating Factor or percentage of light savings that must be heated

= 49%[1162]

ηHeat = Efficiency in COP of Heating equipment

= Actual. If not available use:[1163]

System Type	Age of Equipment	HSPF Estimate	ηHeat (COP Estimate)
Heat Pump	Before 2006	6.8	2.00
	After 2006	7.7	2.26
Resistance	N/A	N/A	1.00

For example, a 2.0COP Heat Pump heated building:

If incandescent fixture: ΔkWH = -((35 – 2)/1000 * 8766 * 0.49) / 2

= -71 kWh

If fluorescent fixture ΔkWH = -((11 – 2)/1000 * 8766 * 0.49) / 2

= -19 kWh

1161 Negative value because this is an increase in heating consumption due to the efficient lighting.

1162 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.

1163 These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Heat Pumps was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate.

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$\Delta kW = ((WattsBase - WattsEE) / 1000) * WHF_d * CF$

Where:

WHF_d = Waste heat factor for demand to account for cooling savings from efficient lighting. The cooling savings are only added to the summer peak savings.

=1.07[1164] for multi family buildings

CF = Summer Peak Coincidence Factor for measure

= 1.0

Default if incandescent fixture

$\Delta kW = (35 – 2)/1000 * 1.07 * 1.0$

$= 0.035$ kW

Default if fluorescent fixture

$\Delta kW = (11 – 2)/1000 * 1.07 * 1.0$

$= 0.0096$ kW

NATURAL GAS SAVINGS

Heating penalty if Natural Gas heated building, or if heating fuel is unknown.

$\Delta therms = - (((WattsBase - WattsEE) / 1000) * Hours * HF * 0.03412) / \eta Heat$

Where:

HF = Heating factor, or percentage of lighting savings that must be replaced by heating system.

= 49% [1165]

0.03412 = Converts kWh to Therms

ηHeat = Average heating system efficiency.

= 0.70 [1166]

[1164] The value is estimated at 1.11 (calculated as 1 + (0.45 * 0.466 / 2.8)). See footnote relating to WHFe for details. Note the 46.6% factor represents the average Residential cooling coincidence factor calculated by dividing average load during the peak hours divided by the maximum cooling load.

[1165] Average result from REMRate modeling of several different configurations and IL locations of homes

Other factors as defined above

Default if incandescent fixture

Δtherms = - (((35 - 2) / 1000) * 8766 * 0.49* 0.03412) / 0.70

= -6.9 therms

Default if fluorescent fixture

Δtherms = - (((11 - 2) / 1000) * 8766 * 0.49* 0.03412) / 0.70

= -1.9 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

The annual O&M Cost Adjustment savings should be calculated using the following component costs and lifetimes.

	Baseline Measures	
Component	Cost	Life (yrs)
Lamp	$7.00[1167]	1.37 years[1168]

MEASURE CODE: RS-LTG-LEDE-V01-120601

[1166] This has been estimated assuming that natural gas central furnace heating is typical for Illinois residences (66% of Illinois homes have a Natural Gas Furnace (based on Energy Information Administration, 2009 Residential Energy Consumption Survey: http://www.eia.gov/consumption/residential/data/2009/xls/HC6.9%20Space%20Heating%20in%20Midwest%20Region.xls))
In 2000, 24% of furnaces purchased in Illinois were condensing (based on data from GAMA, provided to Department of Energy during the federal standard setting process for residential heating equipment - see Furnace Penetration.xls). Furnaces tend to last up to 20 years and so units purchased 10 years ago provide a reasonable proxy for the current mix of furnaces in the State. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows:
(0.24*0.92) + (0.76*0.8) * (1-0.15) = 0.70

[1167] 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).

[1168] 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 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 (EIAS) will require all general-purpose light bulbs between 40 watts and 100 watts to have ~30% increased efficiency, essentially phasing out standard incandescent technology. In 2012, the 100 w lamp standards apply; in 2013 the 75 w lamp standards will apply, followed by restrictions on the 60 w and 40 w lamps in 2014. 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

Lifetime is the life of the product, at the reported operating hours (lamp life in hours divided by operating hours per year. For the residential and multi-family sector, this changes based on where the lamp is used and varies from 4.2 years (multi-family common areas) to 26 years (residential home), however all installations are capped at 10 years[1169].

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 9.5%[1170] for Residential and in-unit Multi Family bulbs and

[1169] Based on recommendation in the Dunsky Energy Consulting, Livingston Energy Innovations and Opinion Dynamics Corporation; NEEP Emerging Technology Research Report: https://www.neep.org/Assets/uploads/files/emv/emv-products/NEEP_EMV_EmergingTechResearch_Report_Final.pdf, p 6-18.
[1170] Based on lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation.

75%[1171] for Multi Family common area bulbs.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = ((Watts_{base} - Watts_{EE})/1000) * Hours * WHF_e * ISR$$

Where:

$Watts_{base}$ = Input wattage of the existing system. Reference the "LED New and Baseline Assumptions" table for default values.

$Watts_{EE}$ = = Actual wattage of LED purchased / installed

LED New and Baseline Assumptions Table

Minimum Lumens	Maximum Lumens	Lumens used to calculate LED Wattage (midpoint)	LED Wattage[1172] (WattsEE)	Baseline 2014-2019 (WattsBase)	Delta Watts 2014-2019 (WattsEE)	Baseline Post EISA 2020 requirement[1173] (WattsBase)	Delta Watts Post 2020 (WattsEE)
5280	6209	5745	104.4	300.0	195.6	300.0	195.6
3000	5279	4140	75.3	200.0	124.7	200.0	124.7
2601	2999	2800	50.9	150.0	99.1	150.0	99.1
1490	2600	2045	37.2	72.0	34.8	45.4	8.3
1050	1489	1270	23.1	53.0	29.9	28.2	5.1
750	1049	900	16.4	43.0	26.6	20.0	3.6
310	749	530	9.6	29.0	19.4	11.8	2.1
250	309	280	5.6	25.0	19.4	25.0	19.4

"ComEd Residential Energy Star Lighting Program Metering Study: Overview of Study Protocols" http://www.icc.illinois.gov/downloads/public/edocket/303835.pdf
"Memo RE: Lighting Logger Study Results – Version 2, Date: May 27, 2011, To: David Nichols and ComEd Residential Lighting Interested Parties, From: Amy Buege and Jeremy Eddy; Navigant Evaluation Team" http://www.icc.illinois.gov/downloads/public/edocket/303834.pdf

[1171] Coincidence factor is based on healthcare/clinic value (used as proxy for multi family common area lighting with similar hours of use) developed using Equest models for various building types averaged across 5 climate zones for Illinois.

