Illinois Statewide Technical Reference Manual for Energy Efficiency

Version 5.0

Volume 1: Overview and User Guide

Final

February 11th, 2016

Effective:

June 1st, 2016

Table of Contents

VOLUME 1: OVERVIEW AND USER GUIDE

1 Purpose of the TRM....4

1.1 Acknowledgements....5

1.2 Summary of Measure Revisions....7

1.3 Enabling ICC Policy....20

1.4 Development Process....20

2 Organizational Structure....23

2.1 Measure Code Specification....24

2.2 Components of TRM Measure Characterizations....24

2.3 Variable Input Tables....25

2.4 Program Delivery & Baseline Definitions....26

3 Assumptions....29

3.1 Footnotes & Documentation of Sources....29

3.2 General Savings Assumptions....29

3.3 Shifting Baseline Assumptions....30

3.3.1 CFL and T5/T8 Linear Fluorescents Baseline Assumptions....30

3.3.2 Early Replacement Baseline Assumptions....30

3.3.3 Furnace Baseline....31

3.4 Glossary....32

3.5 Electrical Loadshapes (kWh)....37

3.6 Summer Peak Period Definition (kW)....49

3.7 Heating and Cooling Degree-Day Data....49

3.8 Measure Incremental Cost Definition....55

3.9 Inflation Rates, O&M Costs and the Weighted Average Cost of Capital (WACC)....56

3.10 Interactive Effects....57

VOLUME 2: COMMERCIAL AND INDUSTRIAL MEASURES

VOLUME 3: RESIDENTIAL MEASURES

VOLUME 4: CROSS-CUTTING MEASURES AND ATTACHMENTS

ATTACHMENT A: ILLINOIS STATEWIDE NET-TO-GROSS METHODOLOGIES

Tables and Figures

Table 1.1: Document Revision History 6
Table 1.2: Summary of Measure Level Changes 7
Table 1.3: Summary of Measure Revisions 7
Table 1.4: Summary of Attachment A: IL-NTG Methods Revisions 18
Table 2.1: End-Use Categories in the TRM 23
Table 2.2: Measure Code Specification Key 24
Table 2.3: Program Delivery Types 26
Table 3.2: Degree-Day Zones and Values by Market Sector 37
Table 3.3: On and Off Peak Energy Definitions 37
Table 3.4: Loadshapes by Season 39
Table 3.5: Loadshapes by Month and Day of Week 43
Table 3.6: Degree-Day Zones and Values by Market Sector 50
Figure 3.1: Cooling Degree-Day Zones by County 51
Figure 3.2: Heating Degree-Day Zones by County 52
Table 3.7: Heating Degree-Day Zones by County 53
Table 3.8: Cooling Degree-day Zones by County 54

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[1] which are administered by the Department of Commerce and Economic Opportunity (DCEO) and the state's largest electric and gas Utilities[2] (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[3] ("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."[4]

[1] 220 ILCS 5/8-103, 220 ILCS 5/16-111.5B and 220 ILCS 5/8-104.
[2] In addition to DCEO, the Program Administrators include: Ameren Illinois, ComEd, Peoples Gas, North Shore Gas, and Nicor Gas (collectively, the Utilities).
[3] The Illinois TRC test is defined in 220 ILCS 5/8-104(b) and 20 ILCS 3855/1-10.
[4] 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 Acknowledgements

This document was created through collaboration amongst the members of the Illinois Energy Efficiency Stakeholder Advisory Group (SAG). The SAG is an open forum where interested parties may participate in the evolution of Illinois' energy efficiency programs. Parties wishing to participate in the SAG process may do so by visiting http://www.ilsag.info/questions.html 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[5]
Ameren Illinois Company (Ameren)
Citizen's Utility Board (CUB)
City of Chicago
Commonwealth Edison Company (ComEd)
Elevate Energy
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)
Metropolitan Mayor's Caucus (MMC)
Midwest Energy Efficiency Association (MEEA)
Natural Resources Defense Council (NRDC)
Nicor Gas
Peoples Gas and North Shore Gas

[5] 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
Illinois_Statewide_TRM_Effective_060115_Final_022415_Clean.docx	6/1/15
IL-TRM_Effective_060116_v5.0_Vol_1_Overview_021116_Final IL-TRM_Effective_060116_v5.0_Vol_2_C_and_I_021116_Final IL-TRM_Effective_060116_v5.0_Vol_3_Res_021116_Final IL-TRM_Effective_060116_v5.0_Vol_4_X-Cutting_Measures_and_Attach._021116_Final	6/1/16

1.2 Summary of Measure Revisions

The following tables summarize the evolution of measures that are new, revised or errata. This version of the TRM contains 97 measure-level changes as described in the following table.

Table 1.2: Summary of Measure Level Changes

Change Type	# Changes
Errata	13
Revision	73
New Measure	11
Total Changes	97

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, 2015. Measures that are identified as 'Revised' were included in the fourth 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, 2016.

The following table provides an overview of the 97 measure-level changes that are included in this version of the TRM.

Table 1.3: Summary of Measure Revisions

Volume	End Use	Measure Name	Measure Code	Change Type	Explanation	Impact on Savings
Overview	Section 1-3			Revision	Hotel and Motel and Low-use Small Business Definitions. Proposed new section 3.8 Measure Incremental Cost Definition. Updates to dates, references, "Summary of Measure Revisions" and Early Replacement section. Replacement of light/heavy industry with manufacturing building type definition. Addition of Childcare/Pre School. Addition of text in regard to applying inflation rates to future costs.	n/a

Volume	End Use	Measure Name	Measure Code	Change Type	Explanation	Impact on Savings
					Updating the real discount rate for O&M NPV calculations.	
C&I	Food Service Equipment	4.2.1 Combination Oven	CI-FSE-CBOV-V02-160601	Revision	Re-write using algorithms rather than deemed savings. Standard updates. Added electric combination ovens.	Unknown
C&I	Food Service Equipment	4.2.3 Commercial Steam Cooker	CI-FSE-STMC-V04-160601	Revision	Formatting edits to algorithm for clarity and improved reference.	None
C&I	Food Service Equipment	4.2.6 ENERGY STAR Dishwasher	CI-FSE-ESDW-V02-160601	Revision	ENERGY STAR standard update. Reworked measure to more accurately reflect calculation. Improved reference.	Unknown
C&I	Food Service Equipment	4.2.8 ENERGY STAR Griddle	CI-FSE-ESGR-V02-160601	Revision	Fixed error in Daily Idle Energy Calculation. Improved reference.	None
C&I	Food Service Equipment	4.2.9 ENERGY STAR Hot Food Holding Cabinets	CI-FSE-ESHH-V02-160601	Revision	Improved reference.	None
C&I	Food Service Equipment	4.2.11 High Efficiency Pre-Rinse Spray Valve	CI-FSE-SPRY-V03-160601	Revision	Added reference to IECC 2015	None
C&I	Hot Water	4.3.1 Storage Water Heater	CI-HW_-STWH-V02-160601	Revision	Changed methodology from deemed approach to algorithm.	Unknown
C&I	Hot Water	4.3.2 Low Flow Faucet Aerators	CI-HWE-LFFA-V06-160601	Revision	Fixed EPG factor dependent on water temperature. Fixed error in example result	Dependent on application
C&I	Hot Water	4.3.5 Tankless Water Heater	CI-HW_-TKWH-V03-160601	Revision	Added reference to IECC 2015	None
C&I	Hot Water	4.3.7 Multifamily Central Domestic Hot Water Plants	CI-HW_-MDHW-V02-160601	Revision	Updated DeOreo reference.	None
C&I	Hot Water	4.3.9 Heat Recovery Grease Trap Filter	CI-HW_-GRTF-V01-160601	New	New Measure	N/A
C&I	HVAC	4.4.1 Air Conditioner Tune up	CI-HVC-ACTU-V03-160601	Revision	Removed SEER test for <65kBtu - now EER test for all. Added explanation of test methodology.	None
C&I	HVAC	4.4.2 Space Heating Boiler Tune Up	CI-HVC-BLRT-V06-160601	Revision	Added clarifying language on	None

Volume	End Use	Measure Name	Measure Code	Change Type	Explanation	Impact on Savings
					appropriate firing rates for combustion efficiency testing.	
C&I	HVAC	4.4.3 Process Boiler Tune Up	CI-HVC-PBTU-V05-160601	Revision	Added clarifying language on appropriate firing rates for combustion efficiency testing.	None
C&I	HVAC	4.4.6 Electric Chiller	CI-HVC-CHIL-V04-160601	Revision	Added specifications for IECC 2015 Updated cost assumptions	None
C&I	HVAC	4.4.9 Heat Pump Systems	CI-HVC-HPSY-V04-160601	Revision	Added specifications for IECC 2015	None
C&I	HVAC	4.4.11 High Efficiency Furnace	CI-HVC-FRNC-V05-150601	Errata	Future deferred baseline replacement cost increased in line with inflation	None
			CI-HVC-FRNC-V06-160601	Revision	Update of Heating Fan hour assumptions Added building specific coincidence factors. Clarification of Early Replacement determination	Dependent on application
C&I	HVAC	4.4.13 PTAC and PTHP	CI-HVC-PTAC-V06-150601	Errata	Future deferred baseline replacement cost increased in line with inflation	None
			CI-HVC-PTAC-V07-160601	Revision	Added specifications for IECC 2015. Updated SEER to EER conversion	None
C&I	HVAC	4.4.14 Pipe Insulation	CI-HVC-PINS-V04-160601	Revision	Allow for custom 3E Plus derived entry. Added ability to use actual boiler efficiency	Unknown
C&I	HVAC	4.4.15 Single-Package and Split System Unitary AC	CI-HVC-SPUA-V04-160601	Revision	Added specifications for IECC 2015. Updated SEER to EER conversion Clarified baseline applicable dates and Time of Sale baseline.	None
C&I	HVAC	4.4.16 Steam Trap Replacement or Repair	CI-HVC-STRE-V04-160601	Revision	Providing clarifying edits and secondary equations to calculate maximum steam loss. Allowing actual steam pressure and HOU	Increase

Volume	End Use	Measure Name	Measure Code	Change Type	Explanation	Impact on Savings
					entry. Update values for deemed average pressure and operating hours based on program data.	
C&I	HVAC	4.4.17 Variable Speed Drives for HVAC Pumps and Cooling Tower Fans	CI-HVC-VSDHP-V03-160601	Revision	Added reference to IECC 2015 Updated Heating and Cooling HOU assumptions	Dependent on application
C&I	HVAC	4.4.19 Demand Control Ventilation	CI-HVC-DCV-V03-160601	Revision	Added heating savings for electrically heated buildings (resistance and heat pump).	None
C&I	HVAC	4.4.21 Linkageless Boiler Controls for Space Heating	CI-HVC-LBC-V05-160601	Revision	Clarity on VSD measure referred to for electric savings	None
C&I	HVAC	4.4.24 Small Pipe Insulation	CI-HVC-SPIN-V02-160601	Revision	Allow for custom 3E Plus derived entry.	Unknown
C&I	HVAC	4.4.26 Variable Speed Drives for Supply and Return Fans	CI-HVC-VSDF-V02-160601	Revision	Added reference to IECC 2015 Updated Heating, Cooling and Ventilation HOU assumptions	Dependent on application
C&I	HVAC	4.4.27 Energy Recovery Ventilator	CI-HVC-ERVE-V02-160601	Revision	Removed reference to previously deleted table of building characteristics and replaced with table showing occupied hours. Added reference to IECC 2015	None
C&I	HVAC	4.4.30 Notched V Belts for HVAC Systems	CI-HVC-NVBE-V02-160601	Revision	Updated Heating, Cooling and Ventilation HOU assumptions	Dependent on application
C&I	HVAC	4.4.31 Small Business Furnace Tune-Up	CI-HVC-FTUN-V02-160601	Revision	Added clarifying language on appropriate firing rates for combustion efficiency testing.	None
C&I	HVAC	4.4.33 Industrial Air Curtains	CI-MSC-AIRC-V01-160601	New	New Measure	N/A
C&I	HVAC	4.4.34 Destratification Fans	CI-HVC-DSFN-V01-160601	New	New Measure	N/A
C&I	HVAC	4.4.35 Economizer Repair and Optimization	CI-HVC-ECRP-V01-160601	New	New Measure	N/A

Volume	End Use	Measure Name	Measure Code	Change Type	Explanation	Impact on Savings
C&I	HVAC	4.4.36 Multi-Family Space Heating Steam Boiler Averaging Controls	CI-HVC-SBAC-V01-160601	New	New Measure	N/A
C&I	HVAC	4.4.37 Unitary HVAC Condensing Furnace	CI-HVC-DSFN-V01-160601	New	New Measure	N/A
C&I	Lighting	4.5 Lighting End Use		Revision	Updated HOU and CF assumptions for select building types based on IL evaluation. Updated hours of use for remaining building types based on eQuest modeling. Provide updated “Unknown” assumptions based on weighted averages. Added Childcare/Pre-School Updated lighting waste heat factors (fixing autosizing issues). Updated remaining building type CFs based on eQuest models.	Dependent on application
C&I	Lighting	4.5.1 Commercial ENERGY STAR Compact Fluorescent Lamp	CI-LTG-CCFL-V06-160601	Revision	Adjustment of Real Discount Rate and O&M values. Clarification that O&M costs should be multiplied by ISR.	None
C&I	Lighting	4.5.3 High Performance and Reduced Wattage T8 Fixtures and Lamps	CI-LTG-T8FX-V05-160601	Revision	Adjustment of T12 baseline until June 1, 2018. Table review – providing nominal and ballast factor assumptions. Adding significant digits to show difference in values.	None
C&I	Lighting	4.5.4 LED Bulbs and Fixtures	CI-LTG-LEDB-V05-160601	Revision	Adjusted language for PAR, MR, and MRX Lamps to use manufacturer recommended incandescent equivalent wattage instead of lumen based approach in the event	Increase

Volume	End Use	Measure Name	Measure Code	Change Type	Explanation	Impact on Savings
					inputs are unknown. Adding incremental cost to reference tables. Updating O&M for Standard Omnidirectional lamps. Updating and consolidating reference tables. Adjustment of Real Discount Rate and O&M values. Clarification that O&M costs should be multiplied by ISR.	
C&I	Lighting	4.5.7 Lighting Power Density	CI-LTG-LPDE-V03-160601	Revision	Added specifications for IECC 2015	None
C&I	Lighting	4.5.9 Multi-Level Lighting Switch	CI-LTG-MLLC-V03-160601	Revision	Added reference to IECC 2015	None
C&I	Lighting	4.5.10 Occupancy Sensor Lighting Controls	CI-LTG-OSLC-V04-160601	Revision	Update to costs, kW connected and % savings.	Reduction
C&I	Lighting	4.5.12 T5 Fixtures and Lamps	CI-LTG-T5FX-V04-160601	Revision	Adjustment of T12 baseline until June 1, 2018.	None
C&I	Lighting	4.5.13 Occupancy Controlled Bi-Level Lighting Fixtures	CI-LTG-OCBL-V02-160601	Revision	Added reference to IECC 2015	None
C&I	Lighting	4.5.14 Commercial ENERGY STAR Specialty Compact Fluorescent Lamp	CI-LTG-SCFL-V02-160601	Revision	Adjusted language for PAR, MR, and MRX Lamps to use manufacturer recommended incandescent equivalent wattage instead of lumen based approach in the event inputs are unknown.. Clarification that O&M costs should be multiplied by ISR.	Unknown
C&I	Compressed Air	4.7.5 Cycling Compressed Air Dryer	CI-CPA-CADR-V01-160601	New	New Measure	N/A
C&I	Miscellaneous	4.7.6 Roof Insulation for C&I Facilities	CI-MSC-RINS-V02-160601	Revision	Changed measure number to 4.8.2. Added specifications for IECC 2015	None

Volume	End Use	Measure Name	Measure Code	Change Type	Explanation	Impact on Savings
C&I	Miscellaneous	4.8.4 Modulating Commercial Gas Clothes Dryer	CI-MSC-MODD-V01-160601	New	New Measure	N/A
Res	Appliances	5.1.1 ENERGY STAR Air Purifier	RS-APL-ESAP-V02-160601	Revision	Updated using more recent ENERGY STAR calculator.	Unknown
Res	Appliances	5.1.2 ENERGY STAR and CEE Tier 2 and 3 Clothes Washers	RS-APL-ESCL-V04-160601	Revision	Added unknown DHW/ known Dryer and known DHW/unknown Dryer to tables. Updated % gas v electric dryer assumptions. Added decimal place to % of combustion table to bring calculated and algorithm derived values closer. Fixed parentheses issue.	None
Res	Appliances	5.1.3 ENERGY STAR Dehumidifier	RS-APL-ESDH-V03-160601	Revision	Removed old ENERGY STAR spec values. Fixed hour assumption listing - calculated deemed values correct. Clarifying text on use of actual capacity.	None
Res	Appliances	5.1.4 ENERGY STAR Dishwasher	RS-APL-ESDI-V03-160601	Revision	Update to ENERGY STAR specification – now for Standard, Standard with Connected Functionality and Compact.	Increases
Res	Appliances	5.1.6 ENERGY STAR and CEE Tier 2 Refrigerator	RS-APL-ESRE-V03-150601	Errata	Future deferred baseline replacement cost increased in line with inflation	None
			RS-APL-ESRE-V04-160601	Revision	Fixed typo in algorithm table	None
Res	Appliances	5.1.7 ENERGY STAR Room AC	RS-APL-ESRA-V04-150601	Errata	Future deferred baseline replacement cost increased in line with inflation	None
			RS-APL-ESRA-V05-160601	Revision	Update of Federal Standard and ENERGY STAR specifications	Dependent on application
Res	Appliances	5.1.8 Refrigerator and Freezer Recycling	RS-APL-RFRC-V06-160601	Revision	Added customers value on lost amenity to measure cost.	None

Volume	End Use	Measure Name	Measure Code	Change Type	Explanation	Impact on Savings
					Deleted redundant variable	
Res	Consumer Electronics	5.2.1 Advanced Power Strip Tier 1	RS-CEL-SSTR-V02-160601	Revision	Changed name of existing measure (Smart Strip) as proprietary name by single manufacturer.	None
Res	Consumer Electronics	5.2.2 Tier 2 Advanced Power Strips (APS) – Residential Audio Visual	RS-CEL-APS2-V01-160601	New	New Measure	N/A
Res	HVAC	5.3.1 Air Source Heat Pump	RS-HVC-ASHP-V05-150601	Errata	Future deferred baseline replacement cost increased in line with inflation	None
			RS-HVC-ASHP-V06-160601	Revision	Clarification of Early Replacement determination. Update to CF and EFLH for multifamily homes.	Reduction for MF weatherized
Res	HVAC	5.3.2 Boiler Pipe Insulation	RS-HVC-PINS-V02-160601	Revision	Clarification in pipe circumference with insulation calculation	None
Res	HVAC	5.3.3 Central AC	RS-HVC-CAC1-V05-150601	Errata	Future deferred baseline replacement cost increased in line with inflation	None
			RS-HVC-CAC1-V06-160601	Revision	Clarification of Early Replacement determination.	None
Res	HVAC	5.3.4 Duct Insulation and Sealing	RS-HVC-DINS-V06-160601	Revision	Added semi-conditioned space savings by use of Thermal Regain Factor.	None
Res	HVAC	5.3.6 Gas High Efficiency Boiler	RS-HVC-GHEB-V04-150601	Errata	Future deferred baseline replacement cost increased in line with inflation. Addition of HF in algorithm and variable list	None
			RS-HVC-GHEB-V05-160601	Revision	Clarification of Early Replacement determination	Reduction for MF
Res	HVAC	5.3.7 Gas High Efficiency Furnace	RS-HVC-GHEF-V05-150601	Errata	Future deferred baseline replacement cost increased in line with inflation. Addition of HF in	None

Volume	End Use	Measure Name	Measure Code	Change Type	Explanation	Impact on Savings
					algorithm	
			RS-HVC-GHEF-V06-160601	Revision	Clarification of Early Replacement determination	None
Res	HVAC	5.3.8 Ground Source Heat Pump	RS-HVC-GSHP-V05-150601	Errata	Future deferred baseline replacement cost increased in line with inflation.	None
			RS-HVC-GSHP-V06-160601	Revision	Updated DeOreo reference. Clarification of Early Replacement determination.	None
Res	HVAC	5.3.10 HVAC Tune Up	RS-HVC-TUNE-V03-160601	Revision	Fix typo of variable name. Adding CF_{PJM} for Heat Pumps	None
Res	HVAC	5.3.12 Ductless Heat Pumps	RS-HVC-DHP-V03-150601	Errata	Removed /1000 from kW calculation since capacity is already in kBtu.	Increased kW
Res	HVAC	5.3.12 Ductless Heat Pumps	RS-HVC-DHP-V04-160601	Revision	Change of algorithm to be based on Capacity and EFLH as opposed to %displaced and annual load. Update to CF and EFLH. Fixing existing efficiency assumptions.	Unknown
Res	HVAC	5.3.13 Residential Furnace Tune-Up	RS-HVC-FTUN-V02-160601	Revision	Added clarifying language on appropriate firing rates for combustion efficiency testing.	None
Res	HVAC	5.3.16 Advanced Thermostats	RS-HVC-ADTH-V01-160601	New	New Measure	N/A
Res	Hot Water	5.4.2 Gas Water Heater	RS-HWE-GWHT-V05-150601	Errata	Future deferred baseline replacement cost increased in line with inflation.	None
			RS-HWE-GWHT-V06-160601	Revision	Updated DeOreo reference.	None
Res	Hot Water	5.4.3 Heat Pump Water Heater	RS-HWE-HPWH-V05-160601	Revision	Updated DeOreo reference.	None
Res	Hot Water	5.4.4 Low Flow Faucet Aerators	RS-HWE-LFFA-V05-160601	Revision	Updated DeOreo reference. Adding ISR assumptions for Efficiency Kits	Dependent on application

Volume	End Use	Measure Name	Measure Code	Change Type	Explanation	Impact on Savings
Res	Hot Water	5.4.5 Low Flow Showerheads	RS-HWE-LFSH-V04-160601	Revision	Adding ISR assumptions for Efficiency Kits	Dependent on application
Res	Hot Water	5.4.8 Thermostatic Restrictor Shower Valve	RS-HWE-TRVA-V02-160601	Revision	Add EPG_electric factor in to equation	Reduced
Res	Lighting	5.5.1 ENERGY STAR Compact Fluorescent Lamp	RS-LTG-ESCF-V05-160601	Revision	Adjustment of Real Discount Rate and O&M values. Clarification that O&M costs should be multiplied by ISR. Clarification on Leakage Rates	None
Res	Lighting	5.5.2 ENERGY STAR Specialty CFL	RS-LTG-ESCC-V04-160601	Revision	Adjusted language for PAR, MR, and MRX Lamps to use manufacturer recommended incandescent equivalent wattage instead of lumen based approach in the event inputs are unknown. Clarification that O&M costs should be multiplied by ISR. Clarification on Leakage Rates	Unknown
Res	Lighting	5.5.3 ENERGY STAR Torchiere	RS-LTG-ESTO-V03-160601	Revision	Clarification that O&M costs should be multiplied by ISR. Clarification on Leakage Rates	None
Res	Lighting	5.5.4 Exterior Hardwired Compact Fluorescent Fixture	RS-LRG-EFOX-V05-160601	Revision	Adjustment of Real Discount Rate and O&M values. Clarification that O&M costs should be multiplied by ISR. Clarification on Leakage Rates	None
Res	Lighting	5.5.5 Interior Hardwired Compact Fluorescent Fixture	RS-LTG-IFIX-V05-160601	Revision	Adjustment of Real Discount Rate and O&M values. Clarification that O&M costs should be multiplied by ISR. Clarification on Leakage Rates	None

Volume	End Use	Measure Name	Measure Code	Change Type	Explanation	Impact on Savings
Res	Lighting	5.5.6 LED Specialty Lamps	RS-LTG-LEDD-V05-150601	Errata	Changed name of existing measure (LED Downlight) to LED Specialty Lamps. Made consistent with CFL Specialty assumptions. Removed default efficient wattages as actuals always used. Adjusted language for PAR, MR, and MRX Lamps to use manufacturer recommended incandescent equivalent wattage instead of lumen based approach in the event inputs are unknown.	Dependent on application
			RS-LTG-LEDD-V06-160601	Revision	Clarification that O&M costs should be multiplied by ISR. Clarification on Leakage Rates	None
Res	Lighting	5.5.8 LED Screw Based Omnidirectional Bulbs	RS-LTG-LEDA-V04-160601	Revision	Adjustment of Real Discount Rate and O&M values. Clarification that O&M costs should be multiplied by ISR. Clarification on Leakage Rates	None
Res	Shell	5.6.1 Air Sealing	RS-SHL-AIRS-V04-150601	Errata	Changing Latent Multiplier assumption to be based on calculation of hours sensible and total loads.	Reduction
Res	Shell	5.6.1 Air Sealing	RS-SHL-AIRS-V05-160601	Revision	Change cooling and heating n-factor values based on applying LBNL infiltration model. Revert HDD assumption back to base temperature 60F. Adjusting default gas efficiency to 72%. Adding prescriptive air	Reduction

Volume	End Use	Measure Name	Measure Code	Change Type	Explanation	Impact on Savings
					sealing savings for when blower door testing is not possible.	
Res	Shell	5.6.2 Basement Sidewall Insulation	RS-SHL-BINS-V07-160601	Revision	Applying 80% adjustment factor to cooling savings and 60% adjustment factor to heating savings. Adjusting default gas efficiency to 72%.	Reduction
Res	Shell	5.6.3 Floor Insulation above Crawlspace	RS-SHL-FINS-V07-160601	Revision	Applying 80% adjustment factor to cooling savings and 60% adjustment factor to heating savings. Adjusting default gas efficiency to 72%.	Reduction
Res	Shell	5.6.4 Wall and Ceiling Insulation	RS-SHL-AINS-V06-160601	Revision	Applying 80% adjustment factor to cooling savings and 60% adjustment factor to heating savings. Adjusting default gas efficiency to 72%.	Reduction
Cross-Cutting Measures and Attachments	Behavior	6.1.1 Adjustments to Behavior Savings to Account for Persistence	CC-BEH-BEHP-V01-170601	New	New measure	N/A

Table 1.4: Summary of Attachment A: IL-NTG Methods Revisions

IL-TRM Volume	Sectors	Protocol Name	Change Type	Explanation
Vol. 4	Sections 1-2		Revision	Clarifying edits made to Diverging from the IL-NTG Methods section Expanded spillover definition and added new Spillover-Specific Issues section with a subsection covering incremental Measure Costs issues related to spillover
Vol. 4	Commercial, Industrial, and Public Sectors	Small Business C&I New Construction Study-Based Training and Technical Assistance	New	Added protocols to cover additional non-residential program types: Small Business New Construction Study-Based Training and Technical Assistance

IL-TRM Volume	Sectors	Protocol Name	Change Type	Explanation
Vol. 4	Commercial, Industrial, and Public Sectors	Changed section name from Standard/Prescriptive and Custom Programs to Core Non-Residential Protocol Free Ridership Participant Spillover	Revision	Changed name of Standard/Prescriptive and Custom Programs to Core Non-Residential Protocol and revised section to make it applicable to a number of non-residential programs Added Core Free Ridership Algorithm Spillover section expanded to include protocol for Participant Spillover which is generally applicable to most non-residential program types
Vol. 4	Residential and Low Income Sectors	Prescriptive Rebate (With No Audit) Single-Family Home Energy Audit Multifamily Energy Savings Kits and Elementary Education Residential New Construction Residential Cross-Cutting Approaches: Participant Spillover Nonparticipant Spillover Measured through Trade Allies Nonparticipant Spillover Measured from Customers	New	Added protocols to cover additional residential program types: Prescriptive Rebate Programs (With No Audit) Single-Family Home Energy Audit Multifamily Energy Savings Kits and Elementary Education Residential New Construction Added Residential Cross-Cutting Approaches section containing general protocols for measuring: Participant Spillover Nonparticipant Spillover Measured through Trade Allies Nonparticipant Spillover Measured from Customers
Vol. 4	Residential and Low Income Sectors	Appliance Recycling Residential Upstream Lighting	Revision	Appliance Recycling protocol changed to allow for spillover Algorithm flow chart added to Residential Upstream Lighting protocol
Vol. 4	Cross-Sector	Behavioral Code Compliance	New	Added protocols to cover cross-sector program types: Behavioral Code Compliance

1.3 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 Illinois Energy Efficiency Stakeholder Advisory Group (SAG) to develop a statewide TRM. *See, e.g.,* ComEd's Final Order *(Docket No. 10-0570, Final Order*[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 include representatives from the following organizations:

- the Utilities (ComEd, Ameren IL, Nicor Gas, Peoples Gas/North Shore Gas),
- DCEO, Implementation contractors (Applied Proactive Technologies (APT), CLEAResult, Conservation Services Group, Elevate Energy, Franklin Energy, GDS Associates, PECI, 360 Energy Group),
- Illinois Department of Commerce and Economic Opportunity (DCEO),
- the independent evaluators (ADM Associates, The Cadmus Group, Itron, Navigant Consulting, Michael's Engineering, Opinion Dynamics Corporation),
- ICC Staff,
- the Illinois Attorney General's Office (AG),
- Natural Resources Defense Council (NRDC),
- the Environmental Law and Policy Center (ELPC),
- the Citizen's Utility Board (CUB),
- The University of Illinois at Chicago,
- Future Energy Enterprises,
- Selective participants including; Geothermal Alliance of Illinois, the Geothermal Exchange Organization, Embertec and TrickleStar.
-

1.4 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

[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, 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

Commission in ICC Docket No. 13-0077[13]. The Commission extended these policies, including the applicability of the IL-TRM, to the Section 16-111.5B energy efficiency programs in ICC Docket No. 14-0588[14] and most recently in ICC Docket No. 15-0541[15], in order to increase certainty for all parties. The third edition of the IL-TRM was approved by the Commission in ICC Docket No. 14-0189[16]. The fourth edition of the IL-TRM was approved by the Commission in ICC Docket No. 15-0187[17]. This document represents the fifth edition of the IL-TRM. It contains a series of new measures, as well as a series of errata items[18] and updates to existing measures that were already present in the first four editions. Like the previous editions, it is a result of an ongoing review process involving the Illinois Commerce Commission (ICC) Staff (Staff or ICC Staff), the Utilities, DCEO, the Evaluators, the SAG TAC, and the SAG. VEIC meets with the SAG and/or the TRM TAC at least once each month to create a high level of transparency and vetting in the development of this TRM.

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

1. High Priority
   - For those existing measures that make up a significant portion of a utilities' portfolio and/or where the impact of the requested change is high
   - For new measures where plans are in place to implement in the next program year
2. Medium Priority
   - For existing measures that are a less significant percent of a utilities' portfolio and value change will not have a significant impact
   - For new measures where a savings value is estimated but implementation plans not yet developed
3. Low Priority
   - For existing measures that represent a very small percent of a utilities' portfolio
   - For new measures that are just beginning to be explored and will not be implemented in the next program year

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

As measure requests are finalized leading up to the next update of the TRM, weekly TAC meetings are often scheduled to maximize the level of collaboration and visibility into the measure characterization process. Where

---

[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

[14] ICC Docket No. 14-0588, Final Order at 227, December 17, 2014.
The adopted consensus language concerning the IL-TRM and its applicability to future Section 16-111.5B energy efficiency programs can be accessed from the following link:
http://www.icc.illinois.gov/downloads/public/June%2018%202014%20Consensus%20Language%20for%20Section%2016-111.5B%20Oversight%20and%20Evaluation%20Responsibility%20Energy%20Efficiency%20Issues.pdf

[15] ICC Docket No. 15-0541, Final Order at 36, 82-83, December 16, 2015.

[16] http://www.icc.illinois.gov/docket/files.aspx?no=14-0189&docId=210478
http://www.icc.illinois.gov/downloads/public/Illinois_Statewide_TRM_Effective_060114_Version_3.0_022414_Clean.pdf

[17] http://www.icc.illinois.gov/docket/files.aspx?no=15-0187&docId=226161
http://www.icc.illinois.gov/downloads/public/Illinois_Statewide_TRM_Effective_060115_Final_022415_Clean.pdf

[18] Errata as well as links to the official IL-TRM documents, dockets, and policy documents are available on the following ICC webpage: http://www.icc.illinois.gov/Electricity/programs/TRM.aspx

consensus does not emerge on specific measures or issues, those items are identified in a memo, and are not included in the TRM. As a result, this TRM represents a broad consensus amongst the SAG and TAC participants. In keeping with the goal of transparency, all of the comments and their status to-date are available through the TAC SharePoint web site, https://portal.veic.org.

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

Accuracy is the overarching principle that governs what value to use for each parameter. When it is explicitly allowed within the text of the measure characterization, the preferred value is the actual or on-site value for the individual measure being implemented. The *deemed values*[19] 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.

[19] 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 Organizational Structure

The organization of this document follows a three-level format. These levels are designed to define and clarify what the measure is and where it is applied.

1. **Market Sectors Volumes**[20]
    - This level of organization specifies the type of customer the measures apply to, either Commercial and Industrial (provided in Volume 2), Residential (provided in Volume 3) or cross-cutting measures, such as Behavior Persistence (provided in Volume 4, together with Attachments including the documentation of Illinois Statewide Net-to-Gross methodologies).
    - 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[21]

Volume 1: Residential Market Sector	Volume 2: Commercial and Industrial Market Sector	Volume 3: Cross-Cutting Measures and Attachments
Appliances	Agricultural Equipment	Behavior
Consumer Electronics	Food Service Equipment	
Hot Water	Hot Water	
HVAC	HVAC	
Lighting	Lighting	
Shell	Refrigeration	
	Compressed Air	
	Miscellaneous	

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

[20] 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.

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

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.

2.1 Measure Code Specification

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

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

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

Table 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)	T5FX	V02	YYMMDD
CC (Cross-Cutting)	BEH (Behavior)	T8FX	V03	YYMMDD
	CEL (Consumer Electronics)	…	…	…
	CPA (Compressed Air)			
	FSE (Food Service Equipment)			
	HVC (HVAC)			
	HW_ (Hot Water)			
	LTG (Lighting)			
	MSC (Miscellaneous)			
	RFG (Refrigeration)			
	SHL (Shell)			

2.2 Components of TRM Measure Characterizations

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

Description

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

Definition of Efficient Equipment

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

Definition of Baseline Equipment

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

Deemed Lifetime of Efficient Equipment

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

Deemed Measure Cost

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

Loadshape

The appropriate loadshape to apply to electric savings is provided.

Coincidence Factor

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

Algorithm

Calculation of Energy Savings

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

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

Electric Energy Savings

Summer Coincident Peak Demand Savings

Natural Gas Savings

Water Impact Descriptions and Calculation

Deemed O&M Cost Adjustment Calculation

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

Measure Code

2.3 Variable Input Tables

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

2.3.1 C&I Custom Value Use in Measure Implementation

This section defines the requirements for capturing Custom variables that can be used in place of defaults for select assumptions within the prescriptive measures defined in this statewide TRM. This approach is to be used when a variable in a measure formula can be replaced by a verifiable and documented value that is not presented in the TRM. This approach assumes that the algorithms presented in the measure are used as stated and only allows changes to certain variable values and is not a replacement algorithm for the measure. A custom variable is when customer input is provided to define the number or the value is measured at the site. Custom values can also be supplied from product data of the measure installed. In certain cases the custom data can be provided from a documented study or report that is applicable to the measure. Custom variables and potential sources are clearly defined in the specific measures where "Actual" or "Custom" is noted.

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

2.4 Program Delivery & Baseline Definitions

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

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

Table 2.3: Program Delivery Types

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

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

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

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

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

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

3 Assumptions

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

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

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

3.1 Footnotes & Documentation of Sources

Each new and updated measure characterization is supported by a work paper, which is posted to the SharePoint web site (https://portal.veic.org).[22] Both the work paper and the measure characterizations themselves use footnotes to document the references that have been used to characterize the technology. The reference documents are too numerous to include in an Appendix and have instead been posted to the TRM's Sharepoint website. These files can be found in the 'Sources and Reference Documents' folder in the main directory, and are also posted to the SAG's public web site (http://www.ilsag.info/technical-reference-manual.html).

3.2 General Savings Assumptions

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

- All estimates of energy (kWh or therms) and peak (kW) savings are for first-year savings, not lifetime savings.
- Unless otherwise noted, measure life is defined to be the life of an energy consuming measure, including its equipment life and measure persistence.
- Where deemed values for savings are provided, they represent the average energy (kWh or therms) or peak (kW) savings that could be expected from the average of all measures that might be installed in Illinois in the program year.
- In general, the baselines included in the TRM are intended to represent average conditions in Illinois. Some are based on data from the state, such as household consumption characteristics provided by the Energy Information Administration. Some are extrapolated from other areas, when Illinois data are not available.

[22] To gain access to the SharePoint web site, please contact the TRM Administrator at iltrmadministrator@veic.org.

3.3 Shifting Baseline Assumptions

The TRM anticipates the effects of changes in efficiency codes and standards on affected measures. When these changes take effect, a shift in the baseline is usually required. This complicates the measure savings estimation somewhat, and will be handled in future versions of the TRM by describing the choice of and reasoning behind a shifting baseline assumption. In this version of the TRM, this applies to CFLs and T5/T8 Linear Fluorescents, Furnaces and Early Replacement Measures.

3.3.1 CFL and T5/T8 Linear Fluorescents Baseline Assumptions

Specific reductions in savings have been incorporated for CFL measures that relate to the shift in appropriate baseline due to changes in Federal Standards for lighting products. Federal legislation (stemming from the Energy Independence and Security Act of 2007) mandates a phase-in process beginning in 2012 for all general-purpose light bulbs between 40W and 100W to be approximately 30% more energy efficient than current incandescent bulbs, in essence beginning the phase-out of the current style, or “standard”, incandescent bulbs. In 2012, standard 100W incandescent bulbs will no longer be manufactured, followed by restrictions on standard 75W bulbs in 2013 and 60W and 40W bulbs in 2014. The baseline for the CFL measure in the corresponding program years starting June 1 each year will therefore become bulbs (improved or “efficient” incandescent, or halogen) that meet the new standard and have the same lumen equivalency. Those products can take several different forms we can envision now and perhaps others we do not yet know about. Halogens are one of those possibilities and have been chosen to represent a baseline at that time. To account for this shifting baseline, annual savings are reduced within the lifetime of the measure. Other lighting measures will also have baseline shifts (for example screw based LED and CFL fixtures) that will result in significant impacts to annual estimated savings in later years.

In July 14, 2012, Federal Standards were enacted that were expected to eliminate T-12s as an option for linear fluorescent fixtures. Through v3.0 of the TRM, it was assumed that the T-12 would no longer be baseline for retrofits from 1/1/2016. However, due to significant loopholes in the legislation, T-12 compliant product is still freely available and in Illinois T-12s continue to hold a significant share of the existing and replacement lamp market. Therefore the timing of the sunsetting of T-12s as a viable baseline was pushed back in v4.0 until 6/1/2016, and again in v5.0 until 6/1/2018, and will be revisited in future update sessions.

3.3.2 Early Replacement Baseline Assumptions

A series of measures have an option to choose an Early Replacement Baseline if the following conditions are met:

Early Replacement determination will be based on meeting the following conditions:

- The existing unit is operational when replaced, or
- The existing unit requires minor repairs (see table below) [23].

Existing System	Maximum repair cost
Air Source Heat Pump	$918
Central Air Conditioner	$734
Boiler	$709
Furnace	$528

[23] The Technical Advisory Committee agreed that if the cost of repair is less than 20% of the new baseline replacement cost it can be considered early replacement.

Existing System	Maximum repair cost
Ground Source Heat Pump	<$249 per ton

- All other conditions will be considered Time of Sale.

The Baseline efficiency of the existing unit replaced:

- If the efficiency of the existing unit is less than the maximum shown below, the Baseline efficiency is the actual efficiency value of the unit replaced. If the efficiency is greater than the maximum, the Baseline efficiency is shown in the "New Baseline" column below:

Existing System	Maximum efficiency for Actual	New Baseline
Air Source Heat Pump	10 SEER	14 SEER
Central Air Conditioner	10 SEER	13 SEER
Boiler	75% AFUE	82% AFUE
Furnace	75% AFUE	80% AFUE
Ground Source Heat Pump	10 SEER	13 SEER

- If the operational status, repair cost or efficiency of the existing unit is unknown, the Baseline efficiency is the "New Baseline" column above.

3.3.3 Furnace Baseline

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

Update*:* On January 14th 2013, the U.S. Department of Energy (DOE) proposed to settle a lawsuit brought by the American Public Gas Association (APGA) that seeks to roll back gas furnace efficiency standards. As a result, the new standards, completed in 2011 and slated to take effect in May 2013, would be eliminated in favor of yet another round of DOE hearings and studies. Even if DOE completes a new rulemaking in two years, it's unlikely to take effect before 2020."[24]

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

"Although the current Federal Standard for gas furnaces is an AFUE rating of 78%, based upon review of available product in the AHRI database, the baseline efficiency for this characterization is assumed to be 80%. The baseline will be adjusted when the Federal Standard is updated."

3.4 Glossary

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

Building Types[25]:

Building Type	Definition
Assisted Living MultiFamily	Applies to residential buildings of three of more units with staff to assist the occupants. Gross Floor Area should include all fully-enclosed space within the exterior walls of the building(s) including individual rooms or units, wellness centers, exam rooms, community rooms, small shops or service areas for residents and visitors (e.g. hair salons, convenience stores), staff offices, lobbies, atriums, cafeterias, kitchens, storage areas, hallways, basements, stairways, corridors between buildings, and elevator shafts.
Auditorium/Assembly	Applies to any performance space such as a theater, arena, or hall. Gross Floor Area should include all space within the building(s), including seating, stage and backstage areas, food service areas, retail areas, rehearsal studios, administrative/office space, mechanical rooms, storage areas, elevator shafts, and stairwells.
Childcare/Pre-school	Applies to any building providing childcare to pre-kindergarten age children.
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.
Convenience Store	Applies to facility space used for the retail sale of a limited selection of food and beverage products. The total gross floor area should include all supporting functions such as kitchens and break rooms used by staff, storage areas (refrigerated and non-refrigerated), and administrative areas.
Elementary School	Applies to a school serving children In any grades from Kindergarten through sixth grade. The total gross floor area should include all supporting functions such as administrative space, conference rooms, kitchens used by staff, lobbies, cafeterias, gymnasiums, auditoria, laboratory classrooms, portable classrooms, greenhouses, stairways, atria, elevator shafts, small landscaping sheds, storage areas, etc.
Exterior	Applies to unconditioned spaces that are outside of the building envelope.
Garage	Applies to unconditioned spaces either attached or detached from the primary building envelope that are not used for living space.
Grocery	Applies to facility space used for the retail sale of food and beverage products. It should not be used by restaurants. The total gross floor area should include all supporting functions such as kitchens and break rooms used by staff, storage areas (refrigerated

[24] Appliance Standards Awareness Project, http://www.appliance-standards.org/product/furnaces

[25] Source: US EPA, www.energystar.gov, Space Type Definitions, or definitions as developed through the Technical Advisory Committee.

Building Type	Definition
	and non-refrigerated), administrative areas, stairwells, atria, lobbies, etc.
Healthcare Clinic	Applies to a facility space used to provide diagnosis and treatment for medical, dental, or psychiatric outpatient care. Gross Floor Area should include all space within the building(s) including offices, exam rooms, laboratories, lobbies, atriums, conference rooms and auditoriums, employee break rooms and kitchens, rest rooms, elevator shafts, stairways, mechanical rooms, and storage areas.
High School/Middle School	Applies to facility space used as a school building for 7th through 12th grade students. This does not include college or university classroom facilities and laboratories, vocational, technical, or trade schools. The total gross floor area should include all supporting functions such as administrative space, conference rooms, kitchens used by staff, lobbies, cafeterias, gymnasiums, auditoria, laboratory classrooms, portable classrooms, greenhouses, stairways, atria, elevator shafts, small landscaping sheds, storage areas, etc.
Hospital	Applies to a general medical and surgical hospital (including critical access hospitals and children's hospitals) that is either a stand-alone building or a campus of buildings. Spaces more accurately characterized as a Healthcare Clinic should use that definition. The definition of Hospital accounts for all space types that are located within the Hospital building/campus, such as medical offices, administrative offices, and skilled nursing. The total floor area should include the aggregate floor area of all buildings on the campus as well as all supporting functions such as: stairways, connecting corridors between buildings, medical offices, exam rooms, laboratories, lobbies, atria, cafeterias, storage areas, elevator shafts, and any space affiliated with emergency medical care, or diagnostic care.
Hotel/Motel Combined (All Spaces)	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. Where distinction between Hotel and Motel is necessary: Hotel: Room entrances and Corridors are located in the *interior* of the building. Corridors are conditioned spaces. Building can be significantly larger in size/height. Motel: Room entrances and Corridors are located on the *exterior* of the building. Corridors are not conditioned spaces. Buildings tend to be two to three stories in height.
Hotel/Motel Common Areas	All the common areas open to guests of the hotel such as the lobby, corridors and stairways, and other spaces that may have continuous or large lighting and HVAC hours.
Hotel/Motel Guest Room	Applies to the guest rooms of the hotel or motel. These spaces are occupied intermittantly.
Low-use Small Business	Any business type with low (<3000) operating hours (provided as option in lighting measures).
Manufacturing	Applies to buildings that are dedicated to manufacturing activities. Includes light industry buildings characterized by consumer product and component manufacturing and heavy industry buildings typically characterized by a plant that includes a main production area that has high-ceilings and contains heavy equipment used for assembly line production. These building types may be distinguished by categorizing NAICS (SIC)

Building Type	Definition
	codes according to the needs of the Program Administrator.
Miscellaneous	Applies to spaces that do not fit clearly within any available categories should be designated as "miscellaneous".
Multifamily-Mid Rise	Applies to residential buildings with up to four floors, including all public and multiuse spaces within the building envelope. Small Multifamily buildings best described as a house should use the residential measure characterizations.
Multifamily-High Rise Combined (All Spaces)	Applies to residential buildings with five or more floors, including all public and multiuse spaces within the building envelope. Gross Floor Area should include all fully-enclosed space within the exterior walls of the building(s) including living space in each unit (including occupied and unoccupied units), interior common areas (e.g. lobbies, offices, community rooms, common kitchens, fitness rooms, indoor pools), hallways, stairwells, elevator shafts, connecting corridors between buildings, storage areas, and mechanical space such as a boiler room. Open air stairwells, breezeways, and other similar areas that are not fully-enclosed should not be included in the Gross Floor Area.
Multifamily-High Rise Common Areas	All the common areas open to occupants of the building such as the lobby, corridors and stairways, and other spaces that may have continuous or high lighting and HVAC hours.
Multifamily-High Rise Residential Units	Applies to the residential units in the building only.
Movie Theater	Applies to buildings used for public or private film screenings. Gross Floor Area should include all space within the building(s), including seating areas, lobbies, concession stands, bathrooms, administrative/office space, mechanical rooms, storage areas, elevator shafts, and stairwells.
Office-Low Rise	Applies to facility spaces in buildings with four floors or fewer used for general office, professional, and administrative purposes. The total gross floor area should include all supporting functions such as kitchens used by staff, lobbies, atria, conference rooms and auditoria, fitness areas for staff, storage areas, stairways, elevator shafts, etc.
Office-Mid Rise	Applies to facility spaces in buildings with ffive to nine floors used for general office, professional, and administrative purposes. The total gross floor area should include all supporting functions such as kitchens used by staff, lobbies, atria, conference rooms and auditoria, fitness areas for staff, storage areas, stairways, elevator shafts, etc.
Office-High Rise	Applies to facility spaces in buildings with ten floors or more used for general office, professional, and administrative purposes. The total gross floor area should include all supporting functions such as kitchens used by staff, lobbies, atria, conference rooms and auditoria, fitness areas for staff, storage areas, stairways, elevator shafts, etc.
Religious Worship/Church	Applies to buildings that are used as places of worship. This includes churches, temples, mosques, synagogues, meetinghouses, or any other buildings that primarily function as a place of religious worship. Gross Floor Area should include all areas inside the building that includes the primary worship area, including food preparation, community rooms, classrooms, and supporting areas such as restrooms, storage areas, hallways, and elevator shafts.
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-Department store	Applies to facility space used to conduct the retail sale of consumer product goods. Stores must be at least 30,000 square feet and have an exterior entrance to the public. The total gross floor area should include all supporting functions such as kitchens and break rooms used by staff, storage areas, administrative areas, elevators, stairwells, etc. Retail segments typically included under this definition are: Department Stores, Discount Stores, Supercenters, Warehouse Clubs, Drug Stores, Dollar Stores, Home Center/Hardware Stores, and Apparel/Hard Line Specialty Stores (e.g., books,

Building Type	Definition
	clothing, office products, toys, home goods, electronics). Retail segments excluded under this definition are: Grocery, Convenience Stores, Automobile Dealerships, and Restaurants.
Retail/Service- Strip Mall	Applies to facility space used to conduct the retail sale of consumer product goods. Stores must less than 30,000 square feet and have an exterior entrance to the public. The total gross floor area should include all supporting functions such as kitchens and break rooms used by staff, storage areas, administrative areas, elevators, stairwells, etc. Retail segments excluded under this definition are: Grocery, Convenience Stores, Automobile Dealerships, and Restaurants.
Warehouse	Applies to unrefrigerated or refrigerated buildings that are used to store goods, manufactured products, merchandise or raw materials. The total gross floor area of Refrigerated Warehouses should include all temperature controlled area designed to store perishable goods or merchandise under refrigeration at temperatures below 50 degrees Fahrenheit. The total gross floor area of Unrefrigerated Warehouses should include space designed to store non-perishable goods and merchandise. Unrefrigerated warehouses also include distribution centers. The total gross floor area of refrigerated and unrefrigerated warehouses should include all supporting functions such as offices, lobbies, stairways, rest rooms, equipment storage areas, elevator shafts, etc. Existing atriums or areas with high ceilings should only include the base floor area that they occupy. The total gross floor area of refrigerated or unrefrigerated warehouse should not include outside loading bays or docks. Self-storage facilities, or facilities that rent individual storage units, are not eligible for a rating using the warehouse model.

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

Commercial & Industrial: The market sector that includes measures that apply to any of the building types defined in this TRM, which includes multifamily common areas and public housing[26].

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

Deemed Value: A value that has been assumed to be representative of the average condition of an input parameter.

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

End-use Category: A general term used to describe the categories of equipment that provide a service to an individual or building. See Table 2.1.1 for a list of the end-use categories that are incorporated in this TRM.

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

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

the end use or uses (220 ILCS 5/8-104(b)).

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

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

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

> **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. See Section 3.8 Measure Incremental Cost Definition for full definition.

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

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

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

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

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

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

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

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

Table 3.2: 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	2,181	Chicago O'Hare AP / Chicago
3	4,379	1,108	3,406	2,666	Springfield #2 / Springfield
4	3,378	1,570	2,515	3,358	Belleville SIU RSCH / Belleville
5	3,438	1,370	2,546	3,090	Carbondale Southern IL AP / Marion
Average	4,860	947	3,812	2,362	Weighted by occupied housing units
Base Temp	60F	65F	55F	55F	Year climate normals, 1981-2010

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 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.

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

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

The following pages provide the loadshape values for most measures provided in the TRM[28]. To distinguish the source of the loadshape, they are color coded. Rows that are shaded in green are Efficiency Vermont loadshapes adjusted for Illinois periods. Rows that are unshaded and are left in white are Itron eShapes data provided by Ameren.

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

[28] All loadshape information has been posted to the VEIC Sharepoint site, and is publically accessible through the Stakeholder Advisory Group's web site. http://www.ilsag.info/technical-reference-manual.html
http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Residential_Loadshapes_References.zip
http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Commercial_Loadshapes_References.zip
http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Sources%20and%20References%20-%20Loadshapes/TRM_Version_3_Loadshapes_2.24.zip

Table 3.4: Loadshapes by Season

	Loadshape Reference Number	Winter Peak Oct-Apr, M-F, non-holiday, 8AM - 11PM	Winter Off-peak Oct-Apr, All other time	Summer Peak May-Sept, M-F, non-holiday, 8AM - 11PM	Summer Off-peak May- Sept, All other time
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%

		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
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%
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%

		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
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%
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%

		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
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	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
Standby Losses - Home Office																									
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%

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

		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 or flashing																									
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, changing day, off night	C27	5.5%	2.9%	4.9%	2.8%	5.2%	3.3%	5.3%	2.9%	5.5%	3.0%	5.2%	3.1%	5.7%	2.8%	5.4%	3.1%	5.3%	3.0%	5.5%	2.9%	5.1%	3.1%	5.4%	3.0%
Traffic Signal - Red Arrows	C28	3.8%	4.6%	3.4%	4.3%	3.6%	5.1%	3.7%	4.4%	3.8%	4.6%	3.6%	4.7%	3.9%	4.3%	3.8%	4.8%	3.7%	4.6%	3.9%	4.4%	3.6%	4.8%	3.8%	4.7%
Traffic Signal - Green Arrows	C29	3.8%	4.6%	3.4%	4.3%	3.6%	5.1%	3.7%	4.4%	3.8%	4.6%	3.6%	4.7%	3.9%	4.3%	3.8%	4.8%	3.7%	4.6%	3.9%	4.4%	3.6%	4.8%	3.8%	4.7%
Traffic Signal - Flashing Yellows	C30	3.8%	4.6%	3.4%	4.3%	3.6%	5.1%	3.7%	4.4%	3.8%	4.6%	3.6%	4.7%	3.9%	4.3%	3.8%	4.8%	3.7%	4.6%	3.9%	4.4%	3.6%	4.8%	3.8%	4.7%
Traffic Signal - “Hand” Don’t Walk Signal	C31	3.8%	4.6%	3.4%	4.3%	3.6%	5.1%	3.7%	4.4%	3.8%	4.6%	3.6%	4.7%	3.9%	4.3%	3.8%	4.8%	3.7%	4.6%	3.9%	4.4%	3.6%	4.8%	3.8%	4.7%
Traffic Signal - “Man” Walk Signal	C32	3.8%	4.6%	3.4%	4.3%	3.6%	5.1%	3.7%	4.4%	3.8%	4.6%	3.6%	4.7%	3.9%	4.3%	3.8%	4.8%	3.7%	4.6%	3.9%	4.4%	3.6%	4.8%	3.8%	4.7%
Traffic Signal - Bi-Modal Walk/Don’t Walk	C33	3.8%	4.6%	3.4%	4.3%	3.6%	5.1%	3.7%	4.4%	3.8%	4.6%	3.6%	4.7%	3.9%	4.3%	3.8%	4.8%	3.7%	4.6%	3.9%	4.4%	3.6%	4.8%	3.8%	4.7%
Industrial Motor	C34	7.0%	1.4%	6.3%	1.4%	6.7%	1.6%	6.8%	1.4%	7.1%	1.5%	6.7%	1.5%	7.3%	1.4%	6.9%	1.6%	6.8%	1.5%	7.1%	1.4%	6.6%	1.5%	7.0%	1.5%
Industrial Process	C35	7.0%	1.4%	6.3%	1.4%	6.7%	1.6%	6.8%	1.4%	7.1%	1.5%	6.7%	1.5%	7.3%	1.4%	6.9%	1.6%	6.8%	1.5%	7.1%	1.4%	6.6%	1.5%	7.0%	1.5%
HVAC Pump Motor (heating)	C36	5.7%	6.9%	5.2%	6.4%	5.5%	7.7%	5.5%	6.6%	1.2%	1.4%	1.1%	1.4%	1.2%	1.3%	1.2%	1.4%	1.2%	1.4%	5.8%	6.6%	5.3%	7.3%	5.7%	7.1%

		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
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 pumps <10 HP	C42	6.4%	6.2%	5.7%	5.9%	6.1%	7.0%	6.1%	6.0%	1.3%	1.3%	1.3%	1.3%	1.4%	1.2%	1.3%	1.3%	1.3%	1.3%	6.4%	6.0%	5.9%	6.6%	6.3%	6.4%
VFD - Chilled water pumps <10 HP	C43	1.7%	0.8%	1.5%	0.7%	1.6%	0.9%	1.6%	0.8%	8.3%	8.5%	7.8%	8.7%	8.5%	8.0%	8.1%	8.9%	7.9%	8.5%	1.7%	0.8%	1.6%	0.8%	1.6%	0.8%
VFD Boiler circulation pumps <10 HP	C44	6.4%	6.2%	5.7%	5.9%	6.1%	7.0%	6.1%	6.0%	1.3%	1.3%	1.3%	1.3%	1.4%	1.2%	1.3%	1.3%	1.3%	1.3%	6.4%	6.0%	5.9%	6.6%	6.3%	6.4%
Refrigeration Economizer	C45	5.4%	7.2%	4.8%	6.7%	5.1%	8.0%	5.2%	7.0%	1.1%	1.5%	1.1%	1.5%	1.2%	1.4%	1.1%	1.5%	1.1%	1.5%	5.4%	7.0%	5.0%	7.6%	5.3%	7.4%
Evaporator Fan Control	C46	3.6%	5.1%	3.2%	4.8%	3.4%	5.7%	3.4%	4.9%	3.4%	4.7%	3.2%	4.8%	3.5%	4.4%	3.3%	4.9%	3.3%	4.7%	3.6%	4.9%	3.3%	5.4%	3.5%	5.2%
Standby Losses - Commercial Office	C47	1.2%	7.1%	1.1%	6.7%	1.2%	8.0%	1.2%	6.9%	1.1%	7.1%	1.1%	7.3%	1.2%	6.7%	1.1%	7.5%	1.1%	7.1%	1.2%	6.9%	1.1%	7.5%	1.2%	7.3%
VFD Boiler draft fans <10 HP	C48	5.5%	6.9%	5.0%	6.5%	5.3%	7.7%	5.3%	6.7%	1.3%	1.5%	1.2%	1.5%	1.3%	1.4%	1.3%	1.5%	1.2%	1.5%	5.6%	6.7%	5.2%	7.3%	5.5%	7.1%
VFD Cooling Tower Fans	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%

		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
<10 HP																									
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[29] from the National Climactic Data Center (NCDC). Note that the base temperature for the calculation of heating degree-days in this document does not follow the historical 65F degree base temperature convention. Instead VEIC used several different temperatures in this TRM to more accurately reflect the outdoor temperature when a heating or cooling system turns on.

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

[29] 30-year normals have been used instead of Typical Meteorological Year (TMY) data due to the fact that few of the measures in the TRM are significantly affected by solar insolation, which is one of the primary benefits of using the TMY approach.
[30] Belzer and Cort, Pacific Northwest National Laboratory in "Statistical Analysis of Historical State-Level Residential Energy Consumption Trends," 2004.
[31] Energy Center of Wisconsin, May 2008 metering study; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research", p. 32 (amended in 2010).
[32] This value is based upon experience, and it is preferable to use building-specific base temperatures when available.

Table 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 3.1: Cooling Degree-Day Zones by County

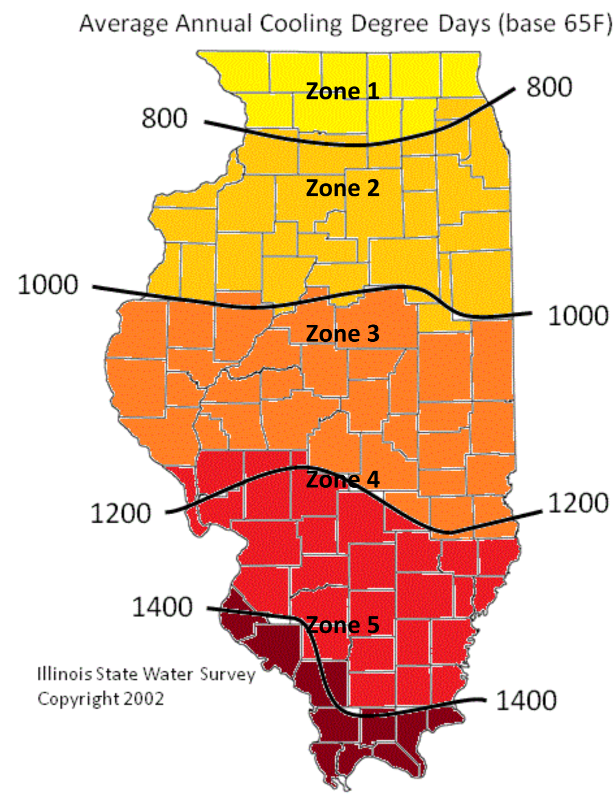


Figure 3.2: Heating Degree-Day Zones by County

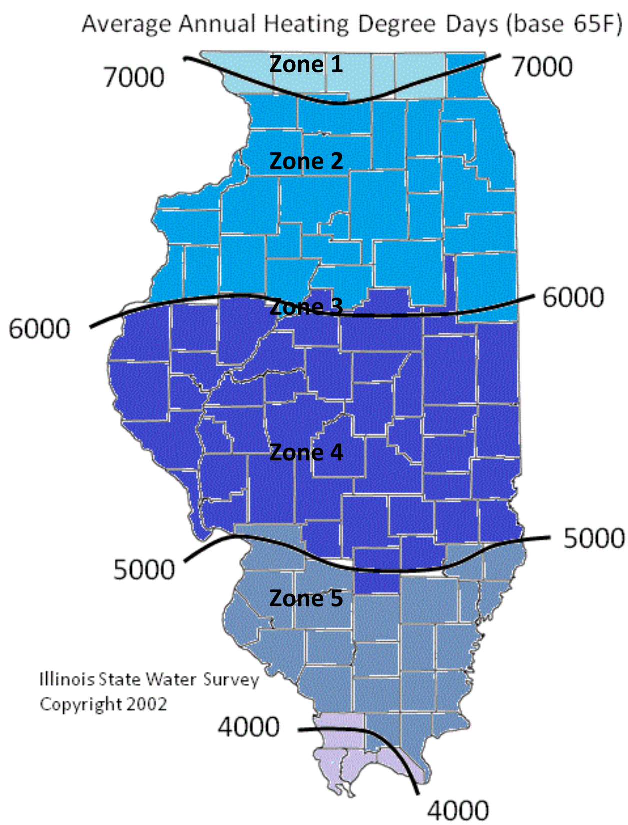


Table 3.7: Heating Degree-Day Zones by County

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 Measure Incremental Cost Definition

Incremental Costs means the difference between the cost of the efficient Measure and the cost of the most relevant baseline measure that would have been installed (if any) in the absence of the efficiency Program. Installation costs (material and labor) and Operations and Maintenance (O&M) costs shall be included if there is a difference between the efficient Measure and the baseline measure. In cases where the efficient Measure has a significantly shorter or longer life than the relevant baseline measure (e.g., LEDs versus halogens), the avoided baseline replacement measure costs should be accounted for in the TRC analysis. The Customer's value of service lost, the Customer's value of their lost amenity, and the Customer's transaction costs shall be included in the TRC analysis where a reasonable estimate or proxy of such costs can be easily obtained (e.g., Program Administrator payment to a Customer to reduce load during a demand response event, Program Administrator payment to a Customer as an inducement to give up duplicative functioning equipment). This Incremental Cost input in the TRC analysis is not reduced by the amount of any Incentives (any Financial Incentives Paid to Customers or Incentives Paid to Third Parties by a Program Administrator that is intended to reduce the price of the efficient Measure to the Customer). Incremental Cost calculations will vary depending on the type of efficient Measure being implemented, as outlined in the examples provided below and as set forth in the IL-TRM

Examples of Incremental Cost calculations include:

a. The Incremental Cost for an efficient Measure that is installed in new construction or is being purchased at the time of natural installation, investment, or replacement is the additional cost incurred to purchase an efficient Measure over and above the cost of the baseline/standard (i.e., less efficient) measure (including any incremental installation, replacement, or O&M costs if there is a difference between the efficient Measure and baseline measure).

b. For a retrofit Measure where the efficiency Program caused the Customer to update their existing equipment, facility, or processes (e.g., air sealing, insulation, tank wrap, controls), where the Customer would not have otherwise made a purchase, the appropriate baseline is zero expenditure, and the Incremental Cost is the full cost of the new retrofit Measure (including installation costs).

c. For the early replacement of a functioning measure with a new efficient Measure, where the Customer would not have otherwise made a purchase for a number of years, the appropriate baseline is a dual baseline that begins as the existing measure and shifts to the new standard measure after the expected remaining useful life of the existing measure ends. Thus, the Incremental Cost is the full cost of the new efficient Measure (including installation costs) being purchased to replace a still-functioning measure less the present value of the assumed deferred replacement cost of replacing the existing measure with a new baseline measure at the end of the existing measure's life (described in section 3.9). This deferred credit may not be necessary when the lifetime of the measure is short, the costs are very low, or for other reasons (e.g., certain Direct Install Measures, Measures provided in Kits to Customers).

d. For study-based services (e.g., facility energy audits, energy surveys, energy assessments, retro-commissioning) that are truly necessary for a Customer to implement efficient Measures, as opposed to being principally intended to be a form of marketing, the Incremental Cost is the full cost of the study-based service. Even if the study-based service is performed entirely by a Program Administrator's implementation contractor, the full cost of the study-based service charged by the implementation contractor is the Incremental Cost, because this is assumed to be the cost of the study-based service that would have been incurred by the Customer if the Customer were to have the study-based service performed in the absence of the efficiency Program. If the Customer implements efficient Measures as a result of the study-based service provided by the efficiency Program, the Incremental Cost for those efficient Measures should also be classified as Incremental Costs in the TRC analysis.

e. For the early retirement of duplicative functioning equipment before its expected life is over (e.g., appliance recycling Programs), the Incremental Costs are composed of the Customer's value placed on their lost amenity, any Customer transaction costs, and the pickup and recycling cost. The Incremental

Costs include the actual cost of the pickup and recycling of the equipment (often paid for by a Program Administrator to an implementation contractor) because this is assumed to be the cost of recycling the equipment that would have been incurred by the Customer if the Customer were to recycle the equipment on their own in the absence of the efficiency Program. The payment a Program Administrator makes to the Customer serves as a proxy for the value the Customer places on their lost amenity and any Customer transaction costs.

3.9 Inflation Rates, O&M Costs and the Weighted Average Cost of Capital (WACC)

The Illinois utilities utilize screening tools that apply the utility's weighted average cost of capital (WACC) to discount any future costs or benefits. The WACC is a combination of common equity, preferred stock, short and long term debt, that includes inflationary risks. Therefore any future costs provided within the TRM (e.g. in early replacement measures where a deferred baseline replacement cost is provided) should include inflation rates. The TAC agreed to use the 20-year Treasury (yield versus Real yield) as a proxy for inflation of 1.91%.

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 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.

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 5.34%[33].

[33] Calculated using the average of ComEd and Ameren's WACC and the rate of inflation 1.91%.

3.10 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[34]. 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.

[34] For more information, please refer to the document, 'Dealing with interactive Effects During Measure Characterization" Memo to the Stakeholder Advisory Group dated 12/13/11.
http://portal.veic.org/projects/illinoistrm/Shared%20Documents/Memos/Interactive_Effects_Memo_121311.docx

Illinois Statewide Technical Reference Manual for Energy Efficiency

Version 5.0

Volume 2: Commercial and Industrial Measures

Final
February 11th, 2016

Effective:
June 1st, 2016

[INTENTIONALLY LEFT BLANK]

TABLE OF CONTENTS

VOLUME 1: OVERVIEW AND USER GUIDE

VOLUME 2: COMMERCIAL AND INDUSTRIAL MEASURES 7

4.1 Agricultural End Use 7

4.1.1 Engine Block Timer for Agricultural Equipment 7
4.1.2 High Volume Low Speed Fans 9
4.1.3 High Speed Fans 11
4.1.4 Live Stock Waterer 13

4.2 Food Service Equipment End Use 15

4.2.1 Combination Oven 15
4.2.2 Commercial Solid and Glass Door Refrigerators & Freezers 22
4.2.3 Commercial Steam Cooker 25
4.2.4 Conveyor Oven 33
4.2.5 ENERGY STAR Convection Oven 35
4.2.6 ENERGY STAR Dishwasher 38
4.2.7 ENERGY STAR Fryer 48
4.2.8 ENERGY STAR Griddle 51
4.2.9 ENERGY STAR Hot Food Holding Cabinets 56
4.2.10 ENERGY STAR Ice Maker 59
4.2.11 High Efficiency Pre-Rinse Spray Valve 62
4.2.12 Infrared Charbroiler 66
4.2.13 Infrared Rotisserie Oven 68
4.2.14 Infrared Salamander Broiler 70
4.2.15 Infrared Upright Broiler 72
4.2.16 Kitchen Demand Ventilation Controls 74
4.2.17 Pasta Cooker 77
4.2.18 Rack Oven - Double Oven 79
4.2.19 ENERGY STAR Electric Convection Oven 81

4.3 Hot Water 86

4.3.1 Storage Water Heater 86
4.3.2 Low Flow Faucet Aerators 93
4.3.3 Low Flow Showerheads 101
4.3.4 Commercial Pool Covers 106
4.3.5 Tankless Water Heater 109

4.3.6 Ozone Laundry ... 115
4.3.7 Multifamily Central Domestic Hot Water Plants ... 121
4.3.8 Controls for Central Domestic Hot Water ... 125
4.3.9 Heat Recovery Grease Trap Filter ... 127

4.4 HVAC End Use ... 131

4.4.1 Air Conditioner Tune-up ... 135
4.4.2 Space Heating Boiler Tune-up ... 138
4.4.3 Process Boiler Tune-up ... 141
4.4.4 Boiler Lockout/Reset Controls ... 144
4.4.5 Condensing Unit Heaters ... 146
4.4.6 Electric Chiller ... 148
4.4.7 ENERGY STAR and CEE Tier 1 Room Air Conditioner ... 154
4.4.8 Guest Room Energy Management (PTAC & PTHP) ... 158
4.4.9 Heat Pump Systems ... 168
4.4.10 High Efficiency Boiler ... 176
4.4.11 High Efficiency Furnace ... 180
4.4.12 Infrared Heaters (all sizes), Low Intensity ... 186
4.4.13 Package Terminal Air Conditioner (PTAC) and Package Terminal Heat Pump (PTHP) ... 188
4.4.14 Pipe Insulation ... 193
4.4.15 Single-Package and Split System Unitary Air Conditioners ... 213
4.4.16 Steam Trap Replacement or Repair ... 220
4.4.17 Variable Speed Drives for HVAC Pumps and Cooling Tower Fans ... 225
4.4.18 Small Commercial Programmable Thermostats ... 229
4.4.19 Demand Controlled Ventilation ... 235
4.4.20 High Turndown Burner for Space Heating Boilers ... 240
4.4.21 Linkageless Boiler Controls for Space Heating ... 243
4.4.22 Oxygen Trim Controls for Space Heating Boilers ... 245
4.4.23 Shut Off Damper for Space Heating Boilers or Furnaces ... 247
4.4.24 Small Pipe Insulation ... 249
4.4.25 Small Commercial Programmable Thermostat Adjustments ... 256
4.4.26 Variable Speed Drives for HVAC Supply and Return Fans ... 264
4.4.27 Energy Recovery Ventilator ... 271
4.4.28 Stack Economizer for Boilers Serving HVAC Loads ... 275
4.4.29 Stack Economizer for Boilers Serving Process Loads ... 278
4.4.30 Notched V Belts for HVAC Systems ... 281

4.4.31 Small Business Furnace Tune-Up 289
4.4.32 Combined Heat and Power 292
4.4.33 Industrial Air Curtain 300
4.4.34 Destratification Fan 311
4.4.35 Economizer Repair and Optimization 319
4.4.36 Multi-Family Space Heating Steam Boiler Averaging Controls 328
4.4.37 Unitary HVAC Condensing Furnace 330

4.5 Lighting End Use 340
4.5.1 Commercial ENERGY STAR Compact Fluorescent Lamp (CFL) 342
4.5.2 Fluorescent Delamping 349
4.5.3 High Performance and Reduced Wattage T8 Fixtures and Lamps 354
4.5.4 LED Bulbs and Fixtures 369
4.5.5 Commercial LED Exit Signs 384
4.5.6 LED Traffic and Pedestrian Signals 388
4.5.7 Lighting Power Density 392
4.5.8 Miscellaneous Commercial/Industrial Lighting 404
4.5.9 Multi-Level Lighting Switch 408
4.5.10 Occupancy Sensor Lighting Controls 411
4.5.11 Solar Light Tubes 415
4.5.12 T5 Fixtures and Lamps 418
4.5.13 Occupancy Controlled Bi-Level Lighting Fixtures 428
4.5.14 Commercial ENERGY STAR Specialty Compact Fluorescent Lamp (CFL) 432

4.6 Refrigeration End Use 440
4.6.1 Automatic Door Closer for Walk-In Coolers and Freezers 440
4.6.2 Beverage and Snack Machine Controls 442
4.6.3 Door Heater Controls for Cooler or Freezer 445
4.6.4 Electronically Commutated Motors (ECM) for Walk-in and Reach-in Coolers / Freezers 448
4.6.5 ENERGY STAR Refrigerated Beverage Vending Machine 452
4.6.6 Evaporator Fan Control 454
4.6.7 Strip Curtain for Walk-in Coolers and Freezers 456
4.6.8 Refrigeration Economizers 458
4.6.9 Night Covers for Open Refrigerated Display Cases 462

4.7 Compressed Air 465
4.7.1 VSD Air Compressor 465

4.7.2 Compressed Air Low Pressure Drop Filters 468
4.7.3 Compressed Air No-Loss Condensate Drains....471
4.7.4 Efficient Compressed Air Nozzles 473
4.7.5 Efficient Refrigerated Compressed Air Dryer 476

4.8 Miscellaneous End Use 479
4.8.1 Pump Optimization....479
4.8.2 Roof Insulation for C&I Facilities 482
4.8.3 Computer Power Management Software 489
4.8.4 Modulating Commercial Gas Clothes Dryer 491

VOLUME 3: RESIDENTIAL MEASURES

VOLUME 4: CROSS-CUTTING MEASURES AND ATTACHMENTS

ATTACHMENT A: ILLINOIS STATEWIDE NET-TO-GROSS METHODOLOGIES

Volume 2: 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[1]

DEEMED MEASURE COST

The incremental cost per installed plug-in timer is $10.19[2].