[1172] 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.

[1173] Calculated as 45lm/W for all EISA non-exempt bulbs.

ISR = In Service Rate, the percentage of units rebated that are actually in service.

Program	Weighted Average 1st year In Service Rate (ISR)	2nd year Installations	3rd year Installations	Final Lifetime In Service Rate
Retail (Time of Sale) or Efficiency Kits	92%[1174]	3.2%	2.8%	98.0%[1175]
Direct Install	96.9%[1176]			

Hours = Average hours of use per year

Installation Location	Hours
Residential and in-unit Multi Family	938 [1177]
Multi Family Common Areas	5,950 [1178]
Exterior	1,825 [1179]
Unknown	1,000 [1180]

WHFe = Waste heat factor for energy to account for cooling energy savings from efficient lighting

[1174] 1st year in service rate is based upon review of the LED logger inventory data from the PY5/PY6 ComEd logger study showing of 24 A-lamp LEDs found, 2 were in storage.

[1175] 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 2nd and 3rd year installations should be counted as part of those future program year savings.

[1176] Based upon Standard CFL assumption in the absence of better data, and is 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.

[1177] Based on lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation. http://www.icc.illinois.gov/downloads/public/edocket/323818.pdf

[1178] Multi family common area lighting assumption is 16.3 hours per day (5950 hours per year) based on Focus on Energy Evaluation, ACES Deemed Savings Desk Review, November 2010.

[1179] Based on secondary research conducted as part of the PY3 ComEd Residential Lighting Program evaluation. http://www.icc.illinois.gov/downloads/public/edocket/323818.pdf

[1180] Assumes 7% exterior lighting, based on lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation. http://www.icc.illinois.gov/downloads/public/edocket/323818.pdf

Bulb Location	WHFe
Interior single family or unknown location	1.06 [1181]
Multi family in unit	1.04 [1182]
Multi family common area	1.04 [1183]
Exterior or uncooled location	1.0

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.

Minimum Lumens	Maximum Lumens	LED Wattage (WattsEE)	Delta Watts 2014-2019 (WattsEE)	Delta Watts Post 2020 (WattsEE)	Mid Life adjustment (made from June 2020) to first year savings
1490	2600	37.2	34.8	8.3	23.8%
1050	1489	23.1	29.9	5.1	17.1%
750	1049	16.4	26.6	3.6	13.5%
310	749	9.6	19.4	2.1	10.8%

[1181] 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)

[1182] 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

[1183] Ibid.

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:

$$\Delta kWH = ((29-8 /1000) * 938 * 1.06 * 0.92$$

$$= 19.2 \text{ kWh}$$

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 (19.2 * 0.108 =) 2.1 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.

$$\Delta kWH_{1st\ year\ installs} = ((29-8/1000)*938*1.06*0.92$$

$$= 19.2 \text{ kWh}$$

$$\Delta kWH_{2nd\ year\ installs} = ((29-8/1000)*938*1.06*0.032$$

$$= 0.7 \text{ kWh}$$

Note: Here we assume no change in hours assumption. NTG value from Purchase year applied.

$$\Delta kWH_{3rd\ year\ installs} = ((29-8/1000)*938*1.06*0.028$$

$$= 0.6 \text{ kWh}$$

HEATING PENALTY

If electric heated home (if heating fuel is unknown assume gas, see Natural Gas section):

ΔkWh[1184] = - (((WattsBase - WattsEE) / 1000) * ISR * Hours * HF) / ηHeat

Where:

HF = Heating Factor or percentage of light savings that must be heated

= 49%[1185] for interior or unknown location

= 0% for exterior or unheated location

ηHeat = Efficiency in COP of Heating equipment

= actual. If not available use[1186]:

System Type	Age of Equipment	HSPF Estimate	ηHeat (COP Estimate)
Heat Pump	Before 2006	6.8	2.00
	After 2006	7.7	2.26
Resistance	N/A	N/A	1.00

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):

$\Delta kWh_{1st\ year}$ = - (((29-8) / 1000) * 0.92 * 938 * 0.49) / 2.0

= - 4.4 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.

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ((WattsBase - WattsEE) / 1 000) * ISR * WHFd * CF

Where:

[1184] Negative value because this is an increase in heating consumption due to the efficient lighting.

[1185] 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.

[1186] These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Heat Pumps was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate.

WHFd = Waste heat factor for demand to account for cooling savings from efficient lighting.

Bulb Location	WHFd
Interior single family or unknown location	1.11[1187]
Multi family in unit	1.07[1188]
Multi family common area	1.07 [1189]
Exterior or uncooled location	1.0

CF = Summer Peak Coincidence Factor for measure.

Bulb Location	CF
Interior single family or unknown location	9.5% [1190]
Multi family in unit	9.5% [1191]
Multi family common area	75% [1192]

Other factors as defined above

[1187] 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.

[1188] 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.

[1189] Ibid

[1190] Based on lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation. "ComEd Residential Energy Star Lighting Program Metering Study: Overview of Study Protocols" http://www.icc.illinois.gov/downloads/public/edocket/303835.pdf
"Memo RE: Lighting Logger Study Results – Version 2, Date: May 27, 2011, To: David Nichols and ComEd Residential Lighting Interested Parties, From: Amy Buege and Jeremy Eddy; Navigant Evaluation Team" http://www.icc.illinois.gov/downloads/public/edocket/303834.pdf

[1191] Ibid.

[1192] Coincidence factor is based on healthcare/clinic value (used as proxy for multi family common area lighting with similar hours of use) developed using Equest models for various building types averaged across 5 climate zones for Illinois for the following building types.

For the same 8 W LED that is installed in a single family interior location in 2014, the demand savings are:

$$\Delta kW = ((29-8) / 1000) * 0.92 * 1.11 * 0.095$$

$$= 0.0020 \text{ kW}$$

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.

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[1193].

	Std Inc.	EISA Compliant Halogen	CFL	LED-A
2014	$0.34	$1.25	$2.50	$13.81
2015	$0.34	$0.90	$2.50	$10.86
2016	$0.34	$0.80	$2.50	$8.60
2017	$0.34	$0.70	$2.50	$7.74
2018	$0.34	$0.60	$2.50	$6.96
2019	$0.34	$0.60	$2.50	$6.27
2020 & after	$0.34	N/A	$2.50	$5.64

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:

Installation Location	Omnidirectional LED Measure Hours	Hours of Use per year	Measure Life in Years (capped at 10)
Residential and in-unit Multi Family	25,000	938 [1194]	10

[1193] Based upon pricing forecast developed by Applied Proactive Technologies Inc (APT) based on industry input and provided to Ameren.
[1194] Based on lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation. http://www.icc.illinois.gov/downloads/public/edocket/323818.pdf

Multi Family Common Areas	25,000	5,950 [1195]	4.2
Exterior	25,000	1,825 [1196]	10
Unknown	25,000	1,000 [1197]	10

The NPV for replacement lamps and annual levelized replacement costs using the statewide real discount rate of 5.23% are presented below:

Location	Lumen Level	NPV of replacement costs for period			Levelized annual replacement cost savings		
		June 2014 - May 2015	June 2015 - May 2016	June 2016 - May 2017	June 2014 - May 2015	June 2015 - May 2016	June 2016 - May 2017
Residential and in-unit Multi Family	Lumens <310 or >2600 (non-EISA compliant)	$2.13	$2.13	$1.07	$0.28	$0.28	$0.14
	Lumens ≥ 310 and ≤ 2600 (EISA compliant)	$3.55	$3.11	$2.74	$0.47	$0.41	$0.36
Multi Family Common Areas	Lumens <310 or >2600 (non-EISA compliant)	$7.13	$7.13	$7.13	$1.93	$1.93	$1.93
	Lumens ≥ 310 and ≤ 2600 (EISA compliant)	$18.75	$15.57	$13.79	$5.09	$4.22	$3.74
Exterior	Lumens <310 or >2600 (non-EISA compliant)	$4.42	$4.42	$2.35	$0.58	$0.58	$0.31
	Lumens ≥ 310 and ≤ 2600 (EISA compliant)	$7.89	$6.76	$5.96	$1.03	$0.89	$0.78
Unknown	Lumens <310 or >2600 (non-EISA compliant)	$2.27	$2.27	$1.14	$0.30	$0.30	$0.15
	Lumens ≥ 310 and ≤ 2600 (EISA compliant)	$3.79	$3.32	$2.92	$0.50	$0.43	$0.38

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.[1198] The replacement cycle is based on the location of the lamp and

[1195] Multi family common area lighting assumption is 16.3 hours per day (5950 hours per year) based on Focus on Energy Evaluation, ACES Deemed Savings Desk Review, November 2010.
[1196] Based on secondary research conducted as part of the PY3 ComEd Residential Lighting Program evaluation. http://www.icc.illinois.gov/downloads/public/edocket/323818.pdf
[1197] Assumes 7% exterior lighting, based on lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation. http://www.icc.illinois.gov/downloads/public/edocket/323818.pdf
[1198] The manufacturers of the new minimally compliant EISA Halogens are using regular incandescent lamps with

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-V01-140601

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.[1199]

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

[1199] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007

represents the *average* savings over the defined summer peak period, and is presented so that savings can be bid into PJM's Forward Capacity Market.

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during utility peak hour)
= 68%[1200]

CF_{SSP} = Summer System Peak Coincidence Factor for Heat Pumps (during system peak hour)
= 72%%[1201]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)
= 46.6%[1202]

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

ΔkWh = ΔkWh_cooling + ΔkWh_heating

Where:

ΔkWh_cooling = If central cooling, reduction in annual cooling requirement due to air sealing

= [(((CFM50_existing - CFM50_new)/N_cool) * 60 * 24 * CDD * DUA * 0.018) / (1000 * ηCool)] * LM

CFM50_existing = Infiltration at 50 Pascals as measured by blower door before air sealing.

= Actual

CFM50_new = Infiltration at 50 Pascals as measured by blower door after air sealing.

= Actual

N_cool = Conversion factor from leakage at 50 Pascal to leakage at natural conditions
=Dependent on exposure:[1203]

1200 Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.

1201 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)'.

1202 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.

1203 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

Climate Zone	Exposure	N-Factor
Zone 2	Well Shielded	22.2
	Normal	18.5
	Exposed	16.7
Zone 3	Well Shielded	25.8
	Normal	21.5
	Exposed	19.4

60 * 24 = Converts Cubic Feet per Minute to Cubic Feet per Day

CDD = Cooling Degree Days

= Dependent on location[1204]:

Climate Zone (City based upon)	CDD 65
1 (Rockford)	820
2 (Chicago)	842
3 (Springfield)	1,108
4 (Belleville)	1,570
5 (Marion)	1,370

DUA = Discretionary Use Adjustment (reflects the fact that people do not always operate their AC when conditions may call for it).

= 0.75 [1205]

0.018 = Specific Heat Capacity of Air (Btu/ft^3*°F)

1000 = Converts Btu to kBtu

ηCool = Efficiency (SEER) of Air Conditioning equipment (kBtu/kWh)

= Actual (where it is possible to measure or reasonably estimate). If unknown assume the following[1206]:

Comfort for Existing Buildings", p284.

[1204] National Climatic Data Center, calculated from 1981-2010 climate normals with a base temp of 65°F.

[1205] 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.

[1206] 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.