COINCIDENCE FACTOR

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

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

[2]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[3].

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[4].

Deemed Measure Cost

The incremental capital cost for the fans are as follows[5]:

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.

[3] Act on Energy Commercial Technical Reference Manual No. 2010-4
[4] Ibid.
[5] Ibid.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS [6]

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	6577
22	8543
24	10018

SUMMER COINCIDENT PEAK DEMAND SAVINGS[7]

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	2.4
22	3.1
24	3.7

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

[6] Ibid.
[7] 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[8].

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[9].

DEEMED MEASURE COST

The incremental capital cost for all fan sizes is $150[10].

LOADSHAPE

Loadshape C34 - Industrial Motor

COINCIDENCE FACTOR

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

[8] Act on Energy Commercial Technical Reference Manual No. 2010-4
[9] Ibid.
[10] Ibid.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS [11]

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
36 through 47	625
48 through 71	1122

SUMMER COINCIDENT PEAK DEMAND SAVINGS[12]

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

[11] Ibid.
[12] 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[13].

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[14].

DEEMED MEASURE COST

The incremental capital cost for the waters are $787.50:[15]

LOADSHAPE

Loadshape C04 - Non-Residential Electric Heating

COINCIDENCE FACTOR

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

[13] Act on Energy Commercial Technical Reference Manual No. 2010-4
[14] Ibid.
[15] Ibid.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS [16]

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

SUMMER COINCIDENT PEAK DEMAND SAVINGS

The annual kW savings from this measure is a deemed value and assumed to be 0.525 kW. [17]

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

[16] Ibid.
[17] Ibid.

4.2 Food Service Equipment End Use

4.2.1 Combination Oven

DESCRIPTION

This measure applies to both natural gas fired and electric high efficiency combination convection and steam ovens installed in a commercial kitchen.

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 new natural gas or electric combination oven meeting the ENERGY STAR idle rate and cooking efficiency requirements as specified below.[18]

ENERGY STAR Requirements (Version 2.1, Effective January 1, 2014)

Fuel Type	Operation	Idle Rate (Btu/h for Gas, kW for Electric)	Cooking-Energy Efficiency, (%)
Natural Gas	Steam Mode Convection Mode	≤ 200P+6,511 ≤ 150P+5,425	≥ 41 ≥ 56
Electric	Steam Mode Convection Mode	≤ 0.133P+0.6400 ≤ 0.080P+0.4989	≥ 55 ≥ 76

Note: P = Pan capacity as defined in Section 1.S, of the Commercial Ovens Program Requirements Version 2.1[19]

DEFINITION OF BASELINE EQUIPMENT

The baseline equipment is a natural gas or electric combination oven that is not ENERGY STAR certified.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 12 years.[20]

DEEMED MEASURE COST

The costs vary based on the efficiency and make of the equipment. Actual costs should be used.

LOADSHAPE

Loadshape C01 - Commercial Electric Cooking

COINCIDENCE FACTOR

Summer Peak Coincidence Factor for measure is provided below for different building type[21]:

---

[18] ENERGY STAR Commercial Ovens Key Product Criteria
http://www.energystar.gov/index.cfm?c=ovens.pr_crit_comm_ovens

[19] Pan capacity is defined as the number of steam table pans the combination oven is able to accommodate as per the ASTM F-1495-05 standard specification.
http://www.energystar.gov/products/specs/system/files/Commercial%20Ovens%20Program%20Requirements%20V2%201.pdf?965d-c5ec&3b06-d2f5

[20] http://www.fishnick.com/saveenergy/tools/calculators/gcombicalc.php

[21] Values taken from Minnesota Technical Reference Manual, 'Electric Oven and Range' measure and is based upon "Project on

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

The algorithm below applies to electric combination ovens only.[22]

$\Delta kWh = (\Delta CookingEnergy_{ConvElec} + \Delta CookingEnergy_{SteamElec} + \Delta IdleEnergy_{ConvElec} + \Delta IdleEnergy_{SteamElec}) * Days / 1,000$

Where:

$\Delta CookingEnergy_{ConvElec}$ = Change in total daily cooking energy consumed by electric oven in convection mode

$= LB_{Elec} * (EFOOD_{ConvElec} / ElecEFF_{ConvBase} - EFOOD_{ConvElec} / ElecEFF_{ConvEE}) * \%_{Conv}$

$\Delta CookingEnergy_{SteamElec}$ = Change in total daily cooking energy consumed by electric oven in steam mode

$= LB_{Elec} * (EFOOD_{SteamElec} / ElecEFF_{SteamBase} – EFOOD_{SteamElec} / ElecEFF_{SteamEE}) * \%_{Steam}$

$\Delta IdleEnergy_{ConvElec}$ = Change in total daily idle energy consumed by electric oven in convection mode

$= [(ElecIDLE_{ConvBase} * ((HOURS – LB_{Elec}/ElecPC_{ConvBase}) * \%_{Conv})) - (ElecIDLE_{ConvEE} * ((HOURS - LB_{Elec}/ElecPC_{ConvEE}) * \%_{Conv}))]$

$\Delta IdleEnergy_{SteamElec}$ = Change in total daily idle energy consumed by electric oven in convection mode

$= [(ElecIDLE_{SteamBase} * ((HOURS – LB_{Elec}/ElecPC_{SteamBase}) * \%_{Steam})) - (ElecIDLE_{SteamEE} * ((HOURS - LB_{Elec}/ElecPC_{SteamEE}) * \%_{Steam}))]$

Where:

LB_{Elec} = Estimated mass of food cooked per day for electric oven (lbs/day)

= Custom, or if unknown, use 200 lbs (If P <15) or 250 lbs (If P >= 15)

$EFOOD_{ConvElec}$ = Energy absorbed by food product for electric oven in convection mode

Restaurant Energy Performance-End-Use Monitoring and Analysis", Appendixes I and II, Claar, et. al., May 1985

[22] Algorithms and assumptions derived from ENERGY STAR Commercial Kitchen Equipment Savings Calculator https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx

= Custom or if unknown, use 73.2 Wh/lb

ElecEFF = Cooking energy efficiency of electric oven

= Custom or if unknown, use values from table below

	Base	EE
$ElecEFF_{Conv}$	72%	76%
$ElecEFF_{Steam}$	49%	55%

$\%_{Conv}$ = Percentage of time in convection mode

= Custom or if unknown, use 50%

$EFOOD_{SteamElec}$ = Energy absorbed by food product for electric oven in steam mode

= Custom or if unknown, use 30.8 Wh/lb

$\%_{steam}$ = Percentage of time in steam mode

= 1 - $\%_{conv}$

$ElecIDLE_{Base}$ = Idle energy rate (W) of baseline electric oven

= Custom or if unknown, use values from table below

Pan Capacity	Convection Mode ($ElecIDLE_{ConvBase}$)	Steam Mode ($ElecIDLE_{SteamBase}$)
< 15	1,320	5,260
> = 15	2,280	8,710

HOURS = Average daily hours of operation

= Custom or if unknown, use 12 hours

$ElecPC_{Base}$ = Production capacity (lbs/hr) of baseline electric oven

= Custom of if unknown, use values from table below

Pan Capacity	Convection Mode ($ElecPC_{ConvBase}$)	Steam Mode ($ElecPC_{SteamBase}$)
< 15	79	126
> = 15	166	295

$ElecIDLE_{ConvEE}$ = Idle energy rate of ENERGY STAR electric oven in convection mode

= (0.08*P +0.4989)*1000

$ElecPC_{EE}$ = Production capacity (lbs/hr) of ENERGY STAR electric oven

= Custom of if unknown, use values from table below

Pan Capacity	Convection Mode ($ElecPC_{ConvEE}$)	Steam Mode ($ElecPC_{SteamEE}$)
< 15	119	177
> = 15	201	349

$ElecIDLE_{SteamEE}$ = Idle energy rate of ENERGY STAR electric oven in steam mode

= (0.133* P+0.64)*1000

Days = Days of operation per year

= Custom or if unknown, use 365 days per year

1,000 = Wh to kWh conversion factor

EXAMPLE

For example, a 10-pan capacity electric combination oven would save:

ΔkWh = ($\Delta CookingEnergy_{ConvElec}$ + $\Delta CookingEnergy_{SteamElec}$ + $\Delta IdleEnergy_{ConvElec}$ + $\Delta IdleEnergy_{SteamElec}$) * Days / 1,000

$\Delta CookingEnergy_{ConvElec}$ = 200 * (73.2 / 0.72 – 73.2 / 0.76) * 0.50

= 535 Wh

$\Delta CookingEnergy_{SteamElec}$ = 200 * (30.8 / 0.49 – 30.8 / 0.55) * (1 – 0.50)

= 686 Wh

$\Delta IdleEnergy_{ConvElec}$ = [(1,320 * ((12 – 200/79) * 0.50)) - (1,299 *((12 - 200/119) * 0.50))]

= -453 Wh

$\Delta IdleEnergy_{SteamElec}$ = [(5,260 * ((12 – 200/126) * (1 – 0.50))) - (1,970 * ((12 - 200/177) * (1 – 0.50)))]

= 16,678 Wh

ΔkWh = (535 + 686 + -453 + 16,678) * 365 /1,000

= 6,368 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ΔkWh / (HOURS * DAYS) *CF

Where:

CF = Summer peak coincidence factor is dependent on building type[23]:

Location	CF
Fast Food Limited Menu	0.32
Fast Food Expanded Menu	0.41

[23]Values taken from Minnesota Technical Reference Manual, 'Electric Oven and Range' measure and is based upon "Project on Restaurant Energy Performance-End-Use Monitoring and Analysis", Appendixes I and II, Claar, et. al., May 1985

Pizza	0.46
Full Service Limited Menu	0.51
Full Service Expanded Menu	0.36
Cafeteria	0.36

All other variables as defined above.

EXAMPLE

For example, a 10-pan capacity electric combination oven in a Full Service Limited Menu restaurant would save:

ΔkW = ΔkWh / (HOURS * DAYS) *CF

= 6,368/ (12 * 365) * 0.51

= 0.74 kW

NATURAL GAS ENERGY SAVINGS

The algorithm below applies to natural gas combination ovens only.[24]

$$\Delta Therms = (\Delta CookingEnergy_{ConvGas} + \Delta CookingEnergy_{SteamGas} + \Delta IdleEnergy_{ConvGas} + \Delta IdleEnergy_{SteamGas}) * Days / 100{,}000$$

Where:

$\Delta CookingEnergy_{ConvGas}$ = Change in total daily cooking energy consumed by gas oven in convection mode

$= LB_{Gas} * (EFOOD_{ConvGas} / GasEFF_{ConvBase} - EFOOD_{ConvGas} / GasEFF_{ConvEE}) * \%_{Conv}$

$\Delta CookingEnergy_{SteamGas}$ = Change in total daily cooking energy consumed by gas oven in steam mode

$= LB_{Gas} * (EFOOD_{SteamGas} / GasEFF_{SteamBase} – EFOOD_{SteamGas} / GasEFF_{SteamEE}) * \%_{Steam}$

$\Delta IdleEnergy_{ConvGas}$ = Change in total daily idle energy consumed by gas oven in convection mode

$= [(GasIDLE_{ConvBase} * ((HOURS – LB_{Gas}/GasPC_{ConvBase}) * \%_{Conv})) - (GasIDLE_{ConvEE} * ((HOURS - LB_{Gas}/GasPC_{ConvEE}) * \%_{Conv}))]$

$\Delta IdleEnergy_{SteamGas}$ = Change in total daily idle energy consumed by gas oven in convection mode

$= [(GasIDLE_{SteamBase} * ((HOURS – LB_{Gas}/GasPC_{SteamBase}) * \%_{Steam})) - (GasIDLE_{SteamEE} * ((HOURS - LB_{Gas}/GasPC_{SteamEE}) * \%_{Steam}))]$

Where:

LB_{Gas} = Estimated mass of food cooked per day for gas oven (lbs/day)

[24] Algorithms and assumptions derived from ENERGY STAR Commercial Kitchen Equipment Savings Calculator https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx

= Custom, or if unknown, use 200 lbs (If P <15), 250 lbs (If 15 <= P 30), or 400 lbs (If P = >30)

$EFOOD_{ConvGas}$ = Energy absorbed by food product for gas oven in convection mode

= Custom or if unknown, use 250 Btu/lb

GasEFF = Cooking energy efficiency of gas oven

= Custom or if unknown, use values from table below

	Base	EE
$GasEFF_{Conv}$	52%	56%
$GasEFF_{Steam}$	39%	41%

$EFOOD_{SteamGas}$ = Energy absorbed by food product for gas oven in steam mode

= Custom or if unknown, use 105 Btu/lb

$GasIDLE_{Base}$ = Idle energy rate (Btu/hr) of baseline gas oven

= Custom or if unknown, use values from table below

Pan Capacity	Convection Mode ($GasIDLE_{ConvBase}$)	Steam Mode ($GasIDLE_{SteamBase}$)
< 15	8,747	18,656
15-30	10,788	24,562
>30	13,000	43,300

$GasPC_{Base}$ = Production capacity (lbs/hr) of baseline gas oven

= Custom of if unknown, use values from table below

Pan Capacity	Convection Mode ($GasPC_{ConvBase}$)	Steam Mode ($GasPC_{SteamBase}$)
< 15	125	195
15-30	176	211
>30	392	579

$GasIDLE_{ConvEE}$ = Idle energy rate of ENERGY STAR gas oven in convection mode

= 150*P + 5,425

$GasPC_{EE}$ = Production capacity (lbs/hr) of ENERGY STAR gas oven

= Custom of if unknown, use values from table below

Pan Capacity	Convection Mode ($GasPC_{ConvEE}$)	Steam Mode ($GasPC_{SteamEE}$)
< 15	124	172
15-30	210	277
>30	394	640

$GasIDLE_{SteamEE}$ = Idle energy rate of ENERGY STAR gas oven in steam mode

= 200 * P +6511

100,000 = Conversion factor from Btu to therms

All other variables as defined above.

EXAMPLE

For example, a 10-pan capacity gas combination oven would save:

$\Delta Therms = (\Delta CookingEnergy_{ConvGas} + \Delta CookingEnergy_{SteamGas} + \Delta IdleEnergy_{ConvGas} + \Delta IdleEnergy_{SteamGas}) * Days / 100,000$

$\Delta CookingEnergy_{ConvGas}$ = 200 * (250 / 0.52 – 250 / 0.56) * 0.50

=3,434 therms

$\Delta CookingEnergy_{SteamGas}$ = 200 * (105 / 0.39 – 105 / 0.41) * (1 – 0.50)

= 1,313 therms

$\Delta IdleEnergy_{ConvGas}$ = [(8,747 * ((12 – 200/125) * 0.50)) - (6,925 *((12 - 200/124) * 0.50))]

= 9,519 therms

$\Delta IdleEnergy_{SteamGas}$ = [(18,658 * ((12 – 200/195) * (1 – 0.50))) - (8,511 * ((12 - 200/172) * (1 – 0.50)))]

= 56,251 therms

ΔTherms = (3,434 + 1,313 + 9,519 + 56,251) * 365 /100,000

= 257 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-FSE-CBOV-V02-160601

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 [25].

DEEMED MEASURE COST

The incremental capital cost for this measure is provided below[26].

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

[25] 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

[26] 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.

COINCIDENCE FACTOR

The summer peak coincidence factor for this measure is assumed to be 0.937.[27]

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 in the table below.

Type	kWhbase[28]
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[29] = 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
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)

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

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

[29] 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>

= Actual installed

365.25 = days per year

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

ΔkWh = (3.54 – 2.76) * 365.25

= 285 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ΔkWh / HOURS * CF

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[30]

DEEMED MEASURE COST

The incremental capital cost for this measure is $998[31] for a natural gas steam cooker or $2490[32] for an electric steam cooker.

LOADSHAPE

Loadshape C01 - Commercial Electric Cooking

COINCIDENCE FACTOR

Summer Peak Coincidence Factor for measure is provided below for different building type[33]:

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

[30] California DEER 2008 which is also used by both the Food Service Technology Center and ENERGY STAR®.
[31] Source for incremental cost for efficient natural gas steamer is RSG Commercial Gas Steamer Workpaper, January 2012.
[32] 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.
[33] Values taken from Minnesota Technical Reference Manual, 'Electric Oven and Range' measure and is based upon "Project on Restaurant Energy Performance-End-Use Monitoring and Analysis", Appendixes I and II, Claar, et. al., May 1985.Unknown is an average of other location types

Location	CF
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)

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

Where:

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

= 90%[34]

$IDLE_{Base}$ = Idle Energy Rate of Base Steamer[35]

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[36]

[34] Food Service Technology Center 2011 Savings Calculator
[35] Food Service Technology Center 2011 Savings Calculator

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[37] (gas steamers) or 0.0308[8] (electric steamers)

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

=15%[38] (gas steamers) or 26%[9] (electric steamers)

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

Type of Food Service	Hoursday[39]
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[40]
Custom	Varies

F = Food cooked per day (lbs/day)

= custom or if unknown, use 100 lbs/day[41]

$CSM_{\%ENERGYSTAR}$ = ENERGY STAR Steamer's Time in Manual Steam Mode (% of time)[42]

---

[36]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.

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

[38]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.

[39] Values taken from Minnesota Technical Reference Manual, 'Electric Oven and Range' measure and is based upon "Project on Restaurant Energy Performance-End-Use Monitoring and Analysis", Appendixes I and II, Claar, et. al., May 1985.

[40]Unknown is average of other locations

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

[42]Reference information from the Food Service Technology Center siting that ENERGY STAR® steamers are not typically

= 0%

$IDLE_{ENERGYSTAR}$ = Idle Energy Rate of ENERGY STAR®[43]

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[44]

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%[45] (gas steamer) or 50%[15] (electric steamer)

PRE_{number} = Number of preheats per day

=1[46] (if unknown, use 1)

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

Where:

PRE_{number} = Number of Preheats per Day

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.

[43]Food Service Technology Center 2011 Savings Calculator

[44]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.

[45]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

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

=1[47](if unknown, use 1)

PRE_{heat} = Preheat energy savings per preheat

= 11,000 Btu/preheat[48] (gas steamer) or 0.5 kWh/preheat[49] (electric steamer)

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

Where:

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

=15%[50] (gas steamer) or 26%[28] (electric steamer)

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

=38%[51] (gas steamer) or 50%[23] (electric steamer)

F = Food cooked per day (lbs/day)

= custom or if unknown, use 100 lbs/day[52]

E_{FOOD} = Amount of Energy Absorbed by the food during cooking known as ASTM Energy to Food[53]

E_{FOOD} - gas(Btu/lb)	E_{FOOD} (kWh/lb)
105[54]	0.0308[55]

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

[48]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

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

[50] 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.

[51] Ibid.

[52]Amount used by both Food Service Technology Center and ENERGY STAR® savings calculator

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

[54]Ibid.

[55]Ibid.

EXAMPLE

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

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

ΔIdle Energy = ((((1- 0.9)* 11000 + 0.9 * 65 * 105 /0.15)*(7 - (100 / 65)-(1*0.25))) - (((1-0) * 6250 + 0 * 55 * 105 / 0.38) * (7 - (100 / 55) - (1*0.25))))

= 188,321

ΔPreheat Energy = (1 *11,000)

= 11,000

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

= 42368

ΔTherms = (188321 + 11000 + 42368) * 365.25 *1/100,000

= 883 therms

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

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

ΔIdle Energy = ((((1- .9)* 1.0 + .9 * 70 * 0.0308 /0.26)*(6 - (100 / 70)-(1*.25))) - (((1-0) * 0.4 + 0 * 50 * 0.0308 / 0.50) * (6 - (100 / 50) - (1*0.25))))

= 31.18

ΔPreheat Energy = (1 *0.5))

= 0.5

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

= 5.69

ΔkWh = (31.18 + 0.5 + 5.69) * 365.25 days

= 13,649 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

This is only applicable to the electric steam cooker.

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

Where:

CF =Summer Peak Coincidence Factor for measure is provided below for different locations[56]:

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

= (13,649/ (6 * 365.25)) * 0.36

= 2.24 kW

WATER IMPACT DESCRIPTIONS AND CALCULATION

This is applicable to both gas and electric steam cookers.

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

Where

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

= 40[57]

$W_{ENERGYSTAR}$ = Water Consumption Rate of ENERGY STAR® Steamer look up[58]

[56] Values taken from Minnesota Technical Reference Manual, 'Electric Oven and Range' measure and is based upon "Project on Restaurant Energy Performance-End-Use Monitoring and Analysis", Appendixes I and II, Claar, et. al., May 1985.
[57] FSTC (2002). Commercial Cooking Appliance Technology Assessment. Chapter 8: Steamers.
[58] 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.

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[59]

EXAMPLE

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

ΔWater = (40 -10) * 7 * 365.25

= 76,703 gallons

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-FSE-STMC-V04-160601

[59]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.[60]

DEEMED MEASURE COST

The incremental capital cost for this measure is $1800[61].

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

[60] Nicor Gas Energy Efficiency Plan 2011-2014. Revised Plan Filed Pursuant to Order Docket 10-0562, May 27, 2011
[61] 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[62].

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

[62]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[63]

DEEMED MEASURE COST

The incremental capital cost for this measure is $50[64]

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

Custom calculation below, otherwise use deemed value of 306 therms. [65]

[63] 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
[64] 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
[65] 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

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

= 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-V01-120601

4.2.6 ENERGY STAR Dishwasher

Description

This measure applies to ENERGY STAR high and low temp under counter, stationary single tank door type, single tank conveyor, and multiple tank conveyor dishwashers, as well as high temp pot, pan, and utensil 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).

ENERGY STAR Requirements (Effective February 1, 2013)

Dishwasher Type	High Temp Efficiency Requirements		Low Temp Efficiency Requirements	
	Idle Energy Rate	Water Consumption	Idle Energy Rate	Water Consumption
Under Counter	≤ 0.50 kW	≤ 0.86 GPR	≤ 0.50 kW	≤ 1.19 GPR
Stationary Single Tank Door	≤ 0.70 kW	≤ 0.89 GPR	≤ 0.60 kW	≤ 1.18 GPR
Pot, Pan, and Utensil	≤ 1.20 kW	≤ 0.58 GPSF	≤ 1.00 kW	≤ 0.58 GPSF
Single Tank Conveyor	≤ 1.50 kW	≤ 0.70 GPR	≤ 1.50 kW	≤ 0.79 GPR
Multiple Tank Conveyor	≤ 2.25 kW	≤ 0.54 GPR	≤ 2.00 kW	≤ 0.54 GPR

Definition of Baseline Equipment

The baseline equipment is a new dishwasher that is not ENERGY STAR certified.Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be[66]

Dishwasher Type		Equipment Life
Low Temp	Under Counter	10
	Stationary Single Tank Door	15
	Single Tank Conveyor	20
	Multi Tank Conveyor	20
High Temp	Under Counter	10
	Stationary Single Tank Door	15
	Single Tank Conveyor	20
	Multi Tank Conveyor	20
	Pot, Pan, and Utensil	10

[66] Lifetime from ENERGY STAR Commerical Kitchen Equipment Savings Calculator which cites reference as “EPA/FSTC research on available models, 2013”
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 provided below:[67]

Dishwasher Type		Incremental Cost
Low Temp	Under Counter	$50
	Stationary Single Tank Door	$0
	Single Tank Conveyor	$0
	Multi Tank Conveyor	$970
High Temp	Under Counter	$120
	Stationary Single Tank Door	$770
	Single Tank Conveyor	$2,050
	Multi Tank Conveyor	$970
	Pot, Pan, and Utensil	$1,710

LOADSHAPE

Loadshape C01 - Commercial Electric Cooking

COINCIDENCE FACTOR

Summer Peak Coincidence Factor for measure is provided below for different restaurant types[68]:

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

[67] Measure cost from ENERGY STAR Commercial Kitchen Equipment Savings Calculator which cites reference as "EPA research on available models using AutoQuotes, 2012"

[68] Values taken from Minnesota Technical Reference Manual, 'Electric Oven and Range' measure and is based upon "Project on Restaurant Energy Performance-End-Use Monitoring and Analysis", Appendixes I and II, Claar, et. al., May 1985

Algorithm

CALCULATION OF SAVINGS

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

ELECTRIC ENERGY SAVINGS

Custom calculation below, otherwise use deemed values found within the tables that follow.

$$\Delta kWh^{69} = \Delta BuildingEnergy + \Delta BoosterEnergy^{70} + \Delta IdleEnergy$$

Where:

ΔBuildingEnergy = Change in annual electric energy consumption of building water heater

= $[(WaterUse_{Base} * RacksWashed * Days) * (\Delta T_{in} *1.0 * 8.2 \div Eff_{Heater} \div 3,413)] - [(WaterUse_{ESTAR} * RacksWashed * Days) * (\Delta T_{in} *1.0 * 8.2 \div Eff_{Heater} \div 3,413)]$

ΔBoosterEnergy = Annual electric energy consumption of booster water heater

= $[(WaterUse_{Base} * RacksWashed * Days) * (\Delta T_{in} *1.0 * 8.2 \div Eff_{Heater} \div 3,413)] - [(WaterUse_{ESTAR} * RacksWashed * Days) * (\Delta T_{in} *1.0 * 8.2 \div Eff_{Heater} \div 3,413)]$

ΔIdleEnergy = Annual idle electric energy consumption of dishwasher

= $[IdleDraw_{Base} * (Hours * Days – Days * RacksWashed * WashTime \div 60)] –$

$[IdleDraw_{ESTAR} * (Hours * Days – Days * RacksWashed * WashTime \div 60)]$

Where:

$WaterUse_{Base}$ = Water use per rack (gal) of baseline dishwasher

= Custom or if unknown, use value from table below as determined by machine type and sanitation method

$WaterUse_{ESTAR}$ = Water use per rack (gal) of ENERGY STAR dishwasher

= Custom or if unknown, use value from table below as determined by machine type and sanitation method

RacksWashed = Number of racks washed per day

= Custom or if unknown, use value from table below as determined by machine type and sanitation method

Days = Annual days of dishwasher operation

= Custom or if unknown, use 365.25 days per year

ΔT_{in} = Inlet water temperature increase (°F)

= Custom or if unknown, use 70 °F for building water heaters and 40 °F for booster water heaters

1.0 = Specific heat of water (Btu/lb/°F)

8.2 = Density of water (lb/gal)

[69]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

[70] Booster water heater energy only applies to high-temperature dishwashers.

Eff_{Heater} = Efficiency of water heater

= Custom or if unknown, use 98% for electric building and booster water heaters

3,413 = kWh to Btu conversion factor

$IdleDraw_{Base}$ = Idle power draw (kW) of baseline dishwasher

= Custom or if unknown, use value from table below as determined by machine type and sanitation method

$IdleDraw_{ESTAR}$ = Idle power draw (kW) of ENERGY STAR dishwasher

= Custom or if unknown, use value from table below as determined by machine type and sanitation method

Hours = Average daily hours of dishwasher operation

= Custom or if unknown, use 18 hours per day

WashTime = Typical wash time (min)

= Custom or if unknown, use value from table below as determined by machine type and sanitation method

60 = Minutes to hours conversion factor

EXAMPLE

For example, an ENERGY STAR high-temperature, under counter dishwasher with electric building and electric booster water heating with defaults from the calculation above and the table below would save:

ΔkWh = ΔBuildingEnergy + ΔBoosterEnergy + ΔIdleEnergy

Where:

ΔBuildingEnergy = [(1.09 * 75 * 365.25) * (70 *1.0 * 8.2 ÷ 0.98 ÷ 3,413)] - [(0.86 * 75 * 365.25) * (70 *1.0 * 8.2 ÷ 0.98 ÷ 3,413)]

= 1,081 kWh

ΔBoosterEnergy = [(1.09 * 75 * 365.25) * (40 *1.0 * 8.2 ÷ 0.98 ÷ 3,413)] - [(0.86 * 75 * 365.25) * (40 *1.0 * 8.2 ÷ 0.98 ÷ 3,413)]

= 618 kWh

ΔIdleEnergy = [0.76 * (18 *365.25 – 365.25 * 75 * 2.0 ÷ 60)] –

[0.50 * (18 *365.25 – 365.25 * 75 * 2.0 ÷ 60)]

= 1,472 Wh

ΔkWh = 1,081 + 618 + 1,472

= 3,171 kWh

Default values for WaterUse, RacksWashed, kW_{Idle}, and WashTime are presented in the table below.

	RacksWashed	WashTime	WaterUse		IdleDraw	
Low Temperature	All Dishwashers	All Dishwashers	Conventional	ENERGY STAR	Conventional	ENERGY STAR
Under Counter	75	2.0	1.73	1.19	0.50	0.50
Stationary Single Tank Door	280	1.5	2.10	1.18	0.60	0.60
Single Tank Conveyor	400	0.3	1.31	0.79	1.60	1.50

Multi Tank Conveyor	600	0.3	1.04	0.54	2.00	2.00
High Temperature	**All Dishwashers**	**All Dishwashers**	**Conventional**	**ENERGY STAR**	**Conventional**	**ENERGY STAR**
Under Counter	75	2.0	1.09	0.86	0.76	0.50
Stationary Single Tank Door	280	1.0	1.29	0.89	0.87	0.70
Single Tank Conveyor	400	0.3	0.87	0.70	1.93	1.50
Multi Tank Conveyor	600	0.2	0.97	0.54	2.59	2.25
Pot, Pan, and Utensil	280	3.0 3.0	0.70	0.58	1.20	1.20

Savings for all water heating combinations are presented in the tables below (calculated without rounding variables as provided above).

Electric building and electric booster water heating

Dishwasher type		kWh_{Base}	kWh_{ESTAR}	ΔkWh
Low Temp	Under Counter	10,972	8,431	2,541
	Stationary Single Tank Door	39,306	23,142	16,164
	Single Tank Conveyor	42,230	28,594	13,636
	Multi Tank Conveyor	50,112	31,288	18,824
High Temp	Under Counter	12,363	9,191	3,173
	Stationary Single Tank Door	39,852	27,981	11,871
	Single Tank Conveyor	45,593	36,375	9,218
	Multi Tank Conveyor	72,523	45,096	27,426
	Pot, Pan, and Utensil	21,079	17,766	3,313

Electric building and natural gas booster water heating

Dishwasher type		kWh_{Base}	kWh_{ESTAR}	ΔkWh
Low Temp	Under Counter	10,972	8,431	2,541
	Stationary Single Tank Door	39,306	23,142	16,164
	Single Tank Conveyor	42,230	28,594	13,636
	Multi Tank Conveyor	50,112	31,288	18,824
High Temp	Under Counter	9,432	6,878	2,554
	Stationary Single Tank Door	26,901	19,046	7,856
	Single Tank Conveyor	33,115	26,335	6,780
	Multi Tank Conveyor	51,655	33,479	18,176
	Pot, Pan, and Utensil	14,052	11,943	2,108

Natural gas building and electric booster water heating

Dishwasher type		kWh_{Base}	kWh_{ESTAR}	ΔkWh

Dishwasher type		kWh_{Base}	kWh_{ESTAR}	ΔkWh
Low Temp	Under Counter	2,831	2,831	0
	Stationary Single Tank Door	2,411	2,411	0
	Single Tank Conveyor	9,350	8,766	584
	Multi Tank Conveyor	10,958	10,958	0
High Temp	Under Counter	7,234	5,143	2,090
	Stationary Single Tank Door	17,188	12,344	4,844
	Single Tank Conveyor	23,757	18,806	4,951
	Multi Tank Conveyor	36,004	24,766	11,238
	Pot, Pan, and Utensil	8,781	7,576	1,205

<u>Natural gas building and natural gas booster water heating</u>

Dishwasher type		kWh_{Base}	kWh_{ESTAR}	ΔkWh
Low Temp	Under Counter	2,831	2,831	0
	Stationary Single Tank Door	2,411	2,411	0
	Single Tank Conveyor	9,350	8,766	584
	Multi Tank Conveyor	10,958	10,958	0
High Temp	Under Counter	4,303	2,831	1,472
	Stationary Single Tank Door	4,237	3,409	828
	Single Tank Conveyor	11,279	8,766	2,513
	Multi Tank Conveyor	15,136	13,149	1,987
	Pot, Pan, and Utensil	1,753	1,753	0

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ΔkWh/ AnnualHours

Where:

AnnualHours = Hours * Days

= 18 * 365.25

= 6575 annual hours

Example:

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

ΔkW = ΔkWh/ AnnualHours

= 2541/6575

= 0.386 kW

NATURAL GAS ENERGY SAVINGS

$$\Delta \text{Therms}^{71} = \Delta \text{BuildingEnergy} + \Delta \text{BoosterEnergy}$$

Where:

ΔBuildingEnergy = Change in annual natural gas consumption of building water heater

= [($WaterUse_{Base}$ * RacksWashed * Days)*(ΔT_{in} * 1.0 * 8.2 ÷ Eff_{Heater} ÷ 100,000)] - [($WaterUse_{ESTAR}$* RacksWashed * Days)*(ΔT_{in} * 1.0*8.2 ÷ Eff_{Heater} ÷ 100,000)]

ΔBoosterEnergy = Change in annual natural gas consumption of booster water heater

= [($WaterUse_{Base}$ * RacksWashed * Days)*(ΔT_{in} * 1.0 * 8.2 ÷ Eff_{Heater} ÷ 100,000)] - [($WaterUse_{ESTAR}$* RacksWashed * Days)*(ΔT_{in} * 1.0*8.2 ÷ Eff_{Heater} ÷ 100,000)]

Where:

$WaterUse_{Base}$ = Water use per rack (gal) of baseline dishwasher

= Custom or if unknown, use value from table within the electric energy savings characterization as determined by machine type and sanitation method

$WaterUse_{ESTAR}$ = Water use per rack (gal) of ENERGY STAR dishwasher

= Custom or if unknown, use value from table within the electric energy savings characterization as determined by machine type and sanitation method

RacksWashed = Number of racks washed per day

= Custom or if unknown, use value from table within the electric energy savings characterization as determined by machine type and sanitation method

Days = Annual days of dishwasher operation

= Custom or if unknown, use 365 days per year

ΔT_{in} = Inlet water temperature increase (°F)

= Custom or if unknown, use 70 °F for building water heaters and 40 °F for booster water heaters

1.0 = Specific heat of water (Btu/lb/°F)

8.2 = Density of water (lb/gal)

Eff_{Heater} = Efficiency of water heater

= Custom or 80% for gas building and booster water heaters

100,000 = Therms to Btu conversion factor

[71] Algorithms and assumptions derived from ENERGY STAR Commercial Kitchen Equipment Savings Calculator

EXAMPLE

For example, an ENERGY STAR high-temperature, under counter dishwasher with gas building and gas booster water heating with defaults from the calculation above and the table within the electric energy savings characterization would save:

ΔTherms = ΔBuildingEnergy + ΔBoosterEnergy

Where:

ΔBuildingEnergy = [(1.09 * 75 * 365.25)*(70 * 1.0 * 8.2 ÷ 0.80 ÷ 100,000)] - [(0.86 * 75 * 365.25)*(70 * 1.0 * 8.2 ÷ 0.80 ÷ 100,000)]

= 45 therms

ΔBoosterEnergy = [(1.09 * 75 * 365.25)*(40 * 1.0 * 8.2 ÷ 0.80 ÷ 100,000)] - [(0.86 * 75 * 365.25)*(40 * 1.0 * 8.2 ÷ 0.80 ÷ 100,000)]

= 26 therms

ΔTherms = 45 + 26

= 71 therms

Savings for all water heating combinations are presented in the tables below.

Electric building and natural gas booster water heating

Dishwasher type		$Therms_{Base}$	$Therms_{ESTAR}$	ΔTherms
Low Temp	Under Counter	NA	NA	NA
	Stationary Single Tank Door	NA	NA	NA
	Single Tank Conveyor	NA	NA	NA
	Multi Tank Conveyor	NA	NA	NA
High Temp	Under Counter	123	97	26
	Stationary Single Tank Door	541	374	168
	Single Tank Conveyor	522	420	102
	Stationary Single Tank Door	872	486	387
	Pot, Pan, and Utensil	294	243	50

Natural gas building and natural gas booster water heating

Dishwasher type		$Therms_{Base}$	$Therms_{ESTAR}$	ΔTherms
Low Temp	Under Counter	340	234	106
	Stationary Single Tank Door	1,543	867	676
	Single Tank Conveyor	1,375	829	546
	Multi Tank Conveyor	1,637	850	787
High	Under Counter	337	266	71

Dishwasher type		$Therms_{Base}$	$Therms_{ESTAR}$	ΔTherms
Temp	Stationary Single Tank Door	1,489	1,027	462
	Single Tank Conveyor	1,435	1,154	280
	Multi Tank Conveyor	2,399	1,336	1,064
	Pot, Pan, and Utensil	808	669	139

Natural gas building and electric booster water heating

Dishwasher type		$Therms_{Base}$	$Therms_{ESTAR}$	ΔTherms
Low Temp	Under Counter	340	234	106
	Stationary Single Tank Door	1,543	867	676
	Single Tank Conveyor	1,375	829	546
	Multi Tank Conveyor	1,637	850	787
High Temp	Under Counter	214	169	45
	Stationary Single Tank Door	948	654	294
	Single Tank Conveyor	913	735	178
	Multi Tank Conveyor	1,527	850	677
	Pot, Pan, and Utensil	514	426	88

WATER IMPACT DESCRIPTIONS AND CALCULATION

$$\Delta\text{Water} = (\text{WaterUse}_{\text{Base}} * \text{RacksWashed} * \text{Days}) - (\text{WaterUse}_{\text{ESTAR}} * \text{RacksWashed} * \text{Days})$$

Where:

$WaterUse_{Base}$ = Water use per rack (gal) of baseline dishwasher

= Custom or if unknown, use value from table within the electric energy savings characterization as determined by machine type and sanitation method

$WaterUse_{ESTAR}$ = Water use per rack (gal) of ENERGY STAR dishwasher

= Custom or if unknown, use value from table within the electric energy savings characterization as determined by machine type and sanitation method

RacksWashed = Number of racks washed per day

= Custom or if unknown, use value from table within the electric energy savings characterization as determined by machine type and sanitation method

Days = Annual days of dishwasher operation

= Custom or if unknown, use 365 days per year

EXAMPLE

For example, an ENERGY STAR low-temperature, under counter dishwasher with defaults from the calculation above and the table within the electric energy savings characterization would save:

$\Delta Water = (WaterUse_{Base} * RacksWashed * Days) - (WaterUse_{ESTAR} * RacksWashed * Days)$

$\Delta Water = (1.73 * 75 * 365.25) - (1.19 * 75 * 365.25)$

$= 14{,}793$ gallons

Savings for all dishwasher types are presented in the table below.

	Annual Water Consumption (gallons)		
	Baseline	ENERGY STAR	Savings
Low Temperature			
Under Counter	47,391	32,599	14,793
Stationary Single Tank Door	214,767	120,679	94,088
Single Tank Conveyor	191,391	115,419	75,972
Multi Tank Conveyor	227,916	118,341	109,575
High Temperature			
Under Counter	29,859	23,559	6,301
Stationary Single Tank Door	131,928	91,020	40,908
Single Tank Conveyor	127,107	102,270	24,837
Multi Tank Conveyor	212,576	118,341	94,235
Pot, Pan, and Utensil	71,589	59,317	12,272

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-FSE-ESDW-V02-160601

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.[72]

Deemed Measure Cost

The incremental capital cost for this measure is $1200.[73]

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[74]

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

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

[72] 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

[73] 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

[74] 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

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
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[75]

DEEMED MEASURE COST

The incremental capital cost for this measure is $0 for and electric griddle and $60 for a gas griddle.[76]

LOADSHAPE

Loadshape C01 - Commercial Electric Cooking

COINCIDENCE FACTOR

Summer Peak Coincidence Factor for measure is provided below for different building type[77]:

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

[75] 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
[76] 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
[77]Values taken from Minnesota Technical Reference Manual, 'Electric Oven and Range' measure and is based upon "Project on Restaurant Energy Performance-End-Use Monitoring and Analysis", Appendixes I and II, Claar, et. al., May 1985

Algorithm

CALCULATION OF SAVINGS [78]

ELECTRIC ENERGY SAVINGS

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

Where:

ΔDailyIdleEnergy =[(IdleBase * Width * Depth * (HOURSday – (LB/(PCBase * Width * Depth)) – (PreheatNumberBase* PreheatTimeBase/60)]- [(IdleENERGYSTAR * Width * Depth * (HOURSday – (LB/(PCENERGYSTAR * Width * Depth)) – (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

= 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 40/6 = 6.67 pounds/hr/sq ft

PCBase = Production Capacity base

= custom or if unknown, use 35/6 = 5.83 pounds/hr/sq ft

PreheatNumberENERGYSTAR = Number of preheats per day

[78] 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 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 8000/6 = 1333 W/sq ft

PreheatRateBase = preheat energy rate baseline

= custom or if unknown, use 16000/6 = 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 * (12 – (100/(35/6 * 3 * 2)) – (1 *15/60)]- [320 * 3 * 2 * (12 – (100/(40/6 * 3 * 2)) – (1* 15/60]

= 3583 W

ΔDailyPreheatEnergy = (1* 15 / 60 * 16000/6 * 3 * 2) – (1* 15/60 * 8000/6 * 3 * 2)

= 2000W

ΔDailyCookingEnergy = (100 * 139 / 0.65) - (100 * 139 / 0.70)

= 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

=2597 kWh/4308 * 0.36

= 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 * Depth * (HOURSday - LB/(PCBase * Width * Depth)) – (PreheatNumberBase* PreheatTimeBase/60)]- [(IdleENERGYSTAR * Width * Depth * (HOURSday – (LB/(PCENERGYSTAR * Width * Depth)) – (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 45/6 = 7.5 pounds/hr/sq ft

PCBase = Production Capacity base

= custom or if unknown, use 25/6 = 4.17 pounds/hr/sq ft

PreheatRateENERGYSTAR = preheat energy rate high efficiency

= custom or if unknown, use 60000/6 = 10000 btu/h/sq ft

PreheatRateBase = preheat energy rate baseline

= custom or if unknown, use 84000/6 = 14000 btu/h/sq ft

IdleENERGYSTAR = Idle energy rate

= custom or if unknown, use 15900/6 = 2650 btu/h/sq ft

IdleBase = Idle energy rate

= custom or if unknown, use 21000/6 = 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 * (12 - 100/(25/6* 3 * 2)) – (1* 15/60))]- [(2650 * 3 * 2 * (12 - (100/(45/6 * 3 * 2)) – (1* 15/60)))]

= 11258 Btu

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

= 6000 btu

ΔDailyCookingEnergy = (100 * 475/ 0.32) - (100 * 475/ 0.38)

=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-V02-160601

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[79]

DEEMED MEASURE COST

The incremental capital cost for this measure is[80]

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

[79] 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

[80] 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[81]:

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[82]

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

HOURSday = Average Daily Operation

= custom or if unknown, use 15 hours

Days = Annual days of operation

[81] Values taken from Minnesota Technical Reference Manual, 'Electric Oven and Range' measure and is based upon "Project on Restaurant Energy Performance-End-Use Monitoring and Analysis", Appendixes I and II, Claar, et. al., May 1985

[82] 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

= 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-V02-160601

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[83].

Deemed Measure Cost

The incremental capital cost for this measure is provided below.[84]

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

Loadshape

Loadshape C23 - Commercial Refrigeration

[83]DEER 2008

[84]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>.

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	kWhbase[85]	kWhee[86]
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[87]

[85]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>.

[86]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>

[87]Duty cycle varies considerably from one installation to the next. TRM assumptions from Vermont, Wisconsin, and New York

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

= Actual installed

365.35 = days per year

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

ΔkWH = [(6.4 – 5.8) / 100] * (0.57 * 450) * 365.25

= 562 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ΔkWh / (HOURS * DC) * CF

Where:

HOURS = annual operating hours

= 8766[88]

CF = 0.937

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

ΔkW = 562/(8766 * 0.57) * .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[89] 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

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.

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

[89] 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.[90] 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[91]

Deemed Measure Cost

The cost of this measure is assumed to be $100[92]

Loadshape

Loadshape C01 - Commercial Electric Cooking

Coincidence Factor

N/A

---

[90] 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)

[91] 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."

[92] 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.

Algorithm

CALCULATION OF ENERGY SAVINGS

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

$$\Delta kWH = \Delta Gallons * 8.33 * 1 * (Tout - Tin) * (1/EFF\_Elec) /3,413 * FLAG$$

Where:

ΔGallons = amount of water saved as calculated below

8.33 = specific mass in pounds of one gallon of water (lbm/gal)

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

Tout = Water Heater Outlet Water Temperature

= custom, otherwise assume Tin + 70°F temperature rise from Tin[93]

Tin = Inlet Water Temperature

= custom, otherwise assume 54.1 °F[94]

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

=custom, otherwise assume 97%[95]

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

[93] 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

[94] 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.

[95] This efficiency value is based on IECC 2012/2015 performance requirement for electric resistant water heaters rounded without the slight adjustment allowing for reduction based on size of storage tank.

NATURAL GAS ENERGY SAVINGS

ΔTherms = ΔGallons * 8.33 * 1 * (Tout - Tin) * (1/EFF_Gas) /100,000 * (1 – FLAG)

Where (new variables only):

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

= custom, otherwise assume 80%[96]

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/.80)/100,000 x (1-0)

= 221 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/.80)/100,000 x (1-0)

=344 Therms

WATER IMPACT CALCULATION[97]

ΔGallons = (FLObase - FLOeff) * 60 * HOURSday * DAYSyear

Where:

FLObase = Base case flow in gallons per minute, or custom (Gal/min)

Time of Sale	Retrofit, Direct Install
1.6 gal/min[98]	1.9 gal/min[99]

FLOeff = Efficient case flow in gallons per minute or custom (Gal/min)

Time of Sale	Retrofit, Direct Install
1.06 gal/min[100]	1.06 gal/min[101]

[96] IECC 2012/2015, Table C404.2, Minimum Performance of Water-Heating Equipment

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

[98] 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.

[99] 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)

[100] 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

60 = Minutes per hour

HOURSday = Hours per day that the pre-rinse spray valve is used at the site, custom, otherwise[102]:

Application	Hours/day
Small, quick- service restaurants	1
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-V03-160601

listed on the FSTC website is 1.06.

[101] 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.

[102] 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[103]

DEEMED MEASURE COST

The incremental capital cost for this measure is $2200[104]

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

The annual natural gas energy savings from this measure is a deemed value equaling 661 Therms.[105]

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

[103]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

[104]Ibid.

[105] 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.

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

4.2.13 Infrared Rotisserie Oven

DESCRIPTION

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

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

DEFINITION OF EFFICIENT EQUIPMENT

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

DEFINITION OF BASELINE EQUIPMENT

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

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 12 years[106]

DEEMED MEASURE COST

The incremental capital cost for this measure is $2700[107]

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

The annual natural gas energy savings from this measure is a deemed value equaling 554 Therms[108]

[106] 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

[107] Ibid.

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

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

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[109]

DEEMED MEASURE COST

The incremental capital cost for this measure is $1000[110]

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

The annual natural gas energy savings from this measure is a deemed value equaling 239 therms[111]

---

[109]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
[110]Ibid.
[111] Nicor Gas Energy Efficiency Plan 2011-2014. Revised Plan Filed Pursuant to Order Docket 10-0562, May 27, 2011.These deemed values should be compared to PY evaluation and revised as necessary.

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

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[112]

DEEMED MEASURE COST

The incremental capital cost for this measure is $5900[113]

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

The annual natural gas energy savings from this measure is a deemed value equaling 1089 therms[114].

[112]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

[113]Ibid.

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

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

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.[115]

DEEMED MEASURE COST

The incremental capital cost for this measure is[116]

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

[115] PG&E Workpaper: Commercial Kitchen Demand Ventilation Controls-Electric, 2004 - 2005
[116] 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

$$\Delta Therms = CFM * HP * Annual\ Heating\ Load / (Eff(heat) * 100{,}000)$$

Where:

CFM = the average airflow reduction with ventilation controls per hood

= 611 cfm/HP[117]

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[118]:

Zone	Annual Heating Load, Btu/cfm
1 (Rockford)	154,000

[117] PGE Workpaper, Commercial Kitchen Demand Ventilation Controls, PGECOFST116, June 1, 2009, 4,734 cfm reduction on average , with 7.75 fan horsepower on average.

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

Zone	Annual Heating Load, Btu/cfm
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%[119]

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

[119] 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[120].

Deemed Measure Cost

The incremental capital cost for this measure is $2400[121].

Loadshape

N/A

Coincidence Factor

N/A

Algorithm

Calculation of Savings

Electric Energy Savings

N/A

Summer Coincident Peak Demand Savings

N/A

Natural Gas Energy Savings

The annual natural gas energy savings from this measure is a deemed value equaling 1380 Therms[122].

[120]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
[121]Ibid.
[122]Nicor Gas Energy Efficiency Plan 2011-2014. Revised Plan Filed Pursuant to Order Docket 10-0562, May 27, 2011.These deemed values should be compared to PY evaluation and revised as necessary.

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

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.[123]

Deemed Measure Cost

The incremental capital cost for this measure is $8646.[124]

Loadshape

N/A

Coincidence Factor

N/A

Algorithm

Calculation of Savings

Electric Energy Savings

N/A

Summer Coincident Peak Demand Savings

N/A

Natural Gas Energy Savings

The annual natural gas energy savings from this measure is a deemed value equaling 2064 therms[125]

---

[123] 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

[124] Ibid.

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

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE CI-FSE-RKOV-VO1-120601

4.2.19 ENERGY STAR Electric Convection Oven

Description

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

This measure was developed to be applicable to the following program types; TOS.

If applied to other program types, the measure savings should be verified.

Definition of Efficient Equipment

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

Definition of Baseline Equipment

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

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 12 years.[126]

Deemed Measure Cost

The incremental cost for this measure is assumed to be $800 for half size units and $1000 for full size[127]

Loadshape

Loadshape C01 - Commercial Electric Cooking

Coincidence Factor

Summer Peak Coincidence Factor for measure is provided below for different building type[128]:

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

[126] Food Service Technology Center (FSTC). Default value from life cycle cost calculator. http://www.fishnick.com/saveenergy/tools/calculators/eovencalc.php

[127] Based on data from the Regional Technical Forum for the Northwest Council (http://rtf.nwcouncil.org/measures/com/ComCookingConvectionOven_v2_0.xlsm) using actual list prices for 23 units from 2012, see "ComCookingConvectionOven_v2_0.xlsm".

[128]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

Algorithm

Calculation of Savings

Electric Energy Savings

$\Delta kWh = kWH_{base} - kWh_{eff}$

$kWh = [(LB * E_{FOOD}/EFF) + (IDLE * (HOURS_{DAY} – LB/PC – PRE_{TIME}/60)) + PRE_{ENERGY}] * DAYS$

Where:

kWH_{base} = the annual energy usage of the baseline equipment calculated using baseline values

kWH_{eff} = the annual energy usage of the efficient equipment calculated using efficient values

$HOURS_{DAY}$ = daily operating hours

= Actual, defaults:

Type of Food Service	$HOURS_{DAY}$ [129]
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[130]
Custom	Varies

DAYS = Days per year of operation

= Actual, default = 365[131]

PRE_{TIME} = Preheat time (min/day), the amount of time it takes a steamer to reach operating temperature when turned on

= 15 min/day[132]

[129] Minnesota 2012 Technical Reference Manual, Electric Food Service_v03.2.xls, http://mn.gov/commerce/energy/topics/conservation/Design-Resources/Deemed-Savings.jspech
[130] Unknown is average of other locations
[131] Food Service Technology Center (FSTC). Default value from life cycle cost calculator. http://www.fishnick.com/saveenergy/tools/calculators/eovencalc.php
[132] Food Service Technology Center (2002). *Commercial Cooking Appliance Technology Assessment*. Prepared by Don Fisher. Chapter 7: Ovens

E_{FOOD} = ASTM Energy to Food (kWh/lb); the amount of energy absorbed by the food during cooking, per pound of food

= 0.0732[133]

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

= Actual, default = 100[134]

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

IDLE = Idle energy rate. See table below.

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

PRE_{ENERGY} = Preheat energy (kWh/day). See table below.

Performance Metrics: Baseline and Efficient Values

Metric	Baseline Model [135]	Energy Efficient Model [136]
PRE_{ENERGY} (kWh)	1.5	1
IDLE (kW)	2	Actual, default = 1.0
EFF	65%	Actual, default = 74%
PC (lb/hr)	70	Actual, default = 79

133 American Society for Testing and Materials. Industry standard for Commercial Ovens
134 Food Service Technology Center (FSTC). Default value from life cycle cost calculator. http://www.fishnick.com/saveenergy/tools/calculators/eovencalc.php
135 Food Service Technology Center (FSTC). Default values from life cycle cost calculator. http://www.fishnick.com/saveenergy/tools/calculators/eovencalc.php
136 Average ratings of units on ENERGY STAR qualified list as of 10/2014. Preheat energy is not provided so default is provided based on FSTC life cycle cost calculator.

EXAMPLE

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

kWH_{base} = [(100 * 0.0732/0.65) + (2 * (6 – 100/70 – 15/60)) + 1.5] * 365

= 7,813 kWh

kWh_{eff} = [(100 * 0.0732/0.74) + (1 * (6 – 100/79 – 15/60)) + 1.0] * 365

= 5,612 kWh

ΔkWh = kWH_{base} - kWh_{eff}

= 7,813 – 5,612

= 2200 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = (\Delta kWh / (HOURS_{DAY} * DAYS)) * CF$$

Where:

ΔkWh = Annual energy savings (kWh)

CF = Summer Peak Coincidence Factor for measure is provided below for different building type[137]:

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

EXAMPLE

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

ΔkW = (2200 / (6 * 365)) * 0.40

= 0.40

[137] 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

Fossil Fuel Impact Descriptions and Calculation

N/A

Water Impact Descriptions and Calculation

N/A

Deemed O&M Cost Adjustment Calculation

N/A

Measure Code CI-FSE-ECON-VO1-150601

4.3 Hot Water

4.3.1 Storage Water Heater

DESCRIPTION

This measure is for upgrading from minimum code to a high efficiency storage-type water heater. 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.

If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

The minimum specifications of the high efficiency equipment should be defined by the programs.

DEFINITION OF BASELINE EQUIPMENT

The baseline condition is assumed to be a new standard water heater of same type as existing, meeting the Federal Standard for <75,000 Btuh units and IECC 2015 for all others. If existing type is unknown, assume Gas Storage Water Heater.

Equipment Type	Sub Category	Federal Standard Minimum Efficiency[138]
Gas Storage Water Heaters ≤ 75,000 Btu/h	≤55 gallon tanks	0.675 – (0.0015 * Rated Storage Volume in Gallons) EF
	>55 gallon tanks	0.8012 – (0.00078 * Rated Storage Volume in Gallons) EF
Gas Storage Water Heaters > 75,000 Btu/h	< 4000 Btu/h/gal	80% E_t Standby Loss: (Q/800 + 110vV)
Electric Water Heaters ≤ 75,000 Btu/h	≤55 gallon tanks	0.96 – (0.0003 * rated volume in gallons) EF
	>55 gallon tanks [139]	2.057 – (0.00113 * rated volume in gallons) EF
Electric Water Heaters > 75,000 Btu/h	≤12 kW	0.97 – (0.00132 * rated volume in gallons) EF
	> 12kW	Standby Loss: $0.30 + 27/V_m$ (%/hr)

V= Rated volume in gallons, Vm = measured volume in gallons.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 15 Years[140]

DEEMED MEASURE COST

The full install cost and incremental cost assumptions are provided below. Actual costs should be used where available[141]:

[138] ≤75,000 Btu/h Storage Water Heater and <200,000 Btu/h Tankless Water Heater Federal Standard is DOE Standard 10 CFR 430.32(d). All other standards are from 10 CFR 431.110.

[139] It is assumed that tanks <75,000Btu/h and >55 gallons will not be eligible measures due to the high baseline.

[140] DEER 08, EUL_Summary_10-1-08.xls.

[141] Cost information is based upon data from "2010-2012 WA017 Ex Ante Measure Cost Study Draft Report", Itron, February 28, 2014. See "NR HW Heater_WA017_MCS Results Matrix - Volume I.xls" for more information.

Equipment Type	Category	Install Cost	Incremental Cost
Gas Storage Water Heaters ≤ 75,000 Btu/h, ≤55 Gallons	Baseline	$616	N/A
	Efficient	$1,055	$440
Gas Storage Water Heaters > 75,000 Btu/h	0.80 Et	$4,886	N/A
	0.83 Et	$5,106	$220
	0.84 Et	$5,299	$413
	0.85 Et	$5,415	$529
	0.86 Et	$5,532	$646
	0.87 Et	$5,648	$762
	0.88 Et	$5,765	$879
	0.89 Et	$5,882	$996
	0.90 Et	$6,021	$1,135

For electric water heaters the incremental capital cost for this measure is assumed to be[142]

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

LOADSHAPE

For electric hot water heaters, use Loadshape C02 - Non-Residential Electric DHW.

COINCIDENCE FACTOR

The coincidence factor is assumed to be 0.925 [143].

[142] Act on Energy Commercial Technical Reference Manual, Table 9.6.1-4

[143] Coincidence factor based on Average W in peak period/Max W from Itron eShape data for Missouri, calibrated to Illinois loads,

Algorithm

Calculation of Savings

Electric Energy Savings

Electric energy savings are calculated for electric storage water heaters per the equations given below.

Electric units ≤12 kW:

$$\Delta kWh = \frac{(T_{out} - T_{in}) * HotWaterUse_{Gallon} * \gamma Water * 1 * \left(\frac{1}{EF_{elecbase}} - \frac{1}{EF_{Eff}}\right)}{3412}$$

Where:

T_{OUT} = Tank temperature

= 125°F

T_{IN} = Incoming water temperature from well or municiple system

= 54°F[144]

$HotWaterUse_{Gallon}$ = Estimated annual hot water consumption (gallons)

= Actual if possible to provide reasonable custom estimate. If not, two methodologies are provided to develop an estimate:

1. Consumption per water heater capacity

= Consumption/cap * Capacity

Where:

Consumption/cap = Estimate of consumption per gallon of tank capacity, dependent on building type:[145]

Building Type	Consumption/cap
Grocery, Convenience Store, and Restaurant	803
Lodging, Hospital, and Multifamily	630
Health Clinic, Church, Warehouse	433
Education, Office, and Retail	594
Industrial	558
Agriculture	558

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

[145] Based on Cadmus analysis. Annual hot water usage in gallons based on CBECS (2003) consumption data of West North Central (removed outliers of 1,000 kBtuh or less) to calculate hot water usage. Annual hot water gallons per tank size gallons based on the tank sizing methodology found in ASHRAE 2011 HVAC Applications. Chapter 50 Service Water Heating. Demand assumptions (gallons per day) for each building type based on ASHRAE Chapter 50 and to LBNL White Paper. LBL-37398 Technology Data Characterizing Water Heating in Commercial Buildings: Application to End Use Forecasting. VEIC consider these relatively conservative estimates and consider this may be a good variable for future evaluation.

Building Type	Consumption/cap
Average Non Residential	558

Capacity = Capacity of hot water heater in gallons

= Actual[146]

2. Consumption by Facility Size[147]

Building Type	Gallons hot water per unit per day	Unit	Units/1000 ft^2	Days per year	Gallons/1000 ft^2 floor area
Small Office	1	person	2.3	250	575
Large Office	1	person	2.3	250	575
Fast Food Rest	0.7	meal/day	784.6	365	200,458
Sit-Down Rest	2.4	meal/day	340	365	297,840
Retail	2	employee	1	365	730
Grocery	2	employee	1.1	365	803
Warehouse	2	employee	0.5	250	250
Elementary School	0.6	person	9.5	200	1,140
Jr High/High School	1.8	person	9.5	200	3,420
Health	90	patient	3.8	365	124,830
Motel	20	room	5	365	36,500
Hotel	14	room	2.2	365	11,242
Other	1	employee	0.7	250	175

γWater = Specific weight capacity of water (lb/gal)

= 8.33 lbs/gal

1 = Specific heat of water (Btu/lb.°F)

$EF_{elecbase}$ = Rated efficiency of baseline water heater expressed as Energy Factor (EF);

Equipment Type	Sub Category	Federal Standard Minimum Efficiency[148]
Electric Water Heaters ≤ 75,000 Btu/h	≤55 gallon tanks	0.96 – (0.0003 * rated volume in gallons) EF
	>55 gallon tanks [149]	2.057 – (0.00113 * rated volume in gallons) EF
Electric Water Heaters > 75,000 Btu/h	≤12 kW	0.97 – (0.00132 * rated volume in gallons) EF
	> 12kW	N/A (For >12 kW Units see below)

[146] If the replaced unit is a tankless water heater, an estimate will need to be made of the required storage tank for the application.

[147] Osman Sezgen and Jonathan G. Koomey. Lawrence Berkeley National Laboratory 1995; "Technology Data Characterizing Water Heating in Commercial Buildings: Application to End-Use Forecasting". December 1995.

[148] ≤75,000 Btu/h Storage Water Heater and <200,000 Btu/h Tankless Water Heater Federal Standard is DOE Standard 10 CFR 430.32(d). All other standards are from 10 CFR 431.110.

[149] It is assumed that tanks <75,000Btu/h and >55 gallons will not be eligible measures due to the high baseline.

EF_{eff} = Rated efficiency of efficient water heater expressed as Energy Factor (EF) or Thermal Efficiency (E_t)

= Actual

3412 = Converts Btu to kWh

> For example, for a 200,000 Btu/h, 150 gallon, 90% Thermal Efficiency storage unit with rated standby loss of 1029 BTU/h installed in a 1500 ft[2] restaurant:
>
> ΔkWh = ((125 – 54) * (297,840 * 1.5) * 8.33 * 1 * (1/0.8 - 1/0.9))/3412
>
> = 10,756 kWh

Electric units > 12kW:

$$\Delta kWh = \frac{\left((T_{out} - T_{air}) * V * \gamma Water * 1 * (SL_{elecbase} - SL_{eff})\right) * 8766}{3412}$$

T_{air} = Ambient Air Temperature

= 70°F

V = Rated tank volume in gallons

= Actual

$SL_{elecbase}$ = Standby loss of electric baseline unit (%/hr)

= 0.30 + 27/V

SL_{eff} = Nameplate standby loss of new water heater, in BTU/h

8766 = Hours per year

> For example, >12kW, 100 gallon storage unit with rated standby loss of 0.5 %/hr:
>
> SLbase = 0.3 + (27 / 100)
>
> = 0.57%/hr
>
> ΔkWh = (((125 – 70) * 100 * 8.33 * 1 * (0.57- 0.5)) * 8766)/3412
>
> = 8,239 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = \frac{\Delta kWh}{Hours} * CF$$

Where:

Hours = Full load hours of water heater

= 6461 [150]

[150] Full load hours assumption based on Wh/Max W Ratio from Itron eShape data for Missouri, calibrated to Illinois loads,

CF = Summer Peak Coincidence Factor for measure

= 0.925 [151]

> For example, >12kW, 100 gallon storage unit with rated standby loss of 0.5 %/hr:
>
> ΔkW = 8,239 / 6,461 * 0.925
>
> = 1.18 kW

NATURAL GAS ENERGY SAVINGS

Natural gas energy savings are calculated for natural gas storage water heaters per the equations given below.

$$\Delta Therms = \frac{(T_{out} - T_{in}) \; * \; HotWaterUse_{Gallon} * \gamma Water * 1 * \left(\frac{1}{EF_{gasbase}} - \frac{1}{EF_{Eff}}\right)}{100{,}000}$$

Where:

100,000 = Converts Btu to Therms

$EF_{gasbase}$ = Rated efficiency of baseline water heater expressed as Energy Factor (EF) or Thermal Efficiency (E_t);

Equipment Type	Sub Category	Federal Standard Minimum Efficiency[152]
Gas Storage Water Heaters ≤ 75,000 Btu/h	≤55 gallon tanks	0.675 – (0.0015 * Rated Storage Volume in Gallons) EF
	>55 gallon tanks	0.8012 – (0.00078 * Rated Storage Volume in Gallons) EF
Gas Storage Water Heaters > 75,000 Btu/h	< 4000 Btu/h/gal	80% E_t

Additional Standby Loss Savings

Gas Storage Water Heaters >75,000 Btu/h can claim additional savings due to lower standby losses.

$$\Delta Therms_{Standby} = \frac{(SL_{gasbase} - SL_{eff}) * 8766}{100{,}000}$$

Where:

$SL_{gasbase}$ = Standby loss of gas baseline unit (Btu/h)

$= Q/800 + 110\sqrt{V}$

Q =Nameplate input rating in Btu/h

V = Rated volume in gallons

SL_{eff} = Nameplate standby loss of new water heater, in Btu/h

8766 = Hours per year

[151] Coincidence factor based on Average W in peak period/Max W from Itron eShape data for Missouri, calibrated to Illinois loads,

[152] ≤75,000 Btu/h Storage Water Heater and <200,000 Btu/h Tankless Water Heater Federal Standard is DOE Standard 10 CFR 430.32(d). All other standards are from 10 CFR 431.110.

For example, for a 200,000 Btu/h, 150 gallon, 90% Thermal Efficiency storage unit with rated standby loss of 1029 BTU/h installed in a 1500 ft^2 restaurant:

ΔTherms = ((125 – 54) * (297,840 * 1.5) * 8.33 * 1 * (1/0.8 - 1/0.9))/100,000

= 367.0 Therms

$\Delta Therms_{Standby}$ = (((200000/800 + 110 * √150) – 1079) * 8766)/100,000

= 49.8 Therms

ΔThermsTotal = 367.0 + 49.8

= 416.8 Therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HW_-STWH-V02-160601

4.3.2 Low Flow Faucet Aerators

Description

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

This measure was developed to be applicable to the following program types, DI.

If applied to other program types, the measure savings should be verified.

Definition of Efficient Equipment

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

Definition of Baseline Equipment

The baseline condition is assumed to be a standard bathroom faucet aerator rated at 2.25 GPM or more, or a standard kitchen faucet aerator rated at 2.75 GPM or more. Note if flow rates are measured, for example through a Direct Install program, then actual baseline flow rates should be used as opposed to the deemed values.

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 9 years.[153]

Deemed Measure Cost

The incremental cost for this measure is $8[154] 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.

[153] 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"

[154] 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[155].

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[156] or custom based on metering studies[157] or if measured during DI:

= Measured full throttle flow * 0.83 throttling factor[158]

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

= 0.94[159] or custom based on metering studies[160] or if measured during DI:

= Rated full throttle flow * 0.95 throttling factor[161]

[155] 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.

[156] DeOreo, B., and P. Mayer. Residential End Uses of Water Study Update. Forthcoming. ©2015 Water Research Foundation. Reprinted With Permission.

[157] 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.

[158] 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

[159] 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.

[160] 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.

[161] 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

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[162] (A)	Unit	Estimated % hot water from Faucets [163] (B)	Multiplier [164] (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)

= 0.0795 kWh/gal for Bath, 0.0969 kWh/gal for Kitchen, 0.0919 kWh/gal for 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[165]

SupplyTemp = Assumed temperature of water entering building

= 54.1°F [166]

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

[163] 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

[164] 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.

[165] 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.

[166] US DOE Building America Program. Building America Analysis Spreadsheet. For Chicago, IL

RE_electric = Recovery efficiency of electric water heater

= 98% [167]

3412 = Converts Btu to kWh (Btu/kWh)

ISR = In service rate of faucet aerators dependant on install method as listed in table below[168]

Selection	ISR
Direct Install - Deemed	0.95

5

EXAMPLE

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

ΔkWh = 1 * ((1.39 – 0.94)/1.39) * 11,250 * 0.0969 * 0.95

= 335.3 kWh

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

ΔkWh = 1 * ((1.39 – 0.94)/1.39) * 3,000 * 0.0795 * 0.95

= 73.4 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = (ΔkWh / Hours) * CF

Where:

ΔkWh = calculated value above on a per faucet basis

Hours = Annual electric DHW recovery hours for faucet use

= (Usage * 0.545[169])/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

http://www1.eere.energy.gov/buildings/building_america/analysis_spreadsheets.html.

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

[168] 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

[169] 54.5% is the proportion of hot 120F water mixed with 54.1F supply water to give 90°F mixed faucet water.

Building Type	Annual Recovery Hours
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[170]

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

[170] Calculated as follows: Assumptions for percentage of usage during peak period (1-5pm) were made and then multiplied by 65/365 (65 being the number of days in peak period) and by the number of total annual recovery hours to give an estimate of the number of hours of recovery during peak periods. There are 260 hours in the peak period so the probability you will see savings during the peak period is calculated as the number of hours of recovery during peak divided by 260. See ‘C&I Faucet Aerator.xls’ for details.

EXAMPLE

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

ΔkW = 335.3/109 * 0.0288

= 0.0886 kW

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

ΔkW = 73.4/29 * 0.0096

= 0.0243 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)

= 0.00397 Therm/gal for Bath, 0.00484 Therm/gal for Kitchen, 0.00459 Therm/gal for unknown

Where:

RE_gas = Recovery efficiency of gas water heater

` = 67% [171]

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

Other variables as defined above.

[171] 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 kitchen faucet in a large office with gas DHW:

ΔTherms = 1 * ((1.39 – 0.94)/1.39) * 11,250 * 0.00484 * 0.95

= 16.7 Therms

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

ΔTherms = 1 * ((1.39 – 0.94)/1.39) * 3,000 * 0.00397 * 0.95

= 3.66 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

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-HWE-LFFA-V06-160601

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.[172]

DEEMED MEASURE COST

The incremental cost for this measure is $12[173] or program actual.

LOADSHAPE

Loadshape C02 - Commercial Electric DHW

COINCIDENCE FACTOR

The coincidence factor for this measure is assumed to be 2.78%[174].

[172] 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"

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

[174] 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 [175]

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% [176]

GPM_base = Flow rate of the baseline showerhead

= 2.67 for Direct-install programs[177]

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[178]

L_base = Shower length in minutes with baseline showerhead

= 8.20 min[179]

L_low = Shower length in minutes with low-flow showerhead

= 8.20 min[180]

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

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

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

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

[178] 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.

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

[180] Set equal to L_base.

8.33 = Specific weight of water (lbs/gallon)

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

ShowerTemp = Assumed temperature of water

= 105°F [181]

SupplyTemp = Assumed temperature of water entering house

= 54.1°F [182]

RE_electric = Recovery efficiency of electric water heater

= 98% [183]

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[184]
Direct Install - Deemed	0.98

EXAMPLE

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

ΔkWh = 1 * ((2.67*8.20)- (1.5*8.20)) * 3*365.25) *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[185] / 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

[181] 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

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

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

[184] 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.

[185] 77.3% is the proportion of hot 120F water mixed with 54.1°F supply water to give 105°F shower water

CF = Coincidence Factor for electric load reduction

= 0.0278[186]

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

= 0.054 kW

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%[187]

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% [188]

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

Other variables as defined above.

[186] 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

[187] 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

[188] 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

= 10,302 gallons

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

SOURCES

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

MEASURE CODE: CI-HW_-LFSH-V03-150601

4.3.4 Commercial Pool Covers

Description

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

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

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

Definition of Efficient Equipment

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

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

Definition of Baseline Equipment

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

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

Deemed Lifetime of Efficient Equipment

The useful life of this measure is assumed to be 6 years [189]

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. [190].

[189] 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

[190] 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. [191]

ΔTherms = SavingFactor x Size of Pool

Where

Savings factor = dependant on pool location and listed in table below[192]

Location	Therm / sq-ft
Indoor	2.61
Outdoor	1.01

Size of Pool = custom input

WATER IMPACT DESCRIPTIONS AND CALCULATION

[191] Full method and supporting information found in reference document: IL TRM - Business Pool Covers WorkPaper.docx. Note that the savings estimates are based upon Chicago weather data.

[192] Business Pool Covers.xlsx

ΔTherms = WaterSavingFactor x Size of Pool

Where

WaterSavingFactor = Water savings for this measure dependant on pool location and listed in table below.[193].

Location	Annual Savings Gal / sq-ft
Indoor	15.28
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

[193] 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) 2012/2015, 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) 2012/2015, Table C404.2

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

Electric	Gas
The expected measure life is assumed to be 5 years[194].	The expected measure life is assumed to be 20 years[195]

DEEMED MEASURE COST

The incremental capital cost for an electric tankless heater this measure is assumed to be[196]

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:

---

[194] 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

[195] Ibid.

[196] Act on Energy Technical Reference Manual, Table 9.6.2-3

Program	Capital Cost, $ per unit
Retrofit	$3,255[197]
Time of Sale or New Construction	$2,526[198]

DEEMED O&M COST ADJUSTMENTS

$100[199]

LOADSHAPE

Loadshape C02 - Commercial Electric DHW

COINCIDENCE FACTOR

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

[197] Based on AOE historical average installation data of 42 tankless gas hot water heaters

[198] http://www.mncee.org/getattachment/7b8982e9-4d95-4bc9-8e64-f89033617f37/, Low contractor estimate used to reflect less labor required in new construction of venting.

[199] 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 [200]

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	2,992
10.0	7,905
15.0	12,879

SUMMER COINCIDENT PEAK DEMAND SAVINGS[201]

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 [202]

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

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

8,766 hr/yr = hours a year

Tout = Unmixed Outlet Water Temperature

= custom, otherwise assume 130 °F[203]

Tin = Inlet Water Temperature

= custom, otherwise assume 54.1 °F[204]

[200] Act on Energy Technical Reference Manual, Table 9.6.2-3
[201] Ibid.
[202] 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.
[203] 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.
[204] August 31, 2011 Memo of Savings for Hot Water Savings Measures to Nicor Gas from Navigant states that 54.1°F was

Eff base = Rated efficiency of baseline water heater expressed as Energy Factor (EF) or Thermal Efficiency (Et); see table below[205]

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[206]

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[207]

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 Rating = nameplate Btu/hr rating of water heater

calculated from the weighted average of monthly water mains temperatures reported in the 2010 Building America Benchmark Study for Chicago-Waukegan, Illinois.

[205] International Energy Conservation Code (IECC) 2012/2015, Table C404.2, Minimum Performance of Water-Heating Equipment

[206] 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.

[207] Stand-by loss is provided in 2012/2015 IECC, Table C404.2, Minimum Performance of Water-Heating Equipment

EXAMPLE

For example, a 75,000 Btu/hr tankless unit using 21,915 gal/yr with outlet temperature at 130.0 and inlet temperature at 54.1, replacing a baseline unit with 0.8 thermal efficiency and standby losses of 1008.3 btu/hr:

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[208]

[208] International Energy Conservation Code (IECC)2012/2015

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 - 0.00 132 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 - 0.00 132 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 - 0.00 19 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-V03-160601

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.[209]

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[210].

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[211].

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

---

[209] Aligned with other national energy efficiency programs and confirmed with national vendors

[210] 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)

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

Where:

ΔkWh_{PUMP} = Electric savings from reduced pumping load

HP = Brake horsepower of boiler feed water pump;

= Actual or use 5 HP if unknown[212]

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

= 0.746

Hours = Actual associated boiler feed water pump hours

= 800 hours if unknown[213]

%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%[214]

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[215]

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.

ΔkW = 0

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

[213] 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.

[214] 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

[215] Average lbs-capacity per project site was generated using data collected from existing ozone laundry projects that received incentives under the Non-Residential Retrofit Demand Reduction program (NRR-DR), as well as from the Nicor Custom Incentive Program, and the Nicor Emerging Technology Program (ETP). See referenced document Table 2

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[216]

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

= actual, if unknown use 916,150 lbs laundry[217], approximately equivalent to 13 cycles/day

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[218]

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%[219]

Savings using defaults above:

ΔTherm = $Therm_{Baseline}$ * %hot_water_savings

[216] 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

[217] 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

[218] 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:

[219] 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

= 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

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[220]

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

= actual, if unknown use 916,150 lbs laundry[221], 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%[222]

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

[220] 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

[221] 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

[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

DEEMED O&M COST ADJUSTMENT CALCULATION

Maintenance is required for the following components annually:[223]

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

Maintenance is expected to cost $0.79 / lbs capacity.

REFERENCES

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-VO1-140601

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

4.3.7 Multifamily Central Domestic Hot Water Plants

DESCRIPTION

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

This measure was developed to be applicable to the following program types: TOS, NC, ER.

If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

To qualify the boiler(s) must have a Thermal Efficiency of 88% or greater and supply domestic hot water to multi-family buildings.

DEFINITION OF BASELINE EQUIPMENT

For TOS the baseline boiler is assumed to have a Thermal Efficiency of 80%.[224]

For Early Replacement the savings are calculated between existing unit and efficient unit consumption during the remaining life of the existing unit, and between new baseline unit as above and efficient unit consumption for the remainder of the measure life.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure life for the domestic hot water boilers is 15 years.[225]

DEEMED MEASURE COST

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

Capacity Range	Baseline Installed Cost per kBtuh[226]
<300kBtuh	$65 per kBTUh
300 – 2500 kBtuh	$38 per kBTUh
>2500 kBtuh	$32 per kBTUh

LOADSHAPE

N/A

[224] International Energy Conservation Code (IECC) 2012/2015, Table C404.2, Minimum Performance of Water-Heating Equipment
[225] Nicor Gas Energy Efficiency Plan 2011-2014. Revised Plan Filed Pursuant to Order Docket 10-0562, May 27, 2011.
[226] Baseline install costs are based on data from the W017 Itron California Measure Cost Study, accessed via http://www.energydataweb.com/cpuc/search.aspx. The data is provided in a file named "MCS Results Matrix – Volume I".

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS

There are no anticipated electrical savings from this measure.

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS SAVINGS

Time of Sale:

ΔTherms = Hot Water Savings + Standby Loss Savings

= [(MFHH * #Units * GPD * Days/yr * עWater * (Tout – Tin) * (1/Eff_base – 1/Eff_ee)) / 100,000] + [((SL * Hours/yr * (1/Eff_base – 1/Eff_ee)) / 100,000]

Early Replacment[227]:

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

= [(MFHH * #Units * GPD * Days/yr * עWater * (Tout – Tin) * (1/Eff_exist – 1/Eff_ee)) / 100,000] + [((SL * Hours/yr * (1/Eff_exist – 1/Eff_ee)) / 100,000]

ΔTherms for remaining measure life (next 10 years):

= [(MFHH * #Units * GPD * Days/yr * עWater * (Tout – Tin) * (1/Eff_base – 1/Eff_ee)) / 100,000] + [((SL * Hours/yr * (1/Eff_base – 1/Eff_ee)) / 100,000]

Where:

MFHH = number of people in Multi-Family House Hold

= Actual. If unknown assume 2.1 persons/unit[228]

[227] 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).

[228] Navigant, ComEd PY3 Multi-Family Home Energy Savings Program Evaluation Report Final, May 16, 2012.

#Units	= Number of units served by hot water boiler	
	= Actual	
GPD	= Gallons of hot water used per person per day	
	= Actual. If unknown assume 17.6 gallons per person per day[229]	
Days/yr	= 365.25	
ⱴWater	= Specific Weight of Water	
	= 8.33 gal/lb	
Tout	= tank temperature of hot water	
	= 125°F or custom	
Tin	= Incoming water temperature from well or municiple system	
	= 54°F[230]	
Eff_base	= thermal efficiency of base unit	
	= 80%[231]	
Eff_ee	= thermal efficiency of efficient unit complying with this measure	
	= Actual. If unknown assume 88%	
Eff_exist	= thermal efficiency of existing unit	
	= Actual. If unknown assume 73%[232]	
SL	= Standby Loss[233]	
	= (Input rating / 800) + (110 * √Tank Volume)	
	Input rating	= Name plate input capacity in Btuh
	Tank Volume	= Rated volume of the tank in gallons
Hours / yr	= 8766 hours	

[229] Deoreo, B., and P. Mayer. Residential End Uses of Water Study Update. Forthcoming. ©2015 Water Research Foundation. Reprinted With Permission.
[230] US DOE Building America Program. Building America Analysis Spreadsheet. For Chicago, IL http://www1.eere.energy.gov/buildings/building_america/analysis_spreadsheets.html
[231] IECC 2012/2015, Table C404.2, Minimum Performance of Water-Heating Equipment
[232] Based upon DCEO data provided 10/2014; average age adjusted efficiency of existing units replaced through the program. Efficiency age adjustment of 0.5% per year based upon NREL “Building America Performance Analysis Procedures for Existing Homes”.
[233] Stand-by loss is provided in IECC 2012/2015, Table C404.2, Minimum Performance of Water-Heating Equipment

100,000 = btu/therm

EXAMPLES

Time of Sale:

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

ΔTherms = Hot Water Savings + Standby Loss Savings

= [(MFHH * #Units * GPD * Days/yr * ɣWater * (Tout – Tin) * (1/Eff_base – 1/Eff_ee)) / 100,000] + [((SL * Hours/yr * (1/Eff_base – 1/Eff_ee)) / 100,000]

=[(2.1 * 50 * 17.6 * 8.33 * 365.25 * 1.0 * (125-54) * (1/0.8 – 1/0.88)) / 100000] + [((150000/800 + (110 * √1000)) * 8766 * (1/0.8 – 1/0.88)) / 100000]

= 454 + 37

= 490 therms

Early Replacement:

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

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

=[(2.1 * 50 * 17.6 * 8.33 * 365.25 * 1.0 * (125-54) * (1/0.73 – 1/0.88)) / 100000] + [((150000/800 + (110 * √1000)) * 8766 * (1/0.73 – 1/0.88)) / 100000]

= 932 + 75

= 1007 therms

ΔTherms for remaining measure life (next 10 years):

= 454 + 37 (as above)

= 490 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HW_-MDHW-V02-160601

4.3.8 Controls for Central Domestic Hot Water

DESCRIPTION

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

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

DEFINITION OF EFFICIENT EQUIPMENT

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

DEFINITION OF BASELINE EQUIPMENT

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

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The effective useful life is 15 years[234].

DEEMED MEASURE COST

Incremental Cost: $1,200 [235]

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

[234] Benningfield Group. (2009). *PY 2009 Monitoring Report: Demand Control for Multifamily Central Domestic Hot Water.* Folsom, CA: Prepared for Southern California Gas Company, October 30, 2009.

[235] Gas Technology Institute. (2014). *1003: Demand-based domestic hot water recirculation Public project report.* Des Plaines, IL: Prepared for Nicor Gas, January 7, 2014.

Algorithm

CALCULATION OF ENERGY SAVINGS[236]

ELECTRIC ENERGY SAVINGS

Deemed at 651 kWh[237].

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS SAVINGS

ΔTherms = 55.9[238] * number of dwelling units

EXAMPLE

For example, an apartment building with 53 units:

ΔTherms = 55.9 * 53

= 2,962.7 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HW_-CDHW-V01-150601

[236] See Illinois_Statewide_TRM_Workpaper_Demand Control Central DHW for more details

[237] Based on results from the Nicor Gas Emerging Technology Program study, this value is the average kWh saved per pump. Note this value does not reflect savings from electric units but electrical savings from gas-fired units.

[238] Based on results from the Nicor Gas Emerging Technology Program study, this value is the average therms saved per dwelling unit.

4.3.9 Heat Recovery Grease Trap Filter

DESCRIPTION

A heat recovery grease trap filter combines grease filters and a heat exchanger to recover heat leaving kitchen hoods. As a direct replacement for conventional hood mounted filters in commercial kitchens, they are plumbed to the domestic hot water system to provide preheating energy to incoming water.

This measure was developed to be applicable to the following program types: TOS and RF. If applied to other program types, the measure savings should be verified. For NC projects, this measure may be applicable if code requirements are otherwise satisfied.

DEFINITION OF EFFICIENT EQUIPMENT

Grease filters with heat exchangers carrying domestic hot water in kitchen exhaust air ducts.

DEFINITION OF BASELINE EQUIPMENT

Kitchen exhaust air duct with constant air flow[239] and no heat recovery.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 15 years.[240]

DEEMED MEASURE COST

Full installation costs, including plumbing materials, labor and any associated contols, should be used for screening purposes.

LOADSHAPE

Loadshape C01 - Commercial Electric Cooking

COINCIDENCE FACTOR

Summer Peak Coincidence Factor for measure is provided below for different building type[241]:

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

[239] Savings methodology factors are for a constant speed fan.
[240] Professional judgement, consistent with expected lifetime of kitchen demand ventilation controls and other kitchen equipment.
[241] Minnesota 2012 Technical Reference Manual, Electric Food Service_v03.2.xls, http://mn.gov/commerce/energy/topics/conservation/Design-Resources/Deemed-Savings.jspech

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS

For electric hot water heaters:

ΔkWh = [(Meal/Day * HW/Meal * Days/Year) * lbs/gal * BTU/lb.°F * (ΔT/filter * Qty_Filter) * 0.00293] /($\eta_{HeaterElec}$)

Where:

Meal/Day = Average number of meals served per day. If not directly available, see Table 1.

HW/Meal = Hot water required per meal

= 3 gal/meal[242]

Days/Year = Number of days kitchen operates per year. If not directly available, see Table 1.

Lbs/gal = weight of water

= 8.3 lbs/gal

BTU/lb.°F = Specific heat of water

= 1.0

ΔT/filter = Temperature difference of domestic water across each filter

= 5.8°F/filter[243]

Qty_Filter = Number of heat recovery grease trap filters installed. If not directly available, see Table 1.

Commercial Kitchen Load based on Building Type

Building Type	Meals/Day[244]	Assumed days/Year	Number of Filters[245]
Primary School	400	312	2
Secondary School	600	312	3
Quick Service Restaurant	800	312	5
Full Service Restaurant	780	312	4
Large Hotel	780	356	4
Hospital	800	356	4

$\eta_{HeaterElec}$ = Efficiency of the Electric water heater.

= Actual. If unknown, use the table C404.2 in IECC 2012 (or IECC 2015 if through new

[242] Average dishwashing and faucet water usage taken from Chapter 8, Table 8.3.3 Normalized Annual End Uses of Water in Select Restaurants in Western United States.
[243] Average value based on case studies. Northwinds Sailing, Inc. and North Shore Sustainable Energy, LLC. *Angry Trout Café Kitchen Exhaust Heat Recovery*. Minnesota Department of Commerce, Division of Energy Resources, 2012.
[244] Commercial Kitchen Loads for listed buildings in U.S. Department of Energy Commercial Reference Building Models of the National Building Stock, NREL
[245] Each filter is 20 X 20 inches.

construction) to assume values based on code estimates

SUMMER COINCIDENT PEAK DEMAND SAVINGS

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

Where:

Hours = Hours of operation of kitchen exhaust air fan. If not directly available use:

Building Type	Kitchen Exhaust Fan Annual Operating Hours[246]
Primary School	4,056
Secondary School	4,056
Quick Service Restaurant	5,616
Full Service Restaurant	5,616
Large Hotel	5,340
Hospital	3,916

CF = Summer Peak Coincidence Factor for measure[247]:

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

NATURAL GAS SAVINGS

For natural gas hot water heaters:

$\Delta Therm$ = [(Meal/Day * HW/Meal * Days/Year) * lbs/gal * BTU/lb .°F * (ΔT/filter * Qty_Filter] / ($\eta_{HeaterGas}$ * 100,000)

Where:

$\eta_{HeaterGas}$ = Efficiency of the Gas water heater. If not directly available, use:

= Actual. If unknown, use the table C404.2 in IECC 2012 (or IECC 2015 if through new construction) to assume values based on code estimates

Other variables as above

[246] Exhaust Fan Schedules for listed buildings in U.S. Department of Energy Commercial Reference Building Models of the National Building Stock, NREL

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

WATER AND OTHER NON-ENERGY IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

O&M savings may result from reduced filter and hood cleaning frequencies. More research should be done to understand any potential savings and the associated value.

MEASURE CODE: CI-HW_-GRTF-V01-160601

4.4 HVAC End Use

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

To calculate the updated EFLHs by building type and climate zone provided below, a TAC Subcommittee utilized building energy models originally developed for ComEd[248], applying some adjustments and additions for new building type models and mechanical systems. Based on comparisons with available field data from Navigant[249], the EFLH calculation was finalized by the Subcommittee to be the annual total (heating or cooling) output (in Btu) divided by the 95th percentile hourly peak output (heating or cooling) demand (in Btu/hr). This calculation keeps EFLH independent of modeled systems efficiency (which is utilized in the TRM savings calculation) and buffers EFLH value from hourly variances in the modeling that are not representative of actual buildings. See "EFLH Description 2015-02-11.doc" for further explanation.

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

Building Type	Heating EFLH				
	Zone 1 (Rockford)	Zone 2 (Chicago)	Zone 3 (Springfield)	Zone 4 (Belleville)	Zone 5 (Marion)
Assembly	1,787	1,831	1,635	1,089	1,669
Assisted Living	1,683	1,646	1,446	1,063	1,277
College	1,530	1,430	1,276	709	849
Convenience Store	1,481	1,368	1,214	871	973
Elementary School	1,781	1,736	1,531	1,057	1,283
Garage	985	969	852	680	752
Grocery	1,608	1,602	1,404	876	1,047
Healthcare Clinic	1,579	1,620	1,414	963	1,019
High School	1,845	1,857	1,666	1,187	1,388
Hospital - CAV no econ[250]	1,764	1,818	1,549	1,332	1,512
Hospital - CAV econ[251]	1,788	1,853	1,580	1,369	1,555
Hospital - VAV econ[252]	731	695	522	314	340
Hospital - FCU	1,325	1,512	1,232	1,448	1,946
Hotel/Motel	1,761	1,712	1,544	1,056	1,290
Hotel/Motel - Common	1,601	1,626	1,548	1,260	1,323

[248] A full description of the ComEd model development is found in "ComEd Portfolio Modeling Report. Energy Center of Wisconsin July 30, 2010"
[249] http://www.icc.illinois.gov/downloads/public/edocket/397867.pdf
[250] Based on model with single duct reheat system with a fixed outdoor air volume.
[251] Based on model with single duct reheat system with airside economizer controls, with constant volume zone reheat boxes and single speed fan motors.
[252] Based on model with single duct reheat system with airside economizer controls, zone VAV reheat boxes and VFD fan motors.

Building Type	Heating EFLH				
	Zone 1 (Rockford)	Zone 2 (Chicago)	Zone 3 (Springfield)	Zone 4 (Belleville)	Zone 5 (Marion)
Hotel/Motel - Guest	1,758	1,702	1,521	1,018	1,252
Manufacturing Facility	1,048	1,013	939	567	634
MF - High Rise	1,526	1,506	1,373	1,169	1,172
MF - High Rise - Common	1,815	1,762	1,580	1,089	1,406
MF - High Rise - Residential	1,475	1,464	1,330	1,152	1,123
MF - Mid Rise	1,666	1,685	1,450	1,067	1,216
Movie Theater	1,916	1,905	1,718	1,288	1,538
Office - High Rise - CAV no econ	2,020	2,050	1,869	1,252	1,363
Office - High Rise - CAV econ	2,089	2,132	1,960	1,351	1,487
Office - High Rise - VAV econ	1,528	1,558	1,284	759	846
Office - High Rise - FCU	1,118	1,102	952	505	530
Office - Low Rise	1,428	1,425	1,132	692	793
Office - Mid Rise	1,585	1,587	1,342	855	950
Religious Building	1,603	1,504	1,440	1,054	1,205
Restaurant	1,350	1,354	1,216	920	1,091
Retail - Department Store	1,392	1,278	1,200	781	891
Retail - Strip Mall	1,332	1,233	1,090	751	810
Warehouse	1,456	1,357	1,400	875	1,078
Unknown	1,553	1,539	1,369	982	1,139

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

Building Type	Cooling EFLH				
	Zone 1 (Rockford)	Zone 2 (Chicago)	Zone 3 (Springfield)	Zone 4 (Belleville)	Zone 5 (Marion)
Assembly	725	796	937	1,183	932
Assisted Living	1,475	1,457	1,773	2,110	1,811
College	475	481	662	746	806
Convenience Store	1,088	1,067	1,368	1,541	1,371
Elementary School	725	764	905	1,142	956
Garage	934	974	1,226	1,582	1,383
Grocery	1,033	1,000	1,236	1,499	1,286
Healthcare Clinic	1,282	1,305	1,519	1,767	1,571
High School	675	721	840	1,060	920
Hospital - CAV no econ	4,166	4,275	4,319	4,692	4,445
Hospital - CAV econ	1,751	1,814	2,120	2,411	2,112
Hospital - VAV econ	1,531	1,592	1,853	2,163	1,876
Hospital - FCU	3,245	3,291	3,451	4,128	3,806
Hotel/Motel	1,233	1,186	1,436	1,274	1,616
Hotel/Motel - Common	2,186	2,103	2,344	1,391	2,651
Hotel/Motel - Guest	1,042	1,019	1,269	1,216	1,418
Manufacturing Facility	1,010	1,055	1,209	1,453	1,273
MF - High Rise	921	845	1,048	1,779	1,099
MF - High Rise - Common	914	839	1,055	2,893	1,132
MF - High Rise - Residential	899	831	1,011	1,569	1,055
MF - Mid Rise	809	767	992	1,119	993
Movie Theater	876	745	1,036	1,178	1,010
Office - High Rise - CAV no econ	1,688	1,708	1,811	1,865	1,725
Office - High Rise - CAV econ	1,454	1,452	1,551	1,568	1,416
Office - High Rise - VAV econ	875	919	1,057	1,275	1,077
Office - High Rise - FCU	1,117	1,170	1,277	1,642	1,412
Office - Low Rise	949	1,010	1,182	1,452	1,281
Office - Mid Rise	883	938	1,072	1,286	1,083
Religious Building	861	817	967	1,159	1,067
Restaurant	1,074	1,134	1,279	1,627	1,325

Building Type	Cooling EFLH				
	Zone 1 (Rockford)	Zone 2 (Chicago)	Zone 3 (Springfield)	Zone 4 (Belleville)	Zone 5 (Marion)
Retail - Department Store	949	889	1,124	1,367	1,157
Retail - Strip Mall	950	919	1,149	1,351	1,215
Warehouse	357	338	422	647	533
Unknown	1,215	1,221	1,408	1,670	1,480

4.4.1 Air Conditioner Tune-up

DESCRIPTION

An air conditioning system that is operating as designed saves energy and provides adequate cooling and comfort to the conditioned space

DEFINITION OF EFFICIENT EQUIPMENT

In order for this characterization to apply, the efficient equipment is assumed to be a unitary or split system air conditioner least 3 tons and preapproved by program. The measure requires that a certified technician performs the following items:

- Check refrigerant charge
- Identify and repair leaks if refrigerant charge is low
- Measure and record refrigerant pressures
- Measure and record temperature drop at indoor coil
- Clean condensate drain line
- Clean outdoor coil and straighten fins
- Clean indoor and outdoor fan blades
- Clean indoor coil with spray-on cleaner and straighten fins
- Repair damaged insulation – suction line
- Change air filter
- Measure and record blower amp draw

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

DEFINITION OF BASELINE EQUIPMENT

In order for this characterization to apply, the baseline condition is assumed to be an AC system that 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.[253]

DEEMED MEASURE COST

The incremental capital cost for this measure is $35[254] per ton.

LOADSHAPE

Loadshape C03 - Commercial Cooling

COINCIDENCE FACTOR

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

= 91.3% [255]

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

[253]Ibid.

[254]Ibid.

[255] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility's peak hour is divided by the maximum AC load during the year.

= 47.8% [256]

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

ΔkWH = (kBtu/hr) * [(1/EERbefore) – (1/EERafter)] * EFLH

Where:

kBtu/hr = capacity of the cooling equipment actually installed in kBtu per hour (1 ton of cooling capacity equals 12 kBtu/hr).

=Actual

EERbefore = Energy Efficiency Ratio[257] of the baseline equipment prior to tune-up

=Actual

EERafter = Energy Efficiency Ratio of the baseline equipment after to tune-up

=Actual

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

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW_{SSP} = (kBtu/hr * (1/EERbefore - 1/EERafter)) * CF_{SSP}

ΔkW_{PJM} = (kBtu/hr * (1/ EERbefore - 1/EERafter)) * CF_{PJM}

Where:

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

= 91.3% [258]

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

= 47.8% [259]

NATURAL GAS ENERGY SAVINGS

N/A

[256]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

[257] In the context of this measure Energy Efficiency Ratio (EER) refers to field-measured steady-state rate of heat energy removal (e.g., cooling capacity) by the equipment in Btuh divided by the steady-state rate of energy input to the equipment in watts. This ratio is expressed in Btuh per watt (Btuh/watt). The cooling capacity may be derived using either refrigerant or air-side measurements. The measurement is performed at the outdoor and indoor environmental conditions that are present at the time the tune-up is being performed, and should be normalized using a correction function to the AHRI 210/240 Standard test conditions. The correction function should be developed based on manufacturer's performance data. Care must be taken to ensure the unit is fully loaded and operating at or near steady-state. Generally this requires that the outside air temperature is at least 60°F, and that the unit runs with all stages of cooling enabled for 10 to 15 minutes prior to making measurements

[258] 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.

[259]Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-ACTU-V03-160601

4.4.2 Space Heating Boiler Tune-up

Description

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

Definition of Efficient Equipment

To qualify for this measure the facility must, as applicable, complete the tune-up requirements[260] 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[261]

[260] Act on Energy Commercial Technical Reference Manual No. 2010-4, 9.2.2 Gas Boiler Tune-up
[261] 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[262] 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 =(Capacity * EFLH * (((Effbefore + Ei)/ Effbefore) – 1)) / 100,000

Where:

Capacity = Boiler gas input size (Btu/hr)

= custom

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

Effbefore = Efficiency of the boiler before the tune-up

Note: Contractors should select a mid-level firing rate that appropriately represents the average building operating condition over the course of the heating season and take readings at a consistent firing rate for pre and post tune-up.

Ei = Efficiency Improvement of the boiler tune-up measure

100,000 = Converts Btu to therms

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

EXAMPLE

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

$$\Delta therms = (1{,}050{,}000 * 2050 * ((0.82 + 0.018)/ 0.82 - 1)) /100{,}000$$

$$= 473 \text{ Therms}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-BLRT-V06-160601

4.4.3 Process Boiler Tune-up

Description

This measure is for a non-residential boiler for process loads. For space heating, see measure 4.4.2. The tune-up will improve boiler efficiency by cleaning and/or inspecting burners, combustion chamber, and burner nozzles. Adjust air flow and reduce excessive stack temperatures, adjust burner and gas input. Check venting, safety controls, and adequacy of combustion air intake. Combustion efficiency should be measured before and after tune-up using an electronic flue gas analyzer.

Definition of Efficient Equipment

To qualify for this measure the facility must, as applicable, complete the tune-up requirements[263] 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[264]

[263] Act on Energy Commercial Technical Reference Manual No. 2010-4, 9.2.2 Gas Boiler Tune-up
[264] 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[265] 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%[266] or custom

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

= Actual

Note: Contractors should select a mid-level firing rate that appropriately represents the average building operating condition over the course of the heating season and take readings at a

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

consistent firing rate for pre and post tune-up.

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

= Actual

100 =converstion from kBtu to therms

8766 = hours a year

EXAMPLE

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

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-V05-160601

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[267]

DEEMED MEASURE COST

The cost of this measure is $612[268]

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

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

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

$$\Delta Therms = Binput * SF * EFLH /(100)$$

Where:

Binput = Boiler Input Capacity (kBtu/hr)

= custom

SF = Savings factor

= 8%[269] or custom

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

100 = conversion from kBtu to therms

EXAMPLE

For example, a 800 kBtu/hr boiler at a restaurant in Rockford, IL

$$\Delta Therms = 800 * 0.08 * 1{,}350 / (100)$$

$$= 864 \text{ Therms}$$

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

[269] 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.

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[270]

DEEMED MEASURE COST

The incremental capital cost for a unit heater is $676[271]

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

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

[270] DEER 2008

[271] 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

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 defined by the program.

Definition of Baseline Equipment

In order for this characterization to apply, the baseline equipment is assumed to meet the efficiency requirements within Table 403.2.3(7) of either the 2012 or the 2015 IECC (applicable from 01/01/2016), depending on the IECC in effect on the date of the building permit (if unknown assume IECC 2015).

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 20 years [272].

Deemed Measure Cost

The incremental capital cost for this measure is provided below.

Equipment Type	Size Category	Incremental Cost ($/ton)
Air cooled, electrically operated	All capacities	$127/ton[273]
Water cooled, electrically operated, positive displacement (reciprocating)	All capacities	$22/ton[274]
Water cooled, electrically operated, positive displacement (rotary screw and scroll)	< 150 tons	$351/ton[275]
	>= 150 tons and < 300 tons	$127/ton
	>= 300 tons	$87/ton

Loadshape

Loadshape C03 - Commercial Cooling

[272] 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)

[273] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Cost Values and Summary Documentation", California Public Utilities Commission, December 16, 2008. Calculated as the simple average of screw and reciprocating air-cooled chiller incremental costs from DEER2008. This assumes that baseline shift from IECC 2012 to IECC 2015 carries the same incremental costs. Values should be verified during evaluation

[274] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Cost Values and Summary Documentation"

[275] Incremental costs for water-cooled, electrically operated, positive displacement (rotary screw and scroll) from the W017 Itron California Measure Cost Study, accessed via http://www.energydataweb.com/cpuc/search.aspx. The data is provided in a file named "MCS Results Matrix – Volume I".

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% [276]

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

= 47.8% [277]

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

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[278] = efficiency of high efficiency equipment expressed as Integrated Part Load Value (kW/ton)[279]

= 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 with IPLV of 14 EER (0.86 kW/ton) and baseline EER of 12.5 (0.96 kW/ton) ,in a low-rise office building in Rockford with a building permit dated on 1/1/2015 would save:

ΔkWH = 100 * ((0.96) – (0.86)) * 949

= 9,490 kWh

[276] 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.

[277] 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

[278] 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.

[279] 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/

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%

> For example, a 100 ton air-cooled electrically operated chiller with a full load IPLV of 12 EER (1.0 kW/ton) and a baseline full load IPLV 9.56 EER (1.3 kW/ton) would save:
>
> ΔkW_{SSP} = 100 * ((1.3) – (1.0)) * 0.913
>
> =27 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 relationships 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

2012 IECC Baseline Efficiency Values by Chiller Type and Capacity

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.

2015 IECC Baseline Efficiency Values by Chiller Type and Capacity

TABLE C403.2.3(7)
WATER CHILLING PACKAGES – EFFICIENCY REQUIREMENTS[a, b, d]

EQUIPMENT TYPE	SIZE CATEGORY	UNITS	BEFORE 1/1/2015		AS OF 1/1/2015		TEST PROCEDURE[c]
			Path A	Path B	Path A	Path B	
Air-cooled chillers	< 150 Tons	EER (Btu/W)	≥ 9.562 FL	NA[c]	≥ 10.100 FL	≥ 9.700 FL	AHRI 550/590
			≥ 12.500 IPLV		≥ 13.700 IPLV	≥ 15.800 IPLV	
	≥ 150 Tons		≥ 9.562 FL	NA[c]	≥ 10.100 FL	≥ 9.700 FL	
			≥ 12.500 IPLV		≥ 14.000 IPLV	≥ 16.100 IPLV	
Air cooled without condenser, electrically operated	All capacities	EER (Btu/W)	Air-cooled chillers without condenser shall be rated with matching condensers and complying with air-cooled chiller efficiency requirements.				
Water cooled, electrically operated positive displacement	< 75 Tons	kW/ton	≤ 0.780 FL	≤ 0.800 FL	≤ 0.750 FL	≤ 0.780 FL	
			≤ 0.630 IPLV	≤ 0.600 IPLV	≤ 0.600 IPLV	≤ 0.500 IPLV	
	≥ 75 tons and < 150 tons		≤ 0.775 FL	≤ 0.790 FL	≤ 0.720 FL	≤ 0.750 FL	
			≤ 0.615 IPLV	≤ 0.586 IPLV	≤ 0.560 IPLV	≤ 0.490 IPLV	
	≥ 150 tons and < 300 tons		≤ 0.680 FL	≤ 0.718 FL	≤ 0.660 FL	≤ 0.680 FL	
			≤ 0.580 IPLV	≤ 0.540 IPLV	≤ 0.540 IPLV	≤ 0.440 IPLV	
	≥ 300 tons and < 600 tons		≤ 0.620 FL	≤ 0.639 FL	≤ 0.610 FL	≤ 0.625 FL	
			≤ 0.540 IPLV	≤ 0.490 IPLV	≤ 0.520 IPLV	≤ 0.410 IPLV	
	≥ 600 tons		≤ 0.620 FL	≤ 0.639 FL	≤ 0.560 FL	≤ 0.585 FL	
			≤ 0.540 IPLV	≤ 0.490 IPLV	≤ 0.500 IPLV	≤ 0.380 IPLV	
Water cooled, electrically operated centrifugal	< 150 Tons	kW/ton	≤ 0.634 FL	≤ 0.639 FL	≤ 0.610 FL	≤ 0.695 FL	
			≤ 0.596 IPLV	≤ 0.450 IPLV	≤ 0.550 IPLV	≤ 0.440 IPLV	
	≥ 150 tons and < 300 tons		≤ 0.634 FL	≤ 0.639 FL	≤ 0.610 FL	≤ 0.635 FL	
			≤ 0.596 IPLV	≤ 0.450 IPLV	≤ 0.550 IPLV	≤ 0.400 IPLV	
	≥ 300 tons and < 400 tons		≤ 0.576 FL	≤ 0.600 FL	≤ 0.560 FL	≤ 0.595 FL	
			≤ 0.549 IPLV	≤ 0.400 IPLV	≤ 0.520 IPLV	≤ 0.390 IPLV	
	≥ 400 tons and < 600 tons		≤ 0.576 FL	≤ 0.600 FL	≤ 0.560 FL	≤ 0.585 FL	
			≤ 0.549 IPLV	≤ 0.400 IPLV	≤ 0.500 IPLV	≤ 0.380 IPLV	
	≥ 600 Tons		≤ 0.570 FL	≤ 0.590 FL	≤ 0.560 FL	≤ 0.585 FL	
			≤ 0.539 IPLV	≤ 0.400 IPLV	≤ 0.500 IPLV	≤ 0.380 IPLV	
Air cooled, absorption, single effect	All capacities	COP	≥ 0.600 FL	NA[c]	≥ 0.600 FL	NA[c]	AHRI 560
Water cooled absorption, single effect	All capacities	COP	≥ 0.700 FL	NA[c]	≥ 0.700 FL	NA[c]	
Absorption, double effect, indirect fired	All capacities	COP	≥ 1.000 FL	NA[c]	≥ 1.000 FL	NA[c]	
			≥ 1.050 IPLV		≥ 1.050 IPLV		
Absorption double effect direct fired	All capacities	COP	≥ 1.000 FL	NA[c]	≥ 1.000 FL	NA[c]	
			≥ 1.000 IPLV		≥ 1.050 IPLV		

a. The requirements for centrifugal chiller shall be adjusted for nonstandard rating conditions in accordance with Section C403.2.3.1 and are only applicable for the range of conditions listed in Section C403.2.3.1. The requirements for air-cooled, water-cooled positive displacement and absorption chillers are at standard rating conditions defined in the reference test procedure.

b. Both the full-load and IPLV requirements shall be met or exceeded to comply with this standard. Where there is a Path B, compliance can be with either Path A or Path B for any application.

c. NA means the requirements are not applicable for Path B and only Path A can be used for compliance.

d. FL represents the full-load performance requirements and IPLV the part-load performance requirements.

MEASURE CODE: CI-HVC-CHIL-V04-160601

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:[280]

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

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

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

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

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

DEFINITION OF EFFICIENT EQUIPMENT

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

DEFINITION OF BASELINE EQUIPMENT

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

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure life is assumed to be 9 years.[281]

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.[282]

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% [283]

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

= 47.8% [284]

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:[285]

---

[281] 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

[282] Based on field study conducted by Efficiency Vermont

[283] 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.

[284] 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

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

Btu/H = Size of unit

= Actual. If unknown assume 8500 Btu/hr [286]

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% [287]

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

= 47.8%[288]

Other variable as defined above

[285] 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.

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

[287] 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.

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

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

$$= 0.073\ kW$$

FOSSIL FUEL SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

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[289].

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[290].

Deemed O&M Cost Adjustments

N/A

Loadshape

Loadshape C03 - Commercial Cooling

Coincidence Factor

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

[289] DEER 2008 value for energy management systems

[290] This value was extracted from Smart Ideas projects in PY1 and PY2.

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 and a hotel[291]. 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

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

Motel Electric Energy Savings			
Climate Zone (City based upon)	Heating Source	Baseline	Electric Savings (kWh/Ton)
		No Housekeeping Setback	736
4 (Belleville)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	559
		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	204
		No Housekeeping Setback	345
	PTAC w/ Gas Heating	Housekeeping Setback	121
		No Housekeeping Setback	197
	PTHP	Housekeeping Setback	152
		No Housekeeping Setback	253
	Central Hot Water Fan Coil w/ Electric Resistance Heating	Housekeeping Setback	177
		No Housekeeping Setback	296
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	94
		No Housekeeping Setback	148
2 (Chicago)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	188
		No Housekeeping Setback	342
	PTAC w/ Gas Heating	Housekeeping Setback	119

Hotel Electric Energy Savings			
Climate Zone (City based upon)	**Heating Source**	**Baseline**	**Electric Savings (kWh/Ton)**
		No Housekeeping Setback	195
	PTHP	Housekeeping Setback	145
		No Housekeeping Setback	250
	Central Hot Water Fan Coil w/ Electric Resistance Heating	Housekeeping Setback	161
		No Housekeeping Setback	294
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	92
		No Housekeeping Setback	147
3 (Springfield)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	182
		No Housekeeping Setback	291
	PTAC w/ Gas Heating	Housekeeping Setback	123
		No Housekeeping Setback	197
	PTHP	Housekeeping Setback	145
		No Housekeeping Setback	233
	Central Hot Water Fan Coil w/ Electric Resistance Heating	Housekeeping Setback	153
		No Housekeeping Setback	240
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	94
		No Housekeeping Setback	146
4 (Belleville)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	182
		No Housekeeping Setback	308
	PTAC w/ Gas Heating	Housekeeping Setback	125
		No Housekeeping Setback	199
	PTHP	Housekeeping Setback	146
		No Housekeeping Setback	240
	Central Hot Water Fan Coil w/ Electric Resistance Heating	Housekeeping Setback	152
		No Housekeeping Setback	255
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	95
		No Housekeeping Setback	147
5 (Marion-Williamson)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	171
		No Housekeeping Setback	295
	PTAC w/ Gas Heating	Housekeeping Setback	122
		No Housekeeping Setback	199

Hotel Electric Energy Savings			
Climate Zone (City based upon)	**Heating Source**	**Baseline**	**Electric Savings (kWh/Ton)**
	PTHP	Housekeeping Setback	140
		No Housekeeping Setback	235
	Central Hot Water Fan Coil w/ Electric Resistance Heating	Housekeeping Setback	141
		No Housekeeping Setback	243
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	92
		No Housekeeping Setback	146

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

Motel Coincident Peak Demand Savings			
Climate Zone (City based upon)	Heating Source	Baseline	Coincident Peak Demand Savings (kW/Ton)
		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	0.08
		No Housekeeping Setback	0.11
	PTAC w/ Gas Heating	Housekeeping Setback	0.08
		No Housekeeping Setback	0.11
	PTHP	Housekeeping Setback	0.08
		No Housekeeping Setback	0.11
	Central Hot Water Fan Coil w/ Electric Resistance Heating	Housekeeping Setback	0.05
		No Housekeeping Setback	0.08
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	0.05
		No Housekeeping Setback	0.08
2 (Chicago)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	0.07
		No Housekeeping Setback	0.11
	PTAC w/ Gas Heating	Housekeeping Setback	0.07
		No Housekeeping Setback	0.11
	PTHP	Housekeeping Setback	0.07
		No Housekeeping Setback	0.11
	Central Hot Water Fan Coil w/ Electric Resistance Heating	Housekeeping Setback	0.05
		No Housekeeping Setback	0.07
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	0.05
		No Housekeeping Setback	0.07
3 (Springfield)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	0.08
		No Housekeeping Setback	0.11
	PTAC w/ Gas Heating	Housekeeping Setback	0.08
		No Housekeeping Setback	0.11

Hotel Coincident Peak Demand Savings			
Climate Zone (City based upon)	**Heating Source**	**Baseline**	**Coincident Peak Demand Savings (kW/Ton)**
	PTHP	Housekeeping Setback	0.08
		No Housekeeping Setback	0.11
	Central Hot Water Fan Coil w/ Electric Resistance Heating	Housekeeping Setback	0.05
		No Housekeeping Setback	0.07
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	0.05
		No Housekeeping Setback	0.07
4 (Belleville)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	0.08
		No Housekeeping Setback	0.11
	PTAC w/ Gas Heating	Housekeeping Setback	0.08
		No Housekeeping Setback	0.11
	PTHP	Housekeeping Setback	0.08
		No Housekeeping Setback	0.11
	Central Hot Water Fan Coil w/ Electric Resistance Heating	Housekeeping Setback	0.05
		No Housekeeping Setback	0.08
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	0.05
		No Housekeeping Setback	0.08
5 (Marion-Williamson)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	0.08
		No Housekeeping Setback	0.11
	PTAC w/ Gas Heating	Housekeeping Setback	0.08
		No Housekeeping Setback	0.11
	PTHP	Housekeeping Setback	0.08
		No Housekeeping Setback	0.11
	Central Hot Water Fan Coil w/ Electric Resistance Heating	Housekeeping Setback	0.05
		No Housekeeping Setback	0.08
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	0.05
		No Housekeeping Setback	0.08

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	3.6
		No Housekeeping Setback	6.4
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	3.6
		No Housekeeping Setback	6.4
2 (Chicago)	PTAC w/ Gas Heating	Housekeeping Setback	3.0
		No Housekeeping Setback	6.5
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	3.0
		No Housekeeping Setback	6.5
3 (Springfield)	PTAC w/ Gas Heating	Housekeeping Setback	2.6
		No Housekeeping Setback	4.1
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	2.6
		No Housekeeping Setback	4.1
4 (Belleville)	PTAC w/ Gas Heating	Housekeeping Setback	2.5
		No Housekeeping Setback	4.8
	Central Hot Water Fan Coil	Housekeeping Setback	2.5

Hotel Natural Gas Energy Savings			
Climate Zone (City based upon)	**Heating Source**	**Baseline**	**Gas Savings (Therms/Ton)**
	w/ Gas Heating	No Housekeeping Setback	4.8
5 (Marion-Williamson)	PTAC w/ Gas Heating	Housekeeping Setback	2.1
		No Housekeeping Setback	4.2
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	2.1
		No Housekeeping Setback	4.2

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-GREM-V05-150601

4.4.9 Heat Pump Systems

DESCRIPTION

This measure applies to the installation of high-efficiency air cooled, water source, ground water source, and ground source heat pump systems. This measure could apply to replacing an existing unit at the end of its useful life, or installation of a new unit in a new or existing building.

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

DEFINITION OF EFFICIENT EQUIPMENT

In order for this characterization to apply, the efficient equipment is assumed to be a high-efficiency air cooled, water source, ground water source, or ground source heat pump system that exceeds the energy efficiency requirements of the 2012 or 2015 (applicable from 01/01/2016) International Energy Conservation Code (IECC), depending on the IECC in effect on the date of the building permit (if unknown assume IECC 2015).

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 2012 or 2015 IECC, depending on the IECC in effect on the date of the building permit (if unknown assume IECC 2015). Note the Time of Sale baseline is assumed to be IECC 2015. 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.[292]

DEEMED MEASURE COST

For analysis purposes, the incremental capital cost for this measure is assumed as $100 per ton for air-cooled units.[293] The incremental cost for all other equipment types should be determined on a site-specific basis.

LOADSHAPE

Loadshape C05 - Commercial Electric Heating and Cooling

COINCIDENCE FACTOR

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

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

= 91.3% [294]

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

= 47.8% [295]

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

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

[294] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility's peak hour is divided by the maximum AC load during the year.

[295] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

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

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

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

Annual kWh $Savings_{heat}$ = $(kBtu/hr_{heat})$ * [(1/HSPFbase) – (1/HSPFee)] * $EFLH_{heat}$

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

ΔkWh = 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

SEERbase =Seasonal Energy Efficiency Ratio of the baseline equipment

= SEER from tables below, based on the applicable IECC on the date of the building permit (if unknown assume IECC 2015).

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

= HSPF from tables below, based on the applicable IECC on the date of the building permit (if unknown assume IECC 2015).

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

= Actual installed. If rating is COP, HSPF = COP * 3.413

$EFLH_{heat}$ = heating mode equivalent full load hours are provided in section 4.4 HVAC End Use.

EERbase = Energy Efficiency Ratio of the baseline equipment

= EER from tables below, based on the applicable IECC on the date of the building permit (if unknown assume IECC 2015).. For air-cooled units < 65 kBtu/hr, assume the following conversion from SEER to EER for calculation of peak savings:[296]

$$EER = (-0.02 * SEER^2) + (1.12 * SEER)$$

EERee = Energy Efficiency Ratio of the energy efficient equipment. For air-cooled units < 65 kBtu/hr, if the actual EERee is unknown, assume the conversion from SEER to EER as provided above.

over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year

[296] 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.

	= 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
	= COP from tables below, based on the applicable IECC on the date of the building permit (if unknown assume IECC 2015). If rating is HSPF, COP = HSPF / 3.413
COPee	= coefficient of performance of the energy efficient equipment.
	= Actual installed

Minimum Efficiency Requirements: 2012 IECC

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.

Minimum Efficiency Requirements: 2015 IECC

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]
				Before 1/1/2016	As of 1/1/2016	
Air cooled (cooling mode)	< 65,000 Btu/h[b]	All	Split System	13.0 SEER[c]	14.0 SEER[c]	AHRI 210/240
			Single Package	13.0 SEER[c]	14.0 SEER[c]	
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	
Single-duct high-velocity air cooled	< 65,000 Btu/h[b]	All	Split System	11.0 SEER	11.0 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	11.0 EER 12.0 IEER	AHRI 340/360
		All other	Split System and Single Package	10.8 EER 11.0 IEER	10.8 EER 11.8 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	10.6 EER 11.6 IEER	
		All other	Split System and Single Package	10.4 EER 10.5 IEER	10.4 EER 11.4 IEER	
	≥ 240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	9.5 EER 9.6 IEER	9.5 EER 10.6 IEER	
		All other	Split System and Single Package	9.3 EER 9.4 IEER	9.3 EER 9.4 IEER	
Water to Air: Water Loop (cooling mode)	< 17,000 Btu/h	All	86°F entering water	12.2 EER	12.2 EER	ISO 13256-1
	≥ 17,000 Btu/h and < 65,000 Btu/h	All	86°F entering water	13.0 EER	13.0 EER	
	≥ 65,000 Btu/h and < 135,000 Btu/h	All	86°F entering water	13.0 EER	13.0 EER	
Water to Air: Ground Water (cooling mode)	< 135,000 Btu/h	All	59°F entering water	18.0 EER	18.0 EER	ISO 13256-1
Brine to Air: Ground Loop (cooling mode)	< 135,000 Btu/h	All	77°F entering water	14.1 EER	14.1 EER	ISO 13256-1
Water to Water: WaterLoop (cooling mode)	< 135,000 Btu/h	All	86°F entering water	10.6 EER	10.6 EER	ISO 13256-2
Water to Water: Ground Water (cooling mode)	< 135,000 Btu/h	All	59°F entering water	16.3 EER	16.3 EER	
Brine to Water: Ground Loop (cooling mode)	< 135,000 Btu/h	All	77°F entering fluid	12.1 EER	12.1 EER	

(continued)

TABLE C403.2.3(2)—continued
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]
				Before 1/1/2016	As of 1/1/2016	
Air cooled (heating mode)	< 65,000 Btu/h[b]	—	Split System	7.7 HSPF[c]	8.2 HSPF[c]	AHRI 210/240
		—	Single Package	7.7 HSPF[c]	8.0 HSPF[c]	
Through-the-wall, (air cooled, heating mode)	≤ 30,000 Btu/h[b] (cooling capacity)	—	Split System	7.4 HSPF	7.4 HSPF	
		—	Single Package	7.4 HSPF	7.4 HSPF	
Small-duct high velocity (air cooled, heating mode)	< 65,000 Btu/h[b]	—	Split System	6.8 HSPF	6.8 HSPF	
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	3.3 COP	AHRI 340/360
			17°F db/15°F wb outdoor air	2.25 COP	2.25 COP	
	≥ 135,000 Btu/h (cooling capacity)	—	47°F db/43°F wb outdoor air	3.2 COP	3.2 COP	
			17°F db/15°F wb outdoor air	2.05 COP	2.05 COP	
Water to Air: Water Loop (heating mode)	< 135,000 Btu/h (cooling capacity)	—	68°F entering water	4.3 COP	4.3 COP	ISO 13256-1
Water to Air: Ground Water (heating mode)	< 135,000 Btu/h (cooling capacity)	—	50°F entering water	3.7 COP	3.7 COP	
Brine to Air: Ground Loop (heating mode)	< 135,000 Btu/h (cooling capacity)	—	32°F entering fluid	3.2 COP	3.2 COP	
Water to Water: Water Loop (heating mode)	< 135,000 Btu/h (cooling capacity)	—	68°F entering water	3.7 COP	3.7 COP	ISO 13256-2
Water to Water: Ground Water (heating mode)	< 135,000 Btu/h (cooling capacity)	—	50°F entering water	3.1 COP	3.1 COP	
Brine to Water: Ground Loop (heating mode)	< 135,000 Btu/h (cooling capacity)	—	32°F entering fluid	2.5 COP	2.5 COP	

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

a. Chapter 6 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.

c. Minimum efficiency as of January 1, 2015.

For example a 5 ton cooling unit with 60 kbtu heating, an efficient EER of 14, and an efficient HSPF of 9, at a restaurant in Chicago with a building permit dated before 1/1/2016 saves:

ΔkWh = [(60) * [(1/13) – (1/14)] * 1134] + [(60) * [(1/7.7) – (1/9)] * 1354]

= 1898 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

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

Where CF value is chosen between:

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

= 91.3% [297]

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

= 47.8% [298]

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

ΔkW = [(60) * [(1/13) – (1/14)] *.913

= 0.3

NATURAL GAS ENERGY SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-HPSY-V04-160601

[297] 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.

[298] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year

4.4.10 High Efficiency Boiler

DESCRIPTION

To qualify for this measure the installed equipment must be replacement of an existing boiler at the end of its service life, in a commercial or multifamily space with a high efficiency, gas-fired steam or hot water boiler. High efficiency boilers achieve gas savings through the utilization of a sealed combustion chamber and multiple heat exchangers that remove a significant portion of the waste heat from flue 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[299]	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

[299] 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[300]	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[301]

DEEMED MEASURE COST

The incremental capital cost for this measure depends on efficiency as listed below[302]

Measure Tier	Incr. Cost, per unit
ENERGY STAR® Minimum	$1,470
AFUE 90%	$2,400
AFUE 95%	$3,370
AFUE ≥ 96%	$4,340
Boilers > 300,000 Btu/hr with TE (thermal efficiency) rating	Custom

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

[300] Ibid.

[301] 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

[302] Average of low and high incremental cost based on Nicor Gas program data for non-condensing and condensing boilers. Nicor Gas Energy Efficiency Plan 2011 - 2014, May 27, 2011 $1,470 for ≤ 300,000 Btu/hr for non-condensing hydronic boilers >85% AFUE & $3,365 for condensing boilers > 90% AFUE. The exception is $4,340 for AFUE ≥ 96% AFUE which was obtained from extrapolation above the size range that Nicor Gas Energy Efficiency Plan provided for incremental cost.

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

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

Where:

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

Capacity = Nominal Heating Input Capacity Boiler Size (Btu/hr) for efficient unit not existing unit

= custom Boiler input capacity in Btu/hr

EfficiencyRating(base) = Baseline Boiler Efficiency Rating, dependant on year and boiler type. Baseline efficiency values by boiler type and capacity are found in the Definition of Baseline Equipment Section

EfficiencyRating(actual) = 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 = 2,089* 150,000 * (0.90-0.80)/0.80) / 100,000 Btu/Therm

= 392 Therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-BOIL-V05-150601

4.4.11 High Efficiency Furnace

Description

This measure covers the installation of a high efficiency gas furnace in lieu of a standard efficiency gas furnace in a commercial or industrial space. High efficiency gas furnaces achieve savings through the utilization of a sealed, super insulated combustion chamber, more efficient burners, and multiple heat exchangers that remove a significant portion of the waste heat from the flue gasses. Because multiple heat exchangers are used to remove waste heat from the escaping flue gasses, most of the flue gasses condense and must be drained. Furnaces equipped with ECM fan motors can save additional electric energy

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

Time of sale:

a. The installation of a new high efficiency, gas-fired condensing furnace in a commercial location. This could relate to the replacement of an existing unit at the end of its useful life, or the installation of a new system.

Early replacement:

Early Replacement determination will be based on meeting the following conditions:

- The existing unit is operational when replaced, or
- The existing unit requires minor repairs (<$528)[303].
- All other conditions will be considered Time of Sale.

The Baseline AFUE of the existing unit replaced:

- If the AFUE of the existing unit is known and <=75%, the Baseline AFUE is the actual AFUE value of the unit replaced. If the AFUE is >75%, the Baseline AFUE = 80%.
- If the AFUE of the existing unit is unknown, use assumptions in variable list below (AFUE(exist)).
- If the operational status or repair cost of the existing unit is unknown, use time of sale assumptions.

Definition of Efficient Equipment

To qualify for this measure the installed equipment must be a furnace with input energy less than 225,000 Btu/hr rated natural gas fired furnace with an Annual Fuel Utilization Efficiency (AFUE) rating and fan electrical efficiency exceeding the program requirements:

Definition of Baseline Equipment

Time of Sale: Although the current Federal Standard for gas furnaces is an AFUE rating of 78%, based upon review of available product in the AHRI database, the baseline efficiency for this characterization is assumed to be 80%. The baseline will be adjusted when the Federal Standard is updated.

Early replacement: The baseline for this measure is the efficiency of the existing equipment for the assumed remaining useful life of the unit and a new baseline unit for the remainder of the measure life. As discussed above we estimate that the new baseline unit that could be purchased in the year the existing unit would have needed replacing is 90%

[303] The Technical Advisory Committee agreed that if the cost of repair is less than 20% of the new baseline replacement cost it can be considered early replacement. Note the non-inflated cost is used as this would be a cost consideration in the program year.

DEFINITION OF MEASURE LIFE

The expected measure life is assumed to be 16.5 years[304]

Remaining life of existing equipment is assumed to be 5.5 years[305].

DEEMED MEASURE COST

Time of Sale: The incremental capital cost for this measure depends on efficiency as listed below[306]:

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 $2876[307]. This cost should be discounted to present value using the utilities' discount rate.

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

ΔkWh = Heating Savings + Cooling Savings + Shoulder Season Savings

Where:

Heating Savings = Brushless DC motor or Electronically commutated motor (ECM)

[304] Average of 15-18 year lifetime estimate made by the Consortium for Energy Efficiency in 2010.
[305] Assumed to be one third of effective useful life
[306] 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.
[307] $2641 inflated using 1.91% rate.

= 418 kWh[308]

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[309]

Shoulder Season Savings = Brushless DC motor or electronically commutated motor (ECM) savings during shoulder seasons

= 51 kWh

EXAMPLE

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

ΔkWh = Heating Savings + Cooling Savings + Shoulder Season Savings

= 418 +241 + 51

= 710 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 = (CoolingSavings/HOURSyear) * CF

Where:

HOURSyear = Actual hours per year if known, otherwise use hours from Table below for building type[310].

Building Type	HOURSyear
Assembly	2150
Assisted Living	4373
College	1605
Convenience Store	2084
Elementary School	3276
Garage	2102
Grocery	2096
Healthcare Clinic	1987
High School	3141

[308] 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.

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

[310] Hours per year are estimated using the eQuest models as the total number of hours the cooling system is operating for each building type.

Hospital - VAV econ	2788
Hospital - CAV econ	2881
Hospital - CAV no econ	8760
Hospital - FCU	8729
Manufacturing Facility	2805
MF - High Rise	4237
MF - Mid Rise	2899
Hotel/Motel – Guest	4479
Hotel/Motel - Common	8712
Movie Theater	2120
Office - High Rise - VAV econ	2038
Office - High Rise - CAV econ	4849
Office - High Rise - CAV no econ	5682
Office - High Rise - FCU	3069
Office - Low Rise	2481
Office - Mid Rise	1881
Religious Building	2830
Restaurant	3350
Retail - Department Store	2528
Retail - Strip Mall	2266
Warehouse	770
Unknown	2718

CF =Summer Peak Coincidence Factor for measure is provided below for different building types[311]:

HVAC Pumps	CF
Assembly	48.3%
Assisted Living	52.9%
College	14.2%
Convenience Store	57.1%
Elementary School	33.3%
Garage	61.9%
Grocery	47.5%
Healthcare Clinic	61.9%
High School	28.8%
Hospital - VAV econ	57.6%
Hospital - CAV econ	61.5%
Hospital - CAV no econ	64.8%
Hospital - FCU	60.9%
Manufacturing Facility	43.3%
MF - High Rise - Common	43.7%
MF - Mid Rise	24.3%
Hotel/Motel - Guest	62.9%
Hotel/Motel - Common	64.6%

311 Coincidence Factors are estimated using the eQuest models..

HVAC Pumps	CF
Movie Theater	41.9%
Office - High Rise - VAV econ	43.2%
Office - High Rise - CAV econ	48.3%
Office - High Rise - CAV no econ	50.3%
Office - High Rise - FCU	46.2%
Office - Low Rise	47.4%
Office - Mid Rise	42.8%
Religious Building	43.3%
Restaurant	48.8%
Retail - Department Store	50.5%
Retail - Strip Mall	52.8%
Warehouse	22.5%
Unknown	42.4%

EXAMPLE

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

ΔkW = (241 / 2481) * 0.474

= 0.05 kW

NATURAL GAS ENERGY SAVINGS

Time of Sale:

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

Early replacement[312]:

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

[312] 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).

= Use actual AFUE rating where it is possible to measure or reasonably estimate.

If unknown, assume 64.4 AFUE% [313].

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

Dependent on program type as listed below[314]:

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%[315]

EXAMPLE

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

ΔTherms = 1428 * 150,000 * ((0.92-0.80)/0.80)/ 100,000

= 321 Therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-FRNC-V06-160601

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

[314] 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.

[315] Minimum ENERGY STAR efficiency after 2.1.2012.

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[316]

DEEMED MEASURE COST

The incremental capital cost for this measure is $1716[317]

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

The annual natural gas energy savings from this measure is a deemed value equaling 451 Therms[318]

[316]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

[317]Ibid.

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

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

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. [319]

Remaining life of existing equipment is assumed to be 5 years[320]

DEEMED MEASURE COST

Time of Sale: The incremental capital cost for this equipment is estimated to be $84/ton.[321]

Early Replacement: The measure cost is the full cost of removing the existing unit and installing a new one. The actual program cost should be used. If unknown assume $1,047 per ton[322].

The assumed deferred cost (after 5 years) of replacing existing equipment with new baseline unit is assumed to be $1,039 per ton[323]. This cost should be discounted to present value using the utilities' discount rate.

---

[319] Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, Inc., June 2007
[320] Standard assumption of one third of effective useful life.
[321] DEER 2008. This assumes that baseline shift from IECC 2012 to IECC 2015 carries the same incremental costs. Values should be verified during evaluation
[322] Based on DCEO – IL PHA Efficient Living Program data.
[323] Based on subtracting TOS incremental cost from the DCEO data and incorporating inflation rate of 1.91%.

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% [324]

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

= 47.8% [325]

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[326] = Annual kWh $Savings_{cool}$

PTHP ΔkWh = 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)] * $EFLH_{heat}$

Early Replacement:

ΔkWh for remaining life of existing unit (1st 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)] * $EFLH_{cool}$

---

[324] 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.

[325] 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

[326] 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.

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

Where:

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

= Actual installed

$EFLH_{cool}$ = 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[327]

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

= Based on applicable IECC code on date of building permit (if unknown assume IECC 2015).

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

Equipment Type	IECC 2012 Minimum Efficiency	IECC 2015 Minimum Efficiency
PTAC (Cooling mode) New Construction	13.8 – (0.300 x Cap/1000) EER	14.0 – (0.300 x Cap/1000) EER
PTAC (Cooling mode) Replacements	10.9 – (0.213 x Cap/1000) EER	10.9 – (0.213 x Cap/1000) EER
PTHP (Cooling mode) New Construction	14.0 – (0.300 x Cap/1000) EER	14.0 – (0.300 x Cap/1000) EER
PTHP (Cooling mode) Replacements	10.8 – (0.213 x Cap/1000) EER	10.8 – (0.213 x Cap/1000) EER
PTHP (Heating mode) New Construction	3.2 – (0.026 x Cap/1000) COP	3.2 – (0.026 x Cap/1000) COP
PTHP (Heating mode) Replacements	2.9 – (0.026 x Cap/1000) COP	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 units < 65 kBtu/hr, if the actual EERee is unknown, assume the following conversion from SEER to EER for calculation of peak savings[328]: $EER = (-0.02 * SEER^2) + (1.12 * SEER)$

327 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.

328 Based on Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy

= 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[329] 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

EXAMPLE:

Time of Sale (assuming new construction baseline):

For example a 1 ton PTAC with an efficient EER of 12 at a guest hotel in Rockford with a building permit dated before 1/1/2016 saves:

= [(12) * [(1/10.2) – (1/12)] * 1,042

= 184 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 at a guest hotel in Rockford replaces a PTAC unit (with electric resistance heat) with unknown efficiency.

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

= (12 * (1/8.1 – 1/12) * 1,042) + (12/3.412 * (1/1.0 – 1/3.0) * 1,758)

= 502 + 4,122

= 4,624 kWh

ΔkWh for remaining measure life (next 10 years)

= (12 * (1/8.3 – 1/12) * 1,042) + (12/3.412 * (1/1.0 – 1/3.0) * 1,758)

= 465 + 4,122

= 34,587 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

Time of Sale:

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

Early Replacement:

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

Calculations. Masters Thesis, University of Colorado at Boulder. Note this is appropriate for single speed units only.

[329] 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

ΔkW 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% [330]

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

= 47.8% [331]

EXAMPLE

Time of Sale:

For example a 1 ton replacement cooling unit with no heating with an efficient EER of 12 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 replacing a PTAC unit with unknown efficiency saves:

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 * (1/8.3 – 1/12) * 0.913

= 0.41 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-V07-160601

[330] 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.

[331] 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.[332]

Definition of Baseline Equipment

The base case for savings estimates is a bare pipe. Pipes are required by new construction code to be insulated but are still commonly found uninsulated in older commercial buildings.

Deemed Lifetime of Efficient Equipment

The measure life is assumed to be 15 years.[333]

Deemed Measure Cost

Actual costs should be used if known. Otherwise the deemed measure costs below based on RS Means[334] pricing

---

[332] *ASHRAE Handbook—Fundamentals*, 23.14; Hart, G., "Saving energy by insulating pipe components on steam and hot water distribution systems", *ASHRAE Journal*, October 2011

[333] 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

[334] RS Means 2008. Mechanical Cost Data, pages 106 to 119

reference materials may be used.[335] 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

NATURAL GAS SAVINGS

Δtherms per foot[336] = $[((Q_{base} - Q_{eff}) * EFLH) / (100,000 * \eta Boiler)] * TRF$

= [Modeled or provided by tables below] * TRF

Δtherms = $(L_{sp} + L_{oc,i}) * \Delta$therms per foot

Where:

EFLH = Equivalent Full Load Hours for Heating

= Actual or defaults by building type provided in Section 4.4, HVAC end use

335 RS Means 2010: “for fittings, add 3 linear feet for each fitting plus 4 linear feet for each flange of the fitting”

336 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”

For year round recirculation or domestic hot water:

= 8,766

For heating season recirculation, hours with the outside air temperature below 55°F:

Zone	Hours
Zone 1 (Rockford)	5,039
Zone 2 (Chicago)	4,963
Zone 3 (Springfield)	4,495
Zone 4 (Belleville/	4,021
Zone 5 (Marion)	4,150
Zone 1 (Rockford)	5,039

Q_{base} = Heat Loss from Bare Pipe (Btu/hr/ft)

= Calculated where possible using 3E Plusv4.0 software. For defaults see table below

Q_{eff} = Heat Loss from Insulated Pipe (Btu/hr/ft)

= Calculated where possible using 3E Plusv4.0 software. For defaults 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

= Actual or if unknown use default values given below:

= 81.9% for water boilers [337]

= 80.7% for steam boilers, except multifamily low-pressure [338]

= 64.8% for multifamily low-pressure steam boilers [339]

TRF = Thermal Regain Factor for space type, applied only to space heating energy and is applied to values resulting from Δtherms/ft tables below [340]

= See table below for base TRF values by pipe location

May vary seasonally such as: TRF[summer] * summer hours + TRF[winter] * winter hours where TRF values reflecting summer and winter conditions are apportioned by the hours for those conditions. TRF may also be adjusted by building specific balance temperature and operating hours above and below that balance temperature.[341]

[337] Average efficiencies of units from the California Energy Commission (CEC).
[338] Ibid.
[339] Katrakis, J. and T.S. Zawacki. "Field-Measured Seasonal Efficiency of Intermediate-sized Low-Pressure Steam Boilers". ASHRAE V99, pt. 2, 1993.
[340] 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.
[341] Thermal Regain Factor_4-30-14.docx

Pipe Location	Assumed Regain	TRF, Thermal Regain Factor
Outdoor	0%	1.0
Indoor, heated space	85%	0.15
Indoor, semi- heated, (unconditioned space, with heat transfer to conditioned space. E.g.: boiler room, ceiling plenum, basement, crawlspace, wall)	30%	0.70
Indoor, unheated, (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.[342] 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	

342 3E Plus is a heat loss calculation software provided by the NAIMA (North American Insulation Manufacturer Association).

The pipe fluid temperature assumption used depends upon both the system type and whether there is outdoor reset controls:

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)[343]	75	75	75	75	48.6	48.6	48.6
Wind speed (mph)[344]	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

343 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.
344 Ibid.