Age of Equipment	SEER Estimate
Before 2006	10
After 2006	13

LM = Latent multiplier to account for latent cooling demand

= dependent on location: [1207]

Climate Zone (City based upon)	LM
1 (Rockford)	8.5
2 (Chicago)	6.2
3 (Springfield)	6.6
4 (St. Louis, MO)	5.8
5 (Evansville, IN)	6.6

ΔkWh_heating = If electric heat (resistance or heat pump), reduction in annual electric heating due to air sealing

= (((CFM50_existing - CFM50_new)/N_heat) * 60 * 24 * HDD * 0.018) / (ηHeat * 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:[1208]

	# Stories:	1	1.5	2	3
Zone 2	Well Shielded	22.2	20.0	17.8	15.5
	Normal	18.5	16.7	14.8	13.0
	Exposed	16.7	15.0	13.3	11.7
Zone 3	Well Shielded	25.8	23.2	20.6	18.1
	Normal	21.5	19.4	17.2	15.1
	Exposed	19.4	17.4	15.5	13.5

HDD = Heating Degree Days

= Dependent on location:[1209]

[1207] 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.
[1208] 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.

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

ηHeat = Efficiency of heating system

= Actual. If not available refer to default table below[1210]:

System Type	Age of Equipment	HSPF Estimate	ηHeat (Effective COP Estimate)= (HSPF/3.413)*0.85
Heat Pump	Before 2006	6.8	1.7
	After 2006	7.7	1.92
Resistance	N/A	N/A	1

3412 = Converts Btu to kWh

For example, a well shielded, 2 story single family home in Chicago with 10.5 SEER central cooling and a heat pump with COP of 2 (1.92 including distribution losses), has pre and post blower door test results of 3,400 and 2,250:

ΔkWh = ΔkWh_cooling + ΔkWh_heating

= [((((3,400 – 2,250) / 22.2) * 60 * 24 * 842 * 0.75 * 0.018) / (1000 * 10.5)) * 6.2] + [((3,400 – 2,250) / 17.8)) * 60 * 24 * 6339 * 0.018 / (1.92 * 3,412)]

= 501 + 1620

= 2,121 kWh

[1209] 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 modeling software.

[1210] 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.

ΔkWh_heating = If gas *furnace* heat, kWh savings for reduction in fan run time

= ΔTherms * F_e * 29.3

F_e = Furnace Fan energy consumption as a percentage of annual fuel consumption

= 3.14%[1211]

29.3 = 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:

ΔkWh = 152 * 0.0314 * 29.3

= 140 kWh

Summer Coincident Peak Demand Savings

ΔkW = (ΔkWh_cooling / FLH_cooling) * CF

Where:

FLH_cooling = Full load hours of air conditioning

= Dependent on location[1212]:

Climate Zone (City based upon)	Single Family	Multifamily
1 (Rockford)	512	467
2 (Chicago)	570	506
3 (Springfield)	730	663
4 (Belleville)	1,035	940
5 (Marion)	903	820

1211 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.

1212 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.

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)

= 68%[1213]

CF_{SSP} = Summer System Peak Coincidence Factor for Heat Pumps (during system peak hour)

= 72%%[1214]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)

= 46.6%[1215]

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:

ΔkW_{SSP} = 501 / 570 * 0.68

= 0.60 kW

ΔkW_{PJM} = 501 / 570 * 0.466

= 0.410 kW

NATURAL GAS SAVINGS

If Natural Gas heating:

ΔTherms = (((CFM50_existing - CFM50_new)/N_heat) * 60 * 24 * HDD * 0.018) / (ηHeat * 100,000)

Where:

N_heat = Conversion factor from leakage at 50 Pascal to leakage at natural conditions

= Based on climate zone, building height and exposure level[1216]:

[1213] Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.
[1214] 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)'.
[1215] 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.
[1216] N-factor is used to convert 50-pascal blower door air flows to natural air flows and is dependent on geographic

	# Stories:	1	1.5	2	3
Zone 2	Well Shielded	22.2	20.0	17.8	15.5
	Normal	18.5	16.7	14.8	13.0
	Exposed	16.7	15.0	13.3	11.7
Zone 3	Well Shielded	25.8	23.2	20.6	18.1
	Normal	21.5	19.4	17.2	15.1
	Exposed	19.4	17.4	15.5	13.5

HDD = Heating Degree Days

= dependent on location[1217]:

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

ηHeat = Efficiency of heating system

= Equipment efficiency * distribution efficiency

= Actual[1218]. If not available use 70%[1219].

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.

[1217] 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..

[1218] Ideally, the System Efficiency should be obtained either by recording the AFUE of the unit, or performing a steady state efficiency test. The Distribution Efficiency can be estimated via a visual inspection and by referring to a look up table such as that provided by the Building Performance Institute: (http://www.bpi.org/files/pdf/DistributionEfficiencyTable-BlueSheet.pdf or by performing duct blaster testing.

[1219] This has been estimated assuming that natural gas central furnace heating is typical for Illinois residences (66% of Illinois homes have a Natural Gas Furnace (based on Energy Information Administration, 2009 Residential Energy Consumption Survey: http://www.eia.gov/consumption/residential/data/2009/xls/HC6.9%20Space%20Heating%20in%20Midwest%20Region.xls)

In 2000, 24% of furnaces purchased in Illinois were condensing (based on data from GAMA, provided to Department of Energy during the federal standard setting process for residential heating equipment - see Furnace Penetration.xls). Furnaces tend to last up to 20 years and so units purchased 10 years ago provide a reasonable proxy for the current mix of furnaces in the State. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows:

(0.24*0.92) + (0.76*0.8) * (1-0.15) = 0.70

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:

ΔTherms = ((3,400 – 2,250)/17.8) * 60 * 24 * 6339 * 0.018) / (0.7 * 100,000)

= 152 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-SHL-AIRS-V02-140601

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.[1220]

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

[1220] 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.

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during utility peak hour)
= 68%[1221]

CF_{SSP} = Summer System Peak Coincidence Factor for Heat Pumps (during system peak hour)
= 72%%[1222]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)
= 46.6%[1223]

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.

ΔkWh = (ΔkWh_cooling + ΔkWh_heating)

Where:

ΔkWh_cooling = If central cooling, reduction in annual cooling requirement due to insulation

= (((1/R_old_AG - 1/(R_added+R_old_AG)) * L_basement_wall_total * H_basement_wall_AG * (1-Framing_factor)) * 24 * CDD * DUA) / (1000 * ηCool))

R_added = R-value of additional spray foam, rigid foam, or cavity insulation.