	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
Annual Energy Savings							
Boiler / Water Heater efficiency	81.9%	80.7% (64.8% for MF)	80.7%	67%	81.9%	80.7% (64.8% for MF)	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

Values below must be multiplied by the appropriate Thermal Regain Factor (TRF). All variables were the same except for hours of operation in the calculation of the default savings per foot for the various building types and applications as presented in the table below:

Savings Summary for Indoor pipe insulation by System Type and Building Type (Δtherms per foot) (continues for 3.5 pages)

			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	Assembly	1.32	1.36	1.21	0.81	1.24
		Assisted Living	1.25	1.22	1.07	0.79	0.95
		College	1.13	1.06	0.95	0.53	0.63
		Convenience Store	1.10	1.01	0.90	0.65	0.72
		Elementary School	1.32	1.29	1.13	0.78	0.95
		Garage	0.73	0.72	0.63	0.50	0.56
		Grocery	1.19	1.19	1.04	0.65	0.78
		Healthcare Clinic	1.17	1.20	1.05	0.71	0.75
		High School	1.37	1.38	1.23	0.88	1.03
		Hospital - CAV no econ	1.31	1.35	1.15	0.99	1.12
		Hospital - CAV econ	1.33	1.37	1.17	1.01	1.15
		Hospital - VAV econ	0.54	0.51	0.39	0.23	0.25
		Hospital - FCU	0.98	1.12	0.91	1.07	1.44
		Hotel/Motel	1.31	1.27	1.14	0.78	0.96
		Hotel/Motel - Common	1.19	1.21	1.15	0.93	0.98
		Hotel/Motel - Guest	1.30	1.26	1.13	0.75	0.93
		Manufacturing Facility	0.78	0.75	0.70	0.42	0.47
		MF - High Rise	1.13	1.12	1.02	0.87	0.87
		MF - High Rise - Common	1.35	1.31	1.17	0.81	1.04
		MF - High Rise - Residential	1.09	1.08	0.99	0.85	0.83
		MF - Mid Rise	1.23	1.25	1.07	0.79	0.90
		Movie Theater	1.35	1.33	1.24	0.94	1.12
		Office - High Rise - CAV no econ	1.50	1.52	1.38	0.93	1.01
		Office - High Rise - CAV econ	1.55	1.58	1.45	1.00	1.10
		Office - High Rise - VAV econ	1.13	1.15	0.95	0.56	0.63
		Office - High Rise - FCU	0.83	0.82	0.71	0.37	0.39

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)
		Office - Low Rise	1.06	1.06	0.84	0.51	0.59
		Office - Mid Rise	1.17	1.18	0.99	0.63	0.70
		Religious Building	1.19	1.11	1.07	0.78	0.89
		Restaurant	1.00	1.00	0.90	0.68	0.81
		Retail - Department Store	1.03	0.95	0.89	0.58	0.66
		Retail - Strip Mall	0.99	0.91	0.81	0.56	0.60
		Warehouse	1.08	1.01	1.04	0.65	0.80
		Unknown	1.15	1.14	1.01	0.73	0.84
	Hot Water Space Heating without outdoor reset – non-recirculation	Assembly	1.96	2.00	1.79	1.19	1.83
		Assisted Living	1.84	1.80	1.58	1.16	1.40
		College	1.67	1.56	1.40	0.78	0.93
		Convenience Store	1.62	1.50	1.33	0.95	1.06
		Elementary School	1.95	1.90	1.68	1.16	1.40
		Garage	1.08	1.06	0.93	0.74	0.82
		Grocery	1.76	1.75	1.54	0.96	1.15
		Healthcare Clinic	1.73	1.77	1.55	1.05	1.11
		High School	2.02	2.03	1.82	1.30	1.52
		Hospital - CAV no econ	1.93	1.99	1.69	1.46	1.65
		Hospital - CAV econ	1.96	2.03	1.73	1.50	1.70
		Hospital - VAV econ	0.80	0.76	0.57	0.34	0.37
		Hospital - FCU	1.45	1.65	1.35	1.58	2.13
		Hotel/Motel	1.93	1.87	1.69	1.16	1.41
		Hotel/Motel - Common	1.75	1.78	1.69	1.38	1.45
		Hotel/Motel - Guest	1.92	1.86	1.66	1.11	1.37
		Manufacturing Facility	1.15	1.11	1.03	0.62	0.69
		MF - High Rise	1.67	1.65	1.50	1.28	1.28
		MF - High Rise - Common	1.99	1.93	1.73	1.19	1.54
		MF - High Rise - Residential	1.61	1.60	1.46	1.26	1.23
		MF - Mid Rise	1.82	1.84	1.59	1.17	1.33

			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)
		Movie Theater	1.99	1.96	1.83	1.39	1.66
		Office - High Rise - CAV no econ	2.21	2.24	2.04	1.37	1.49
		Office - High Rise - CAV econ	2.29	2.33	2.14	1.48	1.63
		Office - High Rise - VAV econ	1.67	1.70	1.40	0.83	0.93
		Office - High Rise - FCU	1.22	1.21	1.04	0.55	0.58
		Office - Low Rise	1.56	1.56	1.24	0.76	0.87
		Office - Mid Rise	1.73	1.74	1.47	0.94	1.04
		Religious Building	1.75	1.65	1.58	1.15	1.32
		Restaurant	1.48	1.48	1.33	1.01	1.19
		Retail - Department Store	1.52	1.40	1.31	0.85	0.97
		Retail - Strip Mall	1.46	1.35	1.19	0.82	0.89
		Warehouse	1.59	1.49	1.53	0.96	1.18
		Unknown	1.70	1.68	1.50	1.07	1.25
	Hot Water with outdoor reset	All buildings, Recirculation heating season only (Hours below 55F)	3.73	3.68	3.33	2.98	3.08
	Hot Water w/o outdoor reset	All buildings, Recirculation heating season only (Hours below 55F)	5.51	5.43	4.92	4.40	4.54
	Hot Water with outdoor reset	All buildings, Recirculation year round (All hours)	4.79	4.79	4.79	4.79	4.79
	Hot Water w/o outdoor reset	All buildings, Recirculation year round (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	Assembly	4.25	4.36	3.89	2.59	3.97
		Assisted Living	4.01	3.92	3.44	2.53	3.04
		College	3.64	3.40	3.04	1.69	2.02
		Convenience Store	3.52	3.26	2.89	2.07	2.32
		Elementary School	4.24	4.13	3.64	2.52	3.05
		Garage	2.34	2.31	2.03	1.62	1.79
		Grocery	3.83	3.81	3.34	2.08	2.49
		Healthcare Clinic	3.76	3.85	3.36	2.29	2.42
		High School	4.39	4.42	3.96	2.82	3.30

			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)**
		Hospital - CAV no econ	4.20	4.33	3.69	3.17	3.60
		Hospital - CAV econ	4.25	4.41	3.76	3.26	3.70
		Hospital - VAV econ	1.74	1.65	1.24	0.75	0.81
		Hospital - FCU	3.15	3.60	2.93	3.44	4.63
		Hotel/Motel	4.19	4.07	3.67	2.51	3.07
		Hotel/Motel - Common	3.81	3.87	3.68	3.00	3.15
		Hotel/Motel - Guest	4.18	4.05	3.62	2.42	2.98
		Manufacturing Facility	2.49	2.41	2.23	1.35	1.51
		MF - High Rise	4.52	4.46	4.07	3.46	3.47
		MF - High Rise - Common	5.38	5.22	4.68	3.23	4.17
		MF - High Rise - Residential	4.37	4.34	3.94	3.41	3.33
		MF - Mid Rise	4.94	4.99	4.30	3.16	3.60
		Movie Theater	4.33	4.26	3.98	3.03	3.61
		Office - High Rise - CAV no econ	4.81	4.88	4.45	2.98	3.24
		Office - High Rise - CAV econ	4.97	5.07	4.66	3.21	3.54
		Office - High Rise - VAV econ	3.64	3.71	3.06	1.81	2.01
		Office - High Rise - FCU	2.66	2.62	2.27	1.20	1.26
		Office - Low Rise	3.40	3.39	2.69	1.65	1.89
		Office - Mid Rise	3.77	3.78	3.19	2.03	2.26
		Religious Building	3.82	3.58	3.43	2.51	2.87
		Restaurant	3.21	3.22	2.89	2.19	2.60
		Retail - Department Store	3.31	3.04	2.86	1.86	2.12
		Retail - Strip Mall	3.17	2.94	2.59	1.79	1.93
		Warehouse	3.46	3.23	3.33	2.08	2.56
		Unknown	3.70	3.66	3.26	2.34	2.71
	LP Steam	All buildings, Recirculation heating season only (Hours below 55F)	11.99	11.81	10.70	9.57	9.88
	LP Steam	All buildings, Recirculation year round (All hours)	20.84	20.84	20.84	20.84	20.84
	HP Steam – non-	Assembly	8.02	8.22	7.34	4.89	7.49

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)
	recirculation	Assisted Living	7.56	7.39	6.49	4.77	5.73
		College	6.87	6.42	5.73	3.18	3.81
		Convenience Store	6.65	6.14	5.45	3.91	4.37
		Elementary School	8.00	7.79	6.87	4.75	5.76
		Garage	4.42	4.35	3.82	3.05	3.38
		Grocery	7.22	7.19	6.30	3.93	4.70
		Healthcare Clinic	7.09	7.27	6.35	4.32	4.57
		High School	8.28	8.34	7.48	5.33	6.23
		Hospital - CAV no econ	7.92	8.16	6.95	5.98	6.79
		Hospital - CAV econ	8.03	8.32	7.09	6.14	6.98
		Hospital - VAV econ	3.28	3.12	2.35	1.41	1.53
		Hospital - FCU	5.95	6.79	5.53	6.50	8.73
		Hotel/Motel	7.91	7.69	6.93	4.74	5.79
		Hotel/Motel - Common	7.18	7.30	6.95	5.65	5.94
		Hotel/Motel - Guest	7.89	7.64	6.83	4.57	5.62
		Manufacturing Facility	4.70	4.55	4.22	2.55	2.84
		MF - High Rise	6.85	6.76	6.16	5.25	5.26
		MF - High Rise - Common	8.15	7.91	7.09	4.89	6.31
		MF - High Rise - Residential	6.62	6.57	5.97	5.17	5.04
		MF - Mid Rise	7.48	7.57	6.51	4.79	5.46
		Movie Theater	8.16	8.04	7.52	5.71	6.80
		Office - High Rise - CAV no econ	9.07	9.20	8.39	5.62	6.12
		Office - High Rise - CAV econ	9.38	9.57	8.80	6.06	6.67
		Office - High Rise - VAV econ	6.86	6.99	5.76	3.41	3.80
		Office - High Rise - FCU	5.02	4.95	4.27	2.27	2.38
		Office - Low Rise	6.41	6.40	5.08	3.11	3.56
		Office - Mid Rise	7.12	7.12	6.03	3.84	4.27
		Religious Building	7.20	6.75	6.46	4.73	5.41
		Restaurant	6.06	6.08	5.46	4.13	4.90

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)
		Retail - Department Store	6.25	5.74	5.39	3.51	4.00
		Retail - Strip Mall	5.98	5.54	4.89	3.37	3.63
		Warehouse	6.53	6.09	6.29	3.93	4.84
		Unknown	6.97	6.91	6.14	4.41	5.11
	HP Steam	All buildings, Recirculation heating season only (Hours below 55F)	22.62	22.28	20.18	18.05	18.63
	HP Steam	All buildings, Recirculation year round (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 3.5 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)	Zone 2 (Chicago)	Zone 3 (Springfield)	Zone 4 (Belleville)	Zone 5 (Marion)
Outdoor	Hot Water Space Heating with outdoor reset – non-recirculation	Assembly	7.58	7.77	6.94	4.62	7.08
		Assisted Living	7.14	6.98	6.13	4.51	5.42
		College	6.49	6.07	5.41	3.01	3.60
		Convenience Store	6.28	5.80	5.15	3.70	4.13
		Elementary School	7.56	7.36	6.50	4.49	5.44
		Garage	4.18	4.11	3.61	2.88	3.19
		Grocery	6.82	6.80	5.96	3.72	4.44
		Healthcare Clinic	6.70	6.87	6.00	4.09	4.32
		High School	7.83	7.88	7.07	5.03	5.89
		Hospital - CAV no econ	7.49	7.71	6.57	5.65	6.41
		Hospital - CAV econ	7.59	7.86	6.70	5.81	6.60
		Hospital - VAV econ	3.10	2.95	2.22	1.33	1.44
		Hospital - FCU	5.62	6.42	5.23	6.14	8.26
		Hotel/Motel	7.47	7.26	6.55	4.48	5.47
		Hotel/Motel - Common	6.79	6.90	6.57	5.34	5.61

			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)**
		Hotel/Motel - Guest	7.46	7.22	6.45	4.32	5.31
		Manufacturing Facility	4.45	4.30	3.98	2.41	2.69
		MF - High Rise	6.48	6.39	5.83	4.96	4.97
		MF - High Rise - Common	7.70	7.48	6.70	4.62	5.96
		MF - High Rise - Residential	6.26	6.21	5.64	4.89	4.77
		MF - Mid Rise	7.07	7.15	6.15	4.53	5.16
		Movie Theater	7.71	7.60	7.10	5.40	6.43
		Office - High Rise - CAV no econ	8.57	8.70	7.93	5.31	5.78
		Office - High Rise - CAV econ	8.86	9.04	8.32	5.73	6.31
		Office - High Rise - VAV econ	6.48	6.61	5.45	3.22	3.59
		Office - High Rise - FCU	4.75	4.67	4.04	2.14	2.25
		Office - Low Rise	6.06	6.05	4.80	2.94	3.36
		Office - Mid Rise	6.73	6.73	5.70	3.63	4.03
		Religious Building	6.80	6.38	6.11	4.47	5.11
		Restaurant	5.73	5.75	5.16	3.90	4.63
		Retail - Department Store	5.91	5.42	5.09	3.31	3.78
		Retail - Strip Mall	5.65	5.23	4.62	3.19	3.44
		Warehouse	6.18	5.76	5.94	3.71	4.57
		Unknown	6.59	6.53	5.81	4.17	4.83
	Hot Water Space Heating without outdoor reset – non-recirculation	Assembly	9.59	9.83	8.77	5.85	8.96
		Assisted Living	9.04	8.83	7.76	5.70	6.86
		College	8.21	7.68	6.85	3.80	4.56
		Convenience Store	7.95	7.34	6.52	4.68	5.22
		Elementary School	9.56	9.32	8.22	5.68	6.89
		Garage	5.28	5.20	4.57	3.65	4.04
		Grocery	8.63	8.60	7.54	4.70	5.62
		Healthcare Clinic	8.47	8.70	7.59	5.17	5.47
		High School	9.90	9.97	8.94	6.37	7.45
		Hospital - CAV no econ	9.47	9.76	8.31	7.15	8.11
		Hospital - CAV econ	9.60	9.95	8.48	7.35	8.34

			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)
		Hospital - VAV econ	3.93	3.73	2.80	1.68	1.82
		Hospital - FCU	7.11	8.12	6.61	7.77	10.45
		Hotel/Motel	9.45	9.19	8.29	5.67	6.92
		Hotel/Motel - Common	8.59	8.73	8.31	6.76	7.10
		Hotel/Motel - Guest	9.44	9.13	8.16	5.47	6.72
		Manufacturing Facility	5.63	5.44	5.04	3.05	3.40
		MF - High Rise	8.19	8.08	7.37	6.27	6.29
		MF - High Rise - Common	9.74	9.46	8.48	5.85	7.54
		MF - High Rise - Residential	7.92	7.86	7.14	6.18	6.03
		MF - Mid Rise	8.94	9.05	7.78	5.73	6.53
		Movie Theater	9.76	9.61	8.99	6.83	8.14
		Office - High Rise - CAV no econ	10.84	11.01	10.03	6.72	7.32
		Office - High Rise - CAV econ	11.21	11.44	10.52	7.25	7.98
		Office - High Rise - VAV econ	8.20	8.36	6.89	4.07	4.54
		Office - High Rise - FCU	6.00	5.91	5.11	2.71	2.84
		Office - Low Rise	7.67	7.65	6.08	3.72	4.25
		Office - Mid Rise	8.51	8.52	7.21	4.59	5.10
		Religious Building	8.61	8.07	7.73	5.66	6.47
		Restaurant	7.25	7.27	6.53	4.94	5.85
		Retail - Department Store	7.47	6.86	6.44	4.19	4.78
		Retail - Strip Mall	7.15	6.62	5.85	4.03	4.35
		Warehouse	7.81	7.29	7.52	4.69	5.78
		Unknown	8.34	8.26	7.35	5.27	6.11
	Hot Water with outdoor reset	All buildings, Recirculation heating season only (Hours below 55F)	21.38	21.06	19.07	17.06	17.61
	Hot Water without outdoor reset	All buildings, Recirculation heating season only (Hours below 55F)	27.05	26.64	24.13	21.58	22.28
	Hot Water with outdoor reset	All buildings, Recirculation year round (All hours)	31.30	31.30	31.30	31.30	31.30
	Hot Water without outdoor reset	All buildings, Recirculation year round (All hours)	47.02	47.02	47.02	47.02	47.02
	LP Steam – non-	Assembly	15.01	15.38	13.73	9.15	14.02

			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)
	recirculation	Assisted Living	14.14	13.82	12.15	8.93	10.73
		College	12.85	12.01	10.72	5.95	7.13
		Convenience Store	12.44	11.49	10.20	7.32	8.17
		Elementary School	14.96	14.58	12.86	8.88	10.78
		Garage	8.27	8.14	7.15	5.71	6.32
		Grocery	13.51	13.46	11.80	7.36	8.79
		Healthcare Clinic	13.26	13.61	11.88	8.09	8.56
		High School	15.50	15.60	13.99	9.97	11.66
		Hospital - CAV no econ	14.82	15.27	13.01	11.19	12.70
		Hospital - CAV econ	15.02	15.57	13.27	11.50	13.06
		Hospital - VAV econ	6.14	5.84	4.39	2.64	2.85
		Hospital - FCU	11.13	12.71	10.35	12.16	16.35
		Hotel/Motel	14.80	14.38	12.97	8.87	10.84
		Hotel/Motel - Common	13.45	13.66	13.00	10.58	11.12
		Hotel/Motel - Guest	14.77	14.29	12.78	8.56	10.52
		Manufacturing Facility	8.80	8.51	7.89	4.77	5.32
		MF - High Rise	15.97	15.76	14.37	12.23	12.26
		MF - High Rise - Common	18.99	18.44	16.53	11.39	14.71
		MF - High Rise - Residential	15.43	15.31	13.92	12.05	11.75
		MF - Mid Rise	17.43	17.63	15.17	11.16	12.72
		Movie Theater	15.27	15.05	14.07	10.69	12.73
		Office - High Rise - CAV no econ	16.97	17.22	15.70	10.51	11.45
		Office - High Rise - CAV econ	17.55	17.91	16.47	11.35	12.49
		Office - High Rise - VAV econ	12.83	13.09	10.79	6.37	7.11
		Office - High Rise - FCU	9.40	9.26	8.00	4.25	4.45
		Office - Low Rise	12.00	11.97	9.51	5.82	6.66
		Office - Mid Rise	13.32	13.33	11.28	7.18	7.98
		Religious Building	13.47	12.64	12.10	8.86	10.13
		Restaurant	11.34	11.38	10.21	7.73	9.16
		Retail - Department Store	11.69	10.74	10.08	6.56	7.48

			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)**
		Retail - Strip Mall	11.19	10.36	9.15	6.31	6.80
		Warehouse	12.23	11.40	11.77	7.35	9.05
		Unknown	13.05	12.93	11.50	8.25	9.57
	LP Steam	All buildings, Recirculation heating season only (Hours below 55F)	42.33	41.69	37.76	33.78	34.86
	LP Steam	All buildings, Recirculation year round (All hours)	73.59	73.59	73.59	73.59	73.59
	HP Steam – non-recirculation	Assembly	23.24	23.81	21.26	14.16	21.70
		Assisted Living	21.89	21.40	18.80	13.82	16.61
		College	19.90	18.60	16.60	9.22	11.04
		Convenience Store	19.26	17.79	15.79	11.33	12.65
		Elementary School	23.16	22.57	19.91	13.75	16.69
		Garage	12.80	12.60	11.08	8.84	9.78
		Grocery	20.91	20.83	18.26	11.39	13.61
		Healthcare Clinic	20.53	21.07	18.39	12.53	13.25
		High School	23.99	24.15	21.66	15.43	18.05
		Hospital - CAV no econ	22.94	23.64	20.14	17.32	19.66
		Hospital - CAV econ	23.25	24.10	20.54	17.80	20.22
		Hospital - VAV econ	9.51	9.03	6.79	4.08	4.42
		Hospital - FCU	17.24	19.67	16.02	18.82	25.31
		Hotel/Motel	22.90	22.27	20.08	13.74	16.77
		Hotel/Motel - Common	20.81	21.15	20.13	16.38	17.21
		Hotel/Motel - Guest	22.87	22.13	19.78	13.24	16.28
		Manufacturing Facility	13.63	13.18	12.21	7.38	8.24
		MF - High Rise	19.85	19.59	17.86	15.20	15.24
		MF - High Rise - Common	23.60	22.92	20.55	14.16	18.28
		MF - High Rise - Residential	19.18	19.03	17.30	14.98	14.61
		MF - Mid Rise	21.67	21.92	18.86	13.87	15.81
		Movie Theater	23.64	23.29	21.78	16.55	19.71
		Office - High Rise - CAV no econ	26.27	26.66	24.30	16.28	17.73
		Office - High Rise - CAV econ	27.16	27.72	25.49	17.57	19.33

			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)
		Office - High Rise - VAV econ	19.87	20.26	16.70	9.87	11.00
		Office - High Rise - FCU	14.54	14.33	12.38	6.57	6.89
		Office - Low Rise	18.58	18.53	14.72	9.00	10.31
		Office - Mid Rise	20.61	20.64	17.46	11.12	12.36
		Religious Building	20.85	19.56	18.72	13.71	15.67
		Restaurant	17.55	17.61	15.81	11.96	14.18
		Retail - Department Store	18.10	16.63	15.61	10.16	11.58
		Retail - Strip Mall	17.32	16.04	14.17	9.77	10.53
		Warehouse	18.93	17.65	18.21	11.37	14.02
		Unknown	20.20	20.01	17.80	12.77	14.81
	HP Steam	All buildings, Recirculation heating season only (Hours below 55F)	65.53	64.54	58.45	52.29	53.97
	HP Steam	All buildings, Recirculation year round (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[345]	Straight Tee[346]
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

[345] Based on the dimensions for diameter, long radius, and short radius given by ANSI/ASME 36.19

[346] Based on the center to face and diameter dimensions given by ANSI/ASME B36.19

Nominal Pipe Diameter	Calculated Surface Area (ft)	
	90 Degree Elbow[345]	Straight Tee[346]
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.

Calculated Surface Areas of Flanges and Valves

Valves				
Class (psi)	150	300	600	900
NPS (in)	ft^2	ft^2	ft^2	ft^2
1	0.69	1.8	1.8	2.4
2	2.21	2.94	2.94	5.2
2.5	2.97	3.51	3.91	6.6
3	3.37	4.39	4.69	6.5
4	4.68	6.06	7.64	9.37
6	7.03	9.71	13.03	15.8
8	10.3	13.5	18.4	23.8
10	13.8	18	26.5	32.1

Flanges				
Class (psi)	150	300	600	900
NPS (in)	ft^2	ft^2	ft^2	ft^2
1	0.36	0.36	0.4	1.23
2	0.71	0.84	0.88	1.54
3	1.06	1.32	1.36	1.85
4	1.44	1.83	2.23	2.64
6	2.04	2.72	3.6	4.37
8	2.92	3.74	4.89	6.4
10	3.68	4.8	6.93	8.47

Valves				
12	16.1	24.1	31.9	41.9

Flanges				
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-V04-160601

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 2012 or 2015 (applicable from 01/01/2016) International Energy Conservation Code (IECC), depending on the IECC in effect on the date of the building permit (if unknown assume IECC 2015).

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 2012 or 2015 IECC, depending on the IECC in effect on the date of the building permit (if unknown assume IECC 2015). For Time of Sale programs assume IECC 2015 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.[347]

DEEMED MEASURE COST

The incremental capital cost for this measure is assumed to be $100 per ton.[348]

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% [349]

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

[347] Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, Inc., June 2007.
[348] Based on a review of TRM incremental cost assumptions from Vermont, Wisconsin, and California. This assumes that baseline shift from IECC 2012 to IECC 2015 carries the same incremental costs. Values should be verified during evaluation
[349] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility's peak hour is divided by the maximum AC load during the year.

= 47.8% [350]

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

= SEER values from tables below, based on applicable IECC on date of building permit (if unknown assume IECC 2015).

SEERee = Seasonal Energy Efficiency Ratio of the energy efficient equipment (actually installed)

EERbase = Energy Efficiency Ratio of the baseline equipment

= EER values from tables below, based on applicable IECC on date of the building permit (if unknown assume IECC 2015). (For air-cooled units < 65 kBtu/hr, assume the following conversion from SEER to EER for calculation of peak savings:[351] $EER = (-0.02 * SEER^2) + (1.12 * SEER)$)

EERee = Energy Efficiency Ratio of the energy efficient equipment. For air-cooled units < 65 kBtu/hr, if the actual EERee is unknown, assume the conversion from SEER to EER for calculation of peak savings as above).

= Actual installed

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

[350] 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

[351] 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.

2012 IECC Minimum Efficiency Requirements

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.

2015 IECC Minimum Efficiency Requirements

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 1/1/2016	As of 1/1/2016	
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	14.0 SEER[c]	
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	11.0 SEER	11.0 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 12.8 IEER	AHRI 340/360
		All other	Split System and Single Package	11.0 EER 11.2 IEER	11.0 EER 12.6 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 12.4 IEER	
		All other	Split System and Single Package	10.8 EER 11.0 IEER	10.8 EER 12.2 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 11.6 IEER	
		All other	Split System and Single Package	9.8 EER 9.9 IEER	9.8 EER 11.4 IEER	
	≥ 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	9.7 EER 9.8 IEER	9.7 EER 11.2 IEER	
		All other	Split System and Single Package	9.5 EER 9.6 IEER	9.5 EER 11.0 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	12.1 EER 12.3 IEER	12.1 EER 13.9 IEER	AHRI 340/360
		All other	Split System and Single Package	11.9 EER 12.1 IEER	11.9 EER 13.7 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	12.5 EER 12.5 IEER	12.5 EER 13.9 IEER	
		All other	Split System and Single Package	12.3 EER 12.5 IEER	12.3 EER 13.7 IEER	
	≥ 240,000 Btu/h and < 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	12.4 EER 12.6 IEER	12.4 EER 13.6 IEER	
		All other	Split System and Single Package	12.2 EER 12.4 IEER	12.2 EER 13.4 IEER	
	≥ 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	12.2 EER 12.4 IEER	12.2 EER 13.5 IEER	
		All other	Split System and Single Package	12.0 EER 12.2 IEER	12.0 EER 13.3 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 1/1/2016	As of 1/1/2016	
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	12.1 EER 12.3 IEER	12.1 EER 12.3 IEER	AHRI 340/360
		All other	Split System and Single Package	11.9 EER 12.1 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	12.0 EER 12.2 IEER	12.0 EER 12.2 IEER	
		All other	Split System and Single Package	11.8 EER 12.0 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	11.9 EER 12.1 IEER	11.9 EER 12.1 IEER	
		All other	Split System and Single Package	11.7 EER 11.9 IEER	11.7 EER 11.9 IEER	
	≥ 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.7 EER 11.9 IEER	11.7 EER 11.9 IEER	
		All other	Split System and Single Package	11.5 EER 11.7 IEER	11.5 EER 11.7 IEER	
Condensing units, air cooled	≥ 135,000 Btu/h			10.5 EER 11.8 IEER	10.5 EER 11.8 IEER	AHRI 365
Condensing units, water cooled	≥ 135,000 Btu/h			13.5 EER 14.0 IEER	13.5 EER 14.0 IEER	
Condensing units, evaporatively cooled	≥ 135,000 Btu/h			13.5 EER 14.0 IEER	13.5 EER 14.0 IEER	

For SI: 1 British thermal unit per hour = 0.2931 W.
a. Chapter 6 contains a complete specification of the referenced test procedure, including the 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.
c. Minimum efficiency as of January 1, 2015.

For example a 5 ton air cooled split system with a SEER of 15 at a retail strip mall in Rockford would save:

$\Delta kWH = (60) * [(1/13) – (1/15)] * 950$

$= 585$ kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$\Delta kW_{SSP} = (kBtu/hr * (1/EERbase - 1/EERee)) * CF_{SSP}$

$\Delta kW_{PJM} = (kBtu/hr * (1/EERbase - 1/EERee)) * CF_{PJM}$

Where:

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

= 91.3% [352]

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

= 47.8% [353]

[352] 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.

[353] 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 5 ton air cooled split system with a SEER of 15 in Rockford would save:

$$\Delta kW_{SSP} = (60) * [(1/13) – (1/15)] * .913$$

$$= 0.562 \text{ kW}$$

NATURAL GAS ENERGY SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

MEASURE CODE: CI-HVC-SPUA-V04-160601

4.4.16 Steam Trap Replacement or Repair

Description

The measure is for the repair or replacement of faulty steam traps that are allowing excess steam to escape and thereby increasing steam generation. The measure is applicable to commercial applications, commercial HVAC (low pressure steam) including multifamily buildings, low pressure industrial applications, medium pressure industrial applications, applications and high pressure industrial applications.

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[354]

Deemed Measure Cost

Steam System	Cost per trap[355] ($)
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

[354]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.

[355] Ibid.

Steam System	Cost per trap[355] ($)
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

ELECTRIC ENERGY SAVINGS

N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS SAVINGS

ΔTherm = Sa * (Hv/B) * Hours * L / 100,000

Where:

Sa = Average actual steam loss per leaking trap

= 24.24 x Pia x D^2 x A x FF

Where:

24.24 = Constant lb/(hr-psia-in^2)

Pia = Pig + Patm

= Average steam trap inlet pressure, absolute, psia

Pig = Average steam trap inlet pressure, gauge, psig

Patm = Atmospheric pressure, 14.7 psia

D = Diameter of Orifice, in.

A = Adjustment factor

= 50%,[356] all steam systems. This factor is to account for reducing the maximum theoretical steam flow to the average steam flow (the Enbridge factor).

FF = Flow Factor. In addition to the Adjustment factor (A), an additional 50 percent flow factor adjustment is recommended for medium and high pressure steam systems to address industrial float and thermostatic style traps where additional blockage is possible.

Steam System	Average Steam Trap Inlet Pressure psig[357]	Diameter of Orifice in	Adjustment Factor	Flow Factor	Average Actual Steam Loss per Leaking Trap (lb/hr/trap)
Commercial Dry Cleaners	-	-	50%	100%	19.1
Commercial Heating (including Multifamily) LPS	-	-	50%	100%	6.9
Industrial or Process Low Pressure, <15 psig	-	-	50%	100%	6.9
Medium Pressure >15 psig < 30 psig	16	0.1875	50%	50%	6.5
Medium Pressure ≥30 <75 psig	47	0.2500	50%	50%	23.4
High Pressure ≥75 <125 psig	101	0.2500	50%	50%	43.8
High Pressure ≥125 <175 psig	146	0.2500	50%	50%	60.9
High Pressure ≥175 <250 psig	202	0.2500	50%	50%	82.1
High Pressure ≥250 ≤300 psig	263	0.2500	50%	50%	105.2
High Pressure > 300 psig	Custom	Custom	50%	50%	Calculated

Hv = Heat of vaporization of steam

Steam System	Average Inlet Pressure psig	Heat of Vaporization[358] (Btu/lb)
Commercial Dry Cleaners	--	890
Commercial Heating (including Multifamily) LPS	--	951
Industrial and Process Low Pressure ≤15 psig	--	951
Medium Pressure >15 psig < 30 psig	16	944
Medium Pressure ≥30 <75 psig	47	915
High Pressure ≥75 <125 psig	101	880
High Pressure ≥125 <175 psig	146	859
High Pressure ≥175 <250 psig	202	837

[356] Enbridge adjustment factor used as referenced in CLEAResult "Work Paper Steam Traps Revision #2" Revision 3 dated March 2, 2012 and DOE Federal Energy Management Program Steam Trap Performance Assessment.

[357] Medium and high pressure steam trap inlet pressure based on Navigant analysis of source collected during program implementation by Nicor Gas for GPY1 through GPY4. For each steam trap project, the data provided measure savings description, operating pressure, installation Zip code, business building type, program year, and annual operating hours.

[358] 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. Referenced in CLEAResult "Work Paper Steam Traps Revision #2" Revision 3 dated March 2, 2012.

High Pressure ≥250 ≤300 psig	263	816
High Pressure > 300 psig	--	Custom

B = Boiler efficiency

= custom, if unknown:

= 80.7% for steam boilers, except multifamily low-pressure [359]

= 64.8% for multifamily low-pressure steam boilers [360]

Hours = Annual operating hours of steam plant

= custom, if unknown:

Steam System	Zone (where applicable)	Hours/Yr[361]
Commercial Dry Cleaners	All Climate Zones	2,425
Industrial and Process Low Pressure ≤15 psig		8,282
Medium Pressure >15 psig < 30 psig		8,282
Medium Pressure ≥30 <75 psig		8,282
High Pressure ≥75 <125 psig		8,282
High Pressure ≥125 <175 psig		8,282
High Pressure ≥175 <250 psig		8,282
High Pressure ≥250 psig		8,282
Commercial Heating (including Multifamily)LPS[362]	1 (Rockford)	4,272
	2 (Chicago O'Hare)	4,029
	3 (Springfield)	3,406
	4 (Belleville)	2,515
	5 (Marion)	2,546

L = Leaking & blow-thru

L is 1.0 when applied to the replacment of an individual leaking trap. If a number of steam traps are replaced and the system has not been audited, the leaking and blow-thru is applied to reflect the assumed percentage of steam traps that were actually leaking and need to be replaced. A custom value can be utilized if a supported by an evaluation.

359 Ibid.

360 Katrakis, J. and T.S. Zawacki. "Field-Measured Seasonal Efficiency of Intermediate-sized Low-Pressure Steam Boilers". ASHRAE V99, pt. 2, 1993.

361 Medium and high pressure steam trap annual operating hours based on Navigant analysis of source collected during program implementation by Nicor Gas for GPY1 through GPY4. For each steam trap project, the data provided measure savings description, operating pressure, installation Zip code, business building type, program year, and annual operating hours.

362 Since commercial LPS reflect heating systems, Hours/yr are equivalent to HDD55 zone table

Steam System	L (%)[363]
Custom	Custom
Commercial Dry Cleaners	27%
Commercial Heating (including Multifamily) LPS	27%
Industrial and Process Low Pressure ≤15 psig	16%
Medium Pressure >15 psig < 30 psig	16%
Medium Pressure ≥30 <75 psig	16%
High Pressure ≥75 <125 psig	16%
High Pressure ≥125 <175 psig	16%
High Pressure ≥175 <250 psig	16%
High Pressure > 300 psig	16%

EXAMPLE

For example, a commercial dry cleaning facility with the default hours of operation and boiler efficiency;

ΔTherms = Sa * (Hv/B) * Hours * L

= 19.1 lbs/hr/trap * (890 Btu/lb / 80%)/100,000 * 2,425 * 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-V04-160601

[363] Dry cleaners survey data as referenced in CLEAResult “Work Paper Steam Traps Revision #2" Revision 3 dated March 2, 2012.

4.4.17 Variable Speed Drives for HVAC Pumps and Cooling Tower Fans

DESCRIPTION

This measure is applied to variable speed drives (VSD) which are installed on the following HVAC system applications: chilled water pump, hot water pumps. There is a separate measure for HVAC supply and return fans. All other VSD applications require custom analysis by the program administrator. The VSD will modulate the speed of the motor when it does not need to run at full load. Since the power of the motor is proportional to the cube of the speed for these types of applications, significant energy savings will result.

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

DEFINITION OF EFFICIENT EQUIPMENT

The VSD is applied to a motor which does not have a VSD. The application must have a variable load and installation is to include the necessary controls. Savings are based on application of VSDs to a range of baseline load conditions including no control, inlet guide vanes, outlet guide vanes and throttling valves.

DEFINITION OF BASELINE EQUIPMENT

The time of sale baseline is a new motor installed without a VSD or other methods of control. Retrofit baseline is an existing motor operating as is. Retrofit baselines may or may not include guide vanes, throttling valves or other methods of control. This information shall be collected from the customer.

Installations of new equipment with VSDs which are required by IECC 2012 or 2015 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;[364] measure life for process is 10 years.[365]

DEEMED MEASURE COST

Customer provided costs will be used when available. Default measure costs[366] are noted below for up to 20 hp motors. Custom costs must be gathered from the customer for motor sizes not listed below.

HP	Cost
1 -5 HP	$ 1,330
7.5 HP	$ 1,622
10 HP	$ 1,898
15 HP	$ 2,518
20 HP	$ 3,059

LOADSHAPE

Loadshape C42 - VFD - Boiler feedwater pumps <10 HP

Loadshape C43 - VFD - Chilled water pumps <10 HP

[364] Efficiency Vermont TRM 10/26/11 for HVAC VSD motors
[365] DEER 2008
[366] 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.

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

$$\Delta kWh = BHP / EFFi * Hours * ESF$$

Where:

BHP = System Brake Horsepower

(Nominal motor HP * Motor load factor)

Motors are assumed to have a load factor of 65% for calculating kW if actual values cannot be determined[367]. Custom load factor may be applied if known.

EFFi = Motor efficiency, installed. Actual motor efficiency shall be used to calculate kW. If not known a default value of 93% shall be used.[368]

Hours = Default hours are provided for HVAC applications which vary by HVAC application and building type[369]. When available, actual hours should be used.

Building Type	Heating Run Hours	Cooling Run Hours	Heating and Cooling Run Hours
Assembly	4888	2150	7235
Assisted Living	4711	4373	8760
College	3990	1605	6103
Convenience Store	4136	2084	7004
Elementary School	5105	3276	7522
Garage	4849	2102	7357
Grocery	4200	2096	7403
Healthcare Clinic	5481	1987	6345
High School	5480	3141	7879
Hospital - VAV econ	3718	2788	8760

[367] Del Balso, Ryan J. "Investigation into the Reliability of Energy Efficiency/Demand Side Management Savings Estimates for Variable Frequency Drives in Commercial Applications", University of Colorado, Department of Civil, Environmental and Architectural Engineering, 2013.

[368] Ohio TRM 8/6/2010 pp207-209, Com Ed TRM June 1, 2010.

[369] Hours per year are estimated using the eQuest models as the total number of hours the heating or cooling system is operating for each building type. "Heating and Cooling Run Hours" are estimated as the total number of hours fans are operating for heating, cooling and ventilation for each building type. This may overclaim certain applications (e.g. pumps) and so where possible actual hours should be used for these applications.

Building Type	Heating Run Hours	Cooling Run Hours	Heating and Cooling Run Hours
Hospital - CAV econ	7170	2881	8760
Hospital - CAV no econ	7139	8760	8760
Hospital - FCU	5844	8729	8760
Manufacturing Facility	3821	2805	8706
MF - High Rise	4522	4237	8760
MF - Mid Rise	5749	2899	8760
Hotel/Motel - Guest	4480	4479	8760
Hotel/Motel - Common	3292	8712	8760
Movie Theater	5063	2120	7505
Office - High Rise - VAV econ	4094	2038	6064
Office - High Rise - CAV econ	5361	4849	5697
Office - High Rise - CAV no econ	5331	5682	5682
Office - High Rise - FCU	3758	3069	6163
Office - Low Rise	3834	2481	6288
Office - Mid Rise	3977	1881	6125
Religious Building	5199	2830	7380
Restaurant	4579	3350	7809
Retail - Department Store	4249	2528	6890
Retail - Strip Mall	4475	2266	6846
Warehouse	4606	770	6786
Unknown	4649	2718	7100

The type of hours to apply depends on the VFD application, according to the table below.

Application	Hours Type
Hot Water Pump	Heating
Chilled Water Pump	Cooling
Air Foil/Backward Incline	Heating and Cooling
Air Foil/Backward Incline Inlet Guide Vanes	Heating and Cooling
Forward Curved Fan, with Discharge Dampers	Heating and Cooling
Forward Curved Inlet Guide Vanes	Heating and Cooling

ESF = Energy savings factor varies by VFD application. Units are kW/HP.

Application	ESF[370]
Hot Water Pump	0.424
Chilled Water Pump	0.411
Air Foil/backward incline	0.354
Air Foil/ backward incline inlet Guide Vanes	0.227

[370] Based on the methodology described in the CT TRM; derived using a temperature BIN analysis of typical heating, cooling and fan load profiles.

Application	ESF[370]
Forward Curved Fan, with discharge dampers	0.179
Forward Curved Inlet Guide Vanes	0.092

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW =BHP/EFFi * DSF

Where:

DSF = Demand Savings Factor varies by VFD application.[371] Units are kW/HP. Values listed below are based on typical peak load for the listed application.

Application	DSF
Hot Water Pump	0
Chilled Water Pump	0.299
Air foil / backward incline	0.260
Air Foil / backward incline inlet Guide Vanes	0.130
Forward Curved Fan, with discharge dampers	0.136
Forward Curved Inlet Guide Vanes	0.029

FOSSIL FUEL IMPACT DESCRIPTIONS AND CALCULATION

There are no expected fossil fuel impacts for this measure.

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-VSDHP-V03-160601

[371] Ibid

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[372] based upon equipment life only[373]. For the purposes of claiming savings for a new programmable thermostat, this is reduced by a 50% persistence factor to give a final measure life of 4 years.

Deemed Measure Cost

Actual material and labor costs should be used if the implementation method allows. If unknown the capital and labor cost for this measure is assumed to be $181 per thermostat[374]. For the purposes of screening and planning it should be assumed that one thermostat will serve 5 tons of Cooling Capacity at a cost of $36.20 / ton or 115kBtuh of Heating Capacity at a cost of $1.57 / kBtu.

Loadshape

N/A

Coincidence Factor

N/A

---

[372] Table 1, HVAC Controls, Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007

[373] 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.

[374] Nicor Rider 30 Business EER Program Database, Paid Rebates with Programmable Thermostat Installation Costs, Program to Date as of January 11, 2013.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS[375]

ΔkWh = [Baseline Energy Use (kWh/Ton) – Proposed Energy Use (kWh/Ton)] * Cooling Capacity (Tons)

The following equations are used to calculate baseline and proposed electric energy use. The savings is the difference between the proposed and baseline calculated usage. This approach allows the savings estimate to account for the operational attributes of the baseline as well as the proposed case, yielding a better estimate than an approach that assumes a particular baseline or proposed energy use to determine savings.

Electric Energy Use Equations (kWh / ton)

Building Type	Fan Mode During Occupied Period (*Fo*)	Equation
Assembly	Continuous	***CZ***+***Fu****(0.83****Tc***+0.83****Th***+1.67****Ws***-293.018)-0.0922****Tc****Th***+1.291****Ws***
	Intermittent	***CZ***+***Fu****(1.911-0.12****Tc***)+***Tc****(0.00311****Ws***-0.229)+0.11****Ws***
Convenience Store	Continuous	***CZ***+***Fu****(-28.629****Tc***-11.69****Th***+19.118****Ws***-2935.12)+0.909****Ws***
	Intermittent	***CZ***+***Tc****(0.0863****Ws***-12.688)+***Th****(0.043****Ws***-6.38)+1.669****Ws***
Office – Low Rise	Continuous	***CZ***+***Fu****(7.082****Tc***-41.199****Th***+18.734****Ws***-3288.55)+***Tc****(0.205****Ws***-34.929)
	Intermittent	***CZ***+***Tc****(0.0806****Ws***-8.984)+***Th****(0.0864****Ws***-9.558)+1.178****Ws***
Religious	Continuous	***CZ***+***Fu****(-1.579****Tc***-18.14****Th***+15.01****Ws***-2417.74)+***Tc****(0.177****Ws***-26.412)
	Intermittent	***CZ***+***Fu****(0.266****Tc***-2.067)+***Tc****(0.0295****Ws***-4.502)+***Th****(0.0517****Ws***-8.251)+0.735****Ws***
Restaurant – Fast Food	Continuous	***CZ***+***Fu****(0.678****Tc***+0.257****Th***+2.88****Ws***-494.006)+***Tc****(0.0231****Ws***-4.074)+***Th****(0.00936****Ws***-1.655)+0.918****Ws***
	Intermittent	***CZ***+***Fu****(0.377****Tc***+0.124****Th***+0.13****Ws***-24.893)+***Tc****(-0.0143****Th***+0.0166****Ws***-2.691)+0.898****Ws***
Restaurant – Full Service	Continuous	***CZ***+***Fu****(-8.41****Th***+11.766****Ws***-1910.81)+***Tc****(0.282****Ws***-43.851)
	Intermittent	***CZ***+0.123****Fu****Tc***+***Tc****(0.0561****Ws***-8.237)+***Th****(0.0219****Ws***-3.284)+1.038****Ws***
Retail – Department Store	Continuous	***CZ***+***Fu****(-1.475****Th***+0.755****Ws***-114.373)+***Th****(0.151****Ws***-24.016)+1.612****Ws***
	Intermittent	***CZ***+***Tc****(0.0173****Ws***-1.912)+***Th****(0.0249****Ws***-3.29)+0.511****Ws***
Retail – Strip Mall	Continuous	***CZ***+***Fu****(1.077****Tc***-10.697****Th***+6.91****Ws***-1117.18)+***Tc****(0.0583****Ws***-7.54)+1.231****Ws***
	Intermittent	***CZ***+0.0894****Fu****Tc***+***Th****(-0.0142****Tc***+0.04****Ws***-5.278)+0.884****Ws***

Where:

CZ = Climate Zone Coefficient

[375] Savings equations and factors determined by regression of results of a series of eQuest simulations. See Programmable T-Stat Work Paper_PECI_FinalDraft_140730_Redline.docx for details.

=Depends on Building Type and Fan Mode During Occupied Period (see table below)

Tc = Degrees of Cooling Setback °F

= Must be between 0-15°F

Th = Degrees of Heating Setback °F

=Must be between 0-15°F

Fo = Fan Mode During Occupied Period (Note: Commercial mechanical code requires continuous fan operation during occupied periods to meet ventilation requirements.)

= Continuous for occupied fan that runs continuously (e.g. Fan Mode Set to 'On')

= Intermittent for occupied fan that runs intermittently (e.g. Fan Mode Set to 'Auto')

Fu = Fan Mode During Unoccupied Period

= 0 for unoccupied fan that runs continuously (e.g. Fan Mode Set to 'On')

= 1 for unoccupied fan that runs intermittently (e.g. Fan Mode Set to 'Auto')

Ws = Weekly Hours thermostat is in Occupied mode

= Minimum values depends on Building Type (see table below), maximum value of 168 (24/7)

(e.g.: Weekly occupancy schedule of Mon-Sat 8AM-5PM, Sun 9AM-2PM, Ws = 59)

Electric Energy Use Climate Zone Coefficients and Minimum Weekly Hours Occupied

Building Type	Fan Mode During Occupied Period (*Fo*)	Climate Zone Coefficient (*CZ*)[376]					Minimum *Ws*
		1	2	3	4	5	
Assembly	Continuous	911.366	928.924	1152.83	1208.999	1210.173	98
	Intermittent	735.752	762.831	966.562	998.927	1028.906	
Convenience Store	Continuous	4817.094	4832.784	5139.133	5182.161	5208.608	108
	Intermittent	1478.133	1514.568	1784.384	1843.463	1930.47	
Office - Low Rise	Continuous	5047.662	5039.592	5187.924	5217.672	5177.449	55
	Intermittent	825.072	808.965	946.571	979.421	945.418	
Religious Facility	Continuous	4197.117	4172.858	4380.025	4370.008	4356.054	133
	Intermittent	632.404	603.395	678.294	664.717	616.853	
Restaurant – Fast Food	Continuous	1342.988	1378.661	1664.018	1714.201	1727.841	108
	Intermittent	993.764	1039.643	1307.8	1340.544	1389.791	
Restaurant – Full Service	Continuous	4070.35	4094.742	4428.966	4501.829	4522.522	117
	Intermittent	1472.014	1516.05	1856.108	1938.441	2056.45	
Retail – Department Store	Continuous	1510.201	1496.47	1706.105	1716.128	1688.464	93
	Intermittent	701.27	702.129	847.735	875.12	881.677	
Retail – Strip Mall	Continuous	1926.294	1930.137	2156.856	2174.435	2165.03	93

[376] Climate Zones Refrenced in Section 3.7, Table 3.6

Building Type	Fan Mode During Occupied Period (*Fo*)	Climate Zone Coefficient (*CZ*)376					Minimum *Ws*
		1	2	3	4	5	
	Intermittent	656.479	673.257	835.906	850.322	869.921	

EXAMPLE
A low rise office in Rockford (Climate Zone 1) is occupied Mon-Fri 7AM-6PM and has a 10 ton DX RTU controlled by a manual thermostat. The fan runs continuously during the occupied hours and building staff do not manually change the fan mode, cooling or heating setpoints during unoccupied periods.

A programmable thermostat is installed by a contractor who sets the occupied schedule to Mon-Fri 7AM-6PM with a 10°F cooling and heating unoccupied temperature setback. The contractor also programs the fan to operate continuously during the occupied periods and to intermittent "auto" during the unoccupied periods.

ΔkWh = [Baseline Energy Use (kWh/Ton) – Proposed Energy Use(kWh/Ton)] * Cooling Capacity (Tons)

Baseline Energy Use (kWh/Ton) = Equation for Office Low Rise, *Fo*=Continuous

= ***CZ***+***Fu****(7.082****Tc***-41.199****Th***+18.734****Ws***-3288.55)+***Tc****(0.205****Ws***-34.929)

= ***5047.662***+***0****(7.082****0***-41.199****0***+18.734****168***-3288.55)+***0****(0.205****168***-34.929)

= 5,047.662 kWh/Ton

Proposed Energy Use (kWh/Ton) = Equation for Office Low Rise, *Fo*=Continuous

= ***CZ***+***Fu****(7.082****Tc***-41.199****Th***+18.734****Ws***-3288.55)+***Tc****(0.205****Ws***-34.929)

= ***5047.662***+***1****(7.082****10***-41.199***10**+18.734***55**-3288.55)+***10*(***0.205***55**-34.929)

= 2,211.722 kWh/Ton

ΔkWh = [5,047.622 (kWh/Ton) – 2,211.722 (kWh/Ton)] * 10 Tons

= 2,835.89 kWh/Ton * 10 Tons

= 28,358.9 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

ΔTherms = [Baseline Energy Use (Therms/kBtuh) – Proposed Energy Use(Therms/kBtuh)] * Output Heating Capacity (kBtuh)

The following equations are used to calculate baseline and proposed natural gas energy use. The savings is the difference between the proposed and baseline calculated usage. This approach allows the savings estimate to account for the operational attributes of the baseline as well as the proposed case, yielding a better estimate than an approach that assumes a particular baseline or proposed energy use to determine savings.

Natural Gas Energy Use Equations (therms / kbtu output)

Building Type	Fan Mode During Occupied Period (*Fo*)	Equation

Building Type	Fan Mode During Occupied Period (*Fo*)	Equation
Assembly	Continuous	***CZ***+***Fu****(0.232****Th***+0.0984****Ws***-18.79)+***Th****(0.00271****Ws***-0.535)+0.0142****Ws***
	Intermittent	***CZ***+***Fu****(0.00405****Th***+0.000519****Ws***-0.11)+***Th****(0.0000689****Ws***-0.0118)+0.0022****Ws***
Convenience Store	Continuous	***CZ***+***Fu****(0.00545****Th***-0.00251****Ws***+0.416)+***Th****(0.000123****Ws***-0.0204)+0.00183****Ws***
	Intermittent	***CZ***+***Fu****(0.00231****Th***-0.0349)+***Th****(0.000309****Ws***-0.0494)+0.00266****Ws***
Office – Low Rise	Continuous	***CZ***+***Fu****(0.0205****Th***+0.364)+***Th****(0.00046****Ws***-0.0554)+0.00169****Ws***
	Intermittent	***CZ***+***Fu****(0.00745****Th***-0.142)+***Th****(0.00077****Ws***-0.111)+0.00199****Ws***
Religious	Continuous	***CZ***+0.00791****Fu****Th***+***Th****(0.00096****Ws***-0.167)+0.00184****Ws***
	Intermittent	***CZ***+***Fu****(0.00143****Th***-0.0309)+***Th****(0.0008****Ws***-0.134)+0.00219****Ws***
Restaurant – Fast Food	Continuous	***CZ***+***Fu****(0.0431****Th***+0.0424****Ws***-7.517)+***Th****(0.00113****Ws***-0.213)+0.0119****Ws***
	Intermittent	***CZ***+***Fu****(0.0125****Th***+0.0036****Ws***-0.71)+***Th****(0.000329****Ws***-0.0615)+0.00738****Ws***
Restaurant –Full Service	Continuous	***CZ***+***Fu****(0.00445****Ws***-0.535)+***Th****(0.000679****Ws***-0.1)+0.00218****Ws***
	Intermittent	***CZ***+***Fu****(0.00144****Th***+0.000262****Ws***-0.0553)+***Th****(0.00018****Ws***-0.0299)+0.00166****Ws***
Retail – Department Store	Continuous	***CZ***+0.00203****Fu****Th***+***Th****(0.000591****Ws***-0.0812)+0.00194****Ws***
	Intermittent	***CZ***+***Th****(0.000406****Ws***-0.0611)+0.00228****Ws***
Retail – Strip Mall	Continuous	***CZ***+***Fu****(0.00998****Th***+0.00207****Ws***-0.206)+***Th****(0.000665****Ws***-0.101)+0.00292****Ws***
	Intermittent	***CZ***+***Fu****(0.00383****Th***-0.0656)+***Th****(0.000575****Ws***-0.0912)+0.00249****Ws***

Where:

CZ = Climate Zone Coefficient

= Depends on Building Type and Fan Mode During Occupied Period (see table below)

Th = Degrees of Heating Setback °F

= Must be between 0-15°F

Fo = Fan Mode During Occupied Period (Note: Commercial mechanical code requires continuous fan operation during occupied periods to meet ventilation requirements.)

= Continuous for occupied fan that runs continuously (e.g. Fan Mode Set to 'On')

= Intermittent for occupied fan that runs intermittently (e.g. Fan Mode Set to 'Auto')

Fu = Fan Mode During Unoccupied Period

= 0 for unoccupied fan that runs continuously (e.g. Fan Mode Set to 'On')

= 1 for unoccupied fan that runs intermittently (e.g. Fan Mode Set to 'Auto')

Ws = Weekly Hours thermostat is in Occupied mode

= Minimum values depends on Building Type (see table below), maximum value of 168 (24/7)

(e.g.: Weekly occupancy schedule of Mon-Sat 8AM-5PM, Sun 9AM-2PM, Ws = 59)

Natural Gas Energy Use Climate Zone Coefficients and Minimum Weekly Hours Occupied

Building Type	Fan Mode During Occupied Period (*Fo*)	Climate Zone Coefficient (*CZ*)					Minimum *Ws*
		1	2	3	4	5	
Assembly	Continuous	19.872	17.83	15.828	15.282	13.482	98
	Intermittent	0.237	0.0989	0.0267	-0.0131	-0.0871	
Convenience Store	Continuous	1.493	1.081	0.782	0.544	0.114	108
	Intermittent	1.128	0.854	0.619	0.437	0.0854	
Office - Low Rise	Continuous	1.718	1.317	0.971	0.739	0.319	55
	Intermittent	3.447	3.022	2.503	2.251	1.646	
Religious Facility	Continuous	6.294	5.55	4.678	4.202	3.122	133
	Intermittent	5.914	5.368	4.557	4.137	3.246	
Restaurant – Fast Food	Continuous	8.383	7.211	6.034	5.767	4.71	108
	Intermittent	1.227	0.636	0.302	0.102	-0.262	
Restaurant – Full Service	Continuous	5.247	4.484	3.753	3.465	2.627	117
	Intermittent	0.951	0.704	0.51	0.381	0.0746	
Retail – Department Store	Continuous	4.385	3.854	3.192	2.784	1.858	93
	Intermittent	3.061	2.672	2.182	1.829	1.008	
Retail – Strip Mall	Continuous	3.917	3.394	2.728	2.394	1.617	93
	Intermittent	2.659	2.292	1.811	1.543	0.909	

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-PROG-V02-150601

4.4.19 Demand Controlled Ventilation

Description

Demand control ventilation (DCV) adjusts outside ventilation air based on the number of occupants and the ventilation demands that those occupants create. DCV is part of a building's ventilation system control strategy. It may include hardware, software, and controls as an integral part of a building's ventilation design. Active control of the ventilation system provides the opportunity to reduce heating and cooling energy use.

The primary component is a control sensor to communicate either directly with the economizer or with a central computer. The component is most typically a carbon dioxide (CO2) 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. [377]

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[378].

Loadshape

Commercial ventilation C23

Coincidence Factor

N/A

Algorithm

[377] 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.

[378] Discussion with vendors

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS

For facilities heated by natural gas,

ΔkWh = Condition Space/1000 * $SF_{cooling}$

For facilities heated by heat pumps,

ΔkWh = Condition Space/1000 * $SF_{cooling}$+ Condition Space/1000 * $SF_{Heat\ HP}$

For facilities heated by electric resistance,

ΔkWh = Condition Space/1000 * $SF_{cooling}$+ Condition Space/1000 * $SF_{Heat\ ER}$

Where:

Conditioned Space = actual square footage of conditioned space controlled by sensor

$SF_{cooling}$ = Cooling Savings Factor

= value in table below based on building type and weather zone

$SF_{Heat\ HP}$ = Heating Savings factor for facilities heated by Heat Pump (HP)

= value in table below based on building type and weather zone

$SF_{Heat\ ER}$ = Heating Savings factor for facilities heated by Electric Resistance (ER)

= value in table below based on building type and weather zone

Saving Factor Tables[379]

Building Type	$SF_{cooling}$ (kWh/1000 SqFt)				
	Zone 1 (Rockford)	Zone 2 (Chicago)	Zone 3 (Springfield)	Zone 4 (Belleville)	Zone 5 (Marion)
Office - Low-rise	454	456	460	456	462
Office - Mid-rise	430	431	432	428	433
Office - High-rise	448	450	452	449	454
Religious Building	493	509	573	584	605
Restaurant	505	515	553	569	581
Retail - Department Store	620	625	630	638	642
Retail - Strip Mall	380	376	356	406	407
Convenience Store	602	603	610	612	614
Elementary School	317	327	352	352	363
High School	305	316	340	340	352
College/University	392	410	434	449	462
Healthcare Clinic	353	358	379	383	389

[379] The electric energy savings was calculated using TMY3 weather data and methodology consistent with ASHRAE standards. Savings are calculated on an annual basis for each given temperature zone in Illinois. Energy savings for DCV were developed utilizing standards, inputs and approaches as set forth by ASHRAE 62.1and 90.1, respectively. Building input parameters like square footage, equipment efficiencies and occupancy match those used in the EFLH calculations. Reference calculation found in Demand Control Ventilation 12-30-13.xls.

Building Type	$SF_{cooling}$ (kWh/1000 SqFt)				
	Zone 1 (Rockford)	Zone 2 (Chicago)	Zone 3 (Springfield)	Zone 4 (Belleville)	Zone 5 (Marion)
lodging	576	578	586	588	591
Manufacturing	481	482	482	477	482
Special Assembly Auditorium	410	427	479	494	514
Default	451	458	475	482	490

Building Type	$SF_{Heat\ HP}$ (kWh/1000 SqFt)				
	Zone 1 (Rockford)	Zone 2 (Chicago)	Zone 3 (Springfield)	Zone 4 (Belleville)	Zone 5 (Marion)
Office - Low-rise	234	203	180	172	148
Office - Mid-rise	156	133	117	117	102
Office - High-rise	209	183	164	153	133
Religious Building	1,495	1,322	1,172	1,116	1,000
Restaurant	1,058	954	828	810	711
Retail - Department Store	365	326	289	283	250
Retail - Strip Mall	244	214	195	185	164
Convenience Store	179	161	141	137	117
Elementary School	652	567	500	470	414
High School	636	553	492	457	406
College/University	1,257	1,105	969	937	789
Healthcare Clinic	443	393	344	331	297
lodging	204	182	156	153	156
Manufacturing	166	145	125	120	109
Special Assembly Auditorium	1,759	1,551	1,399	1,366	1,202
Default	604	533	472	454	400

Building Type	$SF_{Heat\ HP}$ (kWh/1000 SqFt)				
	Zone 1 (Rockford)	Zone 2 (Chicago)	Zone 3 (Springfield)	Zone 4 (Belleville)	Zone 5 (Marion)
Office - Low-rise	703	610	539	516	445
Office - Mid-rise	467	399	352	352	305
Office - High-rise	627	549	492	458	399
Religious Building	4,486	3,966	3,517	3,348	3,001
Restaurant	3,175	2,862	2,485	2,429	2,134
Retail - Department Store	1,094	979	868	848	750
Retail - Strip Mall	732	641	586	554	492

Building Type	$SF_{Heat\ HP}$ (kWh/1000 SqFt)				
	Zone 1 (Rockford)	Zone 2 (Chicago)	Zone 3 (Springfield)	Zone 4 (Belleville)	Zone 5 (Marion)
Convenience Store	537	484	422	410	352
Elementary School	1,956	1,701	1,501	1,409	1,243
High School	1,908	1,659	1,477	1,372	1,219
College/University	3,770	3,314	2,907	2,810	2,368
Healthcare Clinic	1,330	1,179	1,032	992	891
lodging	611	546	469	458	469
Manufacturing	499	436	375	359	328
Special Assembly Auditorium	5,276	4,652	4,197	4,099	3,606
Default	1,811	1,598	1,415	1,361	1,200

For example: 7,500 SqFt of low-rise office space in Chicago with gas heat.

ΔkWh = 7,500 /1000 *456

= 3,420 kWh

Summer Coincident Peak Demand Savings

NA

Natural Gas Savings

$$\Delta therms = Condition\ Space/1000 * SF_{Heat\ Gas}$$

Where:

$SF_{Heat\ Gas}$ = value in table below based on building type and weather zone[380]

Building Type	$SF_{Heat\ Gas}$ (Therm/1000 sq ft)				
	Zone 1 (Rockford)	Zone 2 (Chicago)	Zone 3 (Springfield)	Zone 4 (Belleville)	Zone 5 (Marion)
Office - Low-rise	30	26	23	22	19
Office - Mid-rise	20	17	15	15	13
Office- High-rise	27	23	21	20	17
Religious Building	191	169	150	143	128
Restaurant	135	122	106	104	91

[380] The natural gas energy savings was calculated using TMY3 weather data and methodology consistent with ASHRAE standards. Savings are calculated on an annual basis for each given temperature zone in Illinois. Energy savings for DCV were developed utilizing standards, inputs and approaches as set forth by ASHRAE 62.1 and 90.1, respectively. Building input parameters like square footage, equipment efficiencies and occupancy match those used in the EFLH calculations. Reference calculation found in Demand Control Ventilation 12-30-13.xls.

Building Type	$SF_{Heat\ Gas}$ (Therm/1000 sq ft)				
	Zone 1 (Rockford)	Zone 2 (Chicago)	Zone 3 (Springfield)	Zone 4 (Belleville)	Zone 5 (Marion)
Retail - Department Store	47	42	37	36	32
Retail - Strip Mall	31	27	25	24	21
Convenience Store	23	21	18	17	15
Elementary School	83	73	64	60	53
High School	81	71	63	59	52
College/ University	161	141	124	120	101
Healthcare Clinic	57	50	44	42	38
Lodging	26	23	20	20	20
Manufacturing	21	19	16	15	14
Special Assembly Auditorium	225	198	179	175	154
De-fault	77	68	60	58	51

For example: 7500 SqFt of low-rise office space in Chicago.

ΔTherms = 7,500 * 26

= 195 Therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-DCV-V03-160601

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.[381] 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%[382] of the full fire input MBH for greater than 60%[383] 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.[384]

Deemed Measure Cost

The deemed installed measure cost including labor is approximately $2.53/MBtu/hr.[385]

Deemed O&M Cost Adjustments

N/A

Loadshape

N/A

Coincidence Factor

N/A

[381] The standard turndown ratio for boilers is 6:1. Understanding Fuel Savings in the Boiler Room, ASHRAE Journal, David Eoff, December, 2008 p 38
[382] Focus on Energy Evaluation, Business Programs: Deemed Savings Manual V1.0, March 22, 2010. This factor implies that boilers are 30% oversized on average.
[383] FES Analysis of bin hours based upon a 30% oversizing factor.
[384] "Burner," Obtained from a nation-wide survey conducted by ASHRAE TC 1.8 (Akalin 1978). Data changed by TC 1.8 in 1986.
[385] FES review of PY2/PY3 costs for custom People's and North Shore high turndown burner projects. See High Turndown Costs.xlsx for details.

Algorithm

Calculation of Savings

Electric Energy Savings

N/A

Summer Coincident Peak Demand Savings

N/A

Natural Gas Savings

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 [386]

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.

OSF = Oversizing Factor = 1.3[387] or custom

TDR_base = Turndown ratio = 0.33[388] 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

[386] 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.

[387] PA Consulting, KEMA, Focus on Energy Evaluation, Business Programs: Deemed Savings Manual V1.0, March 22, 2010, Page 4-12.

[388] Ibid.

= TDR_eff / BL

Where:

TDR_eff = Turndown ratio = 0.10[389] 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

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVAC-HTBC-V04-140601

389 10:1 ratio used to qualify for efficient equipment.

4.4.21 Linkageless Boiler Controls for Space Heating

Description

This measure is for a non-residential boiler providing space heating and currently having single point positioning combustion control. In single-point positioning control, the fuel valve is linked to the combustion air damper via a jackshaft mechanism to maintain correspondence between fuel and combustion air input. Most boilers with single point positioning control do not maintain low excess air levels over their entire firing range. Generally these boilers are calibrated at high fire, but due to the non-linearity required for efficient combustion, excess air levels tend to dramatically increase as the firing rate decreases. Boiler efficiency drops as the excess air levels are increased.

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

Definition of Efficient Equipment

To qualify the boiler burner must have a linkageless control system allowing the combustion air damper position to be adjusted and set for optimal efficiency at several firing rates throughout the burner's firing range. This requires the fuel valve and combustion air damper to each be powered by a separate actuator. An alternative to the combustion air damper is a Variable Speed Drive on the combustion air fan.

Definition of Baseline Equipment

The baseline boiler utilizes single point positioning for the burner combustion control.

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 16 years.[390]

Deemed Measure Cost

The deemed measure cost is estimated at $2.50/MBtu/hr burner input.[391]

Deemed O&M Cost Adjustments

N/A

Loadshape

N/A

Coincidence Factor

N/A

[390] Total number of hours for heating with a base temperature of 55°F for Chicago, IL as noted by National Climate Data Center

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

When a Variable Speed Drive is incorporated, electrical savings are calculated according to the "4.4.17 Variable Speed Drive for HVAC Pumps and Cooling Tower Fans" 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.[392] 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.[393] 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

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-LBC-V05-160601

[392] 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

[393] Department of Energy (DOE). January 2012, Steam Tip Sheet #4, Improve Your Boiler's Combustion Efficiency. Advanced Manufacturing Office. Washington, DC: U.S. Department of Energy. This value was determined as an appropriate average over the stack temperatures and excess air levels indicated.

4.4.22 Oxygen Trim Controls for Space Heating Boilers

Description

This measure is for a non-residential boiler providing space heating without oxygen trim combustion controls. Oxygen trim controls limit the amount of excess oxygen provided to the burner for combustion. This oxygen level is dependent upon the amount of air provided. Oxygen trim control converts parallel positioning, linkageless controls, into a closed-loop control configuration with the addition of an exhaust gas analyzer and PID controller. Boilers with oxygen trim controls can maintain a predetermined excess air rate (generally 15% to 30% excess air) over the entire burner firing rate. Boilers without these controls typically have excess air rates around 30% over the entire firing rate. Boiler efficiency drops as the excess air levels are increased.

This measure was developed to be applicable to the following program types: NC, TOS, RF.

If applied to other program types, the measure savings should be verified.

Definition of Efficient Equipment

To qualify the boiler burner must have an oxygen control system allowing the combustion air to be adjusted to maintain a predetermined excess oxygen level in the flue exhaust at all firing rates throughout the burner's firing range. This requires an oxygen sensor in the flue exhaust and linkageless fuel valve and combustion air controls.

Definition of Baseline Equipment

The baseline boiler utilizes single point positioning for the burner combustion control.

Deemed Lifetime of Efficient Equipment

The measure life for the O2 Trim controls is 18 years.[394]

Deemed Measure Cost

The deemed measure cost is approximately $23,250.[395]

Loadshape

N/A

Coincidence Factor

N/A

Algorithm

Calculation of Savings

Electric Energy Savings

N/A

[394] 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.

[395] 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

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.[396] O2 trim controls have an excess air rate of 15%.[397] The average difference is 13%. A 15% reduction in excess air is approximately a 1% increase in efficiency.[398] 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

DEEMED O&M COST ADJUSTMENT CALCULATION

The deemed annual Operations and Maintenance cost is $800.[399]

MEASURE CODE: CI-HVC-O2TC-V01-140601

[396] 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.
[397] Ibid

[399] 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.[400]

Deemed Measure Cost

The deemed measure cost for this approximately $1,500.[401]

Loadshape

N/A

Coincidence Factor

N/A

Algorithm

Calculation of Savings

Electric Energy Savings

N/A

[400] 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.

[401] CODES AND STANDARDS ENHANCEMENT INITIATIVE (CASE) PROCESS BOILERS, 2013 California Building Energy Efficiency Standards, California Utilities Statewide Codes and Standards Team, October 2011, pg. 22

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%[402]

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.[403]

MEASURE CODE: CI-HVC-SODP-V01-140601

[402] 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.

[403] CODES AND STANDARDS ENHANCEMENT INITIATIVE (CASE) PROCESS BOILERS, 2013 California Building Energy Efficiency Standards, California Utilities Statewide Codes and Standards Team, October 2011, pg. 22

4.4.24 Small Pipe Insulation

Description

This measure provides rebates for adding insulation to bare pipes with inner diameters of ½” and ¾”. Insulation must be at least one inch thick. Since new construction projects are required by code to have pipe insulation, this measure is only for retrofits of existing facilities. This covers bare straight pipe as well as all fittings.

Default savings are provided on a per linear foot basis. It is assumed that the majority of pipes less than one inch in commercial facilities are used for domestic hot water. However, this measure can cover hydronic heating systems as well as low and high pressure steam systems.

This measure was developed to be applicable to the following program types: RF.

If applied to other program types, the measure savings should be verified.

Definition of Efficient Equipment

The efficient case is a ½“or ¾“ diameter pipe with at least one inch of insulation. Insulation must be protected from damage which includes moisture, sunlight, equipment maintenance and wind. Outdoor pipes should have a weather protective jacket. Insulation must be continuous over straight pipe, elbows and tees.

Definition of Baseline Equipment

The base case for savings estimates is a bare hot water or steam pipe with a fluid temperature of 105 degrees Fahrenheit or greater. Current new construction code requires insulation amounts similar to this measure though this base case is commonly found in older existing buildings.

Deemed Lifetime of Efficient Equipment

The measure life is assumed to be 15 years.[404]

Deemed Measure Cost

The incremental measure cost for insulation is the full cost of adding insulation to the pipe. Actual installation costs should be used for the measure cost. For planning purposes, the following costs can be used to estimate the full cost of materials and labor.[405]

Insulation Thickness	¾” pipe	½” pipe
1”	$4.45	$4.15

Loadshape

N/A

[404] 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
[405] A market survey was performed to determine these costs.

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS SAVINGS

ΔTherms per foot[406] = $[((Q_{base} – Q_{eff}) * EFLH) / (100,000 * \eta Boiler)] * TRF$

= [Modeled or provided by tables below] * TRF

ΔTherms = $(L_{sp} + L_{oc,i})$ * Δtherms per foot

Where:

EFLH = Equivalent Full Load Hours for Heating

= Actual or defaults by building type provided in Section 4.4, HVAC end use

For year round recirculation or domestic hot water:

= 8,766

For heating season recirculation, hours with the outside air temperature below 55°F:

Zone	Hours
Zone 1 (Rockford)	5,039
Zone 2 (Chicago)	4,963
Zone 3 (Springfield)	4,495
Zone 4 (Belleville/	4,021
Zone 5 (Marion)	4,150

Q_{base} = Heat Loss from Bare Pipe (Btu/hr/ft)

= Calculated where possible using 3E Plusv4.0 software. For defaults see table below

406 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”

Q_{eff} = Heat Loss from Insulated Pipe (Btu/hr/ft)

= Calculated where possible using 3E Plusv4.0 software. For defaults 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 [407]

= 80.7% for steam boilers, except multifamily low-pressure [408]

= 64.8% for multifamily low-pressure steam boilers [409]

TRF = Thermal Regain Factor for space type, applied only to space heating energy and is applied to values resulting from Δtherms/ft tables below [410]

= See table below for base TRF values by pipe location

May vary seasonally such as: TRF[summer] * summer hours + TRF[winter] * winter hours where TRF values reflecting summer and winter conditions are apportioned by the hours for those conditions. TRF may also be adjusted by building specific balance temperature and operating hours above and below that balance temperature.411

Pipe Location	Assumed Regain	TRF, Thermal Regain Factor
Outdoor	0%	1.0
Indoor, heated space	85%	0.15
Indoor, semi- heated, (unconditioned space, with heat transfer to conditioned space. E.g.: boiler room, ceiling plenum, basement, crawlspace, wall)	30%	0.70
Indoor, unheated, (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)

$L_{oc,i}$ = Total equivalent length of (elbows and tees) of pipe to be insulated. Use table below to determine equivalent lengths.

[407] Average efficiencies of units from the California Energy Commission (CEC).
[408] Ibid.
[409] Katrakis, J. and T.S. Zawacki. “Field-Measured Seasonal Efficiency of Intermediate-sized Low-Pressure Steam Boilers”. ASHRAE V99, pt. 2, 1993.
[410] 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.
[411] Thermal Regain Factor_4-30-14.docx

Nominal Pipe Diameter	Equivalent Length (ft)	
	90 Degree Elbow	Straight Tee
1/2"	0.04	0.03
3/4"	0.06	0.05

The table below shows the deemed therm savings by building type and region on a per linear foot basis for both ½” and ¾” copper pipe.

The following table provides deemed values for 1/2" copper pipe, temperatures are assumed by category below, and insulation is assumed to be one inch fiberglass.

Piping Use	Building Type	Annual Therms Saved / Linear Foot				
		Zone 1 (Rockford)	Zone 2 (Chicago)	Zone 3 (Springfield)	Zone 4 (Belleville)	Zone 5 (Marion)
Space Heating Non-recirculating	Assembly	0.117	0.120	0.107	0.071	0.109
	Assisted Living	0.110	0.107	0.094	0.069	0.083
	College	0.100	0.093	0.083	0.046	0.055
	Convenience Store	0.097	0.089	0.079	0.057	0.064
	Elementary School	0.116	0.113	0.100	0.069	0.084
	Garage	0.064	0.063	0.056	0.044	0.049
	Grocery	0.105	0.105	0.092	0.057	0.068
	Healthcare Clinic	0.103	0.106	0.092	0.063	0.066
	High School	0.120	0.121	0.109	0.077	0.091
	Hospital - CAV no econ	0.115	0.119	0.101	0.087	0.099
	Hospital - CAV econ	0.117	0.121	0.103	0.089	0.101
	Hospital - VAV econ	0.048	0.045	0.034	0.020	0.022
	Hospital - FCU	0.087	0.099	0.080	0.094	0.127
	Hotel/Motel	0.115	0.112	0.101	0.069	0.084
	Hotel/Motel - Common	0.104	0.106	0.101	0.082	0.086
	Hotel/Motel - Guest	0.115	0.111	0.099	0.066	0.082
	Manufacturing Facility	0.068	0.066	0.061	0.037	0.041
	MF - High Rise	0.100	0.098	0.090	0.076	0.076
	MF - High Rise - Common	0.118	0.115	0.103	0.071	0.092
	MF - High Rise - Residential	0.096	0.096	0.087	0.075	0.073
	MF - Mid Rise	0.109	0.110	0.095	0.070	0.079

Piping Use	Building Type	Annual Therms Saved / Linear Foot				
		Zone 1 (Rockford)	Zone 2 (Chicago)	Zone 3 (Springfield)	Zone 4 (Belleville)	Zone 5 (Marion)
	Movie Theater	0.119	0.117	0.109	0.083	0.099
	Office - High Rise - CAV no econ	0.132	0.134	0.122	0.082	0.089
	Office - High Rise - CAV econ	0.136	0.139	0.128	0.088	0.097
	Office - High Rise - VAV econ	0.100	0.102	0.084	0.050	0.055
	Office - High Rise - FCU	0.073	0.072	0.062	0.033	0.035
	Office - Low Rise	0.093	0.093	0.074	0.045	0.052
	Office - Mid Rise	0.103	0.104	0.088	0.056	0.062
	Religious Building	0.105	0.098	0.094	0.069	0.079
	Restaurant	0.088	0.088	0.079	0.060	0.071
	Retail - Department Store	0.091	0.083	0.078	0.051	0.058
	Retail - Strip Mall	0.087	0.081	0.071	0.049	0.053
	Warehouse	0.095	0.089	0.091	0.057	0.070
	Unknown	0.101	0.100	0.089	0.064	0.074
Space Heating - recirculation heating season only	All buildings (Hours below 55°F)	0.329	0.324	0.293	0.262	0.271
Space Heating - recirculation year round	All buildings (All hours)	0.572	0.572	0.572	0.572	0.572
DHW	Recirculation loop	0.572	0.572	0.572	0.572	0.572
Process	Custom	Custom				

The following table provides deemed savings values for 3/4" copper pipe with temperatures assumed by category below, insulation is assumed to be one inch fiberglass.

Piping Use	Building Type	Annual Therms Saved / Linear Foot				
		Zone 1 (Rockford)	Zone 2 (Chicago)	Zone 3 (Springfield)	Zone 4 (Belleville)	Zone 5 (Marion)
Space Heating Non-recirculating	Assembly	0.142	0.145	0.129	0.086	0.132
	Assisted Living	0.133	0.130	0.115	0.084	0.101
	College	0.121	0.113	0.101	0.056	0.067
	Convenience Store	0.117	0.108	0.096	0.069	0.077
	Elementary School	0.141	0.137	0.121	0.084	0.102
	Garage	0.078	0.077	0.067	0.054	0.060
	Grocery	0.127	0.127	0.111	0.069	0.083
	Healthcare Clinic	0.125	0.128	0.112	0.076	0.081
	High School	0.146	0.147	0.132	0.094	0.110
	Hospital - CAV no econ	0.140	0.144	0.123	0.105	0.120
	Hospital - CAV econ	0.142	0.147	0.125	0.108	0.123
	Hospital - VAV econ	0.058	0.055	0.041	0.025	0.027
	Hospital - FCU	0.105	0.120	0.098	0.115	0.154
	Hotel/Motel	0.140	0.136	0.122	0.084	0.102
	Hotel/Motel - Common	0.127	0.129	0.123	0.100	0.105
	Hotel/Motel - Guest	0.139	0.135	0.120	0.081	0.099
	Manufacturing Facility	0.083	0.080	0.074	0.045	0.050
	MF - High Rise	0.121	0.119	0.109	0.093	0.093
	MF - High Rise - Common	0.144	0.140	0.125	0.086	0.111
	MF - High Rise - Residential	0.117	0.116	0.105	0.091	0.089
	MF - Mid Rise	0.132	0.134	0.115	0.085	0.096
	Movie Theater	0.144	0.142	0.133	0.101	0.120
	Office - High Rise - CAV no econ	0.160	0.162	0.148	0.099	0.108
	Office - High Rise - CAV econ	0.165	0.169	0.155	0.107	0.118
	Office - High Rise - VAV econ	0.121	0.123	0.102	0.060	0.067
	Office - High Rise - FCU	0.089	0.087	0.075	0.040	0.042
	Office - Low Rise	0.113	0.113	0.090	0.055	0.063
	Office - Mid Rise	0.126	0.126	0.106	0.068	0.075
	Religious Building	0.127	0.119	0.114	0.084	0.095
	Restaurant	0.107	0.107	0.096	0.073	0.086

Piping Use	Building Type	Annual Therms Saved / Linear Foot				
		Zone 1 (Rockford)	Zone 2 (Chicago)	Zone 3 (Springfield)	Zone 4 (Belleville)	Zone 5 (Marion)
	Retail - Department Store	0.110	0.101	0.095	0.062	0.071
	Retail - Strip Mall	0.106	0.098	0.086	0.059	0.064
	Warehouse	0.115	0.108	0.111	0.069	0.085
	Unknown	0.123	0.122	0.108	0.078	0.090
Space Heating - recirculation heating season only	All buildings (Hours below 55°F)	0.399	0.393	0.356	0.319	0.329
Space Heating - recirculation year round	All buildings (All hours)	0.694	0.694	0.694	0.694	0.694
DHW	Recirculation loop	0.694	0.694	0.694	0.694	0.694
Process	Custom	Custom				

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE Code: CI-HVC-SPIN-V02-160601

4.4.25 Small Commercial Programmable Thermostat Adjustments

DESCRIPTION

This measure involves reprogramming existing commercial programmable thermostats or building automation systems for reduced energy consumption through adjustments of unoccupied heating/cooling setpoints and/or fan control. This measure is limited to packaged HVAC units that are controlled by a commercial thermostat or building automation system. The measure is limited to select building types presented below.

Eligible Small Commercial Building Types

Building Type
Assembly
Convenience Store
Office - Low Rise
Restaurant - Fast Food
Religious Facility
Restaurant - Full Service
Retail - Strip Mall
Retail - Department Store

This measure was developed to be applicable to the following program types: RF, DI.

If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

The criteria for this measure is established by optimizing heating/cooling temperature setbacks and fan operation with a commercial programmable thermostat or building automation system, which reprogrammed to match actual facility occupancy.

DEFINITION OF BASELINE EQUIPMENT

The baseline for this measure is a commercial programmable thermostat or building automation system that is currently operating packaged HVAC units with heating/cooling temperature setbacks and fan operation that do not align with a facilities actual occupancy.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life of a programmable thermostat is assumed to be 8 years[412] based upon equipment life only[413]. For the purposes of claiming savings for a adjustment of an existing programmable thermostat, this is reduced to a 25% persistence factor to give a final measure life of 2 years. It is recommended that this assumption be evaluated by future energy measurement and verification activities.

412 Table 1, HVAC Controls, Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007

413 Future evaluation is strongly encouraged to inform the persistence of savings to further refine measure life assumption.

DEEMED MEASURE COST

Actual labor costs should be used if the implementation method allows. If unknown the labor cost for this measure is assumed to be $70.34[414] per thermostat, as summarized in the table below.

Measure	Units	Materials	Labor	Total Cost (including O&P)	City Cost Index (Install Only)*	Total	Source
Adjust Temperature Set Points	4	$0.00	$5.95	$6.55	134.5%	$35.24	RS Means 2010 (pg 255, Section 23-09-8100)
Adjust Fan Schedule	2	$0.00	$11.86	$13.05	134.5%	$35.10	RS Means 2010 (pg 255, Section 23-09-8120)
Totals						**$70.34**	

* Chicago, IL - Division 23

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

414 RSMeans, "Instrumentation and Control for HVAC", Mechanical Cost Data , Kingston, MA: Reed Construction Data, 2010, pg. 255 & 632

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS[415]

ΔkWh = [Baseline Energy Use (kWh/Ton) – Proposed Energy Use (kWh/Ton)] * Cooling Capacity (Tons)

The following equations are used to calculate baseline and proposed electric energy use. The savings is the difference between the proposed and baseline calculated usage. This approach allows the savings estimate to account for the operational attributes of the baseline as well as the proposed case, yielding a better estimate than an approach that assumes a particular baseline or proposed energy use to determine savings.

Electric Energy Use Equations (kWh / ton)

Building Type	Fan Mode During Occupied Period (*Fo*)	Equation
Assembly	Continuous	***CZ***+***Fu****(0.83****Tc***+0.83****Th***+1.67****Ws***-293.018)-0.0922****Tc****+***Th***+1.291****Ws***
	Intermittent	***CZ***+***Fu****(1.911-0.12****Tc***)+***Tc****(0.00311****Ws***-0.229)+0.11****Ws***
Convenience Store	Continuous	***CZ***+***Fu****(-28.629****Tc***-11.69****Th***+19.118****Ws***-2935.12)+0.909****Ws***
	Intermittent	***CZ***+***Tc****(0.0863****Ws***-12.688)+***Th****(0.043****Ws***-6.38)+1.669****Ws***
Office – Low Rise	Continuous	***CZ***+***Fu****(7.082****Tc***-41.199****Th***+18.734****Ws***-3288.55)+***Tc****(0.205****Ws***-34.929)
	Intermittent	***CZ***+***Tc****(0.0806****Ws***-8.984)+***Th****(0.0864****Ws***-9.558)+1.178****Ws***
Religious	Continuous	***CZ***+***Fu****(-1.579****Tc***-18.14****Th***+15.01****Ws***-2417.74)+***Tc****(0.177****Ws***-26.412)
	Intermittent	***CZ***+***Fu****(0.266****Tc***-2.067)+***Tc****(0.0295****Ws***-4.502)+***Th****(0.0517****Ws***-8.251)+0.735****Ws***
Restaurant – Fast Food	Continuous	***CZ***+***Fu****(0.678****Tc***+0.257****Th***+2.88****Ws***-494.006)+***Tc****(0.0231****Ws***-4.074)+***Th****(0.00936****Ws***-1.655)+0.918****Ws***
	Intermittent	***CZ***+***Fu****(0.377****Tc***+0.124****Th***+0.13****Ws***-24.893)+***Tc****(-0.0143****Th***+0.0166****Ws***-2.691)+0.898****Ws***
Restaurant – Sit Down	Continuous	***CZ***+***Fu****(-8.41****Th***+11.766****Ws***-1910.81)+***Tc****(0.282****Ws***-43.851)
	Intermittent	***CZ***+0.123****Fu****+***Tc***+***Tc****(0.0561****Ws***-8.237)+***Th****(0.0219****Ws***-3.284)+1.038****Ws***
Retail – Large	Continuous	***CZ***+***Fu****(-1.475****Th***+0.755****Ws***-114.373)+***Th****(0.151****Ws***-24.016)+1.612****Ws***
	Intermittent	***CZ***+***Tc****(0.0173****Ws***-1.912)+***Th****(0.0249****Ws***-3.29)+0.511****Ws***
Retail – Strip Mall	Continuous	***CZ***+***Fu****(1.077****Tc***-10.697****Th***+6.91****Ws***-1117.18)+***Tc****(0.0583****Ws***-7.54)+1.231****Ws***
	Intermittent	***CZ***+0.0894****Fu****+***Tc***+***Th****(-0.0142****Tc***+0.04****Ws***-5.278)+0.884****Ws***

Where:

[415] Savings equations and factors determined by regression of results of a series of eQuest simulations. See Programmable T-Stat Work Paper_PECI_FinalDraft_140730_Redline.docx for details.

CZ = Climate Zone Coefficient

= Depends on Building Type and Fan Mode During Occupied Period (see table below)

Tc = Degrees of Cooling Setback °F

= Must be between 0-15°F

Th = Degrees of Heating Setback °F

=Must be between 0-15°F

Fo = Fan Mode During Occupied Period (Note: Commercial mechanical code requires continuous fan operation during occupied periods to meet ventilation requirements.)

= Continuous for occupied fan that runs continuously (e.g. Fan Mode Set to 'On')

= Intermittent for occupied fan that runs intermittently (e.g. Fan Mode Set to 'Auto')

Fu = Fan Mode during Unoccupied Period

= 0 for unoccupied fan that runs continuously (e.g. Fan Mode Set to 'On')

= 1 for unoccupied fan that runs intermittently (e.g. Fan Mode Set to 'Auto')

Ws = Weekly Hours thermostat is in Occupied mode,

= Minimum values depend on Building Type (see table below), maximum value of 168 (24/7) ex: Weekly occupancy schedule of Mon-Sat 8AM-5PM, Sun 9AM-2PM, Ws = 59

Electric Energy Use Climate Zone Coefficients and Minimum Weekly Hours Occupied

Building Type	Fan Mode During Occupied Period (*Fo*)	Climate Zone Coefficient (*CZ*)					Minimum *Ws*
		1	2	3	4	5	
Assembly	Continuous	911.366	928.924	1152.83	1208.999	1210.173	98
	Intermittent	735.752	762.831	966.562	998.927	1028.906	
Convenience Store	Continuous	4817.094	4832.784	5139.133	5182.161	5208.608	108
	Intermittent	1478.133	1514.568	1784.384	1843.463	1930.47	
Office - Low Rise	Continuous	5047.662	5039.592	5187.924	5217.672	5177.449	55
	Intermittent	825.072	808.965	946.571	979.421	945.418	
Religious Facility	Continuous	4197.117	4172.858	4380.025	4370.008	4356.054	133
	Intermittent	632.404	603.395	678.294	664.717	616.853	
Restaurant – Fast Food	Continuous	1342.988	1378.661	1664.018	1714.201	1727.841	108
	Intermittent	993.764	1039.643	1307.8	1340.544	1389.791	
Restaurant – Full Service	Continuous	4070.35	4094.742	4428.966	4501.829	4522.522	117
	Intermittent	1472.014	1516.05	1856.108	1938.441	2056.45	
Retail – Department Store	Continuous	1510.201	1496.47	1706.105	1716.128	1688.464	93
	Intermittent	701.27	702.129	847.735	875.12	881.677	
Retail – Strip Mall	Continuous	1926.294	1930.137	2156.856	2174.435	2165.03	93
	Intermittent	656.479	673.257	835.906	850.322	869.921	

EXAMPLE

A low rise office building in Rockford (Climate Zone 1) is occupied Mon-Fri 7AM-6PM and is heated and cooled with a packaged Gas (150 kBtu output) / DX (10 Ton) RTU which is controlled by a programmable thermostat. When the technician reviews the thermostat schedule they find the unoccupied schedule is programmed incorrectly. During the unoccupied periods the fan is programmed correctly, and runs in intermittent “auto” mode, although the heating and cooling temperature setpoints are not setback.

The technician adjusts the unoccupied schedule to include a 10°F cooling and heating temperature setback during the unoccupied periods.

ΔkWh = [Baseline Energy Use (kWh/Ton) – Proposed Energy Use (kWh/Ton)] * Cooling Capacity (Tons)

Baseline Energy Use (kWh/Ton) = Equation for Office Low Rise, *Fo*=Continuous

= ***CZ***+***Fu****(7.082****Tc***-41.199****Th***+18.734****Ws***-3288.55)+***Tc****(0.205****Ws***-34.929)

= ***5047.662***+1*(7.082****0***-41.199****0***+18.734****55***-3288.55)+***0****(0.205****55***-34.929)

= 2,789.482 kWh/Ton

Proposed Energy Use (kWh/Ton) = Equation for Office Low Rise, *Fo*=Continuous

= ***CZ***+***Fu****(7.082****Tc***-41.199****Th***+18.734****Ws***-3288.55)+***Tc****(0.205****Ws***-34.929)

= ***5047.662***+***1****(7.082****10***-41.199***10**+18.734***55**-3288.55)+***10*(***0.205****55***-34.929)

= 2,211.722 kWh/Ton

ΔkWh = [2,789.482 (kWh/Ton) – 2,211.722 (kWh/Ton)] * 10 Tons

= 577.71 kWh/Ton * 10 Tons

= 5777.1 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

ΔTherms = [Baseline Energy Use (Therms/kBtuh) – Proposed Energy Use(Therms/kBtuh)] * Output Heating Capacity (kBtuh)

The following equations are used to calculate baseline and proposed natural gas energy use. The savings is the difference between the proposed and baseline calculated usage. This approach allows the savings estimate to account for the operational attributes of the baseline as well as the proposed case, yielding a better estimate than an approach that assumes a particular baseline or proposed energy use to determine savings.

Natural Gas Energy Use Equations (therms / kbtu)

Building Type	Fan Mode During Occupied Period (*Fo*)	Equation
Assembly	Continuous	**CZ+Fu***(0.232*Th+0.0984*Ws-18.79)+Th*(0.00271*Ws-0.535)+0.0142*Ws
	Intermittent	***CZ***+***Fu****(0.00405****Th***+0.000519****Ws***-0.11)+***Th****(0.0000689****Ws***-0.0118)+0.0022****Ws***
Convenience Store	Continuous	***CZ***+***Fu****(0.00545****Th***-0.00251****Ws***+0.416)+***Th****(0.000123****Ws***-0.0204)+0.00183****Ws***
	Intermittent	***CZ***+***Fu****(0.00231****Th***-0.0349)+***Th****(0.000309****Ws***-0.0494)+0.00266****Ws***
Office – Low Rise	Continuous	***CZ***+***Fu****(0.0205****Th***+0.364)+***Th****(0.00046****Ws***-0.0554)+0.00169****Ws***
	Intermittent	***CZ***+***Fu****(0.00745****Th***-0.142)+***Th****(0.00077****Ws***-0.111)+0.00199****Ws***
Religious	Continuous	***CZ***+0.00791****Fu*******Th***+***Th****(0.00096****Ws***-0.167)+0.00184****Ws***
	Intermittent	***CZ***+***Fu****(0.00143****Th***-0.0309)+***Th****(0.0008****Ws***-0.134)+0.00219****Ws***
Restaurant – Fast Food	Continuous	***CZ***+***Fu****(0.0431****Th***+0.0424****Ws***-7.517)+***Th****(0.00113****Ws***-0.213)+0.0119****Ws***
	Intermittent	***CZ***+***Fu****(0.0125****Th***+0.0036****Ws***-0.71)+***Th****(0.000329****Ws***-0.0615)+0.00738****Ws***
Restaurant –Sit Down	Continuous	***CZ***+***Fu****(0.00445****Ws***-0.535)+***Th****(0.000679****Ws***-0.1)+0.00218****Ws***
	Intermittent	***CZ***+***Fu****(0.00144****Th***+0.000262****Ws***-0.0553)+***Th****(0.00018****Ws***-0.0299)+0.00166****Ws***
Retail – Large	Continuous	***CZ***+0.00203****Fu*******Th***+***Th****(0.000591****Ws***-0.0812)+0.00194****Ws***
	Intermittent	***CZ***+***Th****(0.000406****Ws***-0.0611)+0.00228****Ws***
Retail – Strip Mall	Continuous	***CZ***+***Fu****(0.00998****Th***+0.00207****Ws***-0.206)+***Th****(0.000665****Ws***-0.101)+0.00292****Ws***
	Intermittent	***CZ***+***Fu****(0.00383****Th***-0.0656)+***Th****(0.000575****Ws***-0.0912)+0.00249****Ws***

Where:

CZ = Climate Zone Coefficient

= Depends on Building Type and Fan Mode During Occupied Period (see table below)

Th = Degrees of Heating Setback °F

= Must be between 0-15°F

Fo = Fan Mode During Occupied Period (Note: Commercial mechanical code requires continuous fan operation during occupied periods to meet ventilation requirements.)

= Continuous for occupied fan that runs continuously (e.g. Fan Mode Set to 'On')

= Intermittent for occupied fan that runs intermittently (e.g. Fan Mode Set to 'Auto')

Fu = Fan Mode during Unoccupied Period

= 0 for unoccupied fan that runs continuously (e.g. Fan Mode Set to 'On')

= 1 for unoccupied fan that runs intermittently (e.g. Fan Mode Set to 'Auto')

Ws = Weekly Hours thermostat is in Occupied mode,

= Minimum values depends on Building Type (see table below), maximum value of 168 (24/7) ex: Weekly occupancy schedule of Mon-Sat 8AM-5PM, Sun 9AM-2PM, Ws = 59.

Natural Gas Energy Use Climate Zone Coefficients and Minimum Weekly Hours Occupied

Building Type	Fan Mode During Occupied Period (*Fo*)	Climate Zone Coefficient (*CZ*)					Minimum *Ws*
		1	2	3	4	5	
Assembly	Continuous	19.872	17.83	15.828	15.282	13.482	98
	Intermittent	0.237	0.0989	0.0267	0.0131	0.0871	
Convenience Store	Continuous	1.493	1.081	0.782	0.544	0.114	108
	Intermittent	1.128	0.854	0.619	0.437	0.0854	
Office - Low Rise	Continuous	1.718	1.317	0.971	0.739	0.319	55
	Intermittent	3.447	3.022	2.503	2.251	1.646	
Religious Facility	Continuous	6.294	5.55	4.678	4.202	3.122	133
	Intermittent	5.914	5.368	4.557	4.137	3.246	
Restaurant – Fast Food	Continuous	8.383	7.211	6.034	5.767	4.71	108
	Intermittent	1.227	0.636	0.302	0.102	-0.262	
Restaurant – Full Service	Continuous	5.247	4.484	3.753	3.465	2.627	117
	Intermittent	0.951	0.704	0.51	0.381	0.0746	
Retail – Department Store	Continuous	4.385	3.854	3.192	2.784	1.858	93
	Intermittent	3.061	2.672	2.182	1.829	1.008	
Retail – Strip Mall	Continuous	3.917	3.394	2.728	2.394	1.617	93
	Intermittent	2.659	2.292	1.811	1.543	0.909	

EXAMPLE

A low rise office building in Rockford (Climate Zone 1) is occupied Mon-Fri 7AM-6PM and is heated and cooled with a packaged Gas (150 kBtu output) / DX (10 Ton) RTU which is controlled by a programmable thermostat. When the technician reviews the thermostat schedule they find the unoccupied schedule is programmed incorrectly. During the unoccupied periods the fan is programmed correctly, and runs in intermittent "auto" mode, although the heating and cooling temperature setpoints are not setback.

The technician adjusts the unoccupied schedule to include a 10°F cooling and heating temperature setback during the unoccupied periods.

ΔTherms = [Baseline Energy Use (Therms/kBtuh) – Proposed Energy Use(Therms/kBtuh)] * Output Heating Capacity (kBtuh)

Baseline Energy Use (Therms/kBtuh) = Equation for Office Low Rise, *Fo*=Continuous

= ***CZ***+***Fu****(0.0205****Th***+0.364)+***Th****(0.00046****Ws***-0.0554)+0.00169****Ws***

= ***1.718***+***1****(0.0205****0***+0.364)+***0****(0.00046****55***-0.0554)+0.00169****55***

= 2.17495 Therms/kBtuh output

Proposed Energy Use (Therms/kBtuh) = Equation for Office Low Rise, *Fo*=Continuous

= ***CZ***+***Fu****(0.0205****Th***+0.364)+***Th****(0.00046****Ws***-0.0554)+0.00169****Ws***

= ***1.718***+***1****(0.0205****10***+0.364)+***10****(0.00046****55***-0.0554)+0.00169****55***

= 2.07895 Therms/kBtuh output

ΔTherms = [2.17495 (Therms/kBtuh output) – 2.07895 (Therms/kBtuh output)] * 150kBtuh output

= 0.096 (Therms/kBtuh output) * 150kBtuh output

= 14.4 Therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-PRGA-V01-150601

4.4.26 Variable Speed Drives for HVAC Supply and Return Fans

Description

This measure is applied to variable speed drives (VSD) which are installed on HVAC supply fans and return fans. There is a separate measure for HVAC pumps and cooling tower fans. All other VSD applications require custom analysis by the program administrator. The VSD will modulate the speed of the motor when it does not need to run at full load. Since the power of the motor is proportional to the cube of the speed for these types of applications, significant energy savings will result.

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

Definition of Efficient Equipment

The VSD is applied to a motor which does not have a VSD. The application must have a variable load and installation is to include the necessary controls. Savings are based on application of VSDs to a range of baseline load conditions including no control, inlet guide vanes, outlet guide vanes and throttling valves.

Definition of Baseline Equipment

The time of sale baseline is a new motor installed without a VSD or other methods of control. Retrofit baseline is an existing motor operating as is. Retrofit baselines may or may not include guide vanes, throttling valves or other methods of control. This information shall be collected from the customer.

Installations of new equipment with VSDs which are required by IECC 2012 or 2015 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;[416] measure life for process is 10 years.[417]

Deemed Measure Cost

Customer provided costs will be used when available. Default measure costs[418] are noted below for up to 20 hp motors. Custom costs must be gathered from the customer for motor sizes not listed below.

HP	Cost
1 -5 HP	$ 1,330
7.5 HP	$ 1,622
10 HP	$ 1,898
15 HP	$ 2,518
20 HP	$ 3,059

Loadshape

Loadshape C39 - VFD - Supply fans <10 HP

Loadshape C40 - VFD - Return fans <10 HP

Loadshape C41 - VFD - Exhaust fans <10 HP

Coincidence Factor

The demand savings factor (DSF) is already based upon coincident savings, and thus there is no additional

[416] Efficiency Vermont TRM 10/26/11 for HVAC VSD motors
[417] DEER 2008
[418] Ohio TRM 8/6/2010 varies by motor/fan size based on equipment costs from Granger 2008 Catalog pp 286-289, average across available voltages and models. Labor costs from RS Means Data 2008 Ohio average cost adjustment applied.

coincidence factor for this characterization.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS[419]

kWh_{Base} = $$\left(0.746 \times HP \times \frac{LF}{\eta_{motor}}\right) \times RHRS_{Base} \times \sum_{0\%}^{100\%} (\%FF \times PLR_{Base})$$

$kWh_{Retrofit}$ = $$\left(0.746 \times HP \times \frac{LF}{\eta_{motor}}\right) \times RHRS_{base} \times \sum_{0\%}^{100\%} (\%FF \times PLR_{Retrofit})$$

ΔkWh_{fan} = $$\mathrm{kWh_{Base}} - \mathrm{kWh_{Retrofit}}$$

ΔkWh_{total} = $$\Delta\mathrm{kWh_{fan}} \times (1 + \mathrm{IE_{energy}})$$

Where:

kWh_{Base} = Baseline annual energy consumption (kWh/yr)

$kWh_{Retrofit}$ = Retrofit annual energy consumption (kWh/yr)

ΔkWh_{fan} = Fan-only annual energy savings

ΔkWh_{total} = Total project annual energy savings

0.746 = Conversion factor for HP to kWh

HP = Nominal horsepower of controlled motor

LF = Load Factor; Motor Load at Fan Design CFM (Default = 65%)[420]

η_{motor} = Installed nominal/nameplate motor efficiency

Default motor is a NEMA Premium Efficiency, ODP, 4-pole/1800 RPM fan motor

[419] Methodology developed and tested in Del Balso, Ryan Joseph. "Investigation into the Reliability of Energy Efficiency/Demand Side Management Savings Estimates for Variable Frequency Drives in Commercial Applications". A project report submitted to the Faculty of the Graduate School of the University of Colorado, 2013.

[420] Lawrence Berkeley National Laboratory, and Resource Dynamics Corporation. (2008). "Improving Motor and Drive System Performance; A Sourcebook for Industry". U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy. Golden, CO: National Renewable Energy Laboratory.

NEMA Premium Efficiency Motors Default Efficiencies[421]

Size HP	Open Drip Proof (ODP)			Totally Enclosed Fan-Cooled (TEFC)		
	# of Poles			# of Poles		
	6	4	2	6	4	2
	Speed (RPM)			Speed (RPM)		
	1200	1800 Default	3600	1200	1800	3600
1	0.825	0.855	0.770	0.825	0.855	0.770
1.5	0.865	0.865	0.840	0.875	0.865	0.840
2	0.875	0.865	0.855	0.885	0.865	0.855
3	0.885	0.895	0.855	0.895	0.895	0.865
5	0.895	0.895	0.865	0.895	0.895	0.885
7.5	0.902	0.910	0.885	0.910	0.917	0.895
10	0.917	0.917	0.895	0.910	0.917	0.902
15	0.917	0.930	0.902	0.917	0.924	0.910
20	0.924	0.930	0.910	0.917	0.930	0.910
25	0.930	0.936	0.917	0.930	0.936	0.917
30	0.936	0.941	0.917	0.930	0.936	0.917
40	0.941	0.941	0.924	0.941	0.941	0.924
50	0.941	0.945	0.930	0.941	0.945	0.930
60	0.945	0.950	0.936	0.945	0.950	0.936
75	0.945	0.950	0.936	0.945	0.954	0.936
100	0.950	0.954	0.936	0.950	0.954	0.941
125	0.950	0.954	0.941	0.950	0.954	0.950
150	0.954	0.958	0.941	0.958	0.958	0.950
200	0.954	0.958	0.950	0.958	0.962	0.954
250	0.954	0.958	0.950	0.958	0.962	0.958
300	0.954	0.958	0.954	0.958	0.962	0.958
350	0.954	0.958	0.954	0.958	0.962	0.958
400	0.958	0.958	0.958	0.958	0.962	0.958
450	0.962	0.962	0.958	0.958	0.962	0.958
500	0.962	0.962	0.958	0.958	0.962	0.958

[421] Douglass, J. (2005). Induction Motor Efficiency Standards. Washington State University and the Northwest Energy Efficiency Alliance, Extension Energy Program, Olympia, WA. Retrieved October 17, 2013, from http://www1.eere.energy.gov/manufacturing/tech_assistance/pdfs/motor_efficiency_standards.pdf

$RHRS_{Base}$ = Annual operating hours for fan motor based on building type

Default hours are provided for HVAC applications which vary by HVAC application and building type[422]. When available, actual hours should be used.

Building Type	Total Fan Run Hours
Assembly	7235
Assisted Living	8760
College	6103
Convenience Store	7004
Elementary School	7522
Garage	7357
Grocery	7403
Healthcare Clinic	6345
High School	7879
Hospital - VAV econ	8760
Hospital - CAV econ	8760
Hospital - CAV no econ	8760
Hospital - FCU	8760
Manufacturing Facility	8706
MF - High Rise	8760
MF - Mid Rise	8760
Hotel/Motel - Guest	8760
Hotel/Motel - Common	8760
Movie Theater	7505
Office - High Rise - VAV econ	6064
Office - High Rise - CAV econ	5697
Office - High Rise - CAV no econ	5682
Office - High Rise - FCU	6163
Office - Low Rise	6288
Office - Mid Rise	6125
Religious Building	7380
Restaurant	7809
Retail - Department Store	6890
Retail - Strip Mall	6846
Warehouse	6786
Unknown	7100

$\%FF$ = Percentage of run-time spent within a given flow fraction range

Default Fan Duty Cycle Based on 2012 ASHRAE Handbook; HVAC Systems and Equipment, page 45.11, Figure 12.

[422] Hours per year are estimated using the eQuest models as the total number of hours the fans are operating for heating, cooling and ventilation for each building type.

Flow Fraction (% of design cfm)	Percent of Time at Flow Fraction
0% to 10%	0.0%
10% to 20%	1.0%
20% to 30%	5.5%
30% to 40%	15.5%
40% to 50%	22.0%
50% to 60%	25.0%
60% to 70%	19.0%
70% to 80%	8.5%
80% to 90%	3.0%
90% to 100%	0.5%

PLR_{Base} = Part load ratio for a given flow fraction range based on the baseline flow control type

$PLR_{Retrofit}$ = Part load ratio for a given flow fraction range based on the retrofit flow control type

Control Type	Flow Fraction									
	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
No Control or Bypass Damper	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Discharge Dampers	0.46	0.55	0.63	0.70	0.77	0.83	0.88	0.93	0.97	1.00
Outlet Damper, BI & Airfoil Fans	0.53	0.53	0.57	0.64	0.72	0.80	0.89	0.96	1.02	1.05
Inlet Damper Box	0.56	0.60	0.62	0.64	0.66	0.69	0.74	0.81	0.92	1.07
Inlet Guide Vane, BI & Airfoil Fans	0.53	0.56	0.57	0.59	0.60	0.62	0.67	0.74	0.85	1.00
Inlet Vane Dampers	0.38	0.40	0.42	0.44	0.48	0.53	0.60	0.70	0.83	0.99
Outlet Damper, FC Fans	0.22	0.26	0.30	0.37	0.45	0.54	0.65	0.77	0.91	1.06
Eddy Current Drives	0.17	0.20	0.25	0.32	0.41	0.51	0.63	0.76	0.90	1.04
Inlet Guide Vane, FC Fans	0.21	0.22	0.23	0.26	0.31	0.39	0.49	0.63	0.81	1.04
VFD with duct static pressure controls	0.09	0.10	0.11	0.15	0.20	0.29	0.41	0.57	0.76	1.01
VFD with low/no duct static pressure	0.05	0.06	0.09	0.12	0.18	0.27	0.39	0.55	0.75	1.00

Provided below is the resultant values based upon the defaults provided above:

Control Type	$\sum_{0\%}^{100\%}(\%FF \times PLR_{Base})$
No Control or Bypass Damper	1.00
Discharge Dampers	0.80
Outlet Damper, BI & Airfoil Fans	0.78
Inlet Damper Box	0.69
Inlet Guide Vane, BI & Airfoil Fans	0.63
Inlet Vane Dampers	0.53
Outlet Damper, FC Fans	0.53
Eddy Current Drives	0.49
Inlet Guide Vane, FC Fans	0.39
VFD with duct static pressure controls	0.30
VFD with low/no duct static pressure	0.27

IE_{energy} = HVAC interactive effects factor for energy (default = 15.7%)

SUMMER COINCIDENT PEAK DEMAND SAVINGS

kW_{Base} = $\left(0.746 \times HP \times \frac{LF}{\eta_{motor}}\right) \times PLR_{Base,FFpeak}$

$kW_{Retrofit}$ = $\left(0.746 \times HP \times \frac{LF}{\eta_{motor}}\right) \times PLR_{Retrofit,FFpeak}$

ΔkW_{fan} = $\mathrm{kW_{Base}} - \mathrm{kW_{Retrofit}}$

ΔkW_{total} = $\Delta \mathrm{kW_{fan}} \times (1 + \mathrm{IE_{demand}})$

Where:

kW_{Base} = Baseline summer coincident peak demand (kW)

$kW_{Retrofit}$ = Retrofit summer coincident peak demand (kW)

ΔkW_{fan} = Fan-only summer coincident peak demand impact

ΔkW_{total} = Total project summer coincident peak demand impact

$PLR_{Base,FFpeak}$ = The part load ratio for the average flow fraction between the peak daytime hours during the weekday peak time period based on the baseline flow control type (default average flow fraction during peak period = 90%)

$PLR_{Retrofit,FFpeak}$ = The part load ratio for the average flow fraction between the peak daytime hours during the weekday peak time period based on the retrofit flow control type (default average flow fraction during peak period = 90%)

IE_{demand} = HVAC interactive effects factor for summer coincident peak demand (default = 15.7%)

FOSSIL FUEL IMPACT DESCRIPTIONS AND CALCULATION

There are no expected fossil fuel impacts for this measure.

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-VSDF-V02-160601

4.4.27 Energy Recovery Ventilator

Description

This measure includes the addition of energy recovery equipment on existing or new unitary equipment, where energy recovery is not required by the IECC 2012/2015. This measure analyzes the heating savings potential from recovering energy from exhaust or relief building air. This measure assumes during unoccupied hours of the building no exhaust or relief air is available for energy recovery.

This measure was developed to be applicable to the following program types: TOS, NC, RF.

If applied to other program types, the measure savings should be verified.

Definition of Efficient Equipment

Efficient equipment is unitary equipment that incorporates energy recovery not required by the IECC 2012/2015.

Definition of Baseline Equipment

The baseline is unitary equipment not required by IECC 2012/2015 to incorporate energy recovery.

Deemed Lifetime of Efficient Equipment

The measure life for the domestic energy recovery equipment is 15 years.[423]

Deemed Measure Cost

The incremental cost for this measure assumes cost of cabinet and controls incorporated into packaged and built up air handler units. Additionally it assumes 1 to 1 ratio of fresh and exhausted air.

Energy Recovery Equipment Type	Incremental Cost $/CFM[424]
Fixed Plate	$6
Rotary Wheel	$6
Heat Pipe	$6

Deemed O&M Cost Adjustments

There are no expected O&M savings associated with this measure.

Loadshape

N/A

Coincidence Factor

N/A

[423] Assumed service life limited by controls -" Demand Control Ventilation Using CO2 Sensors", pg. 19, by US Department of Energy Efficiency and Renewable Energy
[424]"Map to HVAC Solutions", by Michigan Air, Issue 3, 2006

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS

SUMMER COINCIDENT PEAK DEMAND SAVINGS

There are no anticipated electrical savings from this measure as it is assumed that the additional fan energy due to the increased static pressure drop offsets cooling energy savings. Where this is not expected to be the case, a custom calculation should be used to determine the savings.

NATURAL GAS SAVINGS

Gas savings algorithm is derived from the following:

ΔTherms = (Design Heating Load * TE_ERV * EFLH * OccHours/24) / (100,000 * μHeat)

Where:

Design Heating Load = (1.08 * CFM * ΔT)

1.08 = A constant for sensible heat equations (BTU/h/CFM.°F)

CFM = Cubic Feet per Minute of Energy Recovery Ventilator

ΔT = T_RA – T_DD

T_RA = Temperature of the Return Air = 70°F or custom

T_DD = Temperature on design day of outside air[425]

= (see Table below) or custom

Zone	Weather Station	T_DD, Temperature, °F
1	Greater Rockford	-5.8
2	Chicago/O'Hare ARPT.	-1.5
3	Springfield/Capital	0.4
4	Scott AFB MidAmerica	9.0
5	Cape Girardeau Regional	9.7
Average	-	2.4

TE_ERV = Thermal Effectiveness of Energy Recovery Equipment[426]

= (see Table below) or custom

[425] Weather Station Data, 99.6% Heating DB - 2013 Fundamentals, ASHRAE Handbook
[426] Energy Recovery Fact Sheet - Center Point Energy, MN

Heat Recovery Equipment Type	TE_ERV (%)
Fixed Plate	0.65
Rotary Equipment	0.68
Heat Pipe	0.55

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

OccHours = Average Hours per day facility is occupied

= custom or use Modeling Inputs in eQuest models:

	Weekday	Saturday	Sunday	Holiday	Annual Operating Hours	OccHours
Assembly/Convention Center	10am-9pm	10am-9pm	10am-9pm	closed	3905	10.7
Assisted Living	24/7	24/7	24/7	24/7	8760	24.0
College	8am-9pm	closed	closed	closed	3263	8.9
Convenience Store	7am-10pm	9am-9pm	10am-5pm	10am-5pm	4823	13.2
Elementary School	8am-4pm (20% in summer)	closed	closed	closed	1606	4.4
Garage	7am-5pm	8am-12pm	closed	closed	3342	9.1
Grocery	7am-9pm	7am-9pm	9am-8pm	closed	4814	13.2
Healthcare Clinic	7am-7pm	9am-5pm	closed	closed	3428	9.4
High School	8am-4pm (20% in summer)	closed	closed	closed	1606	4.4
Hospital	24/7	24/7	24/7	24/7	8760	24.0
Motel	24/7	24/7	24/7	24/7	8760	24.0
Manufacturing Facility (Light Industry)	Mfg: 6am-10pm, Office: 8am-5pm	Mfg: 6am-10pm, Office: closed	closed	closed	4848	13.3
Multi-Family Mid-Rise	24/7; Reduced occupancy 7am - 5pm	24/7; Reduced occupancy 9am - 3pm	24/7; Reduced occupancy 9am - 3pm	24/7; Reduced occupancy 9am - 3pm	7038	19.3
Multi-Family High-Rise	24/7; Reduced occupancy 7am - 5pm	24/7; Reduced occupancy 9am - 3pm	24/7; Reduced occupancy 9am - 3pm	24/7; Reduced occupancy 9am - 3pm	7038	19.3
Movie Theater	10am-Midnight	10am-Midnight	10am-Midnight	10am-Midnight	5110	14.0
Office - Low-rise	8am-5pm	closed	closed	closed	2259	6.2
Office - Mid-rise	8am-5pm	20% 8am-noon	closed	closed	2301	6.3
Office - High-rise	8am-5pm	20% 8am-noon	closed	closed	2301	6.3

	Weekday	Saturday	Sunday	Holiday	Annual Operating Hours	OccHours
Religious Building	Office: 8am-5pm, other: closed	closed	8am-1pm	closed	260	0.7
Restaurant	7am-8pm	7am-8pm	7am-8pm	closed	4615	12.6
Retail - Department Store	9am-9pm	9am-9pm	10am-5pm	10am-5pm	4070	11.1
Retail - Strip Mall	9am-9pm	9am-9pm	10am-5pm	10am-5pm	4070	11.1
Warehouse (Conditioned Storage)	7am-7pm	7am-7pm (reduced occupancy)	closed	closed	3324	9.1

μHeat = Efficiency of heating system

= Actual

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-ERVE-V02-160601

4.4.28 Stack Economizer for Boilers Serving HVAC Loads

MEASURE DESCRIPTION

Stack economizers are designed to recover heat from hot boiler flue gasses. Recovered heat is used to preheat boiler feed water. This measure describes the retrofit of HVAC boilers with stack economizers. HVAC boilers are defined as those used for space heating applications. There is another, similar measure for boilers that serve process loads.

This measure was developed to be applicable to the following program types: NC, TOS, RF.

If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

To qualify the economizer must be installed on a boiler exhaust stack. Heat captured by the economizer is to be used to pre-heat boiler feed water.

DEFINITION OF BASELINE EQUIPMENT

The baseline boiler does not have an economizer installed.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure life for the boiler stack economizer is 15 years.[427]

DEEMED MEASURE COST

The incremental and full measure cost for this measure is custom.

DEEMED O&M COST ADJUSTMENTS

The O&M cost for this measure is custom.

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS SAVINGS

$$\Delta therms = SF * MBH\_In * EFLH / 100$$

Where:

$$SF = (T\_existing - T\_eff) / 40°F * TRE$$

[427] PA Consulting, Focus on Energy Evaluation, Business Programs: Measure Life Study, August 25, 2009.

= see default Savings Factor table below

Where:

T_existing = Existing Full Fire Boiler Flue Gas Temperature as it exits the Stack

= 425F[428] (water, 81.9% eff) or custom

= 480F[3] (steam, 80.7% eff) or custom

T_eff = Efficient Full Fire Boiler Flue Gas Temperature as it exits the Stack

= 338°F (conventional economizer – Water Boiler)[429] or custom

= 365°F (conventional economizer – Steam Boiler)[430] or custom

= 280°F (condensing economizer – Water Boiler)[431] or custom

= 308°F (condensing economizer – Steam Boiler)[432] or custom

TRE = % efficiency increase for 40°F of stack temperature reduction

= 1%[433] or custom

Based on defaults provided above:

Boiler Type	SF[434]	
	Conventional Economizer	Condensing Economizer
Hot Water Boiler	2.19% average SF or custom	3.63% average SF or custom
Steam Boiler	2.88% average SF or custom	4.31% average SF or custom

[428] Cleaver Brooks. March 2012, Boiler Efficiency Guide, Pg. 7, Figure 1.
[429] The minimum stack temperature for a non-condensing economizer is 250°F from Department of Energy (DOE). January 2012, Steam Tip Sheet #26A, Consider Installing a Condensing Economizer. Advanced Manufacturing Office. Washington, DC: U.S. Department of Energy. The average temperature drop is assumed to be ½ way between the existing and efficient temperature minimum, (425°F + 250°F) / 2 = 338°F.
[430] The minimum stack temperature for a non-condensing economizer is 250°F from Department of Energy (DOE). January 2012, Steam Tip Sheet #26A, Consider Installing a Condensing Economizer. Advanced Manufacturing Office. Washington, DC: U.S. Department of Energy. The average temperature drop is assumed to be ½ way between the existing and efficient temperature minimum, (480°F + 250°F) / 2 = 365°F.
[431] The minimum stack temperature for a condensing economizer is 250°F from Department of Energy (DOE). January 2012, Steam Tip Sheet #26A, Consider Installing a Condensing Economizer. Advanced Manufacturing Office. Washington, DC: U.S. Department of Energy. The average temperature drop is assumed to be ½ way between the existing and efficient temperature minimum, (425°F + 135°F) / 2 = 280°F.
[432] The minimum stack temperature for a condensing economizer is 250°F from Department of Energy (DOE). January 2012, Steam Tip Sheet #26A, Consider Installing a Condensing Economizer. Advanced Manufacturing Office. Washington, DC: U.S. Department of Energy. The average temperature drop is assumed to be ½ way between the existing and efficient temperature minimum, (480°F + 135°F) / 2 = 308°F.
[433] United States EPA, Climate Wise: Wise Rules for Industrial Efficiency, July 1998. The Wise Rules indicate savings range of 1-2% per 40°F reduction, so utilizing 1% is a conservative approach.
[434] These average values should be utilized in absence of actual temperature data. An economizer with a zero temperature change between the existing and the efficient temperatures would not be installed, so these average values are conservative.

MBH_In = Rated boiler input capacity, in MBH

= Actual

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

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-BECO-V01-150601

4.4.29 Stack Economizer for Boilers Serving Process Loads

Measure Description

Stack economizers are designed to recover heat from hot boiler flue gasses. Recovered heat is used to preheat boiler feed water. This measure describes the retrofit of process boilers with stack economizers. Process boilers are defined as those used for industrial, manufacturing, or other non-HVAC applications. There is another, similar measure for boilers that serve HVAC loads.

This measure was developed to be applicable to the following program types: NC, TOS, RF.

If applied to other program types, the measure savings should be verified.

Definition of Efficient Equipment

To qualify the economizer must be installed on a boiler exhaust stack. Heat captured by the economizer is to be used to pre-heat boiler feed water.

Definition of Baseline Equipment

The baseline boiler does not have an economizer installed.

Deemed Lifetime of Efficient Equipment

The measure life for the boiler stack economizer is 15 years.[435]

Deemed Measure Cost

The incremental and full measure cost for this measure is custom.

Deemed O&M Cost Adjustments

The O&M cost for this measure is custom.

Loadshape

N/A

Coincidence Factor

N/A

[435] PA Consulting, Focus on Energy Evaluation, Business Programs: Measure Life Study, August 25, 2009.

Algorithm

Calculation of Energy Savings

Electric Energy Savings

N/A

Summer Coincident Peak Demand Savings

N/A

Natural Gas Savings

Δtherms = SF * MBH_In * 8766 * UF / 100

Where:

SF = (T_existing – T_eff)/40°F * TRE

= see default Savings Factor table below

T_existing = Existing Full Fire Boiler Flue Gas Temperature as it exits the Stack

= 425F[436] (water, 81.9% eff per IL TRM) or custom

= 480F[3] (steam, 80.7% eff per IL TRM) or custom

T_eff = Efficient Full Fire Boiler Flue Gas Temperature as it exits the Stack

= 338°F (conventional economizer – Water Boiler)[437] or custom

= 365°F (conventional economizer – Steam Boiler)[438] or custom

= 280°F (condensing economizer – Water Boiler)[439] or custom

= 308°F (condensing economizer – Water Boiler)[440] or custom

---

[436] Cleaver Brooks. March 2012, Boiler Efficiency Guide, Pg. 7, Figure 1.

[437] The minimum stack temperature for a non-condensing economizer is 250°F from Department of Energy (DOE). January 2012, Steam Tip Sheet #26A, Consider Installing a Condensing Economizer. Advanced Manufacturing Office. Washington, DC: U.S. Department of Energy. The average temperature drop is assumed to be ½ way between the existing and efficient temperature minimum, (425°F + 250°F) / 2 = 338°F.

[438] The minimum stack temperature for a non-condensing economizer is 250°F from Department of Energy (DOE). January 2012, Steam Tip Sheet #26A, Consider Installing a Condensing Economizer. Advanced Manufacturing Office. Washington, DC: U.S. Department of Energy. The average temperature drop is assumed to be ½ way between the existing and efficient temperature minimum, (480°F + 250°F) / 2 = 365°F.

[439] The minimum stack temperature for a condensing economizer is 250°F from Department of Energy (DOE). January 2012, Steam Tip Sheet #26A, Consider Installing a Condensing Economizer. Advanced Manufacturing Office. Washington, DC: U.S. Department of Energy. The average temperature drop is assumed to be ½ way between the existing and efficient temperature minimum, (425°F + 135°F) / 2 = 280°F.

[440] The minimum stack temperature for a condensing economizer is 250°F from Department of Energy (DOE). January 2012, Steam Tip Sheet #26A, Consider Installing a Condensing Economizer. Advanced Manufacturing Office. Washington, DC: U.S. Department of Energy. The average temperature drop is assumed to be ½ way between the existing and efficient temperature minimum, (480°F + 135°F) / 2 = 308°F.

TRE = % efficiency increase for 40°F of stack temperature reduction

= 1%[441] or custom

Based on defaults provided above:

Boiler Type	SF[442]	
	Conventional Economizer	Condensing Economizer
Hot Water Boiler	2.19% average SF or custom	3.63% average SF or custom
Steam Boiler	2.88% average SF or custom	4.31% average SF or custom

MBH_In = Rated boiler input capacity, in MBH

= Actual

8766 = Hours a year

UF = Utilization Factor

= 41.9%[443] or custom

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-PECO-V01-150601

441 United States EPA, Climate Wise: Wise Rules for Industrial Efficiency, July 1998. The Wise Rules indicate savings range of 1-2% per 40°F reduction, so utilizing 1% is a conservative approach.

442 These average values should be utilized in absence of actual temperature data. An economizer with a zero temperature change between the existing and the efficient temperatures would not be installed, so these average values are conservative.

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

4.4.30 Notched V Belts for HVAC Systems

MEASURE DESCRIPTION

This measure is for replacement of smooth v-belts in non-residential package and split HVAC systems with notched v-belts. Typically there is a v-belt between the motor and the supply air fan and/or return air fan in larger package and split HVAC systems (RTU).

In general there are two styles of grooved v-belts, notched and synchronous. The DOE defines each as follows;

Notched V-Belts - A notched belt has grooves or notches that run perpendicular to the belt's length, which reduces the bending resistance of the belt. Notched belts can use the same pulleys as cross-section standard V-belts. They run cooler, last longer, and are about 2% more efficient than standard V-belts.

Synchronous Belts - Synchronous belts (also called cogged, timing, positive-drive, or high-torque drive belts) are toothed and require the installation of mating grooved sprockets. These belts operate with a consistent efficiency of 98% and maintain their efficiency over a wide load range.

Smooth v-belts are usually referred to in five basic groups:

- "L" belts are low end belts that are for small, fractional horsepower motors and these are not used in RTUs.
- "A" and "B" belts are the two types typically used in RTUs. The "A" belt is a ½ inch width by 5/16 inch thickness and the "B" belt is larger, 21/32 inch wide and 12/32 inch thick so it can carry more power. V-belts come in a wide variety of lengths where 20 to 100 inches is typical.
- "C" and "D" belts are primarily for industrial applications with high power transmission requirements.
- V-belts are provided by various vendors. The notched version of these belts typically have an "X" added to the designation. For this HVAC fans notched v-belt Replacement measure, only the "A" and "B" v-belts are considered. A typical "A" v-belt is replaced by a notched "AX" v-belt and a "B" is replaced by a "BX." In general, smooth v-belts have an efficiency of 90% to 98% while notched v-belts have an efficiency of 95% to 98%. Because notched v-belts are more flexible they work with smaller diameter pulleys and they have less resistance to bending. Lower bending resistance increases the power transmission efficiency, lowers the waste heat, and allows the belt to last longer than a smooth belt.

Three research papers[444] [445] [446] show that the notched v-belt efficiency is 2% to 5% better than a typical smooth v-belt. A fourth paper by USDOE's Energy Efficiency and Renewable Energy[447] group reviewed most of the earlier literature and recommended using a conservative 2% efficiency improvement for energy savings for calculations.

For this measure it is assumed that upgrading a standard smooth v-belt with a new notched v-belt will result in a fan energy reduction of 2%.

[444] "Gates Corporation Announces New EPDM Molded Notch V-Belts," The Gates Rubber Co., June 2010 (Assumed 3% efficiency improvement) https://ww2.gates.com/news/index.cfm?id=11296&show=newsitem&location_id=753&view=Gates

[445] "Synchronous Belt Drives Offer Low Cost Energy Savings," Baldor., February 2009. (attached in Reference Documents)

[446] "Energy Savings from Synchronous Belts," The Gates Rubber Co., February 2014. (Assumed 5% efficiency improvement) http://www.gates.com/~/media/Files/Gates/Industrial/Power%20Transmission/White%20Papers/Energy%20Savings%20from%20Synchronous%20Belt%20Drives.pdf

[447] "Motor System Tip Sheet #5, Replace V-Belts with Cogged or Synchronous Belt Drives," USDOE-EERE, September 2005. (Assumed 2% efficiency improvement) http://www1.eere.energy.gov/industry/bestpractices/pdfs/replace_vbelts_motor_systemts5.pdf

DEFINITION OF EFFICIENT EQUIPMENT

The Efficient Equipment is HVAC RTUs that have notched v-belts installed on the supply and/or return air fans.

DEFINITION OF BASELINE EQUIPMENT

The Baseline Equipment is HVAC RTUs that have smooth v-belts installed on the supply and/or return air fans (i.e. RTU does not already have a notched v-belt installed).

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

A v-belt has a life based on fan run hours which varies by building type based primarily on occupancy schedule because the fans are required by code to operate continuously during occupied hours. The supply and return fans will also run a few hours during unoccupied hours for heating and cooling as needed. For the notched v-belt EUL calculation, the default hours[448] in the following table are used for a variety of building types and HVAC applications.

EUL = Belt Life / Occupancy Hours per year

Where:

Belt Life = 24,000 hours[449]

Occupancy Hours per year = values from Table below

The notched v-belt measure EUL is summarized by building type in the following table.

Notched v-belt Effective Useful Life (EUL)

Building Type	Total Fan Run Hours	EUL (Years)
Assembly	7235	3.3
Assisted Living	8760	2.7
College	6103	3.9
Convenience Store	7004	3.4
Elementary School	7522	3.2
Garage	7357	3.3
Grocery	7403	3.2
Healthcare Clinic	6345	3.8
High School	7879	3.0
Hospital - VAV econ	8760	2.7
Hospital - CAV econ	8760	2.7
Hospital - CAV no econ	8760	2.7
Hospital - FCU	8760	2.7
Manufacturing Facility	8706	2.8
MF - High Rise	8760	2.7

448 ComEd Trm June 1, 2010 page 139. The Office hours is based upon occupancy from the eQuest model developed for EFLH, since it was agreed the ComEd value was too low.

449 "DEER2014-EUL-table-update_2014-02-05.xlsx," Database for Energy Efficiency Resources (DEER), Deer 2014. www.deerresources.com (attached in Reference Documents)

Building Type	Total Fan Run Hours	EUL (Years)
MF - Mid Rise	8760	2.7
Hotel/Motel - Guest	8760	2.7
Hotel/Motel - Common	8760	2.7
Movie Theater	7505	3.2
Office - High Rise - VAV econ	6064	4.0
Office - High Rise - CAV econ	5697	4.2
Office - High Rise - CAV no econ	5682	4.2
Office - High Rise - FCU	6163	3.9
Office - Low Rise	6288	3.8
Office - Mid Rise	6125	3.9
Religious Building	7380	3.3
Restaurant	7809	3.1
Retail - Department Store	6890	3.5
Retail - Strip Mall	6846	3.5
Warehouse	6786	3.5
Unknown	7100	3.4

DEEMED MEASURE COST

A review of the Grainger online[450] pricing for "A," "B," "AX," and "BX" v-belts showed the incremental cost to upgrade to notched v-belts would result in a 28% price increase. The notched v-belt incremental cost is summarized in the table below:

Notched V-belt Incremental Cost Summary

Smooth V-Belt Industry Number	Outside Length (Inches)	Dayton Smooth V-Belt*	Notched V-belt Industry Number	Dayton Notched v-belt*	Price Increase	% Increase
A30 (Item # 1A095)	32	$12.70	AX29 (Item # 3GWU4)	$17.65	$4.95	28%
B29 (Item # 6L208)	32	$16.75	BX29 (Item # 5TXL4)	$23.23	$6.48	28%
* Pricing based on Dayton Belts as found on Grainger Website 10/30/14						

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape C05 - Commercial Electric Heating and Cooling

COINCIDENCE FACTOR

N/A

[450] Grainger catalog on-line web-site for Dayton v-belt pricing
http://www.grainger.com/Grainger/ecatalog/N-1z0r596/Ntt-v-belts

Algorithm

Calculation of Energy Savings

Electric Energy Savings

$$\Delta kWh = kW_{connected} * Hours * ESF$$

Where:

$kW_{Connected}$ =kW of equipment is calculated using motor efficiency[451].

= (HP * 0.746 kW/HP* Load Factor)/Motor Efficiency

Load Factor =Motors are assumed to have a load factor of 80% for calculating KW if actual values cannot be determined[452]. Custom load factor may be applied if known.

Motor Efficiency = Actual motor efficiency shall be used to calculate KW. If not known a value from the motor efficiency refrence tables below should be used[453]. Default motor is a NEMA Premium Efficiency, ODP, 4-pole/1800 RPM fan motor

Baseline Motor Efficiencies (EPACT)						
Size HP	Open Drip Proof (ODP)			Totally Enclosed Fan-Cooled (TEFC)		
	# of Poles					
	6	*4*	*2*	*6*	*4*	*2*
	Speed (RPM)					
	1200	*1800*	*3600*	*1200*	*1800*	*3600*
1/8	-	44.00%	-	-	-	-
1/6	57.50%	62.00%	-	-	-	-
1/4	68.00%	68.00%	-	68.00%	64.00%	-
1/3	70.00%	70.00%	72.00%	70.00%	68.00%	72.00%
1/2	78.50%	80.00%	68.00%	72.00%	74.00%	68.00%
3/4	77.00%	78.50%	74.00%	77.00%	75.50%	74.00%
1	80.00%	82.50%	75.50%	80.00%	82.50%	75.50%
1.5	84.00%	84.00%	82.50%	85.50%	84.00%	82.50%
2	85.50%	84.00%	84.00%	86.50%	84.00%	84.00%
3	86.50%	86.50%	84.00%	87.50%	87.50%	85.50%
5	87.50%	87.50%	85.50%	87.50%	87.50%	87.50%

451 Note that kWConnected may be determined using various methodologies. The examples provided use rated HP and assumed load factor. Other methodologies include rated voltage and full load current with assumed load factor, or actual measured voltage and current.

452 Com Ed TRM June 1, 2010

453 Efficiency values for motors less than one HP taken from Baldor Electric Catalog 501: http://www.baldor.com/pdf/501_Catalog/CA501.pdf

Baseline Motor Efficiencies (EPACT)						
7.5	88.50%	88.50%	87.50%	89.50%	89.50%	88.50%
10	90.20%	89.50%	88.50%	89.50%	89.50%	89.50%
15	90.20%	91.00%	89.50%	90.20%	91.00%	90.20%
20	91.00%	91.00%	90.20%	90.20%	91.00%	90.20%
25	91.70%	91.70%	91.00%	91.70%	92.40%	91.00%

Efficient Motor Efficiencies (NEMA Premium)						
Size HP	Open Drip Proof (ODP)			Totally Enclosed Fan-Cooled (TEFC)		
	# of Poles			# of Poles		
	2	4	6	2	4	6
	Speed (RPM)			Speed (RPM)		
	1200	1800 (Default)	3600	1200	1800	3600
0.125 *	-	44.00%	-	-	-	-
1/6	57.50%	62.00%	-	-	-	-
1/4	68.00%	68.00%	-	68.00%	64.00%	-
1/3	70.00%	70.00%	72.00%	70.00%	68.00%	72.00%
1/2	78.50%	80.00%	68.00%	72.00%	74.00%	68.00%
3/4	77.00%	78.50%	74.00%	77.00%	75.50%	74.00%
1	82.50%	85.50%	77.00%	82.50%	85.50%	77.00%
1.5	86.50%	86.50%	84.00%	87.50%	86.50%	84.00%
2	87.50%	86.50%	85.50%	88.50%	86.50%	85.50%
3	88.50%	89.50%	85.50%	89.50%	89.50%	86.50%
5	89.50%	89.50%	86.50%	89.50%	89.50%	88.50%
7.5	90.20%	91.00%	88.50%	91.00%	91.70%	89.50%
10	91.70%	91.70%	89.50%	91.00%	91.70%	90.20%
15	91.70%	93.00%	90.20%	91.70%	92.40%	91.00%
20	92.40%	93.00%	91.00%	91.70%	93.00%	91.00%
25	93.00%	93.60%	91.70%	93.00%	93.60%	91.70%

Hours = When available, actual hours should be used. If actual hours are not available default hours[454] are provided in table below for HVAC fan operation which varies by building type:

[454] Hours per year are estimated using the eQuest models as the total number of hours the fans are operating for heating,

Building Type	Total Fan Run Hours
Assembly	7235
Assisted Living	8760
College	6103
Convenience Store	7004
Elementary School	7522
Garage	7357
Grocery	7403
Healthcare Clinic	6345
High School	7879
Hospital - VAV econ	8760
Hospital - CAV econ	8760
Hospital - CAV no econ	8760
Hospital - FCU	8760
Manufacturing Facility	8706
MF - High Rise	8760
MF - Mid Rise	8760
Hotel/Motel - Guest	8760
Hotel/Motel - Common	8760
Movie Theater	7505
Office - High Rise - VAV econ	6064
Office - High Rise - CAV econ	5697
Office - High Rise - CAV no econ	5682
Office - High Rise - FCU	6163
Office - Low Rise	6288
Office - Mid Rise	6125
Religious Building	7380
Restaurant	7809
Retail - Department Store	6890
Retail - Strip Mall	6846
Warehouse	6786
Unknown	7100

ESF = Energy Savings Factor, the ESF for notched v-belt Installation is assumed to be 2%

cooling and ventilation for each building type.

EXAMPLE

For example, an low rise office building RTU with a 5 HP NEMA premium efficiency motor using the default hours of operation, motor load and 89.5% motor efficiency;

$$\Delta kWh = kW_{connected} * Hours * ESF$$

$$= ((HP * 0.746\ kW/HP * Load\ Factor)/Motor\ Efficiency) * Hours * ESF$$

$$= ((5\ HP * 0.746\ kW/HP * 80\%) / 89.5\%) * 6288 * 2\%$$

$$= 419\ kWh\ Savings$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = kW_{connected} * ESF$$

Where:

$kW_{Connected}$ = kW of equipment is calculated using motor efficiency.

= (HP *0 .746 kW/HP* Load Factor)/Motor Efficiency

Variables as provided above

EXAMPLE

For example, an office building RTU with a 5 HP NEMA premium efficiency motor using the default motor load and 89.5% motor efficiency;

$$\Delta kW = kW_{connected} * ESF$$

$$= ((HP * 0.746\ kW/HP * Load\ Factor)/Motor\ Efficiency) * ESF$$

$$= ((5\ HP * 0.746\ kW/HP * 80\%) / 89.5\%) * 2\%$$

$$= 0.0667\ kW\ Savings$$

NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-NVBE-V02-160601

4.4.31 Small Business Furnace Tune-Up

Description

This measure is for a natural gas Small Business furnace that provides space heating. The tune-up will improve furnace performance by inspecting, cleaning and adjusting the furnace and appurtenances for correct and efficient operation. Additional savings maybe realized through a complete system tune-up.

This measure was developed to be applicable to the following program types: Small business.

If applied to other program types, the measure savings should be verified.

Definition of Efficient Equipment

To qualify for this measure an approved technician must complete the tune-up requirements[455] listed below:

- Measure combustion efficiency using an electronic flue gas analyzer
- Check and clean blower assembly and components per manufacturer's recommendations
- Where applicable Lubricate motor and inspect and replace fan belt if required
- Inspect for gas leaks
- Clean burner per manufacturer's recommendations and adjust as needed
- Check ignition system and safety systems and clean and adjust as needed
- Check and clean heat exchanger per manufacturer's recommendations
- Inspect exhaust/flue for proper attachment and operation
- Inspect control box, wiring and controls for proper connections and performance
- Check air filter and clean or replace per manufacturer's
- Inspect duct work connected to furnace for leaks or blockages
- Measure temperature rise and adjust flow as needed
- Check for correct line and load volts/amps
- Check thermostat operation is per manufacturer's recommendations (if adjustments made, refer to 'Small Commercial Programmable Thermostat Adjustment' measure for savings estimate)
- Perform Carbon Monoxide test and adjust heating system until results are within standard industry acceptable limits

Definition of Baseline Equipment

The baseline is furnace assumed not to have had a tune-up in the past 2 years.

Deemed Lifetime of Efficient Equipment

The measure life for the tune up is 2 years.[456]

Deemed Measure Cost

The incremental cost for this measure should be the actual cost of tune up.

[455] American Standard Maintenance for Indoor Units: http://www.americanstandardair.com/owner-support/maintenance.html
[456] Act on Energy Commercial Technical Reference Manual No. 2010-4, 9.2.3 Gas Forced-Air Furnace Tune-up.

DEEMED O&M COST ADJUSTMENTS

There are no expected O&M savings associated with this measure.

LOADSHAPE

Loadshape C04 - Commercial Electric Heating

COINCIDENCE FACTOR

N/A

Algorithms

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS

$\Delta kWh = \Delta Therms * F_e * 29.3$

Where:

$\Delta Therms$ = as calculated below

F_e = Furnace Fan energy consumption as a percentage of annual fuel consumption

= 3.14%[457]

29.3 = kWh per therm

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS SAVINGS

$\Delta Therms = (Capacity * EFLH * (((Effbefore + Ei)/ Effbefore) – 1)) / 100,000$

Where:

Capacity = Furnace gas input size (Btu/hr)

= Actual

EFLH = Equivalent Full Load Hours for heating are provided

[457] 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.

in section 4.4 HVAC End Use

Effbefore = Efficiency of the furnace before the tune-up

= Actual

Note: Contractors should select a mid-level firing rate that appropriately represents the average building operating condition over the course of the heating season and take readings at a consistent firing rate for pre and post tune-up.

EI = Efficiency Improvement of the furnace tune-up measure

= Actual

100,000 = Converts Btu to therms

EXAMPLE

A 200 kBtu furnace in a Rockford low rise office records an efficiency prior to tune up of 82% AFUE and a 1.8% improvement in efficiency are tune up:

Δtherms = (200,000 * 1428 * (((0.82 + 0.018)/ 0.82) – 1)) /100,000

= 62.3 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-FTUN-V02-160601

4.4.32 Combined Heat and Power

Description

The Combined Heat and Power (CHP) measure can provide energy savings within the State of Illinois through the development and operation of CHP projects. This measure is applicable for Conventional or Topping Cycle CHP systems, as well as Waste Heat-to-Power (WHP) or Bottoming Cycle CHP systems. The measure will reduce the total Btu's of energy required to meet the end use needs of the facility.

It is recognized that CHP system design and configuration may be complex, and as such the calculation of energy savings may not be reducible to the equations within this measure. In such cases a more comprehensive engineering and financial analysis may be developed that more accurately incorporates the attributes of complex CHP configurations such as variable-capacity systems, and partial combined-cycle CHP systems. Where noted, the use of values that are determined through an external engineering analysis may be substituted by agreement between the participant, the program administrator and independent evaluator. This substitution of values does not eliminate ex post evaluation risk (retroactive adjustments to savings claims) that exists when using custom inputs.

This measure was developed to be applicable to the following program types: Retrofit (RF), New Construction (NC). If applied to other program types, the measure savings should be verified.

Definition of Efficient Equipment

Conventional or Topping Cycle CHP is defined as an integrated system that is located at or near the building or facility (on-site, on the customer side of the meter) that utilizes a prime mover (reciprocating engine, gas turbine, micro-turbine, fuel cell, boiler/steam turbine combination) for the purpose of generating electricity and useful thermal energy (such as steam, hot water, or chilled water) where the primary function of the facility where the CHP is located is not to generate electricity for use on the grid. An eligible system must demonstrate a minimum total system efficiency of 60% (HHV)[458] with at least 20% of the system's total useful energy output in the form of useful thermal energy on an annual basis.

Measuring and Calculating Conventional CHP Total System Efficiency:

CHP efficiency is calculated using the following equation:

$$CHP_{\ Efficiency}(HHV) = \frac{\left[CHP_{thermal}\ \left(\frac{kBtu}{yr}\right) + E_{CHP}\ \left(\frac{kWh}{yr}\right) * 3.412\ \left(\frac{kBtu}{kWh}\right)\right]}{F_{totalCHP}\left(\frac{kBtu}{yr}\right)}$$

Where:

$CHP_{thermal}$ = Useful annual thermal energy output from the CHP system, defined as the annual thermal energy output of the CHP system that is actually recovered and utilized in the facility/process.

E_{CHP} = Useful annual electricity output produced by the CHP system, defined as the annual electric energy output of the CHP system that is actually utilized to replace purchased electricity required to meet the requirements of the facility/process.

$F_{totalCHP}$ = Total annual fuel consumed by the CHP system

For further definition of the terms, please see "Calculation of Energy Savings" Section below.

[458] Higher Heating Value (HHV): refers to the heating value of the fuel and is defined as the total thermal energy available, including the heat of condensation of water vapors,resulting from complete combustion of the fuel versus the Lower Heating Value (LHV) which assumes the heat of condensation is not available

Waste Heat-to-Power or Bottoming Cycle CHP is defined as an integrated system that is located at or near the building or facility (on-site, on the customer side of the meter) that does one of the following:

- Utilizes exhaust heat from an industrial/commercial process to generate electricity (except for exhaust heat from a facility whose primary purpose is the generation of electricity for use on the grid); or
- Utilizes the pressure drop in an industrial/commercial facility to generate electricity through a backpressure steam turbine where the facility normally uses a pressure reducing valve (PRV) to reduce the pressure in their facility; or
- Utilizes the pressure reduction in natural gas pipelines (located at natural gas compressor stations) before the gas is distributed through the pipeline to generate electricity, provided that the conversion of energy to electricity is achieved without using additional fossil fuels.

Since these types of systems utilize waste heat as their fuel, they do not have to meet any specific total system efficiency level (assuming they use no additional fossil fuel in their operation) If additional fuel is used onsite, it should be accounted for using the following methodology:

- Treat the portion of Waste-Heat-to-Power that does not require any additional fuel using the Waste-Heat-to-Power methodology outlined in this document.
- Treat the portion of Waste-Heat-to-Power that requires additional fuel (if natural gas) using the Conventional CHP methodology outlined in this document. If the additional fuel is not natural gas, custom carbon equivalency calculations would be needed – refer to section “Calculation of Energy Savings” for more details.
- Add the energy savings together.

These systems may export power to the grid.

Definition of Baseline Equipment

Electric Baseline: The baseline facility would be a facility that purchases its electric power from the grid.

Heating Baseline (for CHP applications that displace onsite heat): The baseline equipment would be the boiler/furnace operating onsite, or a boiler/furnace meeting the baseline equipment defined in the High Efficiency Boiler (Section 4.4.10)/Furnace (Section 4.4.11) measures of this TRM.

Cooling Baseline (for CHP applications that displace onsite cooling demands): The baseline equipment would be the chiller (or chillers) operating onsite, or a chiller (or chillers) meeting the definition of baseline equipment defined in the Electric Chiller (Section 4.4.6) measure of this TRM.

Facilities that use biogas or waste gas: Facilities that use (but are not purchasing) biogas or waste gas that is not otherwise used, whether they are using biogas or waste gas only or a combination of biogas or waste gas and natural gas to meet their energy demands are also eligible for this measure. If additional fuel is purchased to power the CHP system, then the additional natural gas should be taken into account using the following methodology:

- Treat the portion of CHP system that does not require any additional fuel, or that requires additional fuel that would otherwise be wasted (e.g. flared), using the Waste-Heat-to-Power methodology outlined in this document.
- Treat the portion of CHP that requires additional fuel (if natural gas) using the Conventional CHP methodology outlined in this document. If the additional fuel is not natural gas, custom carbon equivalency calculations would be needed – refer to section “Calculation of Energy Savings” for more details.
- Add the energy savings together.

Consumption of any biogas or waste gas that would not otherwise being wasted (*e.g.,* flared) will be accounted for in the overall net BTU savings calculations the same as for purchased natural gas.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

Measure life is a custom assumption, dependent on the technology selected and the system installation.

DEEMED MEASURE COST

Custom installation and equipment cost will be used. These costs should include the cost of the equipment and the cost of installing the equipment. Equipment costs include, but are not limited to: prime mover, heat recovery system(s), exhaust gas treatment system(s), controls, and any interconnection/electrical connection costs.

The installations costs include labor and material costs such as, but not limited to: labor costs, materials such as ductwork, piping, and wiring, project and construction management, engineering costs, commissioning costs, and other fees.

Measure costs will also include the present value of expected maintenance costs over the life of the CHP system.

LOADSHAPE

Use Custom Loadshape. The loadshape should be obtained from the actual CHP operation strategy, based on the On-Peak and Off-Peak Energy definitions specified in Table 3.3 of “Section 3.5 Electrical Loadshapes” of the TRM.

COINCIDENCE FACTOR

Custom coincidence factor will be used. Actual value based on the CHP operation strategy will be used.

Algorithm

CALCULATION OF ENERGY SAVINGS

i) Conventional or Topping Cycle CHP Systems:

Step 1: (Calculating Total Annual Source Fuel Savings in Btus)

The first step is to calculate the total annual source fuel savings associated with the CHP installation, in order to ensure the CHP project produces positive total annual source fuel savings (i.e. reduction in source Btus):

$S_{FuelCHP}$ = Annual fuel savings (Btu) associated with the use of a Conventional CHP system to generate the useful electricity output (kWh, converted to Btu) and useful thermal energy output (Btu) versus the use of the equivalent electricity generated and delivered by the local grid and the equivalent thermal energy provided by the onsite boiler/furnace.

$= (F_{grid} + F_{thermalCHP}) – F_{total\ CHP}$

Where:

F_{grid} = Annual fuel in Btu that would have been used to generate the useful electricity output of the CHP system if that useful electricity output was provided by the local utility grid.

$= E_{CHP} * H_{grid}$

Where:

E_{CHP} = Useful annual electricity output produced by the CHP system, defined as the annual electric energy output of the CHP system that is actually utilized to replace purchased electricity required to meet the requirements of the facility/process. [459]

$= (CHP_{capacity} * Hours) - E_{Parasitic}$

$CHP_{capacity}$ = CHP nameplate capacity

= Custom input

Hours = Annual operating hours of the system

= Custom input

$E_{parasitic}$ = The electricity required to operate the CHP system that would otherwise not be required by the facility/process

= Custom input

H_{grid} = Heat rate of the grid in Btu/kWh, based on the average fossil heat rate for the EPA eGRID subregion, adjusted to take into account T&D losses.

For systems operating less than 6,500 hrs per year:

Use the Non-baseload heat rate provided by EPA eGRID for RFC West region for ComEd territory (including independent providers connected to RFC West), and SERC Midwest region for Ameren territory (including independent providers connected to SERC Midwest)[460]. Also include any line losses.

For systems operating more than 6,500 hrs per year:

Use the All Fossil Average heat rate provided by EPA eGRID for RFC West region for ComEd territory (including independent providers connected to RFC West), and SERC Midwest region for Ameren territory (including independent providers connected to SERC Midwest). Also include any line losses.

$F_{thermalCHP}$ = Annual fuel in Btu that would have been used on-site by a boiler/furnace to provide the useful thermal energy output of the CHP system. [461]

$= CHP_{thermal} / Boiler_{eff}$ (or $CHP_{thermal} / Furnace_{eff}$)

$CHP_{thermal}$ = Useful annual thermal energy output from the CHP system, defined as the annual thermal energy output of the CHP system that is actually recovered and utilized in the facility/process.

[459] For complex systems this value may be obtained from a CHP System design/financial analysis study.

[460] Refer to EPA eGRID data http://www.epa.gov/chp/documents/fuel_and_co2_savings.pdf, page 24 and http://www.epa.gov/cleanenergy/documents/egridzips/eGRID_9th_edition_V1-0_year_2010_Summary_Tables.pdf, page 9. Current values are:

- Non-Baseload RFC West: 9,811 Btu/kWh * (1 + Line Losses)
- Non-Baseload SERC Midwest: 10,511 Btu/kWh * (1 + Line Losses)
- All Fossil Average RFC West: 10,038 Btu/kWh * (1 + Line Losses)
- All Fossil Average SERC Midwest: 10,364 Btu/kWh * (1 + Line Losses)

[461] For complex systems this value may be obtained from a CHP System design/financial analysis study.