R_old_AG = R-value value of foundation wall above grade.

= Actual, if unknown assume 1.0[1224]

[1221] Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.

[1222] 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)'.

[1223] 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.

[1224] ORNL Builders Foundation Handbook, crawl space data from Table 5-5: Initial Effective R-values for Uninsulated Foundation System and Adjacent Soil, 1991, http://www.ornl.gov/sci/roofs+walls/foundation/ORNL_CON-295.pdf

L_basement_wall_total = Length of basement wall around the entire insulated perimeter (ft)

H_basement_wall_AG = Height of insulated basement wall above grade (ft)

Framing_factor = Adjustment to account for area of framing when cavity insulation is used

= 0% if Spray Foam or External Rigid Foam

= 25% if studs and cavity insulation[1225]

24 = Converts hours to days

CDD = Cooling Degree Days

= Dependent on location and whether basement is conditioned:[1226]

Climate Zone (City based upon)	Conditioned CDD 65	Unconditioned CDD 65[1227]
1 (Rockford)	820	263
2 (Chicago)	842	281
3 (Springfield)	1,108	436
4 (Belleville)	1,570	538
5 (Marion)	1,370	570
Weighted Average[1228]	947	325

DUA = Discretionary Use Adjustment (reflects the fact that people do not always operate their AC when conditions may call for it).

= 0.75 [1229]

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

1225 ASHREA, 2001, "Characterization of Framing Factors for New Low-Rise Residential Building Envelopes (904-RP)," Table 7.1

1226 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.

1227 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.

1228 Weighted based on number of occupied residential housing units in each zone.

1229 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.

assume the following:[1230]

Age of Equipment	ηCool Estimate
Before 2006	10
After 2006	13

ΔkWh_heating = If electric heat (resistance or heat pump), reduction in annual electric heating due to insulation

= ([((1/R_old_AG - 1/(R_added+R_old_AG)) * L_basement_wall_total * H_basement_wall_AG * (1-Framing_factor)) + ((1/(R_old_BG - 1/(R_added+R_old_BG)) * L_basement_wall_total * (H_basement_wall_total - H_basement_wall_AG) * (1-Framing_factor))] * 24 * HDD) / (3,412 * ηHeat)) * $ADJ_{Basement}$

R_old_BG = R-value value of foundation wall below grade (including thermal resistance of the earth) [1231]

= dependent on depth of foundation (H_basement_wall_total – H_basement_wall_AG):

= Actual R-value of wall plus average earth R-value by depth in table below

Below Grade R-value									
Depth below grade (ft)	0	1	2	3	4	5	6	7	8
Earth R-value (°F-ft^2-h/Btu)	2.44	4.50	6.30	8.40	10.44	12.66	14.49	17.00	20.00
Average Earth R-value (°F-ft2-h/Btu)	2.44	3.47	4.41	5.41	6.42	7.46	8.46	9.53	10.69
Total BG R-value (earth + R-1.0 foundation) default	3.44	4.47	5.41	6.41	7.42	8.46	9.46	10.53	11.69

H_basement_wall_total = Total height of basement wall (ft)

HDD = Heating Degree Days

= dependent on location and whether basement is conditioned:[1232]

[1230] 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.
[1231] Adapted from Table 1, page 24.4, of the 1977 ASHRAE Fundamentals Handbook
[1232] 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

Climate Zone (City based upon)	Conditioned HDD 60	Unconditioned HDD 50
1 (Rockford)	5,352	3,322
2 (Chicago)	5,113	3,079
3 (Springfield)	4,379	2,550
4 (Belleville)	3,378	1,789
5 (Marion)	3,438	1,796
Weighted Average[1233]	4,860	2,895

ηHeat = Efficiency of heating system

= Actual. If not available refer to default table below:[1234]

System Type	Age of Equipment	HSPF Estimate	ηHeat (Effective COP Estimate) (HSPF/3.413)*0.85
Heat Pump	Before 2006	6.8	1.7
	After 2006	7.7	1.92
Resistance	N/A	N/A	1

$ADJ_{Basement}$ = Adjustment for basement wall insulation to account for prescriptive engineering algorithms overclaiming savings.

Market	$ADJ_{Basement}$
Low Income	70%[1235]
Non- Low Income	88%[1236]

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.

[1233] Weighted based on number of occupied residential housing units in each zone.

[1234] 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.

[1235] Based upon comparing algorithm derived savings estimate and evaluated bill analysis estimate in the following 2011 Massachusetts Low Income report: "Low Income Single Family Program Impact Evaluation", June 2012. See "Insulation ADJ calculations.xls" for details or calculation.

[1236] 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.

For example, a non- low income 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:

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 * F_e * 29.3

F_e = Furnace Fan energy consumption as a percentage of annual fuel consumption

= 3.14%[1237]

29.3 = kWh per therm

For example, a non- low income 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

= dependent on location[1238]:

[1237] 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.

Climate Zone (City based upon)	Single Family	Multifamily
1 (Rockford)	512	467
2 (Chicago)	570	506
3 (Springfield)	730	663
4 (Belleville)	1,035	940
5 (Marion)	903	820
Weighted Average[1239]	629	564

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)

= 68%[1240]

CF_{SSP} = Summer System Peak Coincidence Factor for Heat Pumps (during system peak hour)

= 72%%[1241]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)

= 46.6%[1242]

[1238] Full load hours for Chicago, Moline and Rockford are provided in "Final Evaluation Report: Central Air Conditioning Efficiency Services (CACES), 2010, Navigant Consulting", 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.

[1239] Weighted based on number of occupied residential housing units in each zone.

[1240] Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.

[1241] 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)'.

[1242] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.

For example, a non- low income 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:

ΔkW_{SSP} = 49.3 / 570 * 0.68

= 0.059 kW

ΔkW_{PJM} = 49.3 / 570 * 0.466

= 0.040 kW

NATURAL GAS SAVINGS

If Natural Gas heating:

ΔTherms = [((([((1/R_old_AG - 1/(R_added+R_old_AG)) * L_basement_wall_total * H_basement_wall_AG * (1-Framing_factor) + (1/(R_old_BG - 1/(R_added+R_old_BG)) * L_basement_wall_total * (H_basement_wall_total - H_basement_wall_AG) * (1-Framing_factor)] * 24 * HDD) / (ηHeat * 100,067)] * $ADJ_{Basement}$

ηHeat = Efficiency of heating system

= Equipment efficiency * distribution efficiency

= Actual. If unknown assume 70%[1243]

Other factors as defined above

[1243] This has been estimated assuming that natural gas central furnace heating is typical for Illinois residences (66% of Illinois homes have a Natural Gas Furnace (based on Energy Information Administration, 2009 Residential Energy Consumption Survey: http://www.eia.gov/consumption/residential/data/2009/xls/HC6.9%20Space%20Heating%20in%20Midwest%20Region.xls))
In 2000, 24% of furnaces purchased in Illinois were condensing (based on data from GAMA, provided to Department of Energy during the federal standard setting process for residential heating equipment - see Furnace Penetration.xls). Furnaces tend to last up to 20 years and so units purchased 10 years ago provide a reasonable proxy for the current mix of furnaces in the State. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows:
(0.24*0.92) + (0.76*0.8) * (1-0.15) = 0.70

For example, a non- low income 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:

= ((1/2.25 - 1/(13 + 2.25)) * (20+25+20+25) * 3 * (1-0) + (1/8.67 - 1/(13 + 8.67)) * (20+25+20+25) * 4 * (1 - 0)) * 24 * 3079) / (0.7 * 100,067) * 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-V04-140201

NOTE: This represents a mid program year change to this measure, effective from February 1st, 2014. Any projects completed[1244] prior to the effective date should use the version with measure code RS-SHL-BINS-V03-130601.

[1244] Projects may be “completed”, i.e. installation complete, without having received the rebate.

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.[1245]

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

[1245] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007

COINCIDENCE FACTOR

The summer peak coincidence factor for cooling is provided in two different ways below. The first is used to estimate peak savings during the utility peak hour and is most indicative of actual peak benefits, and the second represents the *average* savings over the defined summer peak period, and is presented so that savings can be bid into PJM's Forward Capacity Market.

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during utility peak hour)

= 68%[1246]

CF_{SSP} = Summer System Peak Coincidence Factor for Heat Pumps (during system peak hour)

= 72%%[1247]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)

= 46.6%[1248]

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.

ΔkWh = (ΔkWh_cooling + ΔkWh_heating)

Where: ΔkWh_cooling = If central cooling, reduction in annual cooling requirement due to insulation

= (((1/R_old - 1/(R_added+R_old)) * Area * (1-Framing_factor)) * 24 * CDD * DUA) / (1000 * ηCool))

R_old = R-value value of floor before insulation, assuming 3/4" plywood subfloor and carpet with pad

= Actual. If unknown assume 3.96 [1249]

[1246] Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.

[1247] 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)'.

[1248] 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.

[1249] Based on 2005 ASHRAE Handbook – Fundamentals: assuming 2x8 joists, 16" OC, ¾" subfloor, ½" carpet with

R_added = R-value of additional spray foam, rigid foam, or cavity insulation.

Area = Total floor area to be insulated

Framing_factor = Adjustment to account for area of framing

= 12% [1250]

24 = Converts hours to days

CDD = Cooling Degree Days

Climate Zone (City based upon)	Unconditioned CDD[1251]
1 (Rockford)	263
2 (Chicago)	281
3 (Springfield)	436
4 (Belleville)	538
5 (Marion)	570
Weighted Average[1252]	325

DUA = Discretionary Use Adjustment (reflects the fact that people do not always operate their AC when conditions may call for it).

= 0.75 [1253]

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:[1254]

Age of Equipment	ηCool Estimate

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

[1250] ASHRAE, 2001, "Characterization of Framing Factors for New Low-Rise Residential Building Envelopes (904-RP)," Table 7.1

[1251] 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.

[1252] Weighted based on number of occupied residential housing units in each zone.

[1253] Energy Center of Wisconsin, May 2008 metering study; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research", p31.

[1254] 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.

Before 2006	10
After 2006	13

ΔkWh_heating = If electric heat (resistance or heat pump), reduction in annual electric heating due to insulation

= ((((1/R_old - 1/(R_added + R_old)) * Area * (1-Framing_factor) * 24 * HDD)/ (3,412 * ηHeat)) * ADJ_{Floor}

HDD = Heating Degree Days:[1255]

Climate Zone (City based upon)	Unconditioned HDD
1 (Rockford)	3,322
2 (Chicago)	3,079
3 (Springfield)	2,550
4 (Belleville)	1,789
5 (Marion)	1,796
Weighted Average[1256]	2,895

ηHeat = Efficiency of heating system

= Actual. If not available refer to default table below:[1257]

System Type	Age of Equipment	HSPF Estimate	ηHeat (Effective COP Estimate) (HSPF/3.413)*0.85
Heat Pump	Before 2006	6.8	1.7
	After 2006	7.7	1.92
Resistance	N/A	N/A	1

ADJ_{Floor} = Adjustment for floor insulation to account for prescriptive engineering algorithms overclaiming savings.

Market	ADJ_{Floor}
Low Income	70%[1258]

[1255] 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.

[1256] Weighted based on number of occupied residential housing units in each zone.

[1257] 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.

Non- Low Income	88%[1259]

Other factors as defined above

For example, a non- low income 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:

ΔkWh = (ΔkWh_cooling + ΔkWh_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 kWh

ΔkWh_heating = If gas *furnace* heat, kWh savings for reduction in fan run time

= ΔTherms * F_e * 29.3

F_e = Furnace Fan energy consumption as a percentage of annual fuel consumption

= 3.14%[1260]

29.3 = kWh per therm

For example, a non- low income 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):

ΔkWh = 91.2 * 0.0314 * 29.3

= 83.9 kWh

[1258] Based upon comparing algorithm derived savings estimate and evaluated bill analysis estimate in the following 2011 Massachusetts Low Income report: “Low Income Single Family Program Impact Evaluation”, June 2012. See “Insulation ADJ calculations.xls” for details or calculation. Note that basement walls is used as a proxy for crawlspace ceiling.

[1259] 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.

[1260] 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.