= Custom input

$Boiler_{eff}$ /$Furnace_{eff}$= Efficiency of the on-site Boiler/Furnace that is displaced by the CHP system or if unknown, the baseline equipment value stated in the High Efficiency Boiler (Section 4.4.10) measure or High Efficiency Furnace (Section 4.4.11) measure in this TRM. .

= Custom input

$F_{total\ CHP}$ = Total fuel in Btus consumed by the CHP system

= Custom input

<u>Step 2: (Savings Allocation to Program Administrators for Purposes of Assessing Compliance with Energy Savings Goals (Not for Use in Load Reduction Forecasting))</u>

Savings claims are a function of the electric output of the CHP system (E_{CHP}), the used thermal output of the CHP system ($F_{thermalCHP}$), and the CHP system efficiency (CHP_{Eff}(HHV)). The percentages of electric output and used thermal output that can be claimed also differ slightly depending on whether the project was included in both electric[462] and gas[463] Energy Efficiency Portfolio Standard (EEPS)[464] efficiency programs, only an electric EEPS program or only a gas EEPS program. The tables below provide the specific percentages of electric and/or thermal output that can be claimed under each of those three scenarios. These percentages apply only to cases in which natural gas is the fuel used by the CHP system. Saving estimates for systems using other fuels should be calculated on a custom basis. If the waste heat recovered from the CHP system is offsetting electric equipment, such as an absorption chiller offsetting an electric chiller, then the net change in electricity consumption associated with the electric equipment should be added to the allocated electric savings.

1) For systems participating in both electric EEPS and gas EEPS programs:

CHP Annual System Efficiency (HHV)	Allocated Electric Savings	Allocated Gas Savings
60%	65% of E_{CHP} (kWh)	No gas savings
>60% to 65%	65% of E_{CHP} (kWh) + one percentage point increase for every one percentage point increase in CHP system efficiency (max 70% of E_{CHP} in kWh)	No gas Savings
>65%	70% of E_{chp} (kWh)	2.5% of $F_{thermal}$ (useful thermal output of the CHP system) for every one percentage point increase in CHP system efficiency above 65%.

[462] 220 ILCS 5/8-103; 220 ILCS 5/16-111.5B
[463] 220 ILCS 5/8-104
[464] As used in this measure characterization, EEPS programs are defined as those energy efficiency programs implemented pursuant to Sections 8-103, 8-104, and 16-111.5B of the Illinois Public Utilities Act. Technically, EEPS programs pertain to energy efficiency programs implemented pursuant to 220 ILCS 5/8-103 and 220 ILCS 5/8-104. However, for simplicity in presentation, this measure defines EEPS programs as also including those programs implemented pursuant to 220 ILCS 5/16-111.5B (these programs are funded through the same energy efficiency riders established pursuant to Section 8-103).

Example: System with measured annual system efficiency (HHV) of 70%: Electric savings (kWh) = 70% of E_{CHP} measured over 12 months, and Gas savings (therms) = 12.5% of $F_{thermal}$ measured over 12 months (70% - 65% = 5 X 2.5% = 12.5%)

2) For systems participating in only an electric EEPS program:

CHP Annual System Efficiency (HHV)	Allocated Electric Savings	Allocated Gas Savings
60%	65% of E_{CHP} (useful electric output of CHP system in kWh)	No gas Savings
Greater than 60%	65% + one percentage point increase for every one percentage point increase in CHP system efficiency (no max)	No gas Savings

Example: System with measured annual fuel use efficiency of 75%: Electric savings (kWh) = 65% + 15% = 80% of E_{CHP} measured over 12 months (15% = 1% for every 1% increase in system efficiency). No gas savings (therms).

3) For systems participating in only a gas EEPS program:

CHP Annual System Efficiency (HHV)	Allocated Electric Savings	Allocated Gas Savings
60% or greater	No electric savings	2.5% of Fthermal (useful thermal output of the CHP system) for every one percentage point increase in CHP system efficiency above 60%.

Example: System with measured annual system efficiency (HHV) of 70%: No Electric savings (kWh). Gas savings (therms) = 25% of $F_{thermal}$ measured over 12 months (70% - 60% = 10 X 2.5% = 25%)

Conventional or topping cycle CHP systems virtually always require an increase in the use of fuel on-site in order to produce electricity. Different jurisdictions and experts across the country have employed and/or put forward a variety of approaches[465] to address how increased on-site fuel consumption should be reflected in the attribution of electric savings to CHP systems. The approach reflected in the tables above is generally consistent – for CHP systems consuming natural gas – with approaches recently put forward by the Southwest Energy Efficiency Project (SWEEP) and Institute for Industrial Productivity (IIP) that determine reduced electric savings based on the equivalent amount of carbon dioxide generated from the increased fuel used[466].

[465] Approaches range from ignoring the increased gas use entirely (i.e., no "penalty") to applying approximately 40-60% "penalties", depending on the CHP efficiency and based on the equivalent grid kWh that the increased gas use represents.

[466] Consider, for example, a hypothetical CHP system that produces 5 million kWh annually, consumes 50 million kBtu of gas annual to generate that electricity (i.e. electric efficiency of approximately 34.8% HHV), reduces on-site gas use for space heating by 26 million kBtu of gas (i.e. equivalent to approximately 81.5% CHP thermal output utilization displacing gas used in a 70% efficient space heating boiler) and has a total annual CHP efficiency of 70.6% HHV. In this example, the net increase in on-site gas use is 24 million kBtu. At a carbon dioxide emission rate of 53.06 kg/MMBtu for burning natural gas, that translates to an increase in on-site carbon dioxide emissions of 1404 tons per year. At an estimated marginal emission rate of 1.098 tons of carbon dioxide per MWh in Illinois, that is equivalent to electric grid production of approximately 1.28 million kWh, or penalty of about 25.6% of the CHP system's electrical output if a precise calculation of carbon equivalency was utilized to assign savings. In comparison, the simplified table above would entitle an electric utility to claim savings equal to 75.6% of the electric output (i.e. a penalty of 24.4% of electrical output) if it was the only utility promoting the system. In a gas and electric example, the electric savings claimed would be 70% of the production (a penalty of 30% of the CHP system's electrical output) and 12.5%

There are a variety of ways one could treat the potential for gas utilities to claim savings from CHP projects in their EEPS portfolios. For projects in which a natural gas EEPS program is involved, the tables above treat savings from CHP installations in two steps: (1) a fuel-switch from electricity to natural gas (i.e. using more natural gas to eliminate the need to generate as much electricity on the grid); and (2) possible increases in CHP efficiency above a "benchmark" level. When both electric EEPS and natural gas EEPS programs are involved in a project, the program administrator claims all the electricity savings associated with a fuel-switch up to a "benchmark" 65% efficient CHP system. All the savings associated with increasing CHP efficiencies above that benchmark level are allocated to natural gas (e.g. if the CHP efficiency is 75%, the natural gas savings associated with an increase in CHP efficiency from 65% to 75% are allocated to natural gas). That is consistent with the notion that CHP efficiency typically increases primarily by increasing the use of the thermal output of the system (increasing the displacement of baseline gas use). For projects that involve only a natural gas EEPS program, the "benchmark" above which the gas utility can claim savings is lowered to 60%.

ii) Waste-Heat-to-Power CHP Systems :

ELECTRIC ENERGY SAVINGS:

$\Delta kWh = E_{CHP}$

Where:

E_{CHP} = Useful annual electricity output produced by the CHP system, defined as the annual electric energy output of the CHP system that is actually utilized to replace purchased electricity required to meet the requirements of the facility/process.

= Custom input

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$\Delta kW = CF * CHP_{capacity}$

Where:

CF = Summer Coincidence factor. This factor should also consider any displaced chiller capacity[467]

= Custom input

$CHP_{Capacity}$ = CHP nameplate capacity

= Custom input

NATURAL GAS ENERGY SAVINGS:

$\Delta Therms = F_{thermalCHP} \div 100{,}000$

Where:

$F_{thermalCHP}$ = Net savings in annual purchased fuel in Btu, if any, that would have been used on-site by a boiler/furnace to provide some or all of the useful thermal energy output of the CHP system[468].

of the recovered thermal output, equivalent to 2.23 million kBtu. The difference between the electric only scenario and the electric and gas, on the electric side, is 5% of the electric output or 250,000 kWh, which would require 2.45 million kBtu input at an efficiency of 34.8% HHV.

[467] If some or all of the existing electric chiller peak demand is no longer needed due to new waste heat powered chillers (e.g., absorption), the coincidence factor should be adjusted appropriately.

[468] In most cases, it is expected that waste-heat-to-power systems will not provide any new net useful thermal energy output, since the CHP system will be driven by thermal energy that was otherwise being wasted. If additional natural gas or other purchased energy is used onsite, it should be properly accounted for.

100,000 = Conversion factor for Btu to therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

Custom estimates of maintenance costs that will be incurred for the life of the measure will be used. Maintenance costs vary with type and size of the prime mover. These costs include, but are not limited to:

- Maintenance labor
- Engine parts and materials such as oil filters, air filters, spark plugs, gaskets, valves, piston rings, electronic components, etc. and consumables such as oil
- Minor and major overhauls

For screening purposes, the US EPA has published resource guides that provide average maintenance costs based on CHP technology and system size[469].

COST-EFFECTIVENESS SCREENING AND LOAD REDUCTION FORECASTING

For the purposes of forecasting load reductions due to CHP projects per Section 16-111.5B, changes in site energy use at the customer's meter – reduced consumption of utility provided electricity – adjusted for utility line losses (at-the-busbar savings), customer switching estimates, NTG, and any other adjustment factors deemed appropriate, should be used.

For the purposes of screening a CHP measure application for cost-effectiveness, changes in site energy use – reduced consumption of utility provided electricity and the net change in consumption of fuel – should be used. In general, the benefit and cost components used in evaluating the cost-effectiveness of a CHP project would include at least the following terms:

Benefits: $E_{CHP} + \Delta kW + F_{thermal\_CHP}$

Costs: $F_{total\_CHP} + CHP_{COSTS} + O\&M_{COSTS}$

Where:

CHP_{Costs} = CHP equipment and installation costs as defined in the "Deemed Measure Costs" section

$O\&M_{Costs}$ = CHP operations and maintenance costs as defined in the "Deemed O&M Cost Adjustment Calculation" section

MEASURE CODE: CI-HVC-CHAP-V01-150601

469 "EPA Combined Heat and Power Partnership Resources" Oct 07, 2014, http://www.epa.gov/chp/resources.html in the document "Catalog of CHP technologies" http://www.epa.gov/chp/documents/catalog_chptech_full.pdf pages 2-16, 3-14, 4-14, 5-14, and 6-16.

4.4.33 Industrial Air Curtain

DESCRIPTION

This measure applies to buildings with exterior entryways that utilize overhead doors. All other air curtain applications, such as through sliding door entryways or conventional foot-traffic entryways, require custom analysis as air curtain designs must often accommodate other factors that may change their effectiveness.

The use of overhead doors within exterior entryways during the heating season leads to the exfiltration of warm air from the upper portion of the door opening and the infiltration of colder air from the lower portion of the door opening. This results in increase heating energy use to compensate for heat losses every time a door is opened. By reducing heat losses, air curtains can also enhance the physical comfort of employees or customers near the entryway as there will be reduced temperature fluctuations when the door is opened and closed. In addition, in some cases excess heating capacity may be installed in buildings to meet this larger heating load. The addition of air curtains to exterior entryways that currently utilize overhead doors will result in energy savings and enhanced personal comfort, and also possibly in reduced equipment sizing and corresponding costs.

The primary markets for this measure are commercial and industrial facilities with overhead doors in exterior entryways, including but not limited to the following building types: retail, manufacturing, and warehouse (non-refrigerated).

Limitations

- For use in conditioned spaces with an overhead door in an exterior entryway. This measure does include other door types such doorways to commercial spaces such as retail.
- This measure should only be applied to spaces in which the overhead door separates a conditioned space and an unconditioned space.
- Installation must follow manufacturer recommendations to attain proper air velocity, discharge angle down to the floor level, and unit position.
- Certain heating systems may not be a good fit for air curtains, such as locations with undersized heating capacity. In these cases, the installation of an air curtain may not effectively reduce heating system cycling given the inappropriately sized heating capacity.
- Buildings with slightly positive to slightly negative (~5 Pa to -10 Pa). For all other scenarios, custom analysis is recommended.
- Measure assumes that wind speeds at near ground level are less than or equal to 12 mph for 90% of the heating or cooling season. For areas with more extreme weather, custom analysis is necessary.
- Note: for cost effectiveness, it is recommended that minimum door open times should be approximately 15 hours per week.[470]

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

The following methodology is highly complex and requires significant data collection. It is hoped that simplifying steps can be made in future iterations based on continued metering and evaluation of installations. Also the data collected through implementing the measure in the way currently drafted will aid in simplifying efforts at a future date.

DEFINITION OF EFFICIENT EQUIPMENT

Overhead air curtains designed for commercial and industrial applications that have been tested and certified in

[470] Spentzas, Steve, et. al, "1009: Commercial and Industrial Air Curtains – Public Project Report," Nicor Gas Emerging Technology Program (Oct 2014): 9

accordance with ANSI/AMCA 220 and installed following manufacturer guidelines. Measure is for standard models without added heating.

DEFINITION OF BASELINE EQUIPMENT

No air curtain or other currently installed means to effectively reduce heat loss and air mixing during door openings, such as a vestibule or strip curtain.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 15 years.[471]

DEEMED MEASURE COST

The incremental capital cost for overhead air curtains for exterior entryways are as follows, with an added average installation cost approximately equal to the capital cost.[472]

Door Size	Capital Cost
8'w x 8'h	$3,600
10'w x 10'h	$4,500
10'w x 12'h	$5,400
12'w x 14'h	$8,000
16'w x 16'h	$13,300

LOADSHAPE

Heating Season: If electric heating, use Commercial Electric Heating Loadshape: C04. Otherwise, N/A

Cooling Season: Commercial Cooling Loadshape C03. Or, if applicable, use Commercial Electric Heating and Cooling Loadshape C05.

COINCIDENCE FACTOR

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

= 91.3%[473]

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

= 47.8%[474]

Algorithm

471 Navigant Consulting Inc, Measures and Assumptions for Demand Side Management (DSM) Planning: Appendix C: Substantiation Sheets, "Air Curtains – Single Door," Ontario Energy Board, (April 2009): C-137.
2014 Database for Energy-Efficient Resources, EUL/RUL (Effective/Remaining Useful Life) Values, February 4, 2014.

472 Based on manufacturer interviews and air curtain specification sheets.

473 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.

474 Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year

Calculation of Energy Savings

The following formulas provide a methodology for estimating cooling load (kWh) and heating load (therm) savings associated with the installation of air curtains on exterior entryways such as a single door or loading bay. This algorithm is based on the assumption that therm savings are directly related to the difference in cooling or heating losses due to infiltration or exfiltration through an entryway before and after the installation of an AMCA certified air curtain. Energy savings are assumed to be the result of a reduction of natural infiltration effects due to wind and thermal forces and follow the calculation methodology outlined by the ASHRAE Handbook.[475] The calculation assumes that the air curtain is appropriately sized and commissioned to be effective in mitigating infiltration of winds of up to 12 mph for at a least 90% of the year (based on manufacturer literature and TMY3 wind speed ranges at near ground level for Illinois).[476] Additionally, this measure assumes the HVAC systems are appropriately balanced such that the maximum pressure differential between indoor air and outdoor air is within the range of 5 Pa < ΔP < -10 Pa.[477] Custom analysis is necessary if building pressurization exceeds this range. However, while effectiveness decreases, some studies suggest that air curtains outperform vestibules and single door construction for negatively pressurized buildings with a ΔP of above -30 Pa.[478]

This algorithm allows either actual inputs or provides estimates if actual data is not available. All weather dependent values are derived from TMY3 data for the closest weather station to those locations defined elsewhere in the Illinois TRM (which are based on 30 year climate normals). If TMY3 weather station data was not available for the data used in the Illinois TRM, the next closest weather station was used. It is assumed that weather variations are negligible between the weather stations located within the same region. This approach was followed as the air curtain algorithm has a number of weather dependent variables which are all calculated in relation to the heating season or cooling season as defined by the balance point temperature deemed appropriate for the facility. All weather dependent data is based on TMY3 data and is listed in tables by both climate zone and balance point temperature, which is then normalized to the Illinois TRM climate zoned HDD/CDD definitions unless otherwise noted.

Electric Energy Savings

ΔkWhcooling = [(Q_{tbc} – Q_{tac}) / EER – (HP * 0.7457)] * t_{open} * CD

ΔkWhHPheating = [(Q_{tbc} – Q_{tac}) / HSPF – (HP * 0.7457)] * t_{open} * HD

ΔkWhGasheating = - (HP * 0.7457) * t_{open} * HD

Where:

Q_{tbc} = rate of total heat transfer through the open entryway, before air curtain (kBtu/hr)

Q_{tac} = rate of total heat transfer through the open entryway, after air curtain (kBtu/hr)

(see calculation in 'Heat Transfer Through Open Entryway with/without Air Curtain' sections below)

EER = energy efficiency ratio of the cooling equipment (kBtu/kWh)

= Actual. If unknown, use the table C403.2.3(2) in IECC 2012 (or IECC 2015 if through new

475 ASHRAE, "Ventilation and Infiltration," in 2013 ASHRAE Handbook – Fundamentals (2013): Ch 16.1 - 16.37

476 National Solar Radiation Data Base – 1991 – 2005 Update: Typical Meteorological year 3. http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/by_state_and_city.html

477 Spentzas, Steve, et. al, "1009: Commercial and Industrial Air Curtains – Public Project Report," Nicor Gas Emerging Technology Program (Oct 2014): 10

Wang, Liangzhu, "Investigation of the Impact of Building Entrance Air Curtain on Whole Building Energy Use," Air Movement and Control International, Inc. (2013). 4

478 Wang, Liangzhu, "Investigation of the Impact of Building Entrance Air Curtain on Whole Building Energy Use," Air Movement and Control International, Inc. (2013). 4

construction) to assume values based on code estimates

HP = Input power for air curtain (hp)

= Actual value. If actual value not available, use the following estimates based on manufacturer specs

Door Size	Fan HP
8'w x 8'h	1
10'w x 10'h	1.5
10'w x 12'h	4
12'w x 14'h	6
16'w x 16'h	12

0.7457 = unit conversion factor, brake horsepower to electric power (kW/HP)

t_{open} = average hours per day the door is open (hr/day)

= Actual or user defined estimated value.

CD = cooling days per year, total days in year above balance point temperature (day)

= use table below to select the best value for location[479]

	CD (Balance Point Temperature)				
Climate Zone - Weather Station/City	45 °F	50 °F	55 °F	60 °F	65 °F
1 -Rockford AP / Rockford	194	168	148	124	97
2 - Chicago O'Hare AP / Chicago	194	173	153	127	95
3 - Springfield #2 / Springfield	214	194	174	148	114
4 - Belleville SIU RSCH / Belleville	258	229	208	174	138
5 - Carbondale Southern IL AP / Marion	222	201	181	158	130

HSPF = Heating System Performance Factor of heat pump equipment

[479] National Solar Radiation Data Base – 1991 – 2005 Update: Typical Meteorological year 3. http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/by_state_and_city.html
Note that cooling days (CD) are calculated by first determining its value from the TMY3 data associated with the appropriate weather station as defined by and used elsewhere in the Illinois TRM. Using the TMY3 outdoor air dry bulb hourly data, Error! Reference source not found.the annual hours are totaled for every hour that the outdoor air dry bulb temperature is above a designated zero heat loss balance point temperature or base temperature for cooling. For commercial and industrial (C&I) buildings, a base temperature for heating of 55 °F is designated in the Illinois TRM, but building specific base temperatures are recommended for large C&I projects. Additionally, the TRM uses a 30-year normal data for degree-days while the CD calculation was based on TMY3 data; in order to account for this, calculations of CD were also normalized by the ratio of CDD to align the calculated values more closely with the TRM.

= Actual. If unknown, use the table C403.2.3(2) in IECC 2012 (or IECC 2015 if through new construction) to assume values based on code estimates

HD = heating days per year, total days in year above balance point temperature (day)

= use table below to select an appropriate value[480]:

	HD				
Climate Zone - Weather Station/City	45 °F	50 °F	55 °F	60 °F	65 °F
1 -Rockford AP / Rockford	142	160	183	204	228
2 - Chicago O'Hare AP / Chicago	150	166	192	219	253
3 - Springfield #2 / Springfield	125	142	167	194	230
4 - Belleville SIU RSCH / Belleville	101	115	134	156	180
5 - Carbondale Southern IL AP / Marion	103	123	148	174	205

Heat Transfer Through Open Entryway without Air Curtain (Cooling Season)

Q_{tbc} = 4.5 * CFM_{tot} *(h_{oc} – h_{ic}) / (1,000 Btu/kBtu)

Where:

4.5 = unit conversion factor with density of air: 60 min/hr * 0.075 lbm/ft3 (lb*min/(ft*hr))

CFM_{tot} = Total air flow through entryway (cfm), see calculation below

h_{oc} = average enthalpy of outside air during the cooling season (Btu/lb)

= use the below table to determine the approximate outdoor air enthalpy associated with an indoor temperature setpoint and climate zone.[481]

	h_{oc}		
Climate Zone - Weather Station/City	67 °F	72 °F	77 °F
1 -Rockford AP / Rockford	31.6	33.0	35.3
2 - Chicago O'Hare AP / Chicago	32.0	33.6	35.4
3 - Springfield #2 / Springfield	32.9	34.6	36.6
4 - Belleville SIU RSCH / Belleville	33.5	35.0	36.4
5 - Carbondale Southern IL AP / Marion	34.6	36.2	37.7

h_{ic} = average enthalpy of indoor air, cooling season (Btu/lb)

= use the below table to determine the approximate indoor air enthalpy associated with an indoor temperature setpoint in indoor relative humidity.

	h_{ic}		
Relative Humidity (%)	67 °F	72 °F	77 °F

480 Note that Heating Days (HD) are calculated following the same approach outlined in the Cooling Days section.

481 Average enthalpies were estimated following ASHRAE guidelines for perfect gas relationships for dry air associated with hourly TMY3 data.Error! Reference source not found. Enthalpies were then averaged for all values associated with a dry-bulb outdoor air temperature that exceeded the indoor air temperature setpoint. Other enthalpy values may be interpolated for indoor air temperature setpoints not represented in the table. Note that while outdoor air enthalpies increase with higher temperature setpoints, the change in enthalpy from indoor to outdoor will decrease.

	h_{ic}		
Relative Humidity (%)	**67 °F**	**72 °F**	**77 °F**
60	25.5	28.5	31.8
50	23.9	26.6	29.5
40	22.3	24.7	27.3

= an estimate 26.6 Btu/lb associated with the 72 °F and 50% indoor relative humidity case can be used as an approximation if no other data is available. For other indoor temperature setpoints and RH, enthalpies may be interpolated.

The total airflow through the entryway, CFM_{tot}, includes both infiltration due to wind as well as thermal forces, as follows:

CFM_{tot} = sqrt[$(CFM_w)^2$ + (CFM_t^2)]

Where:

CFM_w = Infiltration due to the wind (cfm)

CFM_t = Infiltration due to thermal forces (cfm)

The infiltration due to the wind is calculated as follows:

CFM_w = $(v_{wc} * C_{wc}) * C_v * A_d$ * (88 fpm/mph)

Where:

v_{wc} = average wind speed during the cooling season based on entryway orientation (mph)

= use the below table to for the wind speed effects based on climate zone and entryway orientation[482]:

	Entryway Orientation			
Climate Zone -Weather Station /City	**N**	**E**	**S**	**W**
1 -Rockford AP / Rockford	4.2	4.1	4.7	4.8
2 - Chicago O'Hare AP / Chicago	4.7	4.5	5.4	4.6
3 - Springfield #2 / Springfield	4.1	3.7	6.0	5.0
4 - Belleville SIU RSCH / Belleville	3.3	2.7	3.8	4.2
5 - Carbondale Southern IL AP / Marion	3.1	2.9	4.4	3.8

C_{wc} = wind speed correction factor due to wind direction in cooling season, (%)

= because wind direction is not constant, a wind speed correction factor is used to adjust for the amount of time during the cooling season prevailing winds can be expected to impact the entryway. Use the following table to determine the correct wind speed correction factor for cooling applications.

	Entryway Orientation			
Climate Zone -Weather Station/City	**N**	**E**	**S**	**W**
1 -Rockford AP / Rockford	0.18	0.13	0.30	0.31

[482] Average wind speeds are calculated based on the TMY3 wind speed data. Because this data is collected at an altitude of 33 ft, wind speed is approximated for a 5 ft level based on ASHRAE Handbook guidelines using the urban/suburban parameters for adjusting wind speed based on altitude (⍰ = 1200, ⍰ = 0.22).
ASHRAE, "Airflow Around Buildings," in 2013 ASHRAE Handbook – Fundamentals (2013): p 24.3

	Entryway Orientation			
Climate Zone -Weather Station/City	N	E	S	W
2 - Chicago O'Hare AP / Chicago	0.18	0.17	0.36	0.26
3 - Springfield #2 / Springfield	0.17	0.12	0.46	0.21
4 - Belleville SIU RSCH / Belleville	0.21	0.15	0.35	0.16
5 - Carbondale Southern IL AP / Marion	0.18	0.15	0.37	0.11

Note that correction factors do not add up to 1 (100%). This is attributed to periods of calm winds.

C_v = effectiveness of openings,

= 0.3, assumes diagonal wind[20]

A_d = area of the doorway (ft^2)

= user defined

The infiltration due to thermal forces is calculated as follows:

CFM_t = $A_d * C_{dc} * (60 \text{ sec/min}) * \text{sqrt}[2 * g * H/2 * (T_{oc} - T_{ic}) / (459.7 + T_{oc})]$

Where:

C_{dc} = the discharge coefficient during the cooling season[483]

= $0.4 + 0.0025 * |T_{ic} – T_{oc}|$

= 0.42, Illinois average at indoor air temp of 72°F

Note, values for C_{dc} show little variation due to balance point temperature, indoor air temperature, and climate zone. As such, if estimating results, the Illinois average value may be used as a simplification.

g = acceleration due to gravity

= 32.2 ft/sec^2

H = the height of the entryway (ft)

= user input

T_{ic} = Average indoor air temperature during cooling season

= User input, can assume indoor cooling temperature set-point

T_{oc} = Average outdoor temp during cooling season (°F)

= the average outdoor temperature is dependent on the CD period and zone. As such, the following table may be used for average outdoor temperature during the cooling period[484]:

	T_{oc}				
Climate Zone - Weather Station/City	62 °F	67 °F	72 °F	77 °F	82 °F
1 -Rockford AP / Rockford	72.9	76.0	79.2	82.5	85.5
2 - Chicago O'Hare AP / Chicago	72.9	76.0	79.4	82.8	85.5
3 - Springfield #2 / Springfield	73.7	76.7	79.9	83.4	86.4
4 - Belleville SIU RSCH / Belleville	74.9	77.7	81.0	84.3	86.9
5 - Carbondale Southern IL AP / Marion	75.1	77.7	80.9	84.7	87.4

483 ASHRAE, "Ventilation and Infiltration," in 2013 ASHRAE Handbook – Fundamentals (2013): p 16.13

484 Based on binned data from TMY3 & adjusted bracketed thermostat setpoint temperatures. Interpolate other values as needed.

459.7 = conversion factor from °F to °R

= calculation requires absolute temperature for values not calculated as a difference of temperatures.

Heat Transfer Through Open Entryway with Air Curtain (Cooling Season)

Q_{tac} = Q_{tbc} * (1 – E)

Where:

E = the effectiveness of the air curtain (%)

= 0.60[485]

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = (ΔkWh$_{cooling}$ / (CD *24)) * CF

Where:

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

= 91.3%[486]

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

= 47.8% [487]

NATURAL GAS SAVINGS

Natural gas savings, Δtherms, associated with reduced infiltration through an entryway during the heating season are calculated by determining the difference between heat loss through the entryway before and after the installation of the air curtain.

Δtherms = (Q_{bc} - Q_{ac}) * t_{open} * HD / η

Where:

Q_{bc} = rate of sensible heat transfer through the open entryway, before air curtain (therm/hr)

Q_{ac} = rate of sensible heat transfer through the open entryway, after air curtain (therm/hr)

t_{open} = average hours per day the door is open (hr/day)

= Actual or estimated user input value

HD = heating days per year, total days in year above balance point temperature (day)

= use table below to select an appropriate value[488]:

485 Assumed conservative estimate based on referenced study results and ASHRAE 2004 effectiveness range of 60-80% for air curtains. Jaramillo, Julian, et. Al. "Application of Air Curtains in Refrigerated Chambers," International Refrigeration and Air-Conditioning Conference, Purdue University e-Pubs (July 14-17, 2008): http://docs.lib.purdue.edu/cgi/viewcontent.cgi?article=1972&context=iracc
ASHRAE, "Room Air Distribution Equipment," in 2004 ASHRAE Handbook – HVAC Systems and Equipment (2004): p 17.8

486 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.

487 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

488 Note that Heating Days (HD) are calculated following the same approach outlined in the Cooling Days section.

Climate Zone - Weather Station/City	HD				
	45 °F	50 °F	55 °F	60 °F	65 °F
1 -Rockford AP / Rockford	142	160	183	204	228
2 - Chicago O'Hare AP / Chicago	150	166	192	219	253
3 - Springfield #2 / Springfield	125	142	167	194	230
4 - Belleville SIU RSCH / Belleville	101	115	134	156	180
5 - Carbondale Southern IL AP / Marion	103	123	148	174	205

η = efficiency of heating equipment

= Actual. If unknown, assume 0.8

Heat Transfer Through Open Entryway without Air Curtain (Heating Season)

Q_{bc} = (1.08 Btu/(hr*°F*cfm)) * CFM_{tot} * (T_{ih} – T_{oh}) / (100,000 Btu/therm)

Where:

1.08 = sensible heat transfer coefficient (specific heat of air and unit conversions)

CFM_{tot} = Total air flow through entryway (cfm)

T_{ih} = Average indoor air temperature during heating season

= User input, can assume indoor heating temperature set-point

T_{oh} = Average outdoor temp during heating season (°F)

= use table below, based on binned data from TMY3 & balance point temperature

Climate Zone - Weather Station/City	Avg Outdoor Air Temp - Heating Season				
	45 °F	50 °F	55 °F	60 °F	65 °F
1 -Rockford AP / Rockford	26.3	28.8	31.6	34.2	37.3
2 - Chicago O'Hare AP / Chicago	29.4	31.2	34.0	36.8	40.3
3 - Springfield #2 / Springfield	29.4	31.5	34.6	37.7	41.6
4 - Belleville SIU RSCH / Belleville	31.7	33.6	36.2	39.2	42.3
5 - Carbondale Southern IL AP / Marion	32.5	34.9	37.8	40.7	44.0

The total airflow through the entryway, CFM_{tot}, includes both infiltration due to wind as well as thermal forces, as follows:

CFM_{tot} = sqrt[$(CFM_w)^2$ + (CFM_t^2)]

Where:

CFM_w = Infiltration due to the wind (cfm)

CFM_t = Infiltration due to thermal forces (cfm)

The infiltration due to the wind is calculated as follows:

CFM_w = (v_{wh} * C_{wh})* C_v * A_d * (88 fpm/mph)

Where:

v_{wh} = average wind speed during the heating season (mph)

= similar to cooling season wind speed assumptions, use the following table to determined average wind speed based on entryway orientation:

	Entryway Orientation			
Climate Zone -Weather Station/ City	N	E	S	W
1 -Rockford AP / Rockford	5.0	4.6	4.9	5.6
2 - Chicago O'Hare AP / Chicago	5.5	5.2	4.9	5.1
3 - Springfield #2 / Springfield	5.0	4.9	5.3	5.1
4 - Belleville SIU RSCH / Belleville	4.3	3.4	3.5	5.3
5 - Carbondale Southern IL AP / Marion	4.6	3.2	4.2	4.4

C_{wh} = wind speed correction factor due to wind direction in heating season, (%)

= because wind direction is not constant, a wind speed correction factor is used to adjust for the amount of time during the heating season prevailing winds can be expected to impact the entryway. Use the following table to determine the correct wind speed correction factor for the heating applications.

	Entryway Orientation			
Climate Zone -Weather Station/ City	N	E	S	W
1 -Rockford AP / Rockford	0.18	0.13	0.30	0.31
2 - Chicago O'Hare AP / Chicago	0.21	0.10	0.26	0.39
3 - Springfield #2 / Springfield	0.21	0.14	0.27	0.34
4 - Belleville SIU RSCH / Belleville	0.31	0.15	0.22	0.29
5 - Carbondale Southern IL AP / Marion	0.31	0.11	0.27	0.18

Note that correction factors do not add up to 1 (100%). This is attributed to periods of calm winds.

C_v = effectiveness of openings,

= 0.3, assumes diagonal wind[24]

A_d = area of the doorway (ft^2)

= user input

The infiltration due to thermal forces is calculated as follows:

$CFM_t = A_d * C_{dh} * (60 \text{ sec/min}) * \text{sqrt}[2 * g * H/2 * (T_{ih} – T_{oh}) / (459.7 + T_{ih})]$

Where:

C_{dh} = the discharge coefficient during the heating season

$= 0.4 + 0.0025 * |T_{ih} – T_{oh}|$

= 0.49, Illinois average at indoor air temp of 72°F

Note, values for C_{dh} show little variation due to balance point temperature, indoor air temperature, and climate zone. As such, if estimating results, the Illinois average value may be used as a simplification.

g = acceleration due to gravity

= 32.2 ft/sec^2

H = the height of the entryway (ft)

= user defined

Heat Transfer Through Open Entryway without Air Curtain (Heating Season)

Q_{ac} = Q_{bc} * (1 – E)

Where:

E = the effectiveness of the air curtain (%)

= 0.60[489]

WATER AND OTHER NON-ENERGY IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

The air curtain would need to be regularly serviced and commissioned to ensure that it is appropriately operating. This is estimated at a cost of $150[490].

MEASURE CODE: CI-MSC-AIRC-V01-160601

[489] Assumed conservative estimate based on referenced study results and ASHRAE 2004 effectiveness range of 60-80% for air curtains. Jaramillo, Julian, et. Al. "Application of Air Curtains in Refrigerated Chambers," International Refrigeration and Air-Conditioning Conference, Purdue University e-Pubs (July 14-17, 2008): http://docs.lib.purdue.edu/cgi/viewcontent.cgi?article=1972&context=iracc
ASHRAE, "Room Air Distribution Equipment," in 2004 ASHRAE Handbook – HVAC Systems and Equipment (2004): p 17.8

[490] Assumes approximately 1 hour of maintenance (include cleaning out filters, greasing, and checking that the designed angle of attack on the blower nozzle is at the designed position) based on manufacturer inpur and product spec sheets.

4.4.34 Destratification Fan

Description

This measure applies to buildings with high bay ceiling construction without fans currently installed for the purpose of destratifying air. There is also a separate measure for destratification fans as applied to agricultural settings ("High Volume Low Speed Fans"). All other destratification fan applications require custom analysis.

Air stratification leads to higher temperatures at the ceiling and lower temperatures at the ground. During the heating season, destratification fans improve air temperature distribution in a space by circulating warmer air from the ceiling back down to the floor level, thereby enhancing comfort and saving energy. Energy savings are realized by a reduction of heat loss through the roof-deck and walls as a result of a smaller temperature differential between indoor temperature and outdoor air.

Note that further, but limited, empirical evidence suggests that improved air mixing due to destratification would also result in shorter heating system runtimes due to warmer air reaching the thermostat level sooner, and possibly even allow a facility to lower the thermostat set point while maintaining a similar level of occupant comfort. This is supported by measured data in which an increase in temperatures was observed at the thermostat (5 foot level) level when air is destratified, resulting in an approximate temperature increase at the 5 foot level in the range of 1 - 3°F[491]. This measure does not currently attempt to quantify the potential impacts of air mixing from destratification; however, it should be noted that additional therms savings may be possible.

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

Limitations

- For use in conditioned, high bay structures. Recommended minimum ceiling height of 20 ft.
- This measure should only be applied to spaces in which the ceiling is subject to heat loss to outdoor air (i.e., single story or top floor spaces) and where there is sufficient space to allow for appropriate spacing of the fans. Other applications require custom analysis.
- Installation must follow manufacturer recommendations sufficient to effectively destratify the entire space. Please see calculation of effective area, A_{eff}, in the therms savings algorithm as a check if this criteria is met. Otherwise, custom calculation is necessary.
- Measure does not currently support facilities with night setbacks on heating equipment. Custom analysis is needed in this case.
- Certain heating systems may not be a good fit for destratification fans, such as locations with: high velocity vertical throw unit heaters, radiant heaters, and centralized forced air systems. In these cases, measured evidence of stratification should be confirmed and custom analysis may be necessary.

Definition of Efficient Equipment

High Volume, Low Speed (HVLS) fans with a minimum diameter of 14 ft with Variable Speed Drive (VSD) installed[492].

Note that bell-shaped fans are currently excluded from this measure due to limited validation of the technology available. Further verification of effectiveness compared to HVLS is needed. A manufacturer of bell shaped fans indicates that four bell-shaped fans provide an equivalent effective area as a typical HVLS fan. However, there is a need for further review of bell shaped fan field test data supporting manufacturer claims regarding comparable

[491] Kosar, Doug, "1026: Destratification Fans – Public Project Report," Nicor Gas, Emerging Technology Program (Oct 2014): 16
[492] Kosar, Doug, "1026: Destratification Fans – Public Project Report," Nicor Gas, Emerging Technology Program (Oct 2014): 16

effectiveness to HVLS technologies.

DEFINITION OF BASELINE EQUIPMENT

No destratification fans or other means to effectively mix indoor air.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 10 years[493]

DEEMED MEASURE COST

Measure cost = [incremental cost of HVLS fans] + [installation costs (including materials and labor)]

The incremental capital cost for HVLS fans are as follows[494]:

Fan Diameter (ft)	Incremental Cost
14	$6,600
16	$6,650
18	$6,700
20	$6,750
22	$6,800
24	$6,850

Since installation cost is depended on a variety of factors, this is a custom entry. Actual costs should be used.

LOADSHAPE

Loadshape C04: Commercial Electric Heating.

COINCIDENCE FACTOR

N/A due to no savings attributable to cooling during the summer peak period.

Algorithm

CALCULATION OF SAVINGS

The following formulas provide a methodology for estimating heating load savings associated with destratification fan use. This algorithm is based on the assumption that savings are directly related to the difference in heat loss through the envelope before and after destratification.

ELECTRIC ENERGY SAVINGS

The algorithm for this measure was developed for natural gas heating applications, however, for electric heating

[493] Consistent with both 2008 Database for Energy-Efficient Resources, EUL/RUL (Effective/Remaining Useful Life) Values, October 10, 2008 and GDS Associates, Inc, "Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures," New England Stat Program Working Group (June 2007), p30.

[494] Costs were obtained from manufacturer interviews and are based off of average or typical prices for base model HVLS fans. Costs include materials and labor to install the fans and tie fans into an existing electrical supply located near the fan.

applications, the same methodology presented in the Natural Gas Savings Section may be used with the standard conversion factor from therms to kWh of 29.31 kWh/therm and an equipment efficiency as follows:

System Type	Age of Equipment	HSPF Estimate	η (Effective COP Estimate) (HSPF/3.413)
Heat Pump	Before 2006	6.8	2.0
	2006 - 2014	7.7	2.3
	2015 on	8.2	2.40
Resistance	N/A	N/A	1

Regardless of how the building is heated, the energy consumption of the fans must be accounted for. If the building is electrically heated, fan energy shall be subtracted from the savings as calculated above. If the building is heated with natural gas, this shall represent an electric penalty, i.e., an increase in consumption. This is calculated as follows:

$\Delta kWh = -(W_{fan} * N_{fan}) * t_{eff}$

W_{fan} = fan input power (kW)

N_{fan} = number of fans

t_{eff} = effective annual operation time, based on balance point temperature (hr)

= see table below in Natural Gas Savings section for further detail

Summer Coincident Peak Demand Savings

N/A

Natural Gas Energy Savings

$\Delta Therms = [(\Delta Q_r + \Delta Q_w) * t_{eff}] / (100,000 * \eta)$

Where:

ΔQ_r = the heat loss reduction through the roof due to the destratification fan (Btu/hr)

= See calculation section below

ΔQ_w = the heat loss reduction through the exterior walls due to destratification fan (Btu/hr)

= See calculation section below

t_{eff} = effective annual operation time, based on balance point temperature (hr)

= use table below to select an appropriate value[495]:

Climate Zone - Weather Station/City	t_{eff}				
	45 °F	50 °F	55 °F	60 °F	65 °F
1 -Rockford AP / Rockford	3810	4226	4880	5571	6436
2 - Chicago O'Hare AP / Chicago	3593	3986	4603	5254	6070

495 These were calculated at various base temperatures using TMY3 data and adjusted to make consistent with the 30 year normal data used elsewhere. For more information see 'Destratification Fan Workpaper'; Robert Irmiger, Gas Technology Institute, 9/6/2015.

Climate Zone - Weather Station/City	t_{eff}				
	45 °F	50 °F	55 °F	60 °F	65 °F
3 - Springfield #2 / Springfield	3038	3370	3891	4442	5131
4 - Belleville SIU RSCH / Belleville	2243	2488	2873	3280	3789
5 - Carbondale Southern IL AP / Marion	2271	2519	2909	3320	3836

100,000 = conversion factor (1 therm = 100,000 Btu)

η = thermal efficiency of heating equipment

= Actual. If unknown assume 0.8.

EXAMPLE:

For a warehouse facility located in Rockford, IL, installing destratification fans could reduce heat loss through the roof of 95,000 Btu/hr and a reduced heat loss through the wall of 51,2282 Btu/hr. Assuming a balance point of 55°F the therms savings for the facility would be estimated as:

ΔTherms = $[(\Delta Q_r + \Delta Q_w) * t_{eff}] / (100,000 * \eta)$

= [(95,000 Btu/hr + 51,282 Btu/hr) * 4880 hr] / [(100,000 Btu/therm) * 0.8)]

= 8,923 therms

Heat loss reduction through the roof

ΔQ_r = $Q_{r,s} – Q_{r,d}$

= $(1/R_r) * A_r * [(T_{r,s} – T_{oa}) – (T_{r,d} – T_{oa})]$

= $(1/R_r) * A_r * (T_{r,s} – T_{r,d})$

Where:

$Q_{r,s}$ = roof heat loss for stratified space

$Q_{r,d}$ = roof heat loss for destratified space

R_r = overall thermal resistance through the roof (hr * ft^2 * °F / Btu)

= Actual or estimated based on construction type. If unknown, assume the following:

Thermal Resistance Factor (R-Factor) for Roof	Retrofit[496]	New Construction[497] (2010 or newer)
R_r	10.0 (hr * ft^2 * °F / Btu)	20.0 (hr * ft^2 * °F / Btu)

[496] ANSI/ASHRAE/IESNA 100-1995, "Energy Conservation in Existing Buildings," ASHRAE Standard (1995). Additionally, professional judgement was used to address older vintage structure prior to adoption of the 1995 standard and an estimate of 50% of current code standard was used.

[497] ANSI/ASHRAE/IESNA Standard 90.1-2007, "Energy Standard for Buildings Except Low-Rise Residential Buildings," ASHRAE Standard (2007): Table 5.5-4 and Table 5.5-5

A_r = roof area (ft^2)

= user input

= can be approximated with floor area

T_{oa} = outside air temperature, note: therm savings calculations are actually independent of outside air because this term drops out of the heat loss reduction equation

$T_{r,s}$ = indoor temperature at roof deck, stratified case (^oF)

= Actual. If unknown, use the following equation

$= m_s * h_r + T_{f,s}$

h_r = ceiling height/roof deck (ft)

m_s = estimated heat gain per foot elevation, stratified case ($^oF/ft$)

= 0.8 $^oF/ft$

= Professional judgement used to define value based on result from a Nicor Gas ETP Pilot field testing results and the Ansley article[498,499]. Estimates from these sources fall on the conservative side of the industry rule of thumb range of 1-2 $^oF/ft$ heat gain.

$T_{f,s}$ = estimated floor temperature, stratified case (^oF)

$= T_{tstat} – m_s * h_{tstat}$

$= T_{tstat} – 4\ ^oF$

T_{tstat} = temperature set point at the thermostat

h_{tstat} = vertical distance between the floor and the thermostat, assumed 5ft

$T_{r,d}$ = indoor temp at roof, destratified case

= actual value, or may be estimated using the following:[500,501]

$= T_{tstat} + 1\ ^oF$

---

[498] Kosar, Doug, "1026: Destratification Fans – Public Project Report," Nicor Gas, Emerging Technology Program (Oct 2014): 10-11. Field testing results indicated approximately 0.6 oF/ft for a garden center.

[499] Aynsley, Richard, "Saving Heating Costs in Warehouses," ASHRAE Journal (Dec 2005): 48. Identifies a 0.8 oF/ft gain.

[500] 12. Kosar, Doug, "1026: Destratification Fans – Public Project Report," Nicor Gas, Emerging Technology Program (Oct 2014): 10-11. Field testing results indicated approximately 0.6 oF/ft for a garden center.

[501] 13. Aynsley, Richard, "Saving Heating Costs in Warehouses," ASHRAE Journal (Dec 2005): 48.

EXAMPLE:

For a 50,000 ft^2 warehouse built in 1997 with 30 ft ceilings and a thermostat set point of 65 ^oF. No further measured values available.

$$\Delta Q_r = (1/R_r) * A_r * (T_{r,s} – T_{r,d}) = (1/R_r) * A_r * [(m_s * h_r + T_{tstat} – 4\ ^oF) – (T_{tstat} + 1\ ^oF)]$$

$$= (1/R_r) * A_r * [(0.8^oF/ft * h_r) – 5\ ^oF]$$

$$= 1/(10\ hr * ft^2 * {^oF} / Btu) * (50,000\ ft^2) * [(0.8^oF/ft * 30\ ft) – 5\ ^oF]$$

$$= 95,000\ Btu/hr$$

Heat loss reduction through exterior walls

Note: a conservative estimate for therms savings would neglect the impact of heat loss through the walls. However, Ansley suggests that estimates based on the roof deck losses alone underestimate actual savings by up to 46%.[502]

$$\Delta Q\_w = Q_{w,s} – Q_{w,d}$$

$$= (1/R_w) * A_w * (T_{w,s} – T_{w,d})$$

Where:

R_w = overall thermal resistance through the exterior walls (hr * ft^2* ^oF / Btu)

= Actual or estimated based on construction type[503]. If unknown, assume the following

Thermal Resistance Factor (R-Factor) for Wall	Retrofit[504]	New Construction[505] (2010 or newer)
R_w	6.5 (hr * ft^2 * ^oF / Btu)	13.0 (hr * ft^2 * ^oF / Btu)

A_w = area of exterior walls (ft^2)

= user input

$T_{w,s}$ = average indoor air temperature for wall heat loss, stratified case

[502] Aynsley, Richard, “Saving Heating Costs in Warehouses,” ASHRAE Journal (Dec 2005): 51

[503] Because heat loss through the walls is estimated using the average space temperature pre- and post- destratification. There are a number of factors that can impact the average space temperature causing deviations from estimates of many degrees in some cases. As such, it is recommended that a conservative value for the thermal resistance through the walls, R_w, be used. A recommended method for determining R_w would be to use the highest R-value for the wall space, neglecting lower R-values associated with windows, thermal bridges, etc.

[504] ANSI/ASHRAE/IESNA 100-1995, “Energy Conservation in Existing Buildings,” ASHRAE Standard (1995). Additionally, professional judgement was used to address older vintage structure prior to adoption of the 1995 standard and an estimate of 50% of current code standard was used.

[505] ANSI/ASHRAE/IESNA Standard 90.1-2007, “Energy Standard for Buildings Except Low-Rise Residential Buildings,” ASHRAE Standard (2007): Table 5.5-4 and Table 5.5-5

= If actual $T_{r,s}$ measurement is available[506]

= $[(T_{r,s} * h_a) + (T_{tstat} * h_b)] / h_r$

h_a = vertical distance between the heat source and the ceiling

h_b = vertical distance between the floor and the heat source

= Otherwise, use the linear stratification equation at average space height, see definition above.

= $m_s * (h_r / 2) + T_{f,s}$

= $m_s * (h_r / 2) + (T_{tstat} – 4)$

$T_{w,d}$ = average indoor air temperature for wall heat loss, destratified case

= $T_{tstat} + 0.5$

= conservative estimate using engineering judgment based on the same assumption used for $T_{r,f}$ estimate.

EXAMPLE:

For a 50,000 ft^2 warehouse built in 1997 with 30 ft ceilings and a thermostat set point of 65 ^oF and a measured temperature at the ceiling of 85 ^oF and unit heaters located 10 feet from the roof:

ΔQ_w = $(1/R_w) * A_w * (T_{w,s} – T_{w,d})$

= $(1/R_w) * A_w$ w* $[([(T_{r,s} * h_a) + (T_{tstat} * h_b)] / h_r) – (T_{tstat} + 0.5\ ^oF)]$

= $1/(6.5\ hr*ft^2*^oF/Btu) * (50{,}000ft^2) * [([(85^oF * 10ft) + (65\ ^oF * 20ft)] / 30ft) – (65 + 0.5\ ^oF)]$

= $1/(6.5\ hr*ft^2*^oF/Btu) * (50{,}000ft^2) * (71.7\ ^oF – 65.5\ ^oF)$

= 51,282 Btu/hr

Measure eligibility check

Use the following algorithm to verify a fan system is sufficiently sized to destratify air across the entire area.

Effective area, A_{eff}, is the area over which a fan or a group of fans can be expected to effectively destratify a space. If A_{eff} is less than the roof area, A_r, a custom analysis approach should be followed to account for the change in the effectiveness of the system. In lieu of more detailed studies, effective area is defined based on the measured results from an Enbridge Gas field study in which the area a fan was expected to effectively destratify was equal to 5 times the fan diameter[507]. Effective area, is calculated as follows:

A_{eff} = $[\pi * (5*D_{fan})^2) / 4] * N_{fan}$

= $6.25 * \pi * D_{fan}^2 * N_{fan}$

Where:

A_{eff} = the effective area fan area on the floor (ft^2)

D_{fan} = fan diameter

[506] Aynsley, Richard, "Saving Heating Costs in Warehouses," ASHRAE Journal (Dec 2005): 48

[507] Enbridge Gas Distribution, Inc., "Big Fans Deliver Big Bonus," (Aug 2007) https://www.enbridgegas.com/businesses/assets/docs/hunter_douglas_case_study.pdf. Additionally, multiple utilities have adopted this definition in their programs in including Enbridge Gas and Consumers Energy.

N_{fan} = the number of fans

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-DSFN-V01-160601

4.4.35 Economizer Repair and Optimization

DESCRIPTION

Economizers are designed to use unconditioned outside air (OSA) instead of mechanical cooling to provide cooling when exterior conditions permit. When the OSA temperature is less than the changeover temperature (determined by a static setpoint or a reference return air sensor) up to 100% OSA is supplied to help meet the facility's cooling needs, thus reducing mechanical cooling energy and saving energy. An economizer that is not working or is not properly adjusted can waste energy and cause comfort issues. This HVAC Economizer Optimization measure involves the repair and optimization of common economizer problems such as adjusting changeover setpoint, repairing damper motors & linkages and replacing non-working sensors and/or controllers. These repairs and adjustments result in proper operation which maximizes both occupant comfort and energy savings.

This measure is only appropriate for single zone packaged rooftop units. Custom calculations are required for savings for multi-zone systems.

In general the HVAC Economizer Optimization measure may involve both repair and/or optimization;

Economizer Repair – The Economizer repair work is preformed to ensure that the existing economizer is working properly. This allows the system to take advantage of free cooling and ensure that the system is not supplying an excess amount of outside air (OSA) during non-economizing periods.

- **Replace Damper Motor** – If the existing damper motor is not operational, the unit will be replaced with a functioning motor to allow proper damper modulation.
- **Repair Damper linkage** – If the existing linkage is broken or not adjusted properly, the unit will be replaced or adjusted to allow proper damper modulation.
- **Repair Economizer Wiring** – If the existing economizer is not operational due to a wiring issue, the issue will be repaired to allow proper economizer operation.
- **Reduce Over Ventilation** – If the unit is supplying excess OSA, the OSA damper position will be adjusted to meet minimum ventilation requirements.
- **Economizer Sensor Replacement** – If the unit is equipped with a nonadjustable dry bulb (i.e. snapdisk) or malfunctioning analog sensor, the sensor is replaced with a new selectable sensor.
- **Economizer Control Replacement** – If the existing economizer controller is not operational, the unit will be replaced or upgraded to allow for proper economizer operation.

Economizer Optimization- The economizer optimization work is preformed to ensure that the existing economizer system is set up properly to maximize use of free cooling for units located in a particular climate zone.

- **Economizer Changeover Setpoint Adjustment** – If the unit is equipped with a fully operational economizer, the controller is adjusted to the appropriate changeover setpoint based on ASHRAE 90.1 (Figure 1 - *Table 6.5.1.1.3 High-Limit Shutoff Control Settings for Air Economizers)* for the corresponding climate zone.
- **Enable Integrated Operation** – If the unit is equipped with a fully operational economizer and is not set up to allow a minimum of two stages of cooling (1st stage – Economizer Only & 2nd Stage – Economizer & Mechanical cooling), the unit will be wired to allow two stage cooling

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 equipment condition is defined by fully functional economizer that is programmed to meet ASHRAE 90.1 economizer changeover setpoint requirements for the facility's climate zone and changeover control type

(Figure 1 - Table 6.5.1.1.3 High-Limit Shutoff Control Settings for Air Economizers)[508].

Figure 1 – Baseline ASHRAE High-Limit Shutoff Control Settings

TABLE 6.5.1.1.3 High-Limit Shutoff Control Settings for Air Economizers[b]

Control Type	Allowed Only in Climate Zone at Listed Setpoint	Required High-Limit Setpoints (Economizer Off When): Equation	Description
Fixed dry-bulb temperature	1b, 2b, 3b, 3c, 4b, 4c, 5b, 5c, 6b, 7, 8	$T_{OA} > 75°F$	Outdoor air temperature exceeds 75°F
	5a, 6a	$T_{OA} > 70°F$	Outdoor air temperature exceeds 70°F
	1a, 2a, 3a, 4a,	$T_{OA} > 65°F$	Outdoor air temperature exceeds 65°F
Differential dry-bulb temperature	1b, 2b, 3b, 3c, 4b, 4c, 5a, 5b, 5c, 6a, 6b, 7, 8	$T_{OA} > T_{RA}$	Outdoor air temperature exceeds return air temperature
Fixed enthalpy with fixed dry-bulb temperature	All	$h_{OA} > 28$ Btu/lb[a] or $T_{OA} > 75°F$	Outdoor air enthalpy exceeds 28 Btu/lb[a] of dry air[a] or outdoor air temperature exceeds 75°F
Differential enthalpy with fixed dry-bulb temperature	All	$h_{OA} > h_{RA}$ or $T_{OA} > 75°F$	Outdoor air enthalpy exceeds return air enthalpy or outdoor air temperature exceeds 75°F

a. At altitudes substantially different than sea level, the fixed enthalpy limit shall be set to the enthalpy value at 75°F and 50% RH. As an example, at approximately 6000 ft elevation, the fixed enthalpy limit is approximately 30.7 Btu/lb.
b. Devices with selectable rather than adjustable setpoints shall be capable of being set to within 2°F and 2 Btu/lb of the setpoint listed.

Figure 2 – ASHRAE Climate Zone Map

NORMATIVE APPENDIX B
CLIMATE ZONES FOR U.S. STATES AND COUNTIES

This normative appendix provides the climate zones for U.S. states and counties. Figure B-1 contains the county-level climate zone map for the United States. Table B-1 lists each state and major counties within the state and shows the climate number and letter for each county listed.

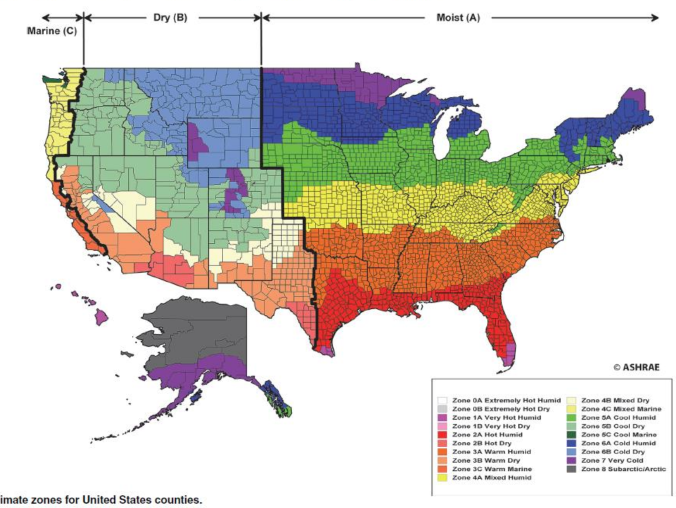


FIGURE B-1 Climate zones for United States counties.

DEFINITION OF BASELINE EQUIPMENT

The baseline for this measure is an existing economizer installed on a packaged single zone rooftop HVAC unit. The existing economizer system is currently not operating as designed due to mechanical and/or control problems, and/or is not optimally adjusted.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure life is assumed to be 5 years[509].

DEEMED MEASURE COST

The cost for this measure can vary considerably depending upon the existing condition of the economizer and the

508 ASHRAE, Standard 90.1-2013 - https://www.ashrae.org/resources--publications/bookstore/standard-90-1
509 California Public Utilities Commission, DEER 2014 EUL Table D08 v2.05

work required to achieve the required efficiency levels. Measure cost should be determined on a site-specific basis.

LOADSHAPE

Loadshape C03 - Commercial Cooling

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF ENERGY SAVINGS

The savings calculation methodology uses a regression equation to calculate the energy savings for a variety of common situations[510].

ELECTRIC ENERGY SAVINGS

ΔkWh = [Baseline Energy Use (kWh/Ton) – Proposed Energy Use (kWh/Ton)] * Cooling Capacity (Tons)

The following equations are used to calculate baseline and proposed electric energy use[511].

Electric Energy Use Equations (kWh / ton)

Building Type	Changeover Type	Equation
Assembly	Fixed Dry-Bulb (DB)	cz+CSP*-2.021+EL*-16.362+OAn*1.665+OAx*-3.13
	Dual Temperature Dry-Bulb (DTDB)	cz+EL*-11.5+OAn*1.635+OAx*-2.817
	Dual Temperature Enthalpy (DTEnth)	cz+EL*-17.772+OAn*1.853+OAx*-3.044
	Fixed Enthalpy (Enth)	cz+CSP*-5.228+EL*-17.475+OAn*1.765+OAx*-3.003
	Analog ABCD Economizers (ABCD)	cz+CSP*-2.234+EL*-16.394+OAn*1.744+OAx*-3.01
Convenience Store	DB	cz+CSP*-2.021+EL*-16.362+OAn*1.665+OAx*-3.13
	DTDB	cz+EL*-11.5+OAn*1.635+OAx*-2.817
	DTEnth	cz+EL*-17.772+OAn*1.853+OAx*-3.044
	Enth	cz+CSP*-5.228+EL*-17.475+OAn*1.765+OAx*-3.003
	ABCD	cz+CSP*-2.234+EL*-16.394+OAn*1.744+OAx*-3.01
Office - Low Rise	DB	cz+CSP*-3.982+EL*-27.508+OAn*2.486+OAx*-4.684
	DTDB	cz+EL*-20.798+OAn*2.365+OAx*-3.773
	DTEnth	cz+EL*-30.655+OAn*2.938+OAx*-4.461
	Enth	cz+CSP*-8.648+EL*-25.678+OAn*2.092+OAx*-3.754
	ABCD	cz+CSP*-3.64+EL*-24.927+OAn*2.09+OAx*-3.788
Religious Facility	DB	cz+CSP*-0.967+EL*-6.327+OAn*2.87+OAx*-1.047
	DTDB	cz+OAn*2.968+OAx*-0.943
	DTEnth	cz+EL*-9.799+OAn*3.106+OAx*-1.085

[510] For more information on methodology, please refer to workpaper submitted by CLEAResult titled "CLEAResult_Economizer Repair_151020_Finalv2.doc". Note that the original ComEd eQuest models were used in the analysis, rather than the VEIC developed models used elsewhere. VEIC do not consider this a significant issue as adjustments from the ComEd models were focused on calibrating EFLH values, not to overall energy use metrics. We also believe using the ComEd models is likely more conservative. It may be appropriate to update the analysis with the updated models at a later time.

[511] This approach allows the savings estimate to account for the operational attributes of the baseline as well as the proposed case, yielding a better estimate than an approach that assumes a particular baseline or proposed energy use to determine savings.

Building Type	Changeover Type	Equation
	Enth	cz+CSP*-2.773+EL*-7.392+OAn*2.941+OAx*-0.974
	ABCD	cz+CSP*-1.234+EL*-7.229+OAn*2.936+OAx*-0.995
Restaurant	DB	cz+CSP*-1.131+OAn*3.542+OAx*-1.01
	DTDB	cz+EL*-10.198+OAn*4.056+OAx*-1.279
	DTEnth	cz+OAn*3.775+OAx*-1.031
	Enth	cz+CSP*-2.13+OAn*3.317+OAx*-0.629
	ABCD	cz+CSP*-0.95+OAn*3.313+OAx*-0.647
Retail - Department Store	DB	cz+CSP*-2.243+EL*-21.523+OAx*-1.909
	DTDB	cz+EL*-14.427+OAn*0.295+OAx*-1.451
	DTEnth	cz+EL*-25.99+OAn*0.852+OAx*-1.951
	Enth	cz+CSP*-4.962+EL*-16.868+OAn*-0.12+OAx*-1.418
	ABCD	cz+CSP*-2.115+EL*-16.15+OAn*-0.125+OAx*-1.432
Retail - Strip Mall	DB	cz+CSP*-1.003+OAn*3.765+OAx*-0.938
	DTDB	cz+OAn*3.688+OAx*-0.676
	DTEnth	cz+OAn*4.081+OAx*-1.072
	Enth	cz+CSP*-2.545+OAn*3.725+OAx*-0.788
	ABCD	cz+CSP*-1.175+OAn*3.708+OAx*-0.809

Where:

CZ = Climate Zone Coefficient

= Depends on Building Type and Changover Type (see table below)

		Electric Climate Zone Coefficients				
Building Type	Changeover Type	CZ1 (Rockford)	CZ2 (Chicago)	CZ3 (Springfield)	CZ4 (Belleville)	CZ5 (Marion)
Assembly	DB	874.07	886.73	1043.38	1071.48	1072.20
	DTDB	698.45	711.89	870.13	899.51	903.10
	DTEnth	702.06	715.42	873.43	902.76	906.50
	Enth	851.95	865.43	1020.65	1047.10	1053.32
	ABCD	884.19	897.63	1053.12	1080.58	1086.35
Convenience Store	DB	1739.12	1787.09	2128.78	2206.65	2245.93
	DTDB	1389.28	1436.30	1780.99	1863.45	1904.89
	DTEnth	1398.42	1446.82	1789.71	1869.89	1912.59
	Enth	1643.51	1691.34	2032.83	2112.21	2157.63
	ABCD	1692.80	1740.62	2082.35	2162.73	2207.68
Office - Low Rise	DB	674.06	687.17	899.17	993.84	989.16
	DTDB	583.62	597.02	811.39	907.61	903.58
	DTEnth	588.94	602.11	816.02	912.49	908.26
	Enth	668.83	682.23	893.61	987.52	986.59
	ABCD	690.27	703.52	915.27	1009.94	1008.59
Religious Facility	DB	613.26	630.50	853.53	923.99	931.74
	DTDB	518.40	535.45	760.76	832.57	840.72
	DTEnth	513.59	531.20	756.26	829.13	837.26
	Enth	576.94	594.17	817.64	888.37	897.18
	ABCD	593.78	611.04	834.69	905.83	914.27
Restaurant	DB	1397.27	1430.45	1763.21	1837.63	1872.18

Building Type	Changeover Type	Electric Climate Zone Coefficients				
		CZ1 (Rockford)	CZ2 (Chicago)	CZ3 (Springfield)	CZ4 (Belleville)	CZ5 (Marion)
	DTDB	1191.82	1225.12	1558.32	1633.95	1669.13
	DTEnth	1192.84	1226.77	1559.41	1635.13	1671.11
	Enth	1343.56	1377.52	1710.11	1783.66	1821.67
	ABCD	1373.72	1407.70	1740.43	1814.74	1852.55
Retail - Department Store	DB	717.89	730.07	968.85	1034.78	1035.06
	DTDB	628.83	641.70	883.37	951.09	951.33
	DTEnth	629.35	641.90	882.84	951.33	951.44
	Enth	705.06	717.99	956.42	1020.57	1024.45
	ABCD	728.60	741.47	980.19	1045.30	1048.57
Retail - Strip Mall	DB	800.69	818.68	1070.39	1129.87	1133.84
	DTDB	692.97	711.31	965.63	1026.68	1030.41
	DTEnth	698.12	716.34	970.06	1031.78	1035.72
	Enth	784.54	803.35	1054.37	1112.72	1120.74
	ABCD	810.10	828.86	1080.11	1139.39	1146.95

CSP = Economizer Changeover Setpoint (°F or Btu/lb) (actual in ranges below)

Economizer Control Type		Economizer Changeover Setpoint
Dry-Bulb		60°F - 80°F
Dual Temperature Dry-Bulb		0°F -5°F delta
Dual Temperature Enthalpy		0 Btu/lb -5 Btu/lb delta
Enthalpy		18 Btu/lb – 28 Btu/lb
Analog ABCD Economizers	A	73°F
	B	70°F
	C	67°F
	D	63°F
	E	55°F

EL = Integrated Economizer Operation (Economizer Lockout)

= 0 for Economizer w/ Integrated Operation (Two Stage Cooling)

= 1 for Economizer w/ out Integrated Operation fan that runs intermittently (One Stage Cooling)

Oan = Minimum Outside Air (% OSA)[512]

= Actual. Must be between 15% -70%. If unknown assume

Functional Economizer – 30%
Non functional Economizer (Damper failed closed) – 15%
Non functional Economizer (Damper failed open) - 30% (Assume Minimum Ventilation (Three Fingers)[513])

Oax = Maximum Outside Air (%)[i]

= Actual. Must be between 15% -70%. If unknown assume

Functional Economizer – 70%

[512] DNV GL, "HVAC Impact Evaluation Final Report WO32 HVAC – Volume 1: Report," California Public Utilities Commission, Energy Division, HVAC Commercial Quality Maintenance (CQM) (1/28/14)

[513] Technician rule of thumb taken from CPUC 'HVAC Impact Evaluation Final Report', WO32, 28Jan 2015, p18.

Non functional Economizer (Damper failed closed) – 15%
Non functional Economizer (Damper failed open) — 30% (Assume Minimum Ventilation (Three Fingers))

EXAMPLE
A low rise office building in Rockford (Climate Zone 1) is heated and cooled with a packaged Gas (92 kBtu output) / DX (5 Ton) RTU. The RTU is equipped with a fixed dry-bulb outside air economizer and is programed for integrated operation. When the technician inspects the RTU they find that the changeover setpoint is programmed to 62°F, which does not meet ASHRAE economizer high limit shut off air economizer recommendations. After further investigation it is found that the OSA damper motor is not operational and is providing 30% outside air.

The technician replaces the damper motor and allow for proper OSA damper modulation (30% Min OSA & 70% Max OSA). They also adjust the fixed dry-bulb changeover setpoint to meet the ASHRAE economizer high limit shut off air economizer recommendation of 70°F.

ΔkWh = [Baseline Energy Use (kWh/Ton) – Proposed Energy Use (kWh/Ton)] * Cooling Capacity (Tons)

Baseline Energy Use (kWh/Ton) = Equation for Office Low Rise
= cz+CSP*-0.967+EL*-6.327+OAn*2.87+OAx*-1.047
= 674.06+62*-0.967+0*-6.327+30*2.87+30*-1.047
= 668.8 kWh/Ton

Proposed Energy Use (kWh/Ton) = Equation for Office Low Rise
= cz+CSP*-0.967+EL*-6.327+OAn*2.87+OAx*-1.047
= 674.06+70*-0.967+0*-6.327+ 30*2.87+70*-1.047
= 619.2 kWh/Ton

ΔkWh = [668.8 (kWh/Ton) – 619.2 (kWh/Ton)] * 5 Tons
= 49.6 kWh/Ton * 5 Tons
= 248.08 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A - It is assumed that repair or optimization of the economizer will not typically have a significant impact summer peak demand.

NATURAL GAS SAVINGS

ΔTherms = [Baseline Energy Use (Therms/kBtuh) – Proposed Energy Use (Therms/kBtuh)] * Output Heating Capacity (kBtuh)

The following equations are used to calculate baseline and proposed electric energy use.

Natural Gas Energy Use Equations (therms / kbtu output)

Building Type	Changeover Type	Equation
Assembly	Fixed Dry-Bulb (DB)	cz+OAn*0.0853
	Dual Temperature Dry-Bulb (DTDB)	cz+OAn*0.0866

Building Type	Changeover Type	Equation
	Dual Temperature Enthalpy (DTEnth)	cz+OAn*0.0866
	Fixed Enthalpy (Enth)	cz+OAn*0.0855
	Analog ABCD Economizers (ABCD)	cz+OAn*0.0855
Convenience Store	DB	cz+OAn*0.26
	DTDB	cz+OAn*0.263
	DTEnth	cz+OAn*0.263
	Enth	cz+OAn*0.261
	ABCD	cz+OAn*0.261
Office - Low Rise	DB	cz+OAn*0.3
	DTDB	cz+OAn*0.301
	DTEnth	cz+OAn*0.301
	Enth	cz+OAn*0.3
	ABCD	cz+OAn*0.3
Religious Facility	DB	cz+OAn*0.35
	DTDB	cz+OAn*0.348
	DTEnth	cz+OAn*0.348
	Enth	cz+OAn*0.349
	ABCD	cz+OAn*0.349
Restaurant	DB	cz+OAn*0.0867
	DTDB	cz+OAx*-0.038+OAn*OAx*0.00149
	DTEnth	cz+OAx*-0.038+OAn*OAx*0.00149
	Enth	cz+OAn*0.0878
	ABCD	cz+OAn*0.0878
Retail - Department Store	DB	cz+OAn*0.319
	DTDB	cz+OAn*0.318
	DTEnth	cz+OAn*0.318
	Enth	cz+OAn*0.318
	ABCD	cz+OAn*0.318
Retail - Strip Mall	DB	cz+OAn*0.215
	DTDB	cz+OAn*0.216
	DTEnth	cz+OAn*0.216
	Enth	cz+OAn*0.215
	ABCD	cz+OAn*0.215

Where:

CZ = Climate Zone Coefficient

= Depends on Building Type and Changover Type (see table below)

		Natural Gas Climate Zone Coefficients				
Building Type	Changeover Type	CZ1 (Rockford)	CZ2 (Chicago)	CZ3 (Springfield)	CZ4 (Belleville)	CZ5 (Marion)
Assembly	DB	-0.03	-0.55	-1.06	-1.28	-1.71
	DTDB	-0.02	-0.57	-1.11	-1.34	-1.79
	DTEnth	-0.02	-0.57	-1.11	-1.34	-1.79
	Enth	-0.03	-0.55	-1.06	-1.29	-1.72

Building Type	Changeover Type	Natural Gas Climate Zone Coefficients				
		CZ1 (Rockford)	CZ2 (Chicago)	CZ3 (Springfield)	CZ4 (Belleville)	CZ5 (Marion)
	ABCD	-0.03	-0.55	-1.06	-1.29	-1.72
Convenience Store	DB	2.95	0.50	-1.48	-2.96	-5.56
	DTDB	3.06	0.52	-1.56	-3.11	-5.81
	DTEnth	3.06	0.52	-1.56	-3.11	-5.81
	Enth	2.96	0.50	-1.49	-2.98	-5.59
	ABCD	2.96	0.50	-1.49	-2.98	-5.59
Office - Low Rise	DB	5.83	3.02	0.46	-0.92	-4.13
	DTDB	5.98	3.08	0.41	-1.03	-4.36
	DTEnth	5.98	3.08	0.41	-1.03	-4.36
	Enth	5.85	3.03	0.46	-0.93	-4.16
	ABCD	5.85	3.03	0.46	-0.93	-4.16
Religious Facility	DB	9.23	6.71	3.75	2.40	-0.80
	DTDB	9.41	6.83	3.77	2.39	-0.86
	DTEnth	9.41	6.83	3.77	2.39	-0.86
	Enth	9.25	6.73	3.75	2.40	-0.80
	ABCD	9.25	6.73	3.75	2.40	-0.80
Restaurant	DB	8.30	6.54	4.94	4.00	1.95
	DTDB	10.51	8.71	7.07	6.10	4.00
	DTEnth	10.51	8.71	7.07	6.10	4.00
	Enth	8.28	6.51	4.91	3.96	1.90
	ABCD	8.28	6.51	4.91	3.96	1.90
Retail - Department Store	DB	8.20	5.86	3.19	1.25	-2.59
	DTDB	8.35	5.94	3.18	1.18	-2.75
	DTEnth	8.35	5.94	3.18	1.18	-2.75
	Enth	8.21	5.87	3.18	1.24	-2.61
	ABCD	8.21	5.87	3.18	1.24	-2.61
Retail - Strip Mall	DB	6.40	4.35	2.07	0.49	-2.18
	DTDB	6.51	4.38	2.03	0.39	-2.34
	DTEnth	6.51	4.38	2.03	0.39	-2.34
	Enth	6.41	4.35	2.06	0.48	-2.20
	ABCD	6.41	4.35	2.06	0.48	-2.20

EXAMPLE

A low rise office building in Rockford (Climate Zone 1) is heated and cooled with a packaged Gas (92 kBtu output) / DX (5 Ton) RTU. The RTU is equipped with a fixed dry-bulb outside air economizer and is programed for integrated operation. When the technician inspects the RTU they find that the changeover setpoint is programmed to 62°F, which does not meet ASHRAE economizer high limit shut off air economizer recommendations. After further investigation it is found the OSA damper motor is not operational and is providing 30% outside air.