Summer Coincident Peak Demand Savings

$\Delta kW = (\Delta kWh\_cooling / FLH\_cooling) * CF$

Where:

FLH_cooling = Full load hours of air conditioning

= Dependent on location:[1261]

Climate Zone (City based upon)	Single Family	Multifamily
1 (Rockford)	512	467
2 (Chicago)	570	506
3 (Springfield)	730	663
4 (Belleville)	1,035	940
5 (Marion)	903	820
Weighted Average[1262]	629	564

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)

= 68%[1263]

CF_{SSP} = Summer System Peak Coincidence Factor for Heat Pumps (during system peak hour)

= 72%%[1264]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)

= 46.6%[1265]

[1261] 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.

[1262] Weighted based on number of occupied residential housing units in each zone.

[1263] Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.

[1264] 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)'.

[1265] 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

For example, a non- low income 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:

ΔkW_{SSP} = 47.3 / 570 * 0.68

= 0.056 kW

ΔkW_{SSP} = 47.3 / 570 * 0.466

= 0.039 kW

NATURAL GAS SAVINGS

If Natural Gas heating:

ΔTherms = (1/R_old - 1/(R_added+R_old)) * Area * (1-Framing_factor)) * 24 * HDD) / (100,000 * ηHeat) * $ADJ_{FloorGasHeat}$

ηHeat = Efficiency of heating system

= Equipment efficiency * distribution efficiency

= Actual. If unknown assume 70%[1266]

Other factors as defined above

For example, a non- low income 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:

ΔTherms = (1 / 3.96 – 1 /(30 + 3.96))*(20 * 25) * (1 - 0.12) * 24 * 3079) / (100,000 * 0.70) * 0.88

= 91.2 therms

during the year.

[1266] This has been estimated assuming that natural gas central furnace heating is typical for Illinois residences (66% of Illinois homes have a Natural Gas Furnace (based on Energy Information Administration, 2009 Residential Energy Consumption Survey: http://www.eia.gov/consumption/residential/data/2009/xls/HC6.9%20Space%20Heating%20in%20Midwest%20Region.xls))
In 2000, 24% of furnaces purchased in Illinois were condensing (based on data from GAMA, provided to Department of Energy during the federal standard setting process for residential heating equipment - see Furnace Penetration.xls). Furnaces tend to last up to 20 years and so units purchased 10 years ago provide a reasonable proxy for the current mix of furnaces in the State. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows:
(0.24*0.92) + (0.76*0.8) * (1-0.15) = 0.70

Water Impact Descriptions and Calculation

N/A

Deemed O&M Cost Adjustment Calculation

N/A

Measure Code: RS-SHL-FINS-V04-140201

NOTE: This represents a mid program year change to this measure, effective from February 1st, 2014. Any projects completed[1267] prior to the effective date should use the version with measure code RS-SHL-FINS-V03-130601

[1267] Projects may be "completed", i.e. installation complete, without having received the rebate.

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.[1268]

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} = Summer System Peak Coincidence Factor for Central A/C (during utility peak hour)
= 68%[1269]

[1268] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007

CF_{SSP} = Summer System Peak Coincidence Factor for Heat Pumps (during system peak hour)

= 72%%[1270]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)
= 46.6%[1271]

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.

ΔkWh = (ΔkWh_cooling + ΔkWh_heating)

Where:ΔkWh_cooling = If central cooling, reduction in annual cooling requirement due to insulation

= [((1/R_old - 1/R_wall) * A_wall * (1-Framing_factor_wall) + (1/R_old - 1/R_attic) * A_attic * (1-Framing_factor_attic)) * 24 * CDD * DUA] / (1000 * ηCool)

R_wall = R-value of new wall assembly (including all layers between inside air and outside air).

R_attic = R-value of new attic assembly (including all layers between inside air and outside air).

R_old = R-value value of existing assemble and any existing insulation.

(Minimum of R-5 for uninsulated assemblies[1272])

A_wall = Net area of insulated wall (ft^2)

A_attic = Total area of insulated ceiling/attic (ft^2)

Framing_factor_wall = Adjustment to account for area of framing

[1269] Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.
[1270] 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)'.
[1271] 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.
[1272] 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).

= 25%[1273]

Framing_factor_attic = Adjustment to account for area of framing

= 7%[1274]

24 = Converts hours to days

CDD = Cooling Degree Days

= dependent on location:[1275]

Climate Zone (City based upon)	CDD 65
1 (Rockford)	820
2 (Chicago)	842
3 (Springfield)	1,108
4 (Belleville)	1,570
5 (Marion)	1,370
Weighted Average[1276]	947

DUA = Discretionary Use Adjustment (reflects the fact that people do not always operate their AC when conditions may call for it).

= 0.75 [1277]

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:[1278]

Age of Equipment	ηCool Estimate
Before 2006	10

[1273] ASHRAE, 2001, "Characterization of Framing Factors for New Low-Rise Residential Building Envelopes (904-RP)," Table 7.1

[1274] Ibid.

[1275] 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.

[1276] Weighted based on number of occupied residential housing units in each zone.

[1277] 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.

[1278] 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.

After 2006	13

kWh_heating = If electric heat (resistance or heat pump), reduction in annual electric heating due to insulation

$= (((1/R\_old - 1/R\_wall) * A\_wall * (1-Framing\_factor\_wall) * ADJ_{Wall}) + (1/R\_old - 1/R\_attic) * A\_attic * (1-Framing\_factor\_attic) * ADJ_{Attic}) * 24 * HDD] / (\eta Heat * 3412)$

HDD = Heating Degree Days

= Dependent on location:[1279]

Climate Zone (City based upon)	HDD 60
1 (Rockford)	5,352
2 (Chicago)	5,113
3 (Springfield)	4,379
4 (Belleville)	3,378
5 (Marion)	3,438
Weighted Average[1280]	4,860

ηHeat = Efficiency of heating system

= Actual. If not available refer to default table below:[1281]

System Type	Age of Equipment	HSPF Estimate	ηHeat (Effective COP Estimate) (HSPF/3.413)*0.85
Heat Pump	Before 2006	6.8	1.7
	After 2006	7.7	1.92
Resistance	N/A	N/A	1

3412 = Converts Btu to kWh

ADJ_{Wall} = Adjustment for wall insulation to account for prescriptive engineering

[1279] 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.