The technician replaces the damper motor and allow for proper OSA damper modulation (30% Min OSA & 70% Max OSA). They also adjust the fixed dry-bulb changeover setpoint to meet the ASHRAE economizer high limit shut off air economizer recommendation of 70°F.

ΔTherms = [Baseline Energy Use (Therms/kBtuh) – Proposed Energy Use(Therms/kBtuh)] * Output Heating Capacity (kBtuh)

Baseline Energy Use (Therms/kBtuh) = Equation for Office Low Rise
= cz+OAn*0.3
= 5.83+30*.3
=14.8 Therms/kBtuh output

Proposed Energy Use (Therms/kBtuh) = Equation for Office Low Rise
= cz+OAn*0.3
= 5.83+30*.3
=14.8 Therms/kBtuh output

ΔTherms = [14.8(Therms/kBtuh output) – 14.8 (Therms/kBtuh output)] * 92kBtuh output
= 0.0 (Therms/kBtuh output) * 92kBtuh output
= 0 Therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-ECRP-V01-160601

4.4.36 Multi-Family Space Heating Steam Boiler Averaging Controls

DESCRIPTION

This measure covers multi-family space heating boiler averaging controls. Temperature sensors are placed in interior spaces to monitor the average temperature of the building. At minimum a sensor must be placed at each corner and at one central location. Additionally, a temperature sensor must monitor the outside air temperature. These sensors shall provide data to the averaging controls. The averaging controls will adjust the boiler operation based upon an average of the indoor sensors and the outside air temperature. These controls shall also incorporate a night-time setback capability. Buildings utilizing thermostatic radiator valves, or other modulating control valves or sequences to control the temperature in individual spaces are not eligible.

This measure was developed to be applicable to the following program types: RF.

DEFINITION OF EFFICIENT EQUIPMENT

To qualify the boiler(s) must incorporate an averaging control system utilizing at least 5 indoor sensors and 1 outdoor sensor. The controls shall have the capability to incorporate a nighttime setback throughout the building.

DEFINITION OF BASELINE EQUIPMENT

The baseline is a boiler system without averaging controls or other steam supply modulating controls. Current boiler control system can utilize a single thermostat or aquastat and timer.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure life for the domestic hot water boilers is 20 years.[514]

DEEMED MEASURE COST

As a retrofit measure, the actual installed cost should be used for screening purposes.

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

[514] The Brooklyn Union Gas Company, High Efficiency Heating and Water and Controls, Gas Energy Efficiency Program Implementation Plan.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

$$\Delta Therms = Capacity \times EFLH \times SF / 100{,}000$$

Where:

Capacity = Boiler gas input size (Btu/h)

= Actual

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

SF = Savings Factor

= 5%[515] or custom if savings can be substantiated

100,000 = converts Btu/h to therm

For Example: A 1,000,000 btu/h steam boiler in a Mid-Rise Multi-Family building in Chicago has averaging controls installed. ΔTherms = 1,000,000 x 1,685 x 0.05 / 100,000 = 843 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-SBAC-V01-160601

515 A conservative estimate considering only setback savings, with DOE estimates as much as 1% per degree per 8 hours of setback. http://energy.gov/energysaver/thermostats

4.4.37 Unitary HVAC Condensing Furnace

DESCRIPTION

Condensing furnaces recover energy in combustion exhaust flue gasses that would otherwise simply be vented to the atmosphere, making them more efficient than non-condensing furnaces. This measure applies to a constant volume (CV), dedicated outside air system (DOAS), make-up air system (MUAS), or any unitary HVAC system that is utilizing an indirect gas fired process to heat 100% OA to provide ventilation or make-up air to commercial and industrial (C&I) building spaces. The unitary package must contain an indirect gas-fired, warm air furnace section, but the unitary package can be with or without an electric air conditioning section. The unitary package can be either a single package or split system that is applied indoors (non-weatherized) or outdoors (weatherized).

This measure excludes demand control ventilation, condensing unit heaters, and high efficiency (condensing) furnaces with annual fuel utilization efficiency (AFUE) ratings (for furnaces with less than 225,000 Btu/hr input capacity), which are covered by other measures for the C&I sector in the Technical Reference Manual (TRM)[516].

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 unitary equipment must contain a condensing, warm air furnace with a natural gas thermal efficiency (TE) rating of 90% or higher, or alternatively, the unitary package must have equipment nameplate information for natural gas that identifies a heating output and heating input rating that has an output over input ratio of 0.90 or higher. These ratings must be certified by a recognized testing laboratory in accordance with American National Standards Institute (ANSI) Standard Z21.47 for Gas-Fired Central Furnaces[517]. The furnace must be vented and condensate disposed of in accordance with the equipment manufacturer installation instructions and applicable codes.

DEFINITION OF BASELINE EQUIPMENT

The baseline equipment is expected to be unitary equipment that contains a non-condensing, warm air furnace with a natural gas thermal efficiency (TE) rating of 80%, or alternatively, the unitary package will have equipment nameplate information for natural gas that identifies a heating output and heating input rating that has an output over input ratio of 0.80. These ratings must be certified by a recognized testing laboratory in accordance with American National Standards Institute (ANSI) Standard Z21.47 for Gas-Fired Central Furnaces.

Note the current Department of Energy (DOE) federal minimum efficiency standard is 80% for 225,000 Btu/hr and higher input capacity furnaces per the Energy Conservation Standard for Commercial Warm Air Furnaces[518]. In the American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) Standard 90.1 Energy Standard for Buildings Except Low-Rise Residential Buildings[519] that minimum TE requirement is extended below 225,000 Btu/hr input capacity to require all commercial warm air furnaces and combination warm air furnace/air conditioning units to meet the minimum 80% TE.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 15 years, which is consistent with the established TRM measure life for

[516] Illinois Statewide Technical Reference Manual (TRM), Version 4.0 (effective June 1, 2015), 2015. http://www.ilsag.info/technical-reference-manual.html (Accessed September 25, 2015).

[517] American National Standards Institute (ANSI), ANSI Z21.47 Standard for Central Gas-Fired Central Furnaces, 2012. http://www.techstreet.com/products/1837013#product (Accessed September 25, 2015).

[518] Department of Energy (DOE), Commercial Warm Air Furnace Standard DOE 10 CFR, Part 431, Subpart D – Commercial Warm Air Furnaces, 2004. https://www.law.cornell.edu/cfr/text/10/part-431/subpart-D (Accessed September 25, 2015).

[519] American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE), ASHRAE Standard 90.1 Energy Standard for Buildings Except Low-Rise Residential Buildings, 2013. https://www.ashrae.org/resources-- publications/bookstore /standard-90-1 (Accessed September 25, 2015).

single-package and split system unitary air conditioners, since in colder climates these unitary packages typically contain a gas-fired, warm air furnace section, with an electric air conditioning section.

DEEMED MEASURE COST

The actual incremental equipment and installation costs should be used, if available. If not, the incremental cost of $5.42 per 1000 Btu/hr of output capacity should be used for the condensing furnace equipment (as part of a unitary package) and its installation (including the combustion condensate drainage and disposal system). This incremental cost is from the DOE Technical Support Document for the Notice of Proposed Rulemaking (NOPR) for the Commercial Warm Air Furnace Standard[520]. Per the DOE documentation, it is based on their representative 250,000 Btu/hr input capacity furnace at a 92% TE.

LOADSHAPE

Loadshape C23 - Commercial Ventilation

COINCIDENCE FACTOR

The coincidence factor is assumed to be 1.0 – that is, building ventilation will always be provided during peak periods.

Algorithm

CALCULATION OF SAVINGS

The following methodology provides formulas for estimating gas heating savings associated with condensing furnaces in unitary HVAC packages when applied as a CV, DOAS, MUAS, or any RTU that is indirectly heating 100% outside air (OA). These types of HVAC systems typically run continuously during the HVAC operating schedule to provide building ventilation and maintain indoor air quality or to compensate for exhaust and maintain neutral or slightly positive building pressurization. The algorithm estimates the gas use reduction resulting from utilizing condensing heating of 90% or higher thermal efficiency (TE) in place of the federal minimum TE of 80% (or other user defined baseline TE) for commercial warm air furnaces.

The methodology provides a representative group of operating schedules for the market sector applications highlighted earlier based on DOE commercial reference building models[521]. Heating loads during the operating schedule are determined based on hourly differences between a range of supply air (SA) heated to temperatures and the OA temperature using Typical Meteorological Year (TMY3)[522] weather data. These hourly heating loads are generated for all hours when the OA temperature is below the base temperature of 55 ^{o}F for heating in C&I settings per the TRM. To accommodate the variability in heating base temperatures in C&I settings, these hourly heating loads are also generated for base temperatures of 45 ^{o}F and 65 ^{o}F for heating. The hourly heating loads are then summed for the entire year. The annual heating loads are calculated in this manner for the climate zone 2 weather station (Chicago O'Hare Airport), which is then normalized to its National Climatic Data Center (NCDC)[523] 30 year (1981-2010) weather average by multiplying by the heating degree day (HDD) ratio of the NCDC/TRM HDD55 over the TMY3 HDD55 (HDD at base temperature of 55 ^{o}F), and likewise for the annual heating loads for HDD45 (HDD at base temperature of 45 ^{o}F) and HDD65 (HDD at base temperature of 65 ^{o}F), using the values in Table 1 and Table 2. Since detailed hourly weather data is not available for all 5 of the TRM climate zone weather

[520] Department of Energy (DOE), Rulemaking for Commercial Warm Air Furnace Standard, Technical Support Document 2015. https://www1.eere.energy.gov/buildings/appliance_standards/rulemaking.aspx/ruleid/70 (Accessed September 25, 2015).
[521] Department of Energy (DOE) National Renewable Energy Laboratory, Commercial Reference Building Models of the National Building Stock, 2011. http://www.nrel.gov/docs/fy11osti/46861.pdf (Accessed September 25, 2015).
[522] Department of Energy (DOE) National Renewable Energy Laboratory, Users Manual for TMY3 Data Sets, 2008. http://www.nrel.gov/docs/fy08osti/43156.pdf (Accessed September 25, 2015).
[523] National Climatic Data Center, 1981-2010 Climate Normals, 2015. https://www.ncdc.noaa.gov/data-access/land-based-station-data/land-based-datasets/climate-normals/1981-2010-normals-data (Accessed November 4, 2015).

stations, the annual heating loads for the other climate zones are determined by multiplying the climate zone 2 annual heating loads by the ratio of the other climate zone NCDC HDD over the climate zone 2 NCDC HDD, using the values in Table 1.

These annual heating loads on a per unit airflow basis are then used in conjunction with the actual airflow of the 100% OA system and its condensing efficiency to calculate the gas heating savings versus the baseline (non-condensing) heating efficiency. This measure results in additional electric use by the unitary HVAC package due to the additional pressure drop of the condensing heat exchanger of the warm air furnace section.

Table 1. NCDC/TRM HDD Values for All Climate Zones

Climate Zone - Weather Station/City	NCDC 30 Year Average HDD45[8]	NCDC 30 Year Average HDD55[1,8]	NCDC 30 Year Average HDD65[8]
1 - Rockford AP / Rockford	2495	4272	6569
2 - Chicago O'Hare AP / Chicago	2263	4029	6340
3 - Springfield #2 / Springfield	1812	3406	5495
4 - Belleville SIU RSCH / Belleville	1197	2515	4379
5 - Carbondale Southern IL AP / Marion	1183	2546	4477

Table 2. TMY3 HDD Values for Climate Zone 2

Climate Zone - Weather Station/City	TMY3 HDD45[7]	TMY3 HDD55[7]	TMY3 HDD65[7]
2 - Chicago O'Hare AP / Chicago	2422	4188	6497

ELECTRIC ENERGY SAVINGS

As noted previously, this measure results in additional SA fan electric use by the unitary HVAC system due to the additional pressure drop of the condensing heat exchanger of the warm air furnace section.

$$\Delta kWh = -(t_{FAN} * cfm * \Delta P) / (\eta_{FAN/MOTOR} * 8520)$$

Where:

t_{FAN} = annual fan runtime (hr), refer to Tables 1 through 4

cfm = airflow (cfm), use actual or rated system airflow

ΔP = incremental pressure drop (inch W.G.), assume 0.15 if actual value not known

$\eta_{FAN/MOTOR}$ = combined fan and motor efficiency, assume 0.60 if actual value not known

8520 = conversion factor (fan horsepower – HP – calculation constant of 6356 for standard air conditions adjusted by 1 HP = 0.746 kW, or 6356/ 0.746 = 8520 for this kW calculation)

EXAMPLE:

For a "big box" retail store operating 24 hours a day and 7 days a week (8760 hours per year) with a 5000 cfm DOAS that has an incremental pressure drop of 0.15 inch W.G. and a combined fan and motor efficiency of 0.6 has annual kWh savings of:

$$\Delta kWh = -(t_{FAN} * cfm * \Delta P) / (\eta_{FAN/MOTOR} * 8520)$$

$$= -(8760 * 5000 * 0.15) / (0.6 * 8520)$$

$$= -1285 \text{ kWh}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

The additional SA fan electric use by the unitary HVAC system will typically result in a modest electric demand increase.

$\Delta kW = (\Delta kWh / t_{FAN}) * CF$

Where:

CF = 1.0

EXAMPLE:

Continuing the previous example:

$\Delta kW = (\Delta kWh / t_{FAN}) * CF$

$= (- 1285 / 8760) * 1.0$

$= - 0.15$ kW

NATURAL GAS ENERGY SAVINGS

$\Delta Therms = [Q_{OA} * cfm * (1/TE_{NC} - 1/TE_{C})]/ 100{,}000$

Where:

Q_{OA} = annual outside air (OA) heating load per cfm of OA (Btu/cfm)

First, select the most representative operating schedule for the application from among the four (4) scenarios listed below and its set of three (3) applicable tables. Second, select the table in that set with the most representative HDD base temperature – the base temperature for OA below which heating is required. If that base temperature is not readily determined, select the TRM default base temperature of 55 ^{o}F (HDD55) for heating in C&I settings. Third, select the climate zone within that table. Fourth, select an appropriate heated to supply air (SA) temperature within that table. Use the resulting Q_{OA} value, with linear interpolation allowed between SA temperatures.

The four (4) scenarios available are indicative of the following building applications and operating schedules:

1. 24 hour a day and 7 day a week (24/7) operation, with HVAC operating schedule of 8760 hours per year, typical of large retail stores with DOAS, hotel/multifamily buildings with corridor MUAS, and healthcare facilities with DOAS. Use Table 3 through Table 5.

2. 6:00 AM to 1:00 AM every day operation, with HVAC operating schedule of 7300 hours per year, typical of full service and quick service restaurants with kitchen MUAS. Use Table 6 through Table 8.

3. 7:00 AM to 9:00 PM Monday-Friday, 7:00 AM to 10:00 PM Saturday, and 9:00 AM to 7:00 PM Sunday operations, with HVAC operating schedule of 5266 hours per year, typical of non-24/7 retail stores with DOAS. Use Table 9 through Table 11.

4. 7:00 AM to 9:00 PM Monday-Friday operation, with HVAC operating schedule of 3911 hours per year, typical of school buildings with DOAS. Use Table 12 through Table 14.

TE_{NC} = non-condensing thermal efficiency (TE), use federal minimum TE of 80% (0.80) or actual TE if known

TE_{C} = condensing thermal efficiency (TE), use actual TE or if unknown assume 90% (0.90)

100,000 = conversion factor (1 therm = 100,000 Btu)

EXAMPLE:

Continuing the previous example, for a climate zone 2 (Chicago O'Hare AP / Chicago) application using a 90% TE condensing DOAS with a supply air temperature from the DOAS of 95 ^{o}F:

ΔTherms = [Q_{OA} * cfm * (1/TE_{NC} - 1/TE_{C})]/ 100,000

= 303,268 * 5,000 * (1/0.80 – 1/0.90)/100,000

= 2,106 therms

8760 Hour Annual Operation Scenario

Table 3. 8760 Hour Annual Operation Scenario for HDD45

Supply Air Fan Runtime = 8760 Hours	Q_{oa} (Annual Btu/cfm) At Supply Air Temperature Of			
Climate Zone - Weather Station/City	75ºF	85ºF	95ºF	105ºF
1 - Rockford AP / Rockford	189,343	230,897	272,451	314,004
2 - Chicago O'Hare AP / Chicago	171,737	209,427	247,116	284,806
3 - Springfield #2 / Springfield	137,511	167,689	197,868	228,046
4 - Belleville SIU RSCH / Belleville	90,839	110,775	130,711	150,647
5 - Carbondale Southern IL AP / Marion	89,777	109,479	129,182	148,885

Table 4. 8760 Hour Annual Operation Scenario for HDD55

Supply Air Fan Runtime = 8760 Hours	Q_{oa} (Annual Btu/cfm) At Supply Air Temperature Of			
Climate Zone - Weather Station/City	75ºF	85ºF	95ºF	105ºF
1 - Rockford AP / Rockford	216,145	268,852	321,559	374,266
2 - Chicago O'Hare AP / Chicago	203,850	253,559	303,268	352,977
3 - Springfield #2 / Springfield	172,329	214,351	256,374	298,397
4 - Belleville SIU RSCH / Belleville	127,248	158,278	189,307	220,337
5 - Carbondale Southern IL AP / Marion	128,817	160,229	191,641	223,053

Table 5. 8760 Hour Annual Operation Scenario for HDD65

Supply Air Fan Runtime = 8760 Hours	Q_{oa} (Annual Btu/cfm) At Supply Air Temperature Of			
Climate Zone - Weather Station/City	75ºF	85ºF	95ºF	105ºF
1 - Rockford AP / Rockford	239,158	308,050	376,942	445,834
2 - Chicago O'Hare AP / Chicago	230,820	297,311	363,802	430,292
3 - Springfield #2 / Springfield	200,056	257,685	315,314	372,943
4 - Belleville SIU RSCH / Belleville	159,426	205,351	251,276	297,200
5 - Carbondale Southern IL AP / Marion	162,994	209,947	256,899	303,852

7300 Hour Annual Operation Scenario

Table 6. 7300 Hour Annual Operation Scenario for HDD45

Supply Air Fan Runtime = 7300 Hours	Q_{oa} (Annual Btu/cfm) At Supply Air Temperature Of			
Climate Zone - Weather Station/City	75°F	85°F	95°F	105°F
1 - Rockford AP / Rockford	151,914	185,369	218,823	252,278
2 - Chicago O'Hare AP / Chicago	137,788	168,132	198,476	228,819
3 - Springfield #2 / Springfield	110,328	134,624	158,921	183,217
4 - Belleville SIU RSCH / Belleville	72,882	88,932	104,982	121,033
5 - Carbondale Southern IL AP / Marion	72,030	87,892	103,755	119,617

Table 7. 7300 Hour Annual Operation Scenario for HDD55

Supply Air Fan Runtime = 7300 Hours	Q_{oa} (Annual Btu/cfm) At Supply Air Temperature Of			
Climate Zone - Weather Station/City	75°F	85°F	95°F	105°F
1 - Rockford AP / Rockford	173,511	215,950	258,389	300,828
2 - Chicago O'Hare AP / Chicago	163,641	203,666	243,691	283,716
3 - Springfield #2 / Springfield	138,338	172,174	206,010	239,846
4 - Belleville SIU RSCH / Belleville	102,149	127,133	152,118	177,103
5 - Carbondale Southern IL AP / Marion	103,408	128,701	153,993	179,286

Table 8. 7300 Hour Annual Operation Scenario for HDD65

Supply Air Fan Runtime = 7300 Hours	Q_{oa} (Annual Btu/cfm) At Supply Air Temperature Of			
Climate Zone - Weather Station/City	75°F	85°F	95°F	105°F
1 - Rockford AP / Rockford	191,803	247,046	302,288	357,531
2 - Chicago O'Hare AP / Chicago	185,117	238,434	291,750	345,067
3 - Springfield #2 / Springfield	160,444	206,655	252,866	299,076
4 - Belleville SIU RSCH / Belleville	127,859	164,685	201,510	238,336
5 - Carbondale Southern IL AP / Marion	130,720	168,370	206,020	243,670

5266 Hour Annual Operation Scenario

Table 9. 5266 Hour Annual Operation Scenario for HDD45

Supply Air Fan Runtime = 5266 Hours	Q_{oa} (Annual Btu/cfm) At Supply Air Temperature Of			
Climate Zone - Weather Station/City	75°F	85°F	95°F	105°F
1 - Rockford AP / Rockford	104,175	127,350	150,524	173,699
2 - Chicago O'Hare AP / Chicago	94,488	115,508	136,527	157,547
3 - Springfield #2 / Springfield	75,657	92,488	109,319	126,149
4 - Belleville SIU RSCH / Belleville	49,979	61,097	72,215	83,334
5 - Carbondale Southern IL AP / Marion	49,394	60,383	71,371	82,359

Table 10. 5266 Hour Annual Operation Scenario for HDD55

Supply Air Fan Runtime = 5266 Hours	Q_{oa} (Annual Btu/cfm) At Supply Air Temperature Of			
Climate Zone - Weather Station/City	75°F	85°F	95°F	105°F
1 - Rockford AP / Rockford	118,320	147,406	176,492	205,578
2 - Chicago O'Hare AP / Chicago	111,590	139,021	166,452	193,884
3 - Springfield #2 / Springfield	94,335	117,524	140,714	163,904
4 - Belleville SIU RSCH / Belleville	69,657	86,780	103,904	121,027
5 - Carbondale Southern IL AP / Marion	70,516	87,850	105,184	122,519

Table 11. 5266 Hour Annual Operation Scenario for HDD65

Supply Air Fan Runtime = 5266 Hours	Q_{oa} (Annual Btu/cfm) At Supply Air Temperature Of			
Climate Zone - Weather Station/City	75°F	85°F	95°F	105°F
1 - Rockford AP / Rockford	130,903	168,718	206,532	244,347
2 - Chicago O'Hare AP / Chicago	126,339	162,836	199,333	235,829
3 - Springfield #2 / Springfield	109,501	141,133	172,765	204,398
4 - Belleville SIU RSCH / Belleville	87,262	112,470	137,678	162,886
5 - Carbondale Southern IL AP / Marion	89,215	114,987	140,759	166,531

3911 Hour Annual Operation Scenario

Table 12. 3911 Hour Annual Operation Scenario for HDD45

Supply Air Fan Runtime = 3911 Hours	Q_{oa} (Annual Btu/cfm) At Supply Air Temperature Of			
Climate Zone - Weather Station/City	75°F	85°F	95°F	105°F
1 - Rockford AP / Rockford	75,029	91,729	108,428	125,128
2 - Chicago O'Hare AP / Chicago	68,053	83,199	98,346	113,492
3 - Springfield #2 / Springfield	54,490	66,618	78,746	90,874
4 - Belleville SIU RSCH / Belleville	35,996	44,008	52,019	60,031
5 - Carbondale Southern IL AP / Marion	35,575	43,493	51,411	59,329

Table 13. 3911 Hour Annual Operation Scenario for HDD55

Supply Air Fan Runtime = 3911 Hours	Q_{oa} (Annual Btu/cfm) At Supply Air Temperature Of			
Climate Zone - Weather Station/City	75°F	85°F	95°F	105°F
1 - Rockford AP / Rockford	85,672	106,825	127,979	149,132
2 - Chicago O'Hare AP / Chicago	80,799	100,749	120,699	140,649
3 - Springfield #2 / Springfield	68,305	85,170	102,035	118,901
4 - Belleville SIU RSCH / Belleville	50,436	62,890	75,343	87,797
5 - Carbondale Southern IL AP / Marion	51,058	63,665	76,272	88,879

Table 14. 3911 Hour Annual Operation Scenario for HDD65

Supply Air Fan Runtime = 3911 Hours	Q_{oa} (Annual Btu/cfm) At Supply Air Temperature Of			
Climate Zone - Weather Station/City	75°F	85°F	95°F	105°F
1 - Rockford AP / Rockford	95,460	123,294	151,128	178,963
2 - Chicago O'Hare AP / Chicago	92,132	118,996	145,860	172,724
3 - Springfield #2 / Springfield	79,853	103,136	126,420	149,703
4 - Belleville SIU RSCH / Belleville	63,635	82,190	100,745	119,299
5 - Carbondale Southern IL AP / Marion	65,059	84,029	102,999	121,969

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

The actual incremental annual maintenance costs should be used, if available. If not, the incremental cost of $0.05 per 1000 Btu/hr of output capacity should be used for maintaining the combustion condensate disposal system yearly. This incremental cost is from the DOE Technical Support Document for the Notice of Proposed Rulemaking (NOPR) for the Commercial Warm Air Furnace Standard6. Per the DOE documentation, it is based on their representative 250,000 Btu/hr input capacity furnace at a 92% TE.

MEASURE CODE: CI-HVC-DSFN-V01-160601

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/Space Type	Fixture Annual Operating Hours[524]	Screw based bulb Annual Operating hours[525]	Waste Heat Cooling Energy WHFe [526]	Waste Heat Cooling Demand WHFd	Coincid-ence Factor CF[527]	Waste Heat Gas Heating IFTherms [528]	Waste Heat Electric Resistance Heating IFkWh[529]	Waste Heat Electric Heat Pump Heating IFkWh
Assisted Living	7,862	5,950	1.14	1.30	0.66	0.035	0.823	0.358
Childcare/Pre-School	2,860	2,860	1.17	1.29	0.72	0.018	0.420	0.183
College	3,395	2,588	1.06	1.39	0.63	0.020	0.462	0.201
Convenience Store	4,672	3,650	1.09	1.26	0.76	0.035	0.828	0.360
Elementary School	3,038	2,118	1.17	1.29	0.72	0.018	0.420	0.183
Garage	3,401	3,540	1.00	1.00	0.92	0.000	0.000	0.000
Garage, 24/7 lighting	8,766	8,766	1.00	1.00	1.00	0.000	0.000	0.000
Grocery	4,650	3,650	1.05	1.22	0.73	0.022	0.511	0.222
Healthcare Clinic	3,890	4,207	1.40	1.85	0.65	0.006	0.144	0.063
High School	3,038	2,327	1.18	1.39	0.72	0.028	0.656	0.285
Hospital - CAV no econ	7,616	4,207	1.11	1.29	0.76	0.022	0.527	0.229
Hospital - CAV econ	7,616	4,207	1.06	1.27	0.75	0.023	0.533	0.232
Hospital - VAV econ	7,616	4,207	1.37	1.79	0.70	0.010	0.241	0.105

[524]Fixtures hours of use are based upon schedule assumptions used in the eQuest models, except for those building types where Illinois based metering results provide a statistically valid estimate (currently: College, Elementary School, High School, Manufacturing, Low and Mid rise Office, Retail Department Store and Warehouse). Miscellaneous is a weighted average of indoor spaces using the relative area of each building type in the region (CBECS).

[525] 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.

[526] The Waste Heat Factor for Energy and is developed using EQuest models for various building types base on Chicago Illinois (closest to statewide average HDD and CDD). Exterior and garage values are 1, unknown is a weighted average of the other building types.

[527]Coincident diversity factors are based on either combined IL evaluation results (College, Elementary School, High School, Manufacturing, Low and Mid rise Office, Retail Department Store and Warehouse) or based upon schedules defined in the eQuest models described (all others).

[528] IF Therms value is developed using EQuest models consistent with methodology for Waste Heat Factor for Energy.

[529] 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%, for Heat Pump is assumed to be 2.3COP:
IFElectricHeat = IFTherms * 29.3 kWh/therm * 78% (Gas Heating Equipment Efficiency) / 100% (Electric Resistance Efficiency)

Building/Space Type	Fixture Annual Operating Hours[524]	Screw based bulb Annual Operating hours[525]	Waste Heat Cooling Energy WHFe [526]	Waste Heat Cooling Demand WHFd	Coincid-ence Factor CF[527]	Waste Heat Gas Heating IFTherms [528]	Waste Heat Electric Resistance Heating IFkWh[529]	Waste Heat Electric Heat Pump Heating IFkWh
Hospital - FCU	7,616	4,207	1.38	1.29	0.73	0.001	0.033	0.015
Manufacturing Facility	4,618	2,629	1.02	1.04	0.81	0.012	0.270	0.117
MF - High Rise - Common	6,138	5,950	1.14	1.32	0.64	0.025	0.596	0.259
MF - Mid Rise - Common	6,138	5,950	1.14	1.32	0.64	0.025	0.596	0.259
Hotel/Motel - Guest	2,390	777	1.18	1.36	0.28	0.020	0.463	0.201
Hotel/Motel - Common	6,138	4,542	1.20	1.24	0.73	0.032	0.748	0.325
Movie Theater	3,506	5,475	1.11	1.38	0.53	0.029	0.673	0.293
Office - High Rise - CAV no econ	2,886	3,088	1.00	1.07	0.57	0.037	0.874	0.380
Office - High Rise - CAV econ	2,886	3,088	1.00	1.07	0.57	0.039	0.905	0.394
Office - High Rise - VAV econ	2,886	3,088	1.27	1.65	0.53	0.022	0.510	0.222
Office - High Rise - FCU	2,886	3,088	1.35	1.56	0.59	0.015	0.346	0.150
Office - Low Rise	2,698	3,088	1.11	1.31	0.52	0.016	0.371	0.161
Office - Mid Rise	3,068	3,088	1.26	1.61	0.52	0.024	0.557	0.242
Religious Building	2,085	1,664	1.12	1.37	0.48	0.015	0.356	0.155
Restaurant	5,571	4,784	1.17	1.31	0.68	0.021	0.491	0.213
Retail - Department Store	5,478	2,935	1.12	1.31	0.95	0.022	0.514	0.223
Retail - Strip Mall	4,093	2,935	1.12	1.29	0.71	0.019	0.450	0.196
Warehouse	5,242	4,293	1.00	1.22	0.68	0.011	0.257	0.112
Unknown	3,379	3,612	1.09	1.36	0.58	0.022	0.522	0.227
Exterior	4,903	4,903	1.00	1.00	0.00	0.000	0.000	0.000
Low-Use Small Business	2,954	2,954	1.31	1.53	0.66	0.023	0.524	0.262
Uncooled Building	Varies	varies	1.00	1.00	0.66	0.014	0.320	0.160
Refrigerated Cases	5,802	n/a	1.29	1.29	0.69	0.000	0.000	0.000
Freezer Cases	5,802	n/a	1.50	1.5	0.69	0.000	0.000	0.000

4.5.1 Commercial ENERGY STAR Compact Fluorescent Lamp (CFL)

DESCRIPTION

A low wattage ENERGY STAR qualified compact fluorescent screw-in bulb (CFL) is installed in place of a baseline screw-in bulb. This characterization assumes that the CFL is installed in a commercial location. If the implementation strategy does not allow for the installation location to be known a deemed split should be used. For Residential targeted programs (e.g. an upstream retail program), a deemed split of 96% Residential and 4% Commercial assumptions should be used[530], and for Commercial targeted programs a deemed split of 4% Residential and 96% Commercial should be used[531].

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[532]) by the run hours. For example using Miscellaneous at 4,589 hours would give 2.2 years. When the number of years exceeds June 2020, the number of years to that date should be used.

DEEMED MEASURE COST

The incremental capital cost assumption for all bulbs under 2600 lumens is $1.25, from June 2014 – May 2015, $1.6 from June 2015 to May 2016 and $1.70 from June 2017 to May 2018[533].

For bulbs over 2600 lumens the assumed incremental capital cost is $5.

[530] RES v C&I split is based on a weighted (by sales volume) average of ComEd PY4-6 and Ameren PY5-6 in store intercept survey results.
[531] Based upon final weighted (by sales volume) average of the BILD program (ComEd's commercial lighting program) for PY 4 and PY5 and PY6.
[532] 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.
[533] Based upon pricing forecast developed by Applied Proactive Technologies Inc (APT) based on industry input and provided to Ameren.

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:

Minimum Lumens	Maximum Lumens	Incandescent Equivalent Post-EISA 2007 (WattsBase)
5280	6209	300

Minimum Lumens	Maximum Lumens	Incandescent Equivalent Post-EISA 2007 (WattsBase)
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%[534] 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:

Weighted Average 1st year In Service Rate (ISR)	2nd year Installations	3rd year Installations	Final Lifetime In Service Rate
71.2%[535]	14.5%	12.3%	98.0%[536]

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[537]. If unknown use the Miscellaneous value.

WHFe = Waste heat factor for energy to account for cooling energy savings from

[534] 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.

[535] 1st year in service rate is based upon review of PY4-6 evaluations from ComEd's commercial lighting program (BILD) (see 'IL Commercial Lighting ISR_2014.xls' for more information. The average first year ISR was calculated weighted by the number of bulbs sold.

[536]The 98% Lifetime ISR assumption is based upon review of two evaluations:
'Nexus Market Research, RLW Analytics and GDS Associates study; "New England Residential Lighting Markdown Impact Evaluation, January 20, 2009' and 'KEMA Inc, Feb 2010, Final Evaluation Report:, Upstream Lighting Program, Volume 1.' This implies that only 2% of bulbs purchased are never installed. The second and third year installations are based upon Ameren analysis of the Californian KEMA study showing that 54% of future installs occur in year 2 and 46% in year 3. The 2nd and 3rd year installations should be counted as part of those future program year savings. Note that this Final Install Rate does NOT account for leakage of purchased bulbs being installed outside of the utility territory. EM&V should assess how and if data from evaluation should adjust this final installation rate to account for this impact

[537] Based on ComEd analysis taking DEER 2008 values and averaging with PY1 and PY2 evaluation results.

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:

$\Delta kWh_{heatpenalty}$[538] = (((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.

[538]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[539] = (((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, 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

539 Negative value because this is an increase in heating consumption due to the efficient lighting.

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[540].

	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 5.34% are presented below. It is important to note that for cost-effectiveness screening purposes, the O&M cost adjustments should only be applied in cases where the light bulbs area actually in service and so should be multiplied by the appropriate ISR:

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)	$2.00	$2.00	$2.00	$0.75	$0.75	$0.75
	Lumens ≥ 310 and ≤ 2600 (EISA compliant)	$6.03	$4.87	$4.29	$2.26	$1.82	$1.60
Multi Family Common Areas	Lumens <310 or >2600 (EISA exempt)	$3.90	$3.90	$3.90	$2.56	$2.56	$2.56
	Lumens ≥ 310 and ≤ 2600 (EISA compliant)	$11.92	$9.55	$8.40	$7.83	$6.28	$5.52

For halogen bulbs, we assume the same replacement cycle as incandescent bulbs.[541] The replacement cycle is

[540] Based upon pricing forecast developed by Applied Proactive Technologies Inc (APT) based on industry input and provided to Ameren.

[541] 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 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-V06-160601

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[542].

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:

Measure Category	Value	Source
8-Foot Lamp Removal	$16.00	ComEd/KEMA regression[543]
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

[542] Based on ComEd's estimate of lamp type saturation.
[543] Based on the assessment of active projects in the 2008-09 ComEd Smart Ideas Program. See files "ltg costs 12-10-10.xl." and "Lighting Unit Costs 102605.doc"

LOADSHAPE

Loadshape C06 - Commercial Indoor Lighting

Loadshape C07 - Grocery/Conv. Store Indoor Lighting

Loadshape C08 - Hospital Indoor Lighting

Loadshape C09 - Office Indoor Lighting

Loadshape C10 - Restaurant Indoor Lighting

Loadshape C11 - Retail Indoor Lighting

Loadshape C12 - Warehouse Indoor Lighting

Loadshape C13 - K-12 School Indoor Lighting

Loadshape C14 - Indust. 1-shift (8/5) (e.g., comp. air, lights)

Loadshape C15 - Indust. 2-shift (16/5) (e.g., comp. air, lights)

Loadshape C16 - Indust. 3-shift (24/5) (e.g., comp. air, lights)

Loadshape C17 - Indust. 4-shift (24/7) (e.g., comp. air, lights)

Loadshape C18 - Industrial Indoor Lighting

Loadshape C19 - Industrial Outdoor Lighting

Loadshape C20 - Commercial Outdoor Lighting

COINCIDENCE FACTOR

The summer peak coincidence factor for this measure is dependent on the location type. Values are provided for each building type in the reference section below.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = ((WattsBase - WattsEE)/1000) * ISR * Hours * WHFe$$

Where:

WattsBase = Assume wattage reduction of lamp removed

	Wattage of lamp removed[544]		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.

For example, delamping a 4 ft T8 fixture in an office building:

$$\Delta kWh = ((19.4 - 0)/1000) * 1.0 * 4439 * 1.25$$

$$= 107.6 \text{ kWh}$$

HEATING PENALTY

If electrically heated building:

$$\Delta kWh_{heatpenalty}{}^{545} = (((WattsBase - WattsEE)/1000) * ISR * Hours * -IFkWh$$

[544] 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.

[545]Negative value because this is an increase in heating consumption due to the efficient lighting.

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

For example, delamping a 4 ft T8 fixture in an office building:

ΔkW =((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[546] = (((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

[546] Negative value because this is an increase in heating consumption due to the efficient lighting.

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-LTG-DLMP-V02-140601

4.5.3 High Performance and Reduced Wattage T8 Fixtures and Lamps

DESCRIPTION

This measure applies to "High Performance T8" (HPT8) lamp/ballast systems that have higher lumens per watt than standard T8 systems. This measure applies to the installation of new equipment with efficiencies that exceed that of the equipment that would have been installed following standard market practices and is applicable to time of sale as well as retrofit measures. Retrofit measures may include new fixtures or relamp/reballast measures. In addition, options have been provided to allow for the "Reduced Wattage T8 lamps" or RWT8 lamps that result in re-lamping opportunities that produce equal or greater light levels than standard T8 lamps while using fewer watts.

If the implementation strategy does not allow for the installation location to be known, a deemed split of 99% Commercial and 1% Residential should be used[547].

This measure was developed to be applicable to the following program types: TOS, RF, DI.

If applied to other program types, the measure savings should be verified.

The measure applies to all commercial HPT8 installations excluding new construction and major renovation or change of use measures (see lighting power density measure). Lookup tables have been provided to account for the different types of installations. Whenever possible, actual costs and hours of use should be utilized for savings calculations. Default new and baseline assumptions have been provided in the reference tables. Default component costs and lifetimes have been provided for Operating and Maintenance Calculations. Please see the Definition Table to determine applicability for each program. HPT8 configurations not included in the TRM may be included in custom program design using the provided algorithms as long as energy savings is achieved. The following table defines the applicability for different programs

Time of Sale (TOS)	Retrofit (RF) and Direct Install (DI)
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 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.

[547] Based on weighted average of Final ComEd's BILD program data from PY5 and PY6. For Residential installations, hours of use assumptions from '5.5 Interior Hardwired Compact Fluorescent Lamp (CFL) Fixture' measure should be used.

DEFINITION OF EFFICIENT EQUIPMENT

The efficient conditions for all applications are a qualifying HP or RWT8 fixture and lamp/ballast combinations listed on the CEE website under qualifying HP T8 products[548] and qualifying RWT8 products[549].

The definition of efficient equipment varies based on the program and is defined below:

Time of Sale (TOS)	Retrofit (RF) and Direct Install (DI)
High efficiency troffers combined with high efficiency lamps and ballasts allow for fewer lamps to be used to provide a given lumen output. High efficiency troffers must have a fixture efficiency of 80% or greater to qualify. Default values are given for a 2 lamp HPT8 fixture replacing a 3 lamp standard efficiency T8 fixture, but other configurations may qualify and the Calculation of savings algorithm used to account for base watts being replaced with EE watts. High bay fixtures must have fixture efficiencies of 85% or greater. RWT8 lamps: 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.	High efficiency troffers (new or retrofit kits) combined with high efficiency lamps and ballasts allow for fewer lamps to be used to provide a given lumen output. High efficiency troffers must have a fixture efficiency of 80% or greater to qualify. Default values are given for a 2 lamp HPT8 fixture replacing a 3 lamp standard efficiency T8 fixture, but other configurations may qualify and the Calculation of savings algorithm used to account for base watts being replaced with EE watts. High bay fixtures will have fixture efficiencies of 85% or greater. RWT8: 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:

[548] http://library.cee1.org/content/cee-high-performance-t8-specification

[549] http://library.cee1.org/content/reduced-wattage-t8-specification

Time of Sale (TOS)	Retrofit (RF) and Direct Install (DI)
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. In July 14, 2012, Federal Standards were enacted that were expected to eliminate T-12s as an option for linear fluorescent fixtures. Through v3.0 of the TRM, it was assumed that the T-12 would no longer be baseline for retrofits from 1/1/2016. However, due to significant loopholes in the legislation, T-12 compliant product is still freely available and in Illinois T-12s continue to hold a significant share of the existing and replacement lamp market. Therefore the timing of the sunsetting of T-12s as a viable baseline has been pushed back in v5.0 until 6/1/2018 and will be revisited in future update sessions. There will be a baseline shift applied to all measures installed before 6/1/2018. 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) and Direct Install (DI)
Fixture lifetime is 15 years[550]. 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.551	Fixture lifetime is 15 years. As per explanation above, for existing T12 fixtures, a mid life baseline shift should be applied in 6/1/2018 as described in table C-1. Note, since the fixture lifetime is deemed at 15 years, the replacement cost of both the lamp and ballast should be incorporated in to the O&M calculation.

DEEMED MEASURE COST

The deemed measure cost is found in the reference table at the end of this characterization.

[550] 15 years from GDS Measure Life Report, June 2007
[551] ibid

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:

$Watts_{base}$ = Input wattage of the existing system which depends on the baseline fixture configuration (number and type of lamp) and number of fixtures. Value can be selected from the appropriate reference table as shown below, or a custom value can be entered if the configurations in the tables is not representative of the 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%[552] 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:

Weighted Average 1st year In Service Rate (ISR)	2nd year Installations	3rd year Installations	Final Lifetime In Service Rate
98%[553]	0%	0%	98.0%[554]

[552] 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.

[553] 1st year in service rate is based upon review of PY5-6 evaluations from ComEd's commercial lighting program (BILD) (see 'IL Commercial Lighting ISR_2014.xls' for more information

[554] The 98% Lifetime ISR assumption is based upon review of two evaluations:
'Nexus Market Research, RLW Analytics and GDS Associates study; "New England Residential Lighting Markdown Impact Evaluation, January 20, 2009' and 'KEMA Inc, Feb 2010, Final Evaluation Report:, Upstream Lighting Program, Volume 1.' This implies that only 2% of bulbs purchased are never installed. The second and third year installations are based upon Ameren analysis of the Californian KEMA study showing that 54% of future installs occur in year 2 and 46% in year 3. The 2nd and 3rd year installations should be counted as part of those future program year savings. Note that this Final Install Rate does NOT account for leakage of purchased bulbs being installed outside of the utility territory. EM&V should assess how and if data from evaluation should adjust this final installation rate to account for this impact

HEATING PENALTY

If electrically heated building:

$$\Delta kWh_{heatpenalty}[555] = (((WattsBase-WattsEE)/1000) * ISR * Hours * -IFkWh$$

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.

CF = Summer Peak Coincidence Factor for measure is selected from the Reference Table in Section 4.5 for each building type. If the building type is unknown, use the Miscellaneous value of 0.66.

Other factors as defined above

NATURAL GAS SAVINGS

$$\Delta Therms[556] = (((WattsBase-WattsEE)/1000) * ISR * Hours *- IFTherms$$

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

Actual operation and maintenance costs will vary by specific equipment installed/replaced. See Reference tables for Operating and Maintenance Values;

[555]Negative value because this is an increase in heating consumption due to the efficient lighting.
[556] Negative value because this is an increase in heating consumption due to the efficient lighting.

Program	Reference Table
Time of Sale	B-1: HPT8 Component Costs and Lifetime
Retrofit	B-2: HPT8 Component Costs and Lifetime
Reduced Wattage T8, time of sale or retrofit	B-3: HPT8 Component Costs and Lifetime

REFERENCE TABLES

See following page

A-1: Time of Sale: HPT8 New and Baseline Assumptions[557]

EE Measure Description	Nominal Watts	$Watts_{EE}$	Baseline Description	Nominal Watt	$Watts_{BASE}$	Incremental Cost	$Watts_{SAVE}$
4-Lamp HPT8 w/ High-BF Ballast High-Bay	190	218.5	200 Watt Pulse Start Metal-Halide	200	232	$75	13.50
4-Lamp HPT8 w/ High-BF Ballast High-Bay	190	218.5	250 Watt Metal Halide	250	295	$75	76.50
6-Lamp HPT8 w/ High-BF Ballast High-Bay	287	330.05	320 Watt Pulse Start Metal-Halide	320	348.8	$75	18.75
6-Lamp HPT8 w/ High-BF Ballast High-Bay	287	330.05	400 Watt Pulse Start Metal Halide	400	455	$75	124.95
8-Lamp HPT8 w/ High-BF Ballast High-Bay	364	418.6	Proportionally Adjusted according to 6-Lamp HPT8 Equivalent to 320 PSMH	320	476	$75	57.40
8-Lamp HPT8 w/ High-BF Ballast High-Bay	364	418.6	Proportionally Adjusted according to 6-Lamp HPT8 Equivalent to 400 W Metal Halide	400	618	75	199.40
1-Lamp HPT8-high performance 32 w lamp	32	24.64	1-Lamp Standard F32T8 w/ Elec. Ballast	32	28.16	$15	3.52
1-Lamp HPT8-high performance 28 w lamp	29	22.33	1-Lamp Standard F32T8 w/ Elec. Ballast	32	28.16	$15	5.83
1-Lamp HPT8-high performance 25 w lamp	25	19.25	1-Lamp Standard F32T8 w/ Elec. Ballast	32	28.16	$15	8.91
2-Lamp HPT8 -high performance 32 w lamp	64	49.28	2-Lamp Standard F32T8 w/ Elec. Ballast	64	56.32	$18	7.04
2-Lamp HPT8-high performance 28 w lamp	56	43.12	2-Lamp Standard F32T8 w/ Elec. Ballast	64	56.32	$18	13.20
2-Lamp HPT8-high performance 25 w lamp	45	34.65	2-Lamp Standard F32T8 w/ Elec. Ballast	64	56.32	$18	21.67
3-Lamp HPT8-high performance 32 w lamp	94	72.38	3-Lamp Standard F32T8 w/ Elec. Ballast	96	84.48	$20	12.10
3-Lamp HPT8-high performance 28 w lamp	85	65.45	3-Lamp Standard F32T8 w/ Elec. Ballast	96	84.48	$20	19.03
3-Lamp HPT8-high performance 25 w lamp	75	57.75	3-Lamp Standard F32T8 w/ Elec. Ballast	96	84.48	$20	26.73
4-Lamp HPT8 -high performance 32 w lamp	122	93.94	4-Lamp Standard F32T8 w/ Elec. Ballast	128	112.64	$23	18.70
4-Lamp HPT8-high performance 28 w lamp	112	86.24	4-Lamp Standard F32T8 w/ Elec. Ballast	128	112.64	$23	26.40
4-Lamp HPT8-high performance 25 w lamp	100	77	4-Lamp Standard F32T8 w/ Elec. Ballast	128	112.64	$23	35.64
2-lamp High-Performance HPT8 Troffer	64	49.28	3-Lamp F32T8 w/ Elec. Ballast	96	84.48	$100	35.20

Table developed using a constant ballast factor of .77 for troffers/linear HPT8 and 1.15 for HPT8 highbay, 1.0 for all MH/MHPS, and 0.95 for T12 and 0.88 for standard T8. Input wattages are an average of manufacturer inputs that account for ballast efficacy

[557] Watt, lumen, lamp life, and ballast factor assumptions for efficient measures are based upon Consortium for Energy Efficiency (CEE) Commercial Lighting Qualifying Product Lists. Watt, lumen, lamp life, and ballast factor assumptions for baseline fixtures are based upon manufacturer specification sheets. Baseline and efficient measure cost data comes from lighting suppliers, past Efficiency Vermont projects, and professional judgment.

A-2: Retrofit HPT8 New and Baseline Assumptions[558]

EE Measure Description	Nominal Watts	Ballast Factor	$Watts_{EE}$	Baseline Description	Nominal Watts	$Watts_{BASE}$	$Watts_{SAVE}$	Full Measure Cost
4-Lamp HPT8 w/ High-BF Ballast High-Bay	190	1.15	218.5	200 Watt Pulse Start Metal-Halide	200	232	13.50	$200
4-Lamp HPT8 w/ High-BF Ballast High-Bay	190	1.15	218.5	250 Watt Metal Halide	250	295	76.50	$200
6-Lamp HPT8 w/ High-BF Ballast High-Bay	287	1.15	330.05	320 Watt Pulse Start Metal-Halide	320	348.8	18.75	$225
6-Lamp HPT8 w/ High-BF Ballast High-Bay	287	1.15	330.05	400 Watt Pulse Start Metal Halide	400	455	124.95	$225
8-Lamp HPT8 w/ High-BF Ballast High-Bay	364	1.15	418.6	Proportionally Adjusted according to 6-Lamp HPT8 Equivalent to 320 PSMH	320	476	57.40	$250
8-Lamp HPT8 w/ High-BF Ballast High-Bay	364	1.15	418.6	Proportionally Adjusted according to 6-Lamp HPT8 Equivalent to 400 W Metal Halide	400	618	199.40	$250
1-Lamp Relamp/Reballast T12 to HPT8	34	0.77	26.18	1-Lamp F34T12 w/ EEMag Ballast	34	42	15.82	$50
2-Lamp Relamp/Reballast T12 to HPT8	68	0.77	52.36	2-Lamp F34T12 w/ EEMag Ballast	68	67	14.64	$55
3-Lamp Relamp/Reballast T12 to HPT8	102	0.77	78.54	3-Lamp F34T12 w/ EEMag Ballast	102	104	25.46	$60
4-Lamp Relamp/Reballast T12 to HPT8	136	0.77	104.72	4-Lamp F34T12 w/ EEMag Ballast	136	144	39.28	$65
1-Lamp Relamp/Reballast T12 to HPT8	40	0.77	30.8	1-Lamp F40T12 w/ EEMag Ballast	40	41	10.20	$50
2-Lamp Relamp/Reballast T12 to HPT8	80	0.77	61.6	2-Lamp F40T12 w/ EEMag Ballast	80	87	25.40	$55
3-Lamp Relamp/Reballast T12 to HPT8	120	0.77	92.4	3-Lamp F40T12 w/ EEMag Ballast	120	141	48.60	$60
4-Lamp Relamp/Reballast T12 to HPT8	160	0.77	123.2	4-Lamp F40T12 w/ EEMag Ballast	160	172	48.80	$65
1-Lamp Relamp/Reballast T12 to HPT8	40	0.77	30.8	1-Lamp F40T12 w/ Mag Ballast	40	51	20.20	$50
2-Lamp Relamp/Reballast T12 to HPT8	80	0.77	61.6	2-Lamp F40T12 w/ Mag Ballast	80	97	35.40	$55
3-Lamp Relamp/Reballast T12 to HPT8	120	0.77	92.4	3-Lamp F40T12 w/ Mag Ballast	120	135	42.60	$60

[558] Watt, lumen, lamp life, and ballast factor assumptions for efficient measures are based upon Consortium for Energy Efficiency (CEE) Commercial Lighting Qualifying Product Lists. Watt, lumen, lamp life, and ballast factor assumptions for baseline fixtures are based upon manufacturer specification sheets. Baseline and efficient measure cost data comes from lighting suppliers, past Efficiency Vermont projects, Xcel Energy Lighting Efficiency Input Wattage Guide and professional judgment.

EE Measure Description	Nominal Watts	Ballast Factor	$Watts_{EE}$	Baseline Description	Nominal Watts	$Watts_{BASE}$	$Watts_{SAVE}$	Full Measure Cost
4-Lamp Relamp/Reballast T12 to HPT8	160	0.77	123.2	4-Lamp F40T12 w/ Mag Ballast	160	175	51.80	$65
1-Lamp Relamp/Reballast T8 to HPT8	32	0.77	24.64	1-Lamp F32T8 w/ Elec. Ballast	32	28.16	3.52	$50
2-Lamp Relamp/Reballast T8 to HPT8	64	0.77	49.28	2-Lamp F32T8 w/ Elec. Ballast	64	56.32	7.04	$55
3-Lamp Relamp/Reballast T8 to HPT8	96	0.77	73.92	3-Lamp F32T8 w/ Elec. Ballast	96	84.48	10.56	$60
4-Lamp Relamp/Reballast T8 to HPT8	128	0.77	98.56	4-Lamp F32T8 w/ Elec. Ballast	128	112.64	14.08	$65
2-lamp High-Performance HPT8 Troffer or high efficiency retrofit troffer	64	0.77	49.28	3-Lamp F32T8 w/ Elec. Ballast	96	84.48	35.20	$100

Table developed using a constant ballast factor of 0.77 for troffers/linear HPT8 and 1.15 for HPT8 highbay, 1.0 for all MH/MHPS, and 0.95 for T12 and 0.88 for standard T8. Input wattages are an average of manufacturer inputs that account for ballast efficacy.

A– 3: RWT8 New and Baseline Assumptions

EE Measure Description	Nominal Watts	$Watts_{EE}$	EE Lamp Cost	Baseline Description	Base Lamp Cost	Nominal Watts	$Watts_{BASE}$	$Watts_{SAVE}$	Measure Cost
RW T8 - F28T8 Lamp	28	24.64	$4.50	F32 T8 Standard Lamp	$2.50	32	28.16	3.52	$2.00
RWT8 F2T8 Extra Life Lamp	28	24.64	$4.50	F32 T8 Standard Lamp	$2.50	32	28.16	3.52	$2.00
RWT8 - F32/25W T8 Lamp	25	22.00	$4.50	F32 T8 Standard Lamp	$2.50	32	28.16	6.16	$2.00
RWT8 - F32/25W T8 Lamp Extra Life	25	22.00	$4.50	F32 T8 Standard Lamp	$2.50	32	28.16	6.16	$2.00
RWT8 F17T8 Lamp - 2 ft	16	14.08	$4.80	F17 T8 Standard Lamp - 2ft	$2.80	17	14.96	0.88	$2.00
RWT8 F25T8 Lamp - 3 ft	23	20.24	$5.10	F25 T8 Standard Lamp - 3ft	$3.10	25	22.00	1.76	$2.00
RWT8 F30T8 Lamp - 6' Utube	30	26.40	$11.31	F32 T8 Standard Utube	$9.31	32	28.16	1.76	$2.00
RWT8 F29T8 Lamp - Utube	29	25.52	$11.31	F32 T8 Standard Utube	$9.31	32	28.16	2.64	$2.00
RWT8 F96T8 Lamp - 8 ft	65	57.20	$9.00	F96 T8 Standard Lamp - 8 ft	$7.00	70	61.60	4.40	$2.00

Table developed using a constant ballast factor of 0.88 for RWT8 and Standard T8.

B-1: Time of Sale T8 Component Costs and Lifetime[559]

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	$87.75	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	$109.35	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	$109.35	40000	$22.50
1-Lamp HPT8 – all qualifying lamps	$5.00	24000	$2.67	$32.50	70000	$15.00	1-Lamp Standard F32T12 w/ Elec Ballast	$2.50	20000	$2.67	$15.00	70000	$15.00
2-Lamp HPT8 – all qualifying lamps	$5.00	24000	$2.67	$32.50	70000	$15.00	2-Lamp Standard F32T12 w/ Elec Ballast	$2.50	20000	$2.67	$15.00	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	$15.00	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	$15.00	70000	$15.00
				$32.50									
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	$15.00	70000	$15.00

559 Watt, lumen, lamp life, and ballast factor assumptions for efficient measures are based upon Consortium for Energy Efficiency (CEE) Commercial Lighting Qualifying Product Lists. Watt, lumen, lamp life, and ballast factor assumptions for baseline fixtures are based upon manufacturer specification sheets. Baseline and efficient measure cost data comes from lighting suppliers, past Efficiency Vermont projects, and professional judgment

B-2: T8 Retrofit Component Costs and Lifetime[560]

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	$87.75	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	$109.35	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	$17.00	20000	$6.67	$109.35	40000	$22.50
1-Lamp Relamp/Reballast T12 to HPT8	$5.00	24000	$2.67	$32.50	70000	$15.00	1-Lamp F34T12 w/ EEMag Ballast	$2.70	20000	$2.67	$20.00	40000	$15.00
2-Lamp Relamp/Reballast T12 to HPT8	$5.00	24000	$2.67	$32.50	70000	$15.00	2-Lamp F34T12 w/ EEMag Ballast	$2.70	20000	$2.67	$20.00	40000	$15.00
3-Lamp Relamp/Reballast T12 to HPT8	$5.00	24000	$2.67	$32.50	70000	$15.00	3-Lamp F34T12 w/ EEMag Ballast	$2.70	20000	$2.67	$20.00	40000	$15.00
4-Lamp Relamp/Reballast T12 to HPT8	$5.00	24000	$2.67	$32.50	70000	$15.00	4-Lamp F34T12 w/ EEMag Ballast	$2.70	20000	$2.67	$20.00	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	$20.00	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	$20.00	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	$20.00	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	$20.00	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	$15.00	70000	$15.00

[560] Cost assumptions for baseline fixtures are based upon manufacturer specification sheets. Baseline and efficient measure cost data comes from lighting suppliers, past Efficiency Vermont projects, and professional judgment

B-3: Reduced Wattage T8 Component Costs and Lifetime[561]

EE measure description	EE Lamp Cost	EE Lamp Life (hrs)	Baseline Description	Base Lamp Cost	Base Lamp Life (hrs)	Base Lamp Rep. Labor Cost
RW T8 - F28T8 Lamp	$4.50	30000	F32 T8 Standard Lamp	$2.50	15000	$2.67
RWT8 F2T8 Extra Life Lamp	$4.50	36000	F32 T8 Standard Lamp	$2.50	15000	$2.67
RWT8 - F32/25W T8 Lamp	$4.50	30000	F32 T8 Standard Lamp	$2.50	15000	$2.67
RWT8 - F32/25W T8 Lamp Extra Life	$4.50	36000	F32 T8 Standard Lamp	$2.50	15000	$2.67
RWT8 F17T8 Lamp - 2 ft	$4.80	18000	F17 T8 Standard Lamp - 2ft	$2.80	15000	$2.67
RWT8 F25T8 Lamp - 3 ft	$5.10	18000	F25 T8 Standard Lamp - 3ft	$3.10	15000	$2.67
RWT8 F30T8 Lamp - 6' Utube	$11.31	24000	F32 T8 Standard Utube	$9.31	15000	$2.67
RWT8 F29T8 Lamp - Utube	$11.31	24000	F32 T8 Standard Utube	$9.31	15000	$2.67
RWT8 F96T8 Lamp - 8 ft	$9.00	24000	F96 T8 Standard Lamp - 8 ft	$7.00	15000	$2.67

[561] Cost assumptions for baseline fixtures are based upon manufacturer specification sheets. Baseline and efficient measure cost data comes from lighting suppliers, past Efficiency Vermont projects, and professional judgment.

C-1: T12 Baseline Adjustment:

For measures installed up to 6/1/2018, the full savings (as calculated above in the Algorithm section) will be claimed up to 6/1/2018. 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 2016 will claim full savings for two years and 2017 for one year,. Savings adjustment factors will be applied to the full savings for savings starting in 6/1/2018 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'.[562]

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%.

MEASURE CODE: CI-LTG-T8FX-V05-160601

[562] See "HPRWT8_reference.xlsx" for more information.
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 96% Commercial and 4% Residential should be used[563].

This measure was developed to be applicable to the following program types: TOS, NC, RF.

If applied to other program types, the measure savings should be verified.

Definition of Efficient Equipment

In order for this characterization to apply, new lamps must be Energy Star labeled. Lamps and fixtures should be found in the reference tables below. Fixtures must be Energy Star labeled or on the Design Lights Consortium qualifying fixture list.

Definition of Baseline Equipment

Refer to the baseline tables. In 2012, Federal legislation stemming from the Energy Independence and Security Act of 2007 (EIAS) required all general-purpose light bulbs between 40 watts and 100 watts to have ~30% increased efficiency, essentially phasing out standard incandescent technology. In 2012, the 100 w lamp standards apply; in 2013 the 75 w lamp standards will apply, followed by restrictions on the 60 w and 40 w lamps in 2014.

Deemed Lifetime of Efficient Equipment

Lifetime is the life of the product, at the reported operating hours (lamp life in hours divided by operating hours per year – see reference table "LED component Costs and Lifetime." The analysis period is the same as the lifetime, capped at 15 years. (15 years from GDS Measure Life Report, June 2007).

Deemed Measure Cost

Wherever possible, actual incremental costs should be used. Refer to reference table "LED component Cost & Lifetime" for defaults.

Loadshape

Loadshape C06 - Commercial Indoor Lighting

Loadshape C07 - Grocery/Conv. Store Indoor Lighting

Loadshape C08 - Hospital Indoor Lighting

Loadshape C09 - Office Indoor Lighting

Loadshape C10 - Restaurant Indoor Lighting

Loadshape C11 - Retail Indoor Lighting

Loadshape C12 - Warehouse Indoor Lighting

[563] Based on final ComEd's BILD program data from PY4,PY5 and PY6. For Residential installations, hours of use assumptions from '5.5.6 LED Downlights' should be used for LED fixtures and '5.5.8 LED Screw Based Omnidirectional Bulbs' should be used for LED bulbs.

Loadshape 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 or baseline system. Reference the "LED New and Baseline Assumptions" table for default values.

$Watts_{EE}$ = Actual wattage of LED purchased / installed. If unknown, use default provided below:

For ENERGY STAR rated lamps the following lumen equivalence tables should be used:

Omnidirectional Lamps - ENERGY STAR Minimum Luminous Efficacy = 50Lm/W for <10W lamps and 55Lm/W for >=10W lamps.

Minimum Lumens	Maximum Lumens	Lumens used to calculate LED Wattage (midpoint)	LED Wattage[564] (WattsEE)	Baseline 2014-2019 (WattsBase)	Delta Watts 2014-2019 (WattsEE)	Baseline Post EISA 2020 requirement[565] (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

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.

564 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.
565 Calculated as 45lm/W for all EISA non-exempt bulbs.

Directional Lamps - ENERGY STAR Minimum Luminous Efficacy = 40Lm/W for lamps with rated wattages less than 20Wand 50 Lm/W for lamps with rated wattages >= 20 watts[566].

For Directional R, BR, and ER lamp types[567]:

Bulb Type	Lower Lumen Range	Upper Lumen Range	$Watts_{Base}$	Lumens used to calculate LED Wattage (midpoint)	LED Wattage ($Watts_{EE}$)	Delta Watts
R, ER, BR with medium screw bases w/ diameter >2.25" (*see exceptions below)	420	472	40	446	11	29
	473	524	45	499	12	33
	525	714	50	620	15	35
	715	937	65	826	21	44
	938	1259	75	1099	22	53
	1260	1399	90	1330	27	63
	1400	1739	100	1570	31	69
	1740	2174	120	1957	39	81
	2175	2624	150	2400	48	102
	2625	2999	175	2812	56	119
	3000	4500	200	3750	75	125
***R, BR, and ER with medium screw bases w/ diameter <=2.25"**	400	449	40	425	11	29
	450	499	45	475	12	33
	500	649	50	575	14	36
	650	1199	65	925	23	42
***ER30, BR30, BR40, or ER40**	400	449	40	425	11	29
	450	499	45	475	12	33
	500	649	50	575	14	36
***BR30, BR40, or ER40**	650	1419	65	1035	21	44
***R20**	400	449	40	425	11	29
	450	719	45	585	15	30
***All reflector lamps below lumen ranges specified above**	200	299	20	250	6	14
	300	399	30	350	9	21

Directional lamps are exempt from EISA regulations.

For PAR, MR, and MRX Lamps Types:

[566] From pg 10 of the Energy Star Specification for lamps v1.1
[567] From pg 11 of the Energy Star Specification for lamps v1.1

For these highly focused directional lamp types, it is necessary to have Center Beam Candle Power (CBCP) and beam angle measurements to accurately estimate the equivalent baseline wattage. The formula below is based on the Energy Star Center Beam Candle Power tool.[568] If CBCP and beam angle information are not available or if the equation below returns a negative value (or undefined), use the manufacturer's recommended baseline wattage equivalent.[569]

$$\text{Wattsbase} = 375.1 - 4.355(D) - \sqrt{227{,}800 - 937.9(D) - 0.9903(D^2) - 1479(BA) - 12.02(D * BA) + 14.69(BA^2) - 16{,}720 * \ln(CBCP)}$$

Where:

D = Bulb diameter (e.g. for PAR20 D = 20)

BA = Beam angle

CBCP = Center beam candle power

The result of the equation above should be rounded DOWN to the nearest wattage established by Energy Star:

Diameter	Permitted Wattages
16	20, 35, 40, 45, 50, 60, 75
20	50
30S	40, 45, 50, 60, 75
30L	50, 75
38	40, 45, 50, 55, 60, 65, 75, 85, 90, 100, 120, 150, 250

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.

=100%[570] 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:

[568] http://energystar.supportportal.com/link/portal/23002/23018/Article/32655/

[569] The Energy Star Center Beam Candle Power tool does not accurately model baseline wattages for lamps with certain bulb characteristic combinations – specifically for lamps with very high CBCP.

[570] Illinois evaluation of PY1 through PY3 has not found that fixtures or lamps placed into storage to be a significant enough issue to warrant including an "In-Service Rate" when commercial customers complete an application form.

Weighted Average 1st year In Service Rate (ISR)	2nd year Installations	3rd year Installations	Final Lifetime In Service Rate
95.7%[571]	1.2%	1.1%	98.0%[572]

HEATING PENALTY

If electrically heated building:

$$\Delta kWh_{heatpenalty}{}^{573} = (((WattsBase-WattsEE)/1000) * ISR * Hours * -IFkWh$$

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, 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

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.

571 Based on ComEd's BILD program data from PY5 and PY6, see "IL Commercial Lighting ISR_2014.xls".

572 In the absence of any data for LEDs specifically it is assumed that the same proportion of bulbs eventually get installed as for CFLS. The 98% CFL assumption is based upon review of two evaluations:
'Nexus Market Research, RLW Analytics and GDS Associates study; "New England Residential Lighting Markdown Impact Evaluation, January 20, 2009' and 'KEMA Inc, Feb 2010, Final Evaluation Report:, Upstream Lighting Program, Volume 1.' This implies that only 2% of bulbs purchased are never installed. The second and third year installations are based upon Ameren analysis of the Californian KEMA study showing that 54% of future installs occur in year 2 and 46% in year 3. The 2nd and 3rd year installations should be counted as part of those future program year savings. Note that this Final Install Rate does NOT account for leakage of purchased bulbs being installed outside of the utility territory. EM&V should assess how and if data from evaluation should adjust this final installation rate to account for this impact

573 Negative value because this is an increase in heating consumption due to the efficient lighting.

SUMMER COINCIDENT PEAK DEMAND SAVINGS

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

Where:

WHFd = Waste Heat Factor for Demand to account for cooling savings from efficient lighting in cooled buildings is provided in Referecne Table in Section 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):

$$\Delta Therms = (((WattsBase - WattsEE)/1000) * ISR * Hours * - IFTherms$$

Where:

IFTherms = Lighting-HVAC Integration Factor for gas heating impacts; this factor represents the increased gas space heating requirements due to the reduction of waste heat rejected by the efficient lighting. Values are provided in the Referecne Table in Section 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[574].

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 25,000/4683 =5.3 years) is calculated[575]. The key assumptions used in this calculation are documented below[576]:

---

[574] See "LED Lighting Systems TRM Reference Tables" for breakdown of component cost assumptions.

[575] See C&I OmniDirectional LED O&M Calc.xls" for more information. The values assume the non-residential average hours assumption of 4683.

[576] Based upon pricing forecast developed by Applied Proactive Technologies Inc (APT) based on industry input and provided to Ameren.

	Std Inc.	EISA Compliant Halogen	CFL
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

The NPV for replacement lamps and annual levelized replacement costs using the statewide real discount rate of 5.34% are presented below. It is important to note that for cost-effectiveness screening purposes, the O&M cost adjustments should only be applied in cases where the light bulbs area actually in service and so should be multiplied by the appropriate ISR:

Location	Lumen Level	NPV of replacement costs for period			Levelized annual replacement cost savings		
		June 2016 - May 2017	June 2017 - May 2018	June 2018 - May 2019	June 2016 - May 2017	June 2017 - May 2018	June 2018 - May 2019
Commercial	Lumens <310 or >2600 (EISA exempt)	$6.88	$6.88	$6.88	$1.51	$1.51	$1.51
	Lumens ≥ 310 and ≤ 2600 (EISA compliant)	$11.63	$9.52	$7.76	$2.55	$2.09	$1.70
Multi Family Common Areas	Lumens <310 or >2600 (non-EISA compliant)	$7.03	$7.03	$7.03	$1.72	$1.72	$1.72
	Lumens ≥ 310 and ≤ 2600 (EISA compliant)	$12.69	$10.28	$8.28	$3.11	$2.52	$2.03

For halogen bulbs, we assume the same replacement cycle as incandescent bulbs.[577] 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.

[577] 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.

REFERENCE TABLES

LED Bulb Assumptions

Wherever possible, actual incremental costs should be used. If unavailable assume the following incremental costs[578]:

Bulb Type	LED Wattage	LED	Incandescent	Incremental Cost
Directional	< 20W	$22.42	$6.31	$16.11
	≥20W	$70.78		$64.47
Decorative and Globe	<15W	$12.76	$3.92	$8.84
	15 to <25W	$25.00		$21.08
	≥25W	$25.00		$21.08

Directional and Decorative O&M; apply incandescent cost assumption provided above with a frequency calculated by dividing the assumed rated life of the baseline bulb (1000 hours) by the building specific hours of use assumption.

[578] LED lamp costs are based on VEIC review of a year's worth of LED sales data through VEIC implemented programs and the retail cost averaged (see 2015 LED Sales Review.xls). Baseline cost based on "2010-2012 WA017 Ex Ante Measure Cost Study Draft Report", Itron, February 28, 2014. Given LED prices are expected to continue declining assumed costs should be reassessed on an annual basis and replaced with IL specific LED program information when available.