[1280] Weighted based on number of occupied residential housing units in each zone.

[1281] 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.

algorithms overclaiming savings.

Market	ADJ_{Wall}
Low Income	63%[1282]
Non- Low Income	63%[1283]

ADJ_{Attic} = Adjustment for attic insulation to account for prescriptive engineering algorithms overclaiming savings.

Market	ADJ_{Attic}
Low Income	74%[1284]
Non- Low Income	74%[1285]

For example, a non- low income single family home in Chicago with 990 ft^2 of R-5 walls insulated to R-11 and 700 ft^2 of R-5 attic insulated to R-38, 10.5 SEER Central AC and 2.26 (1.92 including distribution losses) COP Heat Pump:

ΔkWh = (ΔkWh_cooling + ΔkWh_heating)

= ((((1/5 - 1/11) * 990 * (1-0.25)) + ((1/5 - 1/38) * 700 * (1-0.07))) * 842 * 0.75 * 24)/ (1000 * 10.5)) + (((((1/5 - 1/11) * 990 * (1-0.25) * 0.63) + ((1/5 - 1/38) * 700 * (1-0.07) * 0.74)) * 5113 * 24) / (1.92 * 3412))

= 280 + 2523

= 2803 kWh

ΔkWh_heating = If gas *furnace* heat, kWh savings for reduction in fan run time

= ΔTherms * F_e * 29.3

F_e = Furnace Fan energy consumption as a percentage of annual fuel consumption

= 3.14%[1286]

1282 Based upon comparing algorithm derived savings estimate and evaluated bill analysis estimate in the following 2011 Massachusetts Low Income report: “Low Income Single Family Program Impact Evaluation”, June 2012. See “Insulation ADJ calculations.xls” for details or calculation.

1283 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.

1284 Based upon comparing algorithm derived savings estimate and evaluated bill analysis estimate in the following 2011 Massachusetts Low Income report: “Low Income Single Family Program Impact Evaluation”, June 2012. See “Insulation ADJ calculations.xls” for details or calculation.

1285 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.

29.3 = kWh per therm

For example, a non- low income 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):

ΔkWh = 250.3 * 0.0314 * 29.3

= 230 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = (ΔkWh_cooling / FLH_cooling) * CF

Where:

FLH_cooling = Full load hours of air conditioning

= Dependent on location as below:[1287]

Climate Zone (City based upon)	Single Family	Multifamily
1 (Rockford)	512	467
2 (Chicago)	570	506
3 (Springfield)	730	663
4 (Belleville)	1,035	940
5 (Marion)	903	820
Weighted Average[1288]	629	564

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)

= 68%[1289]

CF_{SSP} = Summer System Peak Coincidence Factor for Heat Pumps (during system peak hour)

72%%[1290]

[1286] 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.
[1287] 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.
[1288] Weighted based on number of occupied residential housing units in each zone.
[1289] Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.
[1290] Based on analysis of metering results from 24 heat pumps in Ameren Illinois service territory in PY5 coincident

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)

= 46.6%[1291]

For example, a non- low income single family home in Chicago with 990 ft^2 of R-5 walls insulated to R-11 and 700 ft^2 of R-5 attic insulated to R-38, 10.5SEER Central AC and 2.26 COP Heat Pump:

ΔkW_{SSP} = 280 / 570 * 0.68

= 0.33 kW

ΔkW_{PJM} = 280 / 570 * 0.466

= 0.23 kW

NATURAL GAS SAVINGS

If Natural Gas heating:

ΔTherms = ((((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 * 100,067 Btu/therm)

Where:

HDD = Heating Degree Days

= Dependent on location:[1292]

Climate Zone (City based upon)	HDD 60
1 (Rockford)	5,352
2 (Chicago)	5,113
3 (Springfield)	4,379
4 (Belleville)	3,378
5 (Marion)	3,438

with AIC's 2010 system peak; 'Impact and Process Evaluation of Ameren Illinois Company's Residential HVAC Program (PY5)'.

[1291] 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.

[1292] 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.

Weighted Average[1293]	4,860

ηHeat = Efficiency of heating system

= Equipment efficiency * distribution efficiency

= Actual.[1294] If unknown assume 70%.[1295]

Other factors as defined above

For example, a non- low income single family home in Chicago with 990 ft^2 of R-5 walls insulated to R-11 and 700 ft^2 of R-5 attic insulated to R-38, with a gas furnace with system efficiency of 66%:

ΔTherms = ((((1/5 - 1/11) * 990 * (1-0.25) *0.63) + ((1/5 - 1/38) * 700 * (1-0.07)*0.74)) * 24 * 5113) / (0.66 * 100,067)

= 250.3 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-SHL-AINS-V04-140201

NOTE: This represents a mid program year change to this measure, effective from February 1st, 2014. Any projects completed[1296] prior to the effective date should use the version with measure code RS-SHL-AINS-V03-130601.

1293 Weighted based on number of occupied residential housing units in each zone.

1294 Ideally, the System Efficiency should be obtained either by recording the AFUE of the unit, or performing a steady state efficiency test. The Distribution Efficiency can be estimated via a visual inspection and by referring to a look up table such as that provided by the Building Performance Institute: (http://www.bpi.org/files/pdf/DistributionEfficiencyTable-BlueSheet.pdf) or by performing duct blaster testing.

1295 This has been estimated assuming that natural gas central furnace heating is typical for Illinois residences (66% of Illinois homes have a Natural Gas Furnace (based on Energy Information Administration, 2009 Residential Energy Consumption Survey: http://www.eia.gov/consumption/residential/data/2009/xls/HC6.9%20Space%20Heating%20in%20Midwest%20Region.xls)). In 2000, 24% of furnaces purchased in Illinois were condensing (based on data from GAMA, provided to Department of Energy during the federal standard setting process for residential heating equipment - see Furnace Penetration.xls). Furnaces tend to last up to 20 years and so units purchased 10 years ago provide a reasonable proxy for the current mix of furnaces in the State. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows:
(0.24*0.92) + (0.76*0.8) * (1-0.15) = 0.70

1296 Projects may be "completed", i.e. installation complete, without having received the rebate.