LED Fixture Wattage and Incremental Cost Assumptions[579]

LED Category	EE Measure Description	$Watts_{EE}$	Baseline Description	$Watts_{BASE}$	Incremental Cost	Mid Life Savings Adjustment (2018)
LED Downlight Fixtures	LED Recessed, Surface, Pendant Downlights	17.6	Baseline LED Recessed, Surface, Pendant Downlights	54.3	$27	N/A
LED Interior Directional	LED Track Lighting	12.2	Baseline LED Track Lighting	60.4	$59	N/A
	LED Wall-Wash Fixtures	8.3	Baseline LED Wall-Wash Fixtures	17.7	$59	N/A
LED Display Case	LED Display Case Light Fixture	7.1 per ft	Baseline LED Display Case Light Fixture	36.2 per ft	$11/ft	N/A
	LED Undercabinet Shelf-Mounted Task Light Fixtures	7.1 per ft	Baseline LED Undercabinet Shelf-Mounted Task Light Fixtures	36.2 per ft	$11/ft	N/A
	LED Refrigerated Case Light, Horizontal or Vertical	7.6 per ft	Baseline LED Refrigerated Case Light, Horizontal or Vertical (per foot)	15.2 per ft	$11/ft	N/A
	LED Freezer Case Light, Horizontal or Vertical	7.7 per ft	Baseline LED Freezer Case Light, Horizontal or Vertical (per foot)	18.7 per ft	$11/ft	N/A
LED Linear Replacement Lamps	LED 4' Linear Replacement Lamp	18.7	80:20 T12:T8; Lamp Only 32w T8:34w T12	33.6	$24	89%
	LED 2' Linear Replacement Lamp	9.7	80:20 T12:T8; Lamp Only 17w T8:20w T12	19.4	$13	75%
LED Troffers	LED 2x2 Recessed Light Fixture, 2000-3500 lumens	34.1	80:20 T12:Standard T8 2-Lamp 32w T8, 2-Lamp 34w T12	61.0	$48	85%
	LED 2x2 Recessed Light Fixture, 3501-5000 lumens	42.8	80:20 T12:Standard T8 3-Lamp 32w T8, 3-Lamp 34w T12	103.3	$91	69%
	LED 2x4 Recessed Light Fixture, 3000-4500 lumens	37.9	80:20 T12:Standard T8 2-Lamp 32w T8, 2-Lamp 34w T12	61.0	$62	83%
	LED 2x4 Recessed Light Fixture, 4501-6000 lumens	54.3	80:20 T12:Standard T8 3-Lamp 32w T8, 3-Lamp 34w T12	103.3	$99	62%
	LED 2x4 Recessed Light Fixture, 6001-7500 lumens	72.7	80:20 T12:Standard T8 4-Lamp 32w T8, 4-Lamp 34w T12	137.7	$150	61%
	LED 1x4 Recessed Light Fixture, 1500-3000 lumens	18.1	80:20 T12:Standard T8 1-Lamp 32w T8 , 1-Lamp 34w T12	30.6	$36	88%
	LED 1x4 Recessed Light Fixture, 3001-4500 lumens	39.6	80:20 T12:Standard T8 2-Lamp 32w T8, 2-Lamp 34w T12	61.0	$76	81%

[579] Watt, lumen, lamp life, and ballast factor assumptions for efficient measures are based upon Consortium for Energy Efficiency (CEE) Commercial Lighting Qualifying Product Lists alongside past Efficiency Vermont projects and PGE refrigerated case study. Watt, lumen, lamp life, and ballast factor assumptions for baseline fixtures are based upon manufacturer specification sheets. Baseline cost data comes from lighting suppliers, past Efficiency Vermont projects, and professional judgment. Efficient cost data comes from 2012 DOE “Energy Savings Potential of Solid-State Lighting in General Illumination Applications”, Table A.1. See "LED Lighting Systems TRM Reference Tables.xlsx" for more information and specific product links.

LED Category	EE Measure Description	$Watts_{EE}$	Baseline Description	$Watts_{BASE}$	Incremental Cost	Mid Life Savings Adjustment (2018)
	LED 1x4 Recessed Light Fixture, 4501-6000 lumens	53.1	80:20 T12:Standard T8 3-Lamp 32w T8, 3-Lamp 34w T12	103.3	$130	62%
LED Linear Ambient Fixtures	LED Surface & Suspended Linear Fixture, <= 3000 lumens	19.7	80:20 T12:Standard T8 1-Lamp 32w T8, 1-Lamp 34w T12	30.6	$54	86%
	LED Surface & Suspended Linear Fixture, 3001-4500 lumens	37.8	80:20 T12:Standard T8 2-Lamp 32w T8, 2-Lamp 34w T12	61.0	$104	83%
	LED Surface & Suspended Linear Fixture, 4501-6000 lumens	55.9	80:20 T12:Standard T8 3-Lamp 32w T8, 3-Lamp 34w T12	103.3	$158	60%
	LED Surface & Suspended Linear Fixture, 6001-7500 lumens	62.6	T5HO 2L-F54T5HO - 4'	120.0	$215	N/A
	LED Surface & Suspended Linear Fixture, > 7500 lumens	95.4	T5HO 3L-F54T5HO - 4'	180.0	$374	N/A
LED High & Low Bay Fixtures	LED Low-Bay Fixtures, <= 10,000 lumens	90.3	3-Lamp T8HO Low-Bay	157.0	$191	N/A
	LED High-Bay Fixtures, 10,001-15,000 lumens	127.5	4-Lamp T8HO High-Bay	196.0	$331	N/A
	LED High-Bay Fixtures, 15,001-20,000 lumens	191.0	6-Lamp T8HO High-Bay	294.0	$482	N/A
	LED High-Bay Fixtures, > 20,000 lumens	249.7	8-Lamp T8HO High-Bay	392.0	$818	N/A
LED Agricultural Interior Fixtures	LED Ag Interior Fixtures, <= 2,000 lumens	17.0	25% 73 Watt EISA Inc, 75% 1L T8	42.0	$33	N/A
	LED Ag Interior Fixtures, 2,001-4,000 lumens	27.8	25% 146 Watt EISA Inc, 75% 2L T8	81.0	$54	N/A
	LED Ag Interior Fixtures, 4,001-6,000 lumens	51.2	25% 217 Watt EISA Inc, 75% 3L T8	121.0	$125	N/A
	LED Ag Interior Fixtures, 6,001-8,000 lumens	71.7	25% 292 Watt EISA Inc, 75% 4L T8	159.0	$190	N/A
	LED Ag Interior Fixtures, 8,001-12,000 lumens	103.5	200W Pulse Start Metal Halide	227.3	$298	N/A
	LED Ag Interior Fixtures, 12,001-16,000 lumens	143.8	320W Pulse Start Metal Halide	363.6	$450	N/A
	LED Ag Interior Fixtures, 16,001-20,000 lumens	183.3	350W Pulse Start Metal Halide	397.7	$595	N/A
	LED Ag Interior Fixtures, > 20,000 lumens	305.0	(2) 320W Pulse Start Metal Halide	727.3	$998	N/A
LED Exterior Fixtures	LED Exterior Fixtures, <= 5,000 lumens	42.6	100W Metal Halide	113.6	$190	N/A
	LED Exterior Fixtures, 5,001-10,000 lumens	68.2	175W Pulse Start Metal Halide	198.9	$287	N/A

LED Category	EE Measure Description	$Watts_{EE}$	Baseline Description	$Watts_{BASE}$	Incremental Cost	Mid Life Savings Adjustment (2018)
	LED Exterior Fixtures, 10,001-15,000 lumens	122.5	250W Pulse Start Metal Halide	284.1	$391	N/A
	LED Exterior Fixtures, > 15,000 lumens	215.0	400W Pulse Start Metal Halide	454.5	$793	N/A

LED Fixture Component Costs & Lifetime[580]

		EE Measure				Baseline			
LED Category	EE Measure Description	Lamp Life (hrs)	Total Lamp Replacement Cost	LED Driver Life (hrs)	Total LED Driver Replacement Cost	Lamp Life (hrs)	Total Lamp Replacement Cost	Ballast Life (hrs)	Total Ballast Replacement Cost
LED Downlight Fixtures	LED Recessed, Surface, Pendant Downlights	50,000	$30.75	70,000	$47.50	2,500	$8.86	40,000	$14.40
LED Interior Directional	LED Track Lighting	50,000	$39.00	70,000	$47.50	2,500	$12.71	40,000	$11.00
	LED Wall-Wash Fixtures	50,000	$39.00	70,000	$47.50	2,500	$9.17	40,000	$27.00
LED Display Case	LED Display Case Light Fixture	50,000	$9.75/ft	70,000	$11.88/ft	2,500	$6.70	40,000	$5.63
	LED Undercabinet Shelf-Mounted Task Light Fixtures	50,000	$9.75/ft	70,000	$11.88/ft	2,500	$6.70	40,000	$5.63
	LED Refrigerated Case Light, Horizontal or Vertical	50,000	$8.63/ft	70,000	$9.50/ft	15,000	$1.13	40,000	$8.00
	LED Freezer Case Light, Horizontal or Vertical	50,000	$7.88/ft	70,000	$7.92/ft	12,000	$0.94	40,000	$6.67
LED Linear Replacement Lamps	LED 4' Linear Replacement Lamp	50,000	$8.57	70,000	$13.67	24,000	$6.17	40,000	$11.96
	LED 2' Linear Replacement Lamp	50,000	$5.76	70,000	$13.67	24,000	$6.17	40,000	$11.96
LED Troffers	LED 2x2 Recessed Light Fixture, 2000-3500 lumens	50,000	$46.68	70,000	$40.00	24,000	$26.33	40,000	$35.00

580 Note some measures have blended baselines (T12:T8 80:20). All values are provided to enable calculation of appropriate O&M impacts. Total costs include lamp, labor and disposal cost assumptions where applicable, see "IL LED Lighting Systems TRM Tables" for more information.

		EE Measure				Baseline			
LED Category	EE Measure Description	Lamp Life (hrs)	Total Lamp Replacement Cost	LED Driver Life (hrs)	Total LED Driver Replacement Cost	Lamp Life (hrs)	Total Lamp Replacement Cost	Ballast Life (hrs)	Total Ballast Replacement Cost
	LED 2x2 Recessed Light Fixture, 3501-5000 lumens	50,000	$56.31	70,000	$40.00	24,000	$39.50	40,000	$35.00
	LED 2x4 Recessed Light Fixture, 3000-4500 lumens	50,000	$49.58	70,000	$40.00	24,000	$12.33	40,000	$35.00
	LED 2x4 Recessed Light Fixture, 4501-6000 lumens	50,000	$57.76	70,000	$40.00	24,000	$18.50	40,000	$35.00
	LED 2x4 Recessed Light Fixture, 6001-7500 lumens	50,000	$68.89	70,000	$40.00	24,000	$24.67	40,000	$35.00
	LED 1x4 Recessed Light Fixture, 1500-3000 lumens	50,000	$43.43	70,000	$40.00	24,000	$6.17	40,000	$35.00
	LED 1x4 Recessed Light Fixture, 3001-4500 lumens	50,000	$52.31	70,000	$40.00	24,000	$12.33	40,000	$35.00
	LED 1x4 Recessed Light Fixture, 4501-6000 lumens	50,000	$63.86	70,000	$40.00	24,000	$18.50	40,000	$35.00
LED Linear Ambient Fixtures	LED Surface & Suspended Linear Fixture, <= 3000 lumens	50,000	$45.01	70,000	$40.00	24,000	$6.17	40,000	$35.00
	LED Surface & Suspended Linear Fixture, 3001-4500 lumens	50,000	$58.73	70,000	$40.00	24,000	$12.33	40,000	$35.00
	LED Surface & Suspended Linear Fixture, 4501-6000 lumens	50,000	$73.50	70,000	$40.00	24,000	$18.50	40,000	$35.00
	LED Surface & Suspended Linear Fixture, 6001-7500 lumens	50,000	$88.69	70,000	$40.00	30,000	$26.33	40,000	$60.00
	LED Surface & Suspended Linear Fixture, > 7500 lumens	50,000	$123.91	70,000	$40.00	30,000	$39.50	40,000	$60.00
LED High & Low Bay	LED Low-Bay Fixtures, <= 10,000	50,000	$90.03	70,000	$62.50	18,000	$64.50	40,000	$92.50

		EE Measure				Baseline			
LED Category	EE Measure Description	Lamp Life (hrs)	Total Lamp Replacement Cost	LED Driver Life (hrs)	Total LED Driver Replacement Cost	Lamp Life (hrs)	Total Lamp Replacement Cost	Ballast Life (hrs)	Total Ballast Replacement Cost
Fixtures	lumens								
	LED High-Bay Fixtures, 10,001-15,000 lumens	50,000	$122.59	70,000	$62.50	18,000	$86.00	40,000	$92.50
	LED High-Bay Fixtures, 15,001-20,000 lumens	50,000	$157.22	70,000	$62.50	18,000	$129.00	40,000	$117.50
	LED High-Bay Fixtures, > 20,000 lumens	50,000	$228.52	70,000	$62.50	18,000	$172.00	40,000	$142.50
LED Agricultural Interior Fixtures	LED Ag Interior Fixtures, <= 2,000 lumens	50,000	$37.00	70,000	$40.00	1,000	$1.23	40,000	$26.25
	LED Ag Interior Fixtures, 2,001-4,000 lumens	50,000	$44.96	70,000	$40.00	1,000	$1.43	40,000	$26.25
	LED Ag Interior Fixtures, 4,001-6,000 lumens	50,000	$63.02	70,000	$40.00	1,000	$1.62	40,000	$26.25
	LED Ag Interior Fixtures, 6,001-8,000 lumens	50,000	$79.78	70,000	$40.00	1,000	$1.81	40,000	$26.25
	LED Ag Interior Fixtures, 8,001-12,000 lumens	50,000	$119.91	70,000	$62.50	15,000	$63.00	40,000	$112.50
	LED Ag Interior Fixtures, 12,001-16,000 lumens	50,000	$151.89	70,000	$62.50	15,000	$68.00	40,000	$122.50
	LED Ag Interior Fixtures, 16,001-20,000 lumens	50,000	$184.62	70,000	$62.50	15,000	$73.00	40,000	$132.50
	LED Ag Interior Fixtures, > 20,000 lumens	50,000	$285.75	70,000	$62.50	15,000	$136.00	40,000	$202.50
LED Exterior Fixtures	LED Exterior Fixtures, <= 5,000 lumens	50,000	$86.92	70,000	$62.50	15,000	$58.00	40,000	$102.50
	LED Exterior Fixtures, 5,001-10,000 lumens	50,000	$111.81	70,000	$62.50	15,000	$63.00	40,000	$112.50
	LED Exterior Fixtures, 10,001-	50,000	$138.32	70,000	$62.50	15,000	$68.00	40,000	$122.50

		EE Measure				Baseline			
LED Category	EE Measure Description	Lamp Life (hrs)	Total Lamp Replacement Cost	LED Driver Life (hrs)	Total LED Driver Replacement Cost	Lamp Life (hrs)	Total Lamp Replacement Cost	Ballast Life (hrs)	Total Ballast Replacement Cost
	15,000 lumens								
	LED Exterior Fixtures, > 15,000 lumens	50,000	$223.67	70,000	$62.50	15,000	$73.00	40,000	$132.50

MEASURE CODE: CI-LTG-LEDB-V05-160601

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[581].

DEEMED MEASURE COST

The incremental cost for this measure is assumed to be $30[582].

LOADSHAPE

Loadshape C53 - Flat

COINCIDENCE FACTOR

The summer peak coincidence factor for this measure is assumed to be 100%[583].

[581] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Effective/Remaining Useful Life Values", California Public Utilities Commission, December 16, 2008.
[582] NYSERDA Deemed Savings Database, Labor cost assumes 25 minutes @ $18/hr.
[583] 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[584]
Fluorescent	11W[585]
Unknown (e.g. time of sale)	23W[586]

WattsEE = Actual wattage if known, if unknown assume 2W[587]

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

HEATING PENALTY

If electrically heated building:

$\Delta kWh_{heatpenalty}$[588] = (((WattsBase-WattsEE)/1000) * Hours * -IFkWh

Where:

IFkWh = Lighting-HVAC Interation Factor for electric heating impacts; this factor represents the

584 Based on review of available product.

585 Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010

586 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)

587 Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010

588 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, replacing incandescent fixture in a heat pump heated office

$\Delta kWh_{heatpenalty}$ = (35 – 2)/1000 * 8766 * -0.151

= -43.7 kWh

For example, replacing fluorescent fixture in a heat pump heated hospital

$\Delta kWh_{heatpenalty}$ = (11 – 2)/1000 * 8766 * -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

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):

$\Delta therms$ = (((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 * 8766 * -0.016

= -4.63 Therms

For example, replacing fluorescent fixture in a hospital

ΔTherms = (11 – 2)/1000 * 8766 * -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[589]	1.37 years[590]

MEASURE CODE: CI-LTG-LEDE-V02-140601

[589] 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).

[590] 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.[591] The life in years is calculated by dividing 100,000 hrs by the annual operating hours for the particular signal type.

Deemed Measure Cost

The actual measure installation cost should be used (including material and labor).

Loadshape

Loadshape C24 - Traffic Signal - Red Balls, always changing or flashing

Loadshape C25 - Traffic Signal - Red Balls, changing day, off night

Loadshape C26 - Traffic Signal - Green Balls, always changing

Loadshape C27 - Traffic Signal - Green Balls, changing day, off night

Loadshape C28 - Traffic Signal - Red Arrows

Loadshape C29 - Traffic Signal - Green Arrows

Loadshape C30 - Traffic Signal - Flashing Yellows

Loadshape C31 - Traffic Signal - "Hand" Don't Walk Signal

Loadshape C32 - Traffic Signal - "Man" Walk Signal

Loadshape C33 - Traffic Signal - Bi-Modal Walk/Don't Walk

[591] ACEEE, (1998) A Market Transformation Opportunity Assessment for LED Traffic Signals, http://www.cee1.org/gov/led/led-ace3/ace3led.pdf

Coincidence Factor[592]

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’

EFLH = annual operating hours of the lamp

= see Table ‘Traffic Signals Technology Equivalencies’

1000 = conversion factor (W/kW)

EXAMPLE

For example, an 8 inch red, round signal:

$$\Delta kWh = ((69 - 7) \times 4818) / 1000$$

$$= 299 \text{ kWh}$$

Summer Coincident Peak Demand Savings

$$\Delta kW = (Wbase – Weff) \times CF / 1000$$

[592] Ibid

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[593]

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[594]	8" Red	LED	Incandescent	4380	7	69	272
Flashing Signal	12" Red	LED	Incandescent	4380	6	150	631
Flashing Signal	8" Yellow	LED	Incandescent	4380	10	69	258
Flashing Signal	12" Yellow	LED	Incandescent	4380	13	150	600
Round Signals	8" Yellow	LED	Incandescent	175	10	69	10
Round Signals	12" Yellow	LED	Incandescent	175	13	150	24
Round Signals	8" Green	LED	Incandescent	3767	9	69	266
Round Signals	12" Green	LED	Incandescent	3767	12	150	520
Turn Arrows	8" Yellow	LED	Incandescent	701	7	116	76
Turn Arrows	12" Yellow	LED	Incandescent	701	9	116	75
Turn Arrows	8" Green	LED	Incandescent	701	7	116	76
Turn Arrows	12" Green	LED	Incandescent	701	7	116	76
Pedestrian Sign	12" Hand/Man	LED	Incandescent	8766	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

593 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

594 Technical Reference Manual for Ohio, August 6, 2010

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 or 2015, depending on the IECC in effect on the date of the building permit (if unknown assume IECC 2015)., can be used for calculating the Interior Lighting Power Density[595]. 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 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 or 2015, depending on the IECC in effect on the date of the building permit (if unknown assume IECC 2015)..

Deemed Calculation for this Measure

Annual kWh Savings

$\Delta kWh = (WSFbase - WSFeffic)/1000 * SF * Hours * WHF_e$

Summer Coincident Peak kW Savings

$\Delta kW = (WSFbase - WSFeffic)/1000 * SF * CF * WHF_d$

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 15 years[596]

Deemed Measure Cost

The actual incremental cost over a baseline system will be collected from the customer if possible or developed on a fixture by fixture basis.

Loadshape

Loadshape C06 - Commercial Indoor Lighting

Loadshape C07 - Grocery/Conv. Store Indoor Lighting

Loadshape C08 - Hospital Indoor Lighting

Loadshape C09 - Office Indoor Lighting

Loadshape C10 - Restaurant Indoor Lighting

---

[595] 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).

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

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.[597]

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.

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:

$$\Delta kWh_{heatpenalty}{}^{598} = (WSF_{base} - WSF_{effic})/1000 * SF * Hours * -IFkWh$$

Where:

[597]See IECC 2012 and 2015 - Reference Code documentation for additional information.

[598]Negative value because this is an increase in heating consumption due to the efficient lighting.

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

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

Reference Tables

Lighting Power Density Values from IECC 2012 and 2015 for Interior Commercial New Construction and Substantial Renovation Building Area Method:

Building Area Type [599]	IECC 2012 Lighting Power Density (w/ft^2)	IECC 2015 Lighting Power Density (w/ft^2)
Automotive Facility	0.9	0.80
Convention Center	1.2	1.01
Court House	1.2	1.01
Dining: Bar Lounge/Leisure	1.3	1.01
Dining: Cafeteria/Fast Food	1.4	0.9
Dining: Family	1.6	0.95
Dormitory	1.0	0.57
Exercise Center	1.0	0.84
Fire station	0.8	0.67
Gymnasium	1.1	0.94
Healthcare – clinic	1.0	0.90
Hospital	1.2	1.05
Hotel	1.0	0.87
Library	1.3	1.19
Manufacturing Facility	1.3	1.17
Motel	1.0	0.87
Motion Picture Theater	1.2	0.76
Multifamily	0.7	0.51
Museum	1.1	1.02
Office	0.9	0.82
Parking Garage	0.3	0.21
Penitentiary	1.0	0.81
Performing Arts Theater	1.6	1.39
Police Station	1.0	0.87
Post Office	1.1	0.87
Religious Building	1.3	1.0
Retail[600]	1.4	1.26

[599] In cases where both a general building area type and a more specific building area type are listed, the more specific building area type shall apply.

Building Area Type [599]	IECC 2012 Lighting Power Density (w/ft^2)	IECC 2015 Lighting Power Density (w/ft^2)
School/University	1.2	0.87
Sports Arena	1.1	0.91
Town Hall	1.1	0.89
Transportation	1.0	0.70
Warehouse	0.6	0.66
Workshop	1.4	1.19

[600] 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.

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

Lighting Power Density Values from IECC 2015 for Interior Commercial New Construction and Substantial Renovation Space by Space Method:

TABLE C405.4.2(2)
INTERIOR LIGHTING POWER ALLOWANCES: SPACE-BY-SPACE METHOD

COMMON SPACE TYPES[a]	LPD (watts/sq.ft)
Atrium	
Less than 40 feet in height	0.03 per foot in total height
Greater than 40 feet in height	0.40 + 0.02 per foot in total height
Audience seating area	
In an auditorium	0.63
In a convention center	0.82
In a gymnasium	0.65
In a motion picture theater	1.14
In a penitentiary	0.28
In a performing arts theater	2.43
In a religious building	1.53
In a sports arena	0.43
Otherwise	0.43
Banking activity area	1.01
Breakroom (See Lounge/Breakroom)	
Classroom/lecture hall/training room	
In a penitentiary	1.34
Otherwise	1.24
Conference/meeting/multipurpose room	1.23
Copy/print room	0.72
Corridor	
In a facility for the visually impaired (and not used primarily by the staff)[b]	0.92
In a hospital	0.79
In a manufacturing facility	0.41
Otherwise	0.66
Courtroom	1.72
Computer room	1.71
Dining area	
In a penitentiary	0.96
In a facility for the visually impaired (and not used primarily by the staff)[b]	1.9
In bar/lounge or leisure dining	1.07
In cafeteria or fast food dining	0.65
In family dining	0.89
Otherwise	0.65
Electrical/mechanical room	0.95
Emergency vehicle garage	0.56

(continued)

TABLE C405.4.2(2)—continued
INTERIOR LIGHTING POWER ALLOWANCES: SPACE-BY-SPACE METHOD

COMMON SPACE TYPES[a]	LPD (watts/sq.ft)
Food preparation area	1.21
Guest room	0.47
Laboratory	
In or as a classroom	1.43
Otherwise	1.81
Laundry/washing area	0.6
Loading dock, interior	0.47
Lobby	
In a facility for the visually impaired (and not used primarily by the staff)[b]	1.8
For an elevator	0.64
In a hotel	1.06
In a motion picture theater	0.59
In a performing arts theater	2.0
Otherwise	0.9
Locker room	0.75
Lounge/breakroom	
In a healthcare facility	0.92
Otherwise	0.73
Office	
Enclosed	1.11
Open plan	0.98
Parking area, interior	0.19
Pharmacy area	1.68
Restroom	
In a facility for the visually impaired (and not used primarily by the staff[b]	1.21
Otherwise	0.98
Sales area	1.59
Seating area, general	0.54
Stairway (See space containing stairway)	
Stairwell	0.69
Storage room	0.63
Vehicular maintenance area	0.67
Workshop	1.59
BUILDING TYPE SPECIFIC SPACE TYPES[a]	**LPD (watts/sq.ft)**
Facility for the visually impaired[b]	
In a chapel (and not used primarily by the staff)	2.21
In a recreation room (and not used primarily by the staff)	2.41
Automotive (See Vehicular Maintenance Area above)	
Convention Center—exhibit space	1.45
Dormitory—living quarters	0.38
Fire Station—sleeping quarters	0.22
Gymnasium/fitness center	
In an exercise area	0.72
In a playing area	1.2

(continued)

TABLE C405.4.2(2)—continued
INTERIOR LIGHTING POWER ALLOWANCES:
SPACE-BY-SPACE METHOD

BUILDING TYPE SPECIFIC SPACE TYPES[a]	LPD (watts/sq.ft)
healthcare facility	
In an exam/treatment room	1.66
In an imaging room	1.51
In a medical supply room	0.74
In a nursery	0.88
In a nurse's station	0.71
In an operating room	2.48
In a patient room	0.62
In a physical therapy room	0.91
In a recovery room	1.15
Library	
In a reading area	1.06
In the stacks	1.71
Manufacturing facility	
In a detailed manufacturing area	1.29
In an equipment room	0.74
In an extra high bay area (greater than 50′ floor-to-ceiling height)	1.05
In a high bay area (25-50′ floor-to-ceiling height)	1.23
In a low bay area (less than 25′ floor-to-ceiling height)	1.19
Museum	
In a general exhibition area	1.05
In a restoration room	1.02
Performing arts theater—dressing room	0.61
Post Office—Sorting Area	0.94
Religious buildings	
In a fellowship hall	0.64
In a worship/pulpit/choir area	1.53
Retail facilities	
In a dressing/fitting room	0.71
In a mall concourse	1.1
Sports arena—playing area	
For a Class I facility	3.68
For a Class II facility	2.4
For a Class III facility	1.8
For a Class IV facility	1.2
Transportation facility	
In a baggage/carousel area	0.53
In an airport concourse	0.36
At a terminal ticket counter	0.8
Warehouse—storage area	
For medium to bulky, palletized items	0.58
For smaller, hand-carried items	0.95

a. In cases where both a common space type and a building area specific space type are listed, the building area specific space type shall apply

b. A 'Facility for the Visually Impaired' is a facility that is licensed or will be licensed by local or state authorities for senior long-term care, adult daycare, senior support or people with special visual needs.

The exterior lighting design will be based on the building location and the applicable "Lighting Zone" as defined in IECC 2015 Table C405.5.2(1) which follows. This table is identical to IECC 2012 Table C405.62(1).

TABLE C405.5.2(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 not classified as lighting zone 1, 2 or 4
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 C405.6.2(2) or IECC 2015 Table C405.5.2(2).

Allowable Design Levels from IECC 2012

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.

Allowable Design Levels from IECC 2015

TABLE C405.5.2(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/ft²	0.06 W/ft²	0.10 W/ft²	0.13 W/ft²
	Building Grounds				
	Walkways less than 10 feet wide	0.7 W/linear foot	0.7 W/linear foot	0.8 W/linear foot	1.0 W/linear foot
	Walkways 10 feet wide or greater, plaza areas special feature areas	0.14 W/ft²	0.14 W/ft²	0.16 W/ft²	0.2 W/ft²
	Stairways	0.75 W/ft²	1.0 W/ft²	1.0 W/ft²	1.0 W/ft²
	Pedestrian tunnels	0.15 W/ft²	0.15 W/ft²	0.2 W/ft²	0.3 W/ft²
	Building Entrances and Exits				
	Main entries	20 W/linear foot of door width	20 W/linear foot of door width	30 W/linear foot of door width	30 W/linear foot of door width
	Other doors	20 W/linear foot of door width	20 W/linear foot of door width	20 W/linear foot of door width	20 W/linear foot of door width
	Entry canopies	0.25 W/ft²	0.25 W/ft²	0.4 W/ft²	0.4 W/ft²
	Sales Canopies				
	Free-standing and attached	0.6 W/ft²	0.6 W/ft²	0.8 W/ft²	1.0 W/ft²
	Outdoor Sales				
	Open areas (including vehicle sales lots)	0.25 W/ft²	0.25 W/ft²	0.5 W/ft²	0.7 W/ft²
	Street frontage for vehicle sales lots in addition to "open area" allowance	No allowance	10 W/linear foot	10 W/linear foot	30 W/linear foot
Nontradable Surfaces (Lighting power density calculations for the following applications can be used only for the specific application and cannot be traded between surfaces or with other exterior lighting. The following allowances are in addition to any allowance otherwise permitted in the "Tradable Surfaces" section of this table.)	Building facades	No allowance	0.075 W/ft² of gross above-grade wall area	0.113 W/ft² of gross above-grade wall area	0.15 W/ft² of gross above-grade wall area
	Automated teller machines (ATM) and night depositories	270 W per location plus 90 W per additional ATM per location	270 W per location plus 90 W per additional ATM per location	270 W per location plus 90 W per additional ATM per location	270 W per location plus 90 W per additional ATM per location
	Entrances and gatehouse inspection stations at guarded facilities	0.75 W/ft² of covered and uncovered area	0.75 W/ft² of covered and uncovered area	0.75 W/ft² of covered and uncovered area	0.75 W/ft² of covered and uncovered area
	Loading areas for law enforcement, fire, ambulance and other emergency service vehicles	0.5 W/ft² of covered and uncovered area	0.5 W/ft² of covered and uncovered area	0.5 W/ft² of covered and uncovered area	0.5 W/ft² of covered and uncovered area
	Drive-up windows/doors	400 W per drive-through	400 W per drive-through	400 W per drive-through	400 W per drive-through
	Parking near 24-hour retail entrances	800 W per main entry	800 W per main entry	800 W per main entry	800 W per main entry

For SI: 1 foot = 304.8 mm, 1 watt per square foot = W/0.0929 m².
W = watts.

MEASURE CODE: CI-LTG-LPDE-V03-160601

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[601].

Deemed Measure Cost

The actual cost of the efficient light fixture should be used.

Loadshape

Loadshape C06 - Commercial Indoor Lighting

Loadshape C07 - Grocery/Conv. Store Indoor Lighting

Loadshape C08 - Hospital Indoor Lighting

Loadshape C09 - Office Indoor Lighting

Loadshape C10 - Restaurant Indoor Lighting

Loadshape C11 - Retail Indoor Lighting

Loadshape C12 - Warehouse Indoor Lighting

Loadshape C13 - K-12 School Indoor Lighting

Loadshape C14 - Indust. 1-shift (8/5) (e.g., comp. air, lights)

Loadshape C15 - Indust. 2-shift (16/5) (e.g., comp. air, lights)

Loadshape C16 - Indust. 3-shift (24/5) (e.g., comp. air, lights)

Loadshape C17 - Indust. 4-shift (24/7) (e.g., comp. air, lights)

Loadshape C18 - Industrial Indoor Lighting

Loadshape C19 - Industrial Outdoor Lighting

Loadshape C20 - Commercial Outdoor Lighting

[601] 15 years from GDS Measure Life Report, June 2007

COINCIDENCE FACTOR

The summer peak coincidence factor for this measure is dependent on the location type. Values are provided for each building type in section 4.5.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = ((Watts_{base} - Watts_{EE})/1000) * Hours * WHF_e * ISR$$

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%[602] 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

[602] 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
75.5%[603]	12.1%	10.3%	98.0%[604]

HEATING PENALTY

If electrically heated building:

$$\Delta kWh_{heatpenalty}{}^{605} = (((WattsBase-WattsEE)/1000) * ISR * Hours * -IFkWh$$

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.

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.

---

603 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.

604 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.

605 Negative value because this is an increase in heating consumption due to the efficient lighting.

Other factors as defined above

NATURAL GAS ENERGY SAVINGS

ΔTherms[606] = (((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

[606] 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 2012/2015).

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[607].

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[608].

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

---

[607] Consistent with Occupancy Sensor control measure.

[608] 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 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[609]:

Building Type	Energy Savings Factor (ESF)
Private Office	21.6%
Open Office	16.0%
Retail	14.8%
Classrooms	8.3%
Unknown, average	15%

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:

609 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/

$$\Delta kWh_{heatpenalty}{}^{610} = KW_{Controlled} * Hours * ESF * -IFkWh$$

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[611].

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-MLLC-V03-160601

[610]Negative value because this is an increase in heating consumption due to the efficient lighting.

[611] 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.

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. This measure is intended for controlling interior lighting only.

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[612].

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[613]
Full cost of wall mounted occupancy sensor	$51
Full cost of ceiling or remote mounted occupancy sensor	$102
Full cost of fixture-mounted occupancy sensor	$91.83
Full cost of fixture embedded occupancy sensor	$54

[612] DEER 2008

[613] Taken from NEEP Commercial Lighting Controls, Incremental Cost Data Analysis, 2011 "NEEP Commercial Lighting Controls 2011_08_29.xlsx"

[614] Fixture embedded Occupancy Sensors are included with the fixture and therefore no additional installation costs are incurred for these sensors. Therefore, it is assumed that the costs associated with Fixture-embedded Occupancy Sensors should not surpass those of the wall mounted due to the similarity in installation.

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[615]
Wall mounted occupancy sensor (per control)	0.305
Remote mounted occupancy sensor (per control)	0.517
Fixture mounted sensor (per fixture)	0.180

[615] Based on EVT control data for Occupancy Sensor Costs 2009-2014.

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[616]
Wall, Ceiling or Fixture-Mounted Occupancy Sensors	24%
Wall-Mounted Occupancy Sensors Configured as "Vacancy Sensors"	31%[617]

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:

$$\Delta kWh_{heatpenalty}{}^{618} = KW_{Controlled} * Hours * ESF * -IFkWh$$

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

$$\Delta kW = KW_{controlled} * WHF_d * (CFbaseline - CFos)$$

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

[616] Lawrence Berkeley National Laboratory. *A Meta-Analysis of Energy Savings from Lighting Controls in Commercial Buildings.* Page & Associates Inc. 2011

[617] 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; 24% * 1.3 = 31%.

[618] Negative value because this is an increase in heating consumption due to the efficient lighting.

installed is 0.15 regardless of building type.[619]

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-V04-160601

[619] 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[620].

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)[621]

Coincidence Factor

The summer peak coincidence factor for this measure is dependent on location.

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

[620] Equal to the manufacturers standard warranty

[621] 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.

Size of Tube	Average Lumen output for Chicago Illinois (minimum)[622]	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 [623]

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:

$\Delta kWh_{heatpenalty}$[624] = 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 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.

622 Solatube Test Report (2005). http://www.mainegreenbuilding.com/files/file/solatube/stb_lumens_datasheet.pdf
623 Ibid. The lumen values presented in the kW table represent the average of the lightest 2400 hours.
624 Negative value because this is an increase in heating consumption due to the efficient lighting.

Natural Gas Savings

$$\Delta Therms^{625} = \Delta kW_f * HOURS * - IFTherms$$

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

[625] Negative value because this is an increase in heating consumption due to the efficient lighting.

4.5.12 T5 Fixtures and Lamps

Description

T5 Lamp/ballast systems have higher lumens per watt than a standard T8 or an existing T8 or T12 system. The smaller lamp diameter allows for better optical systems, and more precise control of lighting. These characteristics result in light fixtures that produce equal or greater light than standard T8 or T12 fixtures, while using fewer watts.

This measure applies to the installation of new equipment with efficiencies that exceed that of the equipment that would have been installed following standard market practices and is applicable to time of sale as well as retrofit measures.

If the implementation strategy does not allow for the installation location to be known, a deemed split of 99% Commercial and 1% Residential should be used[626].

This measure was developed to be applicable to the following program types: TOS, RF, DI.

If applied to other program types, the measure savings should be verified.

The measure applies to all commercial T5 installations excluding new construction and substantial renovation or change of use measures (see lighting power density measure). Lookup tables have been provided to account for various installations. Actual existing equipment wattages should be compared to new fixture wattages whenever possible while maintaining lumen equivalent designs. Default new and baseline assumptions are provided if existing equipment cannot be determined. Actual costs and hours of use should be utilized when available. Default component costs and lifetimes have been provided for Operating and Maintenance Calculations. Please see the Definition Table to determine applicability for each program. Configurations not included in the TRM may be included in custom program design using the provided algorithms as long as energy savings is achieved. The following table defines the applicability for different programs:

Time of Sale (TOS)	Retrofit (RF) and DI
This program applies to installations where customer and location of equipment is not known, or at time of burnout of existing equipment. T5 Lamp/ballast systems have higher lumens per watt than a standard T8 system. The smaller lamp diameter allows for better optical systems, and more precise control of lighting. These characteristics result in light fixtures that produce equal or greater light than standard T8 fixtures, while using fewer watts.	For installations that upgrade installations before the end of their useful life. T5 Lamp/ballast systems have higher lumens per watt than a standard T8 or T12 system. The smaller lamp diameter allows for better optical systems, and more precise control of lighting. These characteristics result in light fixtures that produce equal or greater light than standard T8 or T12 fixtures, while using fewer watts and having longer life.

Definition of Efficient Equipment

The definition of efficient equipment varies based on the program and is defined below:

Time of Sale (TOS)	Retrofit (RF) and DI
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	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

[626] Based on weighted average of Final ComEd's BILD program data from PY5 and PY6. For Residential installations, hours of use assumptions from '5.5 Interior Hardwired Compact Fluorescent Lamp (CFL) Fixture' measure should be used.

Time of Sale (TOS)	Retrofit (RF) and DI
greater. T5 HO high bay fixtures must be 3, 4 or 6 lamps and 90% efficient or better.	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) and DI
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. In July 14, 2012, Federal Standards were enacted that were expected to eliminate T-12s as an option for linear fluorescent fixtures. Through v3.0 of the TRM, it was assumed that the T-12 would no longer be baseline for retrofits from 1/1/2016. However, due to significant loopholes in the legislation, T-12 compliant product is still freely available and in Illinois T-12s continue to hold a significant share of the existing and replacement lamp market. Therefore the timing of the sunsetting of T-12s as a viable baseline has been pushed back in v5.0 until 6/1/2018 and will be revisited in future update sessions. There will be a baseline shift applied to all measures installed before 2018 in 2018 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[627].

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)

627 15 years from GDS Measure Life Report, June 2007

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:

$Watts_{base}$ = 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, DI	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%[628] 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:

[628] 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
98%[629]	0%	0%	98.0%[630]

HEATING PENALTY

If electrically heated building:

$$\Delta kWh_{heatpenalty}{}^{631} = (((WattsBase-WattsEE)/1000) * ISR * Hours * -IFkWh$$

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.

NATURAL GAS ENERGY SAVINGS

$$\Delta Therms^{632} = (((WattsBase-WattsEE)/1000) * ISR * Hours *- IFTherms$$

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.

---

[629] 1st year in service rate is based upon review of PY5-6 evaluations from ComEd's commercial lighting program (BILD) (see 'IL Commercial Lighting ISR_2014.xls' for more information

[630] 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.

[631] Negative value because this is an increase in heating consumption due to the efficient lighting.

[632] Negative value because this is an increase in heating consumption due to the efficient lighting.

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, DI	B-2: T5 Component Costs and Lifetime

REFERENCE TABLES

See following page.

A-1: Time of Sale: T5 New and Baseline Assumptions[633]

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

[633] 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[634]

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

[634]Ibid.

B-1: Time of Sale T5 Component Costs and Lifetime[635]

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

[635] 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[636]

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

636 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 2016 will claim full savings for two years, 2017 for one year. Savings adjustment factors based on a T8 baseline will be applied to the full savings for savings starting in 2018 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-V04-160601

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 2012/2015).

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[637].

Deemed Measure Cost

When available, the actual cost of the measure shall be used. When not available, the assumed measure cost is $274[638].

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

---

[637] DEER 2008.

[638] 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 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 participant 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%[639]	50%	39.3%

[639] 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

Application	% Standby Mode	% Full Light at Standby Mode	Energy Savings Factor (ESF)
		33%	52.6%
		10%	70.7%
		5%	74.6%
Corridors	50.0%[640]	50%	25.0%
		33%	33.5%
		10%	45.0%
		5%	47.5%
Other 24/7 Space Type	50.0%[641]	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:

$$\Delta kWh_{heatpenalty}{}^{642} = (KW_{Baseline} - (KW_{Controlled} *(1 - ESF))) * Hours * -IFkWh$$

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 effícent lighting. Values are provided in the Reference Table in Section 4.5. If unknown, use the Miscellaneous value.

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = (KW_{Baseline} - (KW_{Controlled} * (1 - ESF))) * WHF_d * (CF_{baseline} - CF_{os})$$

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

[640] 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

[641] Conservative estimate.

[642] Negative value because this is an increase in heating consumption due to the efficient lighting.

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.[643]

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-V02-160601

[643] Coincidence Factor Study Residential and Commercial Industrial Lighting Measures, RLW Analytics, Spring 2007. Note, the connected load used in the calculation of the CF for occupancy sensor lights includes the average ESF.

4.5.14 Commercial ENERGY STAR Specialty Compact Fluorescent Lamp (CFL)

DESCRIPTION

An ENERGY STAR qualified specialty compact fluorescent bulb is installed in place of an incandescent specialty bulb in a commercial location. If the implementation strategy does not allow for the installation location to be known a deemed split should be used. For Residential targeted programs (e.g. an upstream retail program), a deemed split of 96% Residential and 4% Commercial assumptions should be used[644], and for Commercial targeted programs a deemed split of 4% Residential and 96% Commercial should be used[645].

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

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 (number of years that savings should be claimed) should be calculated by dividing the rated life of the bulb (10,000 hours[646]) by the run hours. For example using Miscellaneous at 4,589 hours would give 2.2 years. When the number of years exceeds June 2020, the number of years to that date should be used.

DEEMED MEASURE COST

For the Retail (Time of Sale) measure, the incremental capital cost for this measure is $5[647].

For the Refrtofit measures, the full cost of $8.50 should be used plus $5 labor[648] for a total of $13.50. However actual program delivery costs should be utilized if available.

LOADSHAPE

Loadshape C06 - Commercial Indoor Lighting
Loadshape C07 - Grocery/Conv. Store Indoor Lighting
Loadshape C08 - Hospital Indoor Lighting
Loadshape C09 - Office Indoor Lighting
Loadshape C10 - Restaurant Indoor Lighting

[644] RES v C&I split is based on a weighted (by sales volume) average of ComEd PY4-6 and Ameren PY5-6 in store intercept survey results.
[645] Based upon final weighted (by sales volume) average of the BILD program (ComEd's commercial lighting program) for PY 4 and PY5 and PY6.
[646] 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.
[647] NEEP Residential Lighting Survey, 2011
[648] Based on 15 minutes at $20 per hour.

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 wattage equivalent of incandescent specialty bulb, use the tables below to obtain the incandescent bulb equivalent wattage[649]; use 60W if unknown[650]

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

[649] 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.

[650] 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
	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 (Shapes B, BA, C, CA, DC, F, G, medium and intermediate bases less than 750 lumens)	70	89	10
	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

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

Directional Lamps - ENERGY STAR Minimum Luminous Efficacy = 40Lm/W for lamps with rated wattages less than 20Wand 50 Lm/W for lamps with rated wattages >= 20 watts[651].

For Directional R, BR, and ER lamp types[652]:

[651] From pg 10 of the Energy Star Specification for lamps v1.1
[652] From pg 11 of the Energy Star Specification for lamps v1.1

Bulb Type	Lower Lumen Range	Upper Lumen Range	$Watts_{Base}$
R, ER, BR with medium screw bases w/ diameter >2.25" (*see exceptions below)	420	472	40
	473	524	45
	525	714	50
	715	937	65
	938	1259	75
	1260	1399	90
	1400	1739	100
	1740	2174	120
	2175	2624	150
	2625	2999	175
	3000	4500	200
***R, BR, and ER with medium screw bases w/ diameter <=2.25"**	400	449	40
	450	499	45
	500	649	50
	650	1199	65
***ER30, BR30, BR40, or ER40**	400	449	40
	450	499	45
	500	649	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	30

Directional lamps are exempt from EISA regulations.

For PAR, MR, and MRX Lamps Types:

For these highly focused directional lamp types, it is necessary to have Center Beam Candle Power (CBCP) and beam angle measurements to accurately estimate the equivalent baseline wattage. The formula below is based on the Energy Star Center Beam Candle Power tool.[653] If CBCP and beam angle information are not available or if the equation below returns a negative value (or undefined), use the manufacturer's recommended baseline wattage equivalent.[654]

[653] http://energystar.supportportal.com/link/portal/23002/23018/Article/32655/

[654] The Energy Star Center Beam Candle Power tool does not accurately model baseline wattages for lamps with certain bulb characteristic combinations – specifically for lamps with very high CBCP.

Wattsbase =

$$375.1 - 4.355(D) - \sqrt{227{,}800 - 937.9(D) - 0.9903(D^2) - 1479(BA) - 12.02(D * BA) + 14.69(BA^2) - 16{,}720 * \ln(CBCP)}$$

Where:

D = Bulb diameter (e.g. for PAR20 D = 20)

BA = Beam angle

CBCP = Center beam candle power

The result of the equation above should be rounded DOWN to the nearest wattage established by Energy Star:

Diameter	Permitted Wattages
16	20, 35, 40, 45, 50, 60, 75
20	50
30S	40, 45, 50, 60, 75
30L	50, 75
38	40, 45, 50, 55, 60, 65, 75, 85, 90, 100, 120, 150, 250

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[655]

ISR = In Service Rate or the percentage of units rebated that get installed.

=100%[656] if application form completed with sign off that equipment is not

[655] 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).

[656] 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
71.2%[657]	14.5%	12.3%	98.0%[658]

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[659]. 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.

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.

issue to warrant including an "In-Service Rate" when commercial customers complete an application form.

657 1st year in service rate is based upon review of PY4-6 evaluations from ComEd's commercial lighting program (BILD) (see 'IL Commercial Lighting ISR_2014.xls' for more information. The average first year ISR was calculated weighted by the number of bulbs sold.

658 The 98% Lifetime ISR assumption is based upon review of two evaluations:
'Nexus Market Research, RLW Analytics and GDS Associates study; "New England Residential Lighting Markdown Impact Evaluation, January 20, 2009' and 'KEMA Inc, Feb 2010, Final Evaluation Report:, Upstream Lighting Program, Volume 1.' This implies that only 2% of bulbs purchased are never installed. The second and third year installations are based upon Ameren analysis of the Californian KEMA study showing that 54% of future installs occur in year 2 and 46% in year 3. The 2nd and 3rd year installations should be counted as part of those future program year savings. Note that this Final Install Rate does NOT account for leakage of purchased bulbs being installed outside of the utility territory. EM&V should assess how and if data from evaluation should adjust this final installation rate to account for this impact

659 Based on ComEd analysis taking DEER 2008 values and averaging with PY1 and PY2 evaluation results.

EXAMPLE

For example, for a 14W 500 lumen R20 reflector lamp is installed in an office and sign off form provided.

ΔkWh = (((45 - 14)/1000) * 1.0 * 3088 * 1.25

= 119.7 kWh

HEATING PENALTY

If electrically heated building:

$\Delta kWh_{heatpenalty}$[660] = (((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.

EXAMPLE

For example, for a 14W 500 lumen R20 reflector lamp is installed in a heat pump heated office and sign off form provided.

$\Delta kWh_{heatpenalty}$ = (((45 - 14)/1000) * 1.0 * 3088 * -0.183

= - 17.5 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

[660] Negative value because this is an increase in heating consumption due to the efficient lighting.

EXAMPLE

For example, for a 14W 500 lumen R20 reflector lamp is installed in an office and sign off form provided.

ΔkW = ((45 - 14)/1000) * 1.0 * 1.3 * 0.66

= 0.027kW

NATURAL GAS SAVINGS

Heating Penalty if fossil fuel heated building (or if heating fuel is unknown):

ΔTherms[661] = (((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

EXAMPLE

For example, for a 14W 500 lumen R20 reflector lamp is installed in a gas heated office and sign off form provided.

ΔTherms = (((45 - 14)/1000) * 1.0 * 3088 * -0.016

= - 1.5 Therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

The following O&M assumptions should be used: Life of the baseline bulb is assumed to be (1000/HOURS) year; baseline replacement cost is assumed to be $3.5 for those bulbs types exempt from EISA and $5 for non-exempt EISA bulb types defined above[662]. . It is important to note that for cost-effectiveness screening purposes, the O&M cost adjustments should only be applied in cases where the light bulbs area actually in service and so should be multiplied by the appropriate ISR.

MEASURE CODE: CI-LTG-SCFL-V02-160601

[661] Negative value because this is an increase in heating consumption due to the efficient lighting.
[662] NEEP Residential Lighting Survey, 2011

4.6 Refrigeration End Use

4.6.1 Automatic Door Closer for Walk-In Coolers and Freezers

DESCRIPTION

This measure is for installing an auto-closer to the main insulated opaque door(s) of a walk-in cooler or freezer. The auto-closer must firmly close the door when it is within 1 inch of full closure.

This measure was developed to be applicable to the following program types: RF.

If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

This measure consists of the installation of an automatic, hydraulic-type door closer on main walk-in cooler or freezer doors. These closers save energy by reducing the infiltration of warm outside air into the refrigeration itself.

DEFINITION OF BASELINE EQUIPMENT

In order for this characterization to apply, the baseline condition is assumed to be a walk in cooler or freezer without an automatic closure.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The deemed measure life is 8 years.[663]

DEEMED MEASURE COST

The deemed measure cost is $156.82 for a walk-in cooler or freezer.[664]

LOADSHAPE

Loadshape C22 - Commercial Refrigeration

COINCIDENCE FACTOR

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

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

Savings calculations are based on values from through PG&E's Workpaper PGECOREF110.1 – Auto-Closers for Main Cooler or Freezer Doors. Savings are averaged across all California climate zones and vintages[665].

Annual Savings	kWh
Walk in Cooler	943
Walk in Freezer	2307

[663] Source: DEER 2008
[664] Ibid.
[665] Measure savings from ComEd TRM developed by KEMA. June 1, 2010

Summer Coincident Peak Demand Savings

Annual Savings	kW
Walk in Cooler	0.137
Walk in Freezer	0.309

Natural Gas Energy Savings

N/A

Water Impact Descriptions and Calculation

N/A

Deemed O&M Cost Adjustment Calculation

N/A

Measure Code: CI-RFG-ATDC-V01-120601

4.6.2 Beverage and Snack Machine Controls

DESCRIPTION

This measure relates to the installation of new controls on refrigerated beverage vending machines, non-refrigerated snack vending machines, and glass front refrigerated coolers. Controls can significantly reduce the energy consumption of vending machine and refrigeration systems. Qualifying controls must power down these systems during periods of inactivity but, in the case of refrigerated machines, must always maintain a cool product that meets customer expectations. This measure relates to the installation of a new control on a new or existing unit. This measure should **not** be applied to ENERGY STAR qualified vending machines, as they already have built-in controls.

This measure was developed to be applicable to the following program types: RF.

If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

In order for this characterization to apply, the efficient equipment is assumed to be a standard efficiency refrigerated beverage vending machine, non-refrigerated snack vending machine, or glass front refrigerated cooler with a control system capable of powering down lighting and refrigeration systems during periods of inactivity.

DEFINITION OF BASELINE EQUIPMENT

In order for this characterization to apply, the baseline equipment is assumed to be a standard efficiency refrigerated beverage vending machine, non-refrigerated snack vending machine, or glass front refrigerated cooler without a control system capable of powering down lighting and refrigeration systems during periods of inactivity

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 5 years [666].

DEEMED MEASURE COST

The actual measure installation cost should be used (including material and labor), but the following can be assumed for analysis purposes[667]:

Refrigerated Vending Machine and Glass Front Cooler: $180.00

Non-Refrigerated Vending Machine: $80.00

LOADSHAPE

Loadshape C52 - Beverage and Snack Machine Controls

COINCIDENCE FACTOR

The summer peak coincidence factor for this measure is assumed to be 0[668].

[666] Measure Life Study, prepared for the Massachusetts Joint Utilities, Energy & Resource Solutions, November 2005.
[667] ComEd workpapers, 8—15-11.pdf
[668] Assumed that the peak period is coincident with periods of high traffic diminishing the demand reduction potential of occupancy based controls.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

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[669]
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)[670]
Refrigerated Beverage Vending Machines	46%
Non-Refrigerated Snack Vending Machines	46%
Glass Front Refrigerated Coolers	30%

EXAMPLE

For example, adding controls to a refrigerated beverage vending machine:

ΔkWh = WATTSbase / 1000 * HOURS * ESF

=400/1000* 8766* 0.46

= 1613 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

669 USA Technologies Energy Management Product Sheets, July 2006; cited September 2009. <http:// http://www.usatech.com/energy_management/energy_productsheets.php>
670 Ibid.

NATURAL GAS ENERGY SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-RFG-BEVM-V02-150601

4.6.3 Door Heater Controls for Cooler or Freezer

Description

By installing a control device to turn off door heaters when there is little or no risk of condensation, one can realize significant energy savings. There are two commercially available control strategies that achieve "on-off" control of door heaters based on either (1) the relative humidity of the air in the store or (2) the "conductivity" of the door (which drops when condensation appears). In the first strategy, the system activates your door heaters when the relative humidity in your store rises above a specific setpoint, and turns them off when the relative humidity falls below that setpoint. In the second strategy, the sensor activates the door heaters when the door conductivity falls below a certain setpoint, and turns them off when the conductivity rises above that setpoint.

This measure was developed to be applicable to the following program types: RF.

If applied to other program types, the measure savings should be verified.

Definition of Efficient Equipment

In order for this characterization to apply, the efficient equipment is assumed to be a door heater control on a commercial glass door cooler or refrigerator utilizing humidity or conductivity control.

Definition of Baseline Equipment

In order for this characterization to apply, the baseline condition is assumed to be a commercial glass door cooler or refrigerator with a standard heated door with no controls installed.

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 12 years [671].

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[672].

Loadshape

Loadshape C51 - Door Heater Control

Coincidence Factor[673]

The summer peak coincidence factor for this measure is assumed to be 0%[674].

---

[671] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Effective/Remaining Useful Life Values", California Public Utilities Commission, December 16, 2008.

[672] Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010

[673] Source partial list from DEER 2008

[674] Based on the assumption that humidity levels will most likely be relatively high during the peak period, reducing the likelihood of demand savings from door heater controls.

Algorithm

Calculation of Savings

Electric Energy Savings

ΔkWH = kWbase * NUMdoors * ESF * BF * 8766

Where:

kWbase[675] = 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[676] = 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[677] = 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.

Definition	Representative Evaporator Temperature Range, °F[678]	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

8766 = annual hours of operation

Summer Coincident Peak Demand Savings

N/A

[675] 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.

[676] 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.

[677] Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010

[678] Energy Efficiency Supermarket Refrigeration, Wisconsin Electric Power Company, July 23, 1993

NATURAL GAS ENERGY SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-RFG-DHCT-V01-120601

4.6.4 Electronically Commutated Motors (ECM) for Walk-in and Reach-in Coolers / Freezers

DESCRIPTION

This measure is applicable to the replacement of an existing standard-efficiency shaded-pole evaporator fan motor in refrigerated display cases or fan coil in walk-ins.

This measure was developed to be applicable to the following program types: RF.

If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

This measure applies to the replacement of an existing standard-efficiency shaded-pole evaporator fan motor in refrigerated display cases or fan coil in walk-ins. The replacement unit must be an electronically commutated motor (ECM). This measure cannot be used in conjunction with the evaporator fan controller measure

DEFINITION OF BASELINE EQUIPMENT

In order for this characterization to apply, the baseline equipment is assumed to be a shaded pole motor

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 15 years[679]

DEEMED MEASURE COST

The measure cost is assumed to be $50 for a walk in cooler and walk in freezer. [680]

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 [681]

Savings values are obtained from the SCE workpaper for efficient evaporator fan motors, which covers all 16 California climate zones. SCE savings values were determined using a set of assumed conditions for restaurants and grocery stores. We have used only PG&E climate zones in calculating our averages and have taken out the drier, warmer climates of southern California. SCE's savings approach calculates refrigeration demand, by taking into consideration temperature, compressor efficiency, and various loads involved for both walk-in and reach-in refrigerators. Details on cooling load calculations, including refrigeration conditions, can be found in the SCE workpaper. The baseline for this measure assumes that the refrigeration unit has a shaded-pole motor. The following tables are values calculated within the SCE workpaper.

Table 156 SCE Restaurant Savings Walk-In

[679] DEER
[680] Act on Energy Commercial Technical Reference Manual No. 2010-4
[681] "Efficient Evaporator Fan Motors (Shaded Pole to ECM)," Workpaper WPSCNRRN0011. Southern California Edison Company. 2007.

	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/motor
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[682]

DEEMED MEASURE COST

The incremental cost of this measure is $500[683]

LOADSHAPE

Loadshape C22 - Commercial Refrigeration

COINCIDENCE FACTOR

It is assumed that controls are only effective during off-peak hours and so have no peak-kW savings.

Algorithm

CALCULATION OF SAVINGS

Beverage machine savings are taken from the ENERGY STAR savings calculator and summarized in the following table. ENERGY STAR provides savings numbers for machines with and without control software. The average savings are calculated here.

ELECTRIC ENERGY SAVINGS

ENERGY STAR Vending Machine Savings[684]

Vending Machine Capacity (cans)	kWh Savings Per Machine w/o software	kWh Savings Per Machine w/ software

[682] ENERGY STAR
[683] ENERGY STAR
[684] Savings from Vending Machine Calculator: http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=VMC

Vending Machine Capacity (cans)	kWh Savings Per Machine w/o software	kWh Savings Per Machine w/ software
<500	1,099	1,659
500 - 599	1,754	2,231
600 - 699	1,242	1,751
700 - 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-V02-150601

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[685]

Deemed Measure Cost

The measure cost is assumed to be $291[686]

Loadshape

Loadshape C46 - Evaporator Fan Control

Coincidence Factor

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

Algorithm

Calculation of Savings

Savings for this measure were obtained from the DEER database. The baseline is assumed to be evaporator fans that run continuously with either a permanent split capacitor or shaded-pole motors. In the energy-efficient case the fan is still assumed to operate even with the evaporator inactive.[687]

[685] Source: DEER
[686] Source: DEER
[687] 2005 Database for Energy Efficiency Resources (DEER) Update Study Final Report

ELECTRIC ENERGY SAVINGS

DEER provides savings numbers for building vintages and grocery only. The numbers are averages of these vintages. We are assuming that this measure will be applicable for all building types. The DEER savings vary by climate zone between 476 and 483 kWh/motor. Climate zone most closely remembling IL are 1, 3, and 16. The simple average of the savings in those zones is given below.[688]

ΔkWh = Savings per motor * motors

Where:

Savings per motor = 481 kWh

motors = number of fan motors controlled

SUMMER COINCIDENT PEAK DEMAND SAVINGS

Using the same source and methodology as for ΔkWh:

ΔkW = 0.060 kW

NATURAL GAS ENERGY SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-RFG-EVPF-V02-140601

[688] See "Ca Climate Zone Translation.docx" and "CDD Base 80 zone comparison.xlsx"

4.6.7 Strip Curtain for Walk-in Coolers and Freezers

DESCRIPTION

This commercial measure pertains to the installation of infiltration barriers (strip curtains) on walk-in coolers or freezers. Strip curtains impede heat transfer from adjacent warm and humid spaces into walk-ins when the main door is opened, thereby reducing the cooling load. As a result, compressor run time and energy consumption are reduced. The engineering assumption is that the walk-in door is open 72 minutes per day every day, and the strip curtain covers the entire door frame.

This measure was developed to be applicable to the following program types: RF.

If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

The efficient equipment is a polyethylene strip curtain added to a walk-in cooler or freezer

DEFINITION OF BASELINE EQUIPMENT

The baseline assumption is a walk-in cooler or freezer that previously had either no strip curtain installed or an old, ineffective strip curtain installed.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 6 years[689].

DEEMED MEASURE COST

The incremental capital cost for this measure is $286.16 [690]

LOADSHAPE

Loadshape C22 - Commercial Refrigeration

COINCIDENCE FACTOR

The summer peak coincidence factor for this measure is 100%[691].

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS[692]

ΔkWh = 2,974 per freezer with curtains installed

[689] 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.

[690] 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

[691] 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.

[692] 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.

= 422 per cooler with curtains installed

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ΔkWh / 8766 * CF

= 0.34 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-V03-150601

4.6.8 Refrigeration Economizers

DESCRIPTION

This measure applies to commercial walk in refrigeration systems and includes two components, outside air economizers and evaporator fan controllers. Economizers save energy by bringing in outside air when weather conditions allow, rather than operating the compressor. Walk-in refrigeration systems evaporator fans run almost all the time; 24 hrs/day, 365 days/yr. This is because they must run constantly to provide cooling when the compressor is running, and to provide air circulation when the compressor is not running. However, evaporator fans are a very inefficient method of providing air circulation. Installing an evaporator fan control system will turn off evaporator fans while the compressor is not running, and instead turn on an energy-efficient 35 watt fan to provide air circulation, resulting in significant energy savings. This measure allows for economizer systems with evaporator fan controls plus a circulation fan and without a circulation fan.

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure an economizer is installed on a walk in refrigeration system.

DEFINITION OF BASELINE EQUIPMENT

The baseline condition is a walk-in refrigeration system without an economizer

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The estimated life of this measure is 15 years[693].

DEEMED MEASURE COST

The installation cost for an economizer is $2,558.[694]

LOADSHAPE

Loadshape C22 - Commercial Refrigeration

COINCIDENCE FACTOR

The summer peak coincidence factor for this measure is assumed to be 0%[695].

[693] Estimated life from Efficiency Vermont TRM
[694] Based on average of costs from Freeaire, Natural Cool, and Cooltrol economizer systems.
[695] Based on the assumption that humidity levels will most likely be relatively high during the peak period, reducing the likelihood of demand savings.

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS

Electric energy savings is calculated based on whether evaporator fans run all

With Fan Control Installed

ΔkWh = [HP * kWhCond] + [((kWEvap * nFans) – kWCirc) * Hours * DCComp * BF] – [kWEcon * DCEcon * Hours]

Without Fan Control Installed

ΔkWh = [HP * kWhCond] – [kWEcon * DCEcon * Hours]

Where:

HP = Horsepower of Compressor

= actual installed

kWhCond = Condensing unit savings, per hp. (value from savings table) [696]

	Hermetic / Semi-Hermetic	Scroll	Discus
kWh/HP	1,256	1,108	1,051

Hours = Number of annual hours that economizer operates [697].

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% [698]

[696] 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

[697] 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).

[698] 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)

kWEvap = Connected load kW of each evaporator fan,

= If known, actual installed. Otherwise assume 0.123 kW[699]

kWCirc = Connected load kW of the circulating fan

= If known, actual installed. Otherwise assume 0.035 kW[700]

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%[701]

BF = Bonus factor for reduced cooling load from running the evaporator fan less or (1.3)[702]

kWEcon = Connected load kW of the economizer fan

= If known, actual installed. Otherwise assume 0.227 kW.[703]

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) – kWCirc) * Hours * DCComp * BF] – [kWEcon * DCEcon * Hours]

= [5 * 1256] + [((0.123 * 3) – 0.035) * 2376 *0.5 * 1.3] – [0.227 * 0.63 * 2376]

= 6456 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

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

NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

---

699 Based on an a weighted average of 80% shaded pole motors at 132 watts and 20% PSC motors at 88 watts

700 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

701 Average of two manufacturer estimates of 50% and 75%.

702 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

703 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).

MEASURE CODE: CI-RFG-ECON-V05-150601

4.6.9 Night Covers for Open Refrigerated Display Cases

Description

This measure is the installation of fitted covers on existing open-type refrigerated and freezer display cases that are deployed during the facility unoccupied hours. Night covers are designed to reduce refrigeration energy consumption by reducing the work done by the compressor. Night covers reduce the heat and moisture entry into the refrigerated space through various heat transfer mechanisms. By fully or partially covering the case opening, night covers reduce the convective heat transfer into the case through reduced air infiltration. Additionally, they provide a measure of insulation, reducing conduction into the case, and also decrease radiation into the case by blocking radiated heat from entering the refrigerated space.

Definition of Efficient Equipment

Curtains or covers on top of open refrigerated or freezer display cases that are applied at least six hours (during off-hours) in a 24-hour period.

Definition of Baseline Equipment

Refrigerated and freezer, open-type display case in vertical, semi-vertical, and horizontal displays, with no night cover.

Deemed Lifetime of Efficient Equipment

The measure life is 5 years, based on DEER 2014.[704]

Deemed Measure Cost

The incremental capital cost for this measure is $42 per linear foot of cover installed including material and labor.[705]

Loadshape

Loadshape 22: Commercial Refrigeration

Coincidence Factor

N/A – savings occur at night only.

[704] 2014 Database for Energy-Efficiency Resources (DEER), Version 2014, “Cost Values and Summary Documentation”, California Public Utilities Commission, January, 2014.
[705] 2014 Database for Energy-Efficiency Resources (DEER), Version 2014, “Cost Values and Summary Documentation”, California Public Utilities Commission, January, 2014.

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS

ΔkWh = ES * L

Where:

ES = the energy savings (ΔkWh/ft) found in table below:

Display Case Description	Case Temperature Range (°F)	Annual Electricity Use kWh/ft[706]	ES ΔkWh/ft reduction (= 9% reduction of electricity use[707,708])
Vertical Open, Remote Condensing, Medium Temperature	35°F to 55°F	1453	131
Vertical Open, Remote Condensing, Low Temperature	0°F to 30°F	3292	296
Vertical Open, Self-Contained Medium Temperature	35°F to 55°F	2800	252
Horizontal Open, Remote Condensing, Medium Temperature	35°F to 55°F	439	40
Horizontal Open, Remote Condensing, Low Temperature	0°F to 30°F	1007	91
Horizontal Open, Self-Contained, Medium Temperature	35°F to 55°F	1350	121
Horizontal Open, Self-Contained, Low Temperature	0°F to 30°F	2749	247

L = the length of the refrigerated case in linear feet

= Actual

[706] Energy Conservation Standards for Commercial Refrigeration Equipment: Technical Support Document, U.S. Department of Energy, September 2013. The information required to estimate annual energy savings for refrigerated display cases is taken from the 2013-2014 U.S. Department of Energy (DOE) energy conservation standard rulemaking for Commercial Refrigerated Equipment. During the rulemaking process, DOE estimates the energy savings specific to night covers through extensive simulation and energy models that are validated by both manufacturers of night covers and refrigerated cases. The information is also referenced from a study done by Southern California Edison and testing by Technischer Uberwachungs-Verein Rheinland, which are used by DOE for the rulemaking process.

[707] Southern California Edison Refrigeration Technology and Test Center. Effects of the Low Emissivity Shields on Performance and Power Use of a Refrigerated Display Case. 1997. Southern California Edison, Rancho Cucamonga, CA.

[708] Technischer Uberwachungs-Verein Rheinland E.V. Laboratory test results for energy savings on refrigerated dairy case, conducted for Econofrost.

SUMMER COINCIDENT PEAK DEMAND SAVINGS

Peak savings are null because savings occur at night only.

NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-RFG-NCOV-V01-150601

4.7 Compressed Air

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[709] = compressor motor nominal hp to incremental cost conversion factor and offset

$hp_{compressor}$ = compressor motor nominal

Deemed O&M Cost Adjustments

N/A

Loadshape

Loadshape C35 - Industrial Process

Coincidence Factor

The coincidence factor equals 0.95

[709] Conversion factor and offset based on a linear regression analysis of the relationship between air compressor motor nominal horsepower and incremental cost. Several Vermont vendors were surveyed to determine the cost of equipment. See "Compressed Air Analysis.xls" and "Compiled Data ReQuest Results.xls" for incremental cost details.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = 0.9 \times hp_{compressor} \times HOURS \times (CF_b - CF_e)$$

Where:

ΔkWh = gross customer annual kWh savings for the measure

$hp_{compressor}$ = compressor motor nominal hp

0.9[710] = 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[711]

=0.890

CF_e = efficient compressor [712]

=0.705

[710] 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".

[711] Compressor factors were developed using DOE part load data for different compressor control types as well as load profiles from 50 facilities employing air compressors less than or equal to 40 hp. "See "BHP Weighted Compressed Air Load Profiles.xls" for source data and calculations (The "variable speed drive" compressor factor has been adjusted up from the 0.675 presented in the analysis to 0.705 to account for the additional power draw of the VSD).

[712] Ibid.

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

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[713]

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. Use Use actual compressor control type if known:

[713] Incremental cost research found in LPDF Costs. xlsx

Compressor $kW_{typical}$

Control Type	$kW_{typical}$ [714]
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 %	$kW_{typical}$ [715]
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[716]

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[717]

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

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

714 See "Industrial System Standard Deemed Saving Analysis.xls"
715 See "Industrial System Standard Deemed Saving Analysis.xls"
716 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
717 "Optimizing pneumatic systems for extra savings," 10, 2010, http://www.compressedairchallenge.org/library/articles/2010-10-CABP.pdf

down time)

$HP_{typical}$ = Nominal HP for typical compressor = 100 hp[718]

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

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

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

[718] 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 [719]

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:

$CFM_{reduced}$ = Reduced air consumption (CFM) per drain

= 3 CFM[720]

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[721]

[719] Based on empirical project data from ComEd Comprehensive Compressed Air Study program and VEIC review of pricing data found in CAS Cost Data.xls

[720] 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"

[721] 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"

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[722]

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-CANCLD-V01-140601

[722] US DOE, Evaluation of the Compressed Air Challenge® Training Program, Page 19

4.7.4 Efficient Compressed Air Nozzles

DESCRIPTION

This measure is for the replacement of standard air nozzle with high-efficiency air nozzle used in a compressed air system. High-efficiency air nozzles reduce the amount of air required to blow off parts or for drying. These nozzles utilize the Coandă effect to pull in free air to accomplish tasks with significantly less compressed air. High-efficiency nozzles often replace simple copper tubes. These nozzles have the added benefits of noise reduction and improved safety in systems with greater than 30 psig.

DEFINITION OF EFFICIENT EQUIPMENT

The high-efficiency air nozzle must meet the following specifications:

1. High-efficiency air nozzle must replace continuous open blow-offs
2. High-efficiency air nozzle must meet SCFM rating at 80psig less than or equal to: 1/8" 11 SCFM, 1/4" 29 SCFM, 5/16" 56 SCFM, 1/2" 140 SCFM.
3. Manufacturer's specification sheet of the high-efficiency air nozzle must be provided along with the make and model

DEFINITION OF BASELINE EQUIPMENT

The baseline condition is a standArd air nozzle

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure life is 15 years[723]

DEEMED MEASURE COST

The estimated incremental measure costs are presented in the following table[724]

Nozzle Diameter	1/8"	1/4"	5/16"	1/2"
Average IMC	$42	$57	$87	$121

LOADSHAPE

Loadshape C35 - Industrial Process

COINCIDENCE FACTOR

The coincidence factor equals 0.95

Algorithm

[723] PA Consulting Group (2009). Business Programs: Measure Life Study. Prepared for State of Wisconsin Public Service Commission.

[724] Costs are from EXAIR's website and are an average of nozzles that meet the flow requirements. Models include Atto Super, Pico Super, Nano Super, Micro Super, Mini Super, Super and Large Super nozzles. www.exair.com. Accessed March 20, 2014

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS

ΔkWh = (SCFM * SCFM%Reduced) * kW/CFM * %USE * HOURS

Where:

SCFM = Air flow through standard nozzle. Use actual rated flow at 80 psi if known. If unknown, the table below includes the CFM by orifice diameter[725, 726].

Orifice Diameter	SCFM
1/8”	21
1/4”	58
5/16”	113
1/2"	280

SCFM%Reduced = Percent in reduction of air loss per nozzle. Estimated at 50%[727]

kW/CFM = System power reduction per air demand (kW/CFM) depending on the type of air compressor found in table below[728]

Air Compressor Type	ΔkW/CFM
Reciprocating – On/off Control	0.18
Reciprocating – Load/Unload	0.14
Screw – Load/Unload	0.15
Screw – Inlet Modulation	0.06
Screw – Inlet Modulation w/ Unloading	0.06
Screw – Variable Displacement	0.15
Screw - VFD	0.18

%USE = percent of the compressor total operating hours that the nozzle is in use

= Custom, if unknown assume 5%[729]

[725] Review of manufacturer’s information
[726] Technical Reference Manual (TRM) for Ohio Senate Bill 221”Energy Efficiency and Conservation Program” and 09-512-GE-UNC, October 15,
2009. Pgs 170-171
[727] Conservative estimate based on average values provided by the Compressed Air Challenge Training Program, Machinery’s Handbook 25th
Edition, and manufacturers’ catalog.
[728] 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”
[729] Assumes 50% handheld air guns and 50% stationary air nozzles. Manual air guns tend to be used less than stationary air nozzles, and a conservative estimate of 1 second of blow-off per minute of compressor run time is assumed. Stationary air nozzles are commonly more wasteful as they are often mounted on machine tools and can be manually operated resulting in the possibility of a long term open blow situation. An assumption of 5 seconds of blow-off per minute of compressor run time is used.

Hours = Compressed air system pressurized hours.

= Use actual hours if known, otherwise assume values in table below:

Shift	Hours
Single Shift	1976
Two Shifts	3952
Three Shifts	5928
Four Shifts or Continual Operation	8320
Unknown / Weighted average[730]	5702

SUMMER COINCIDENT PEAK DEMAND SAVINGS

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

Where:

ΔkWh = As calculated above

CF = 0.95

NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE CI-MSC-CNOZ-V01-150601

[730] Weighting of 16% single shift, 23% two shift, 25% three shift and 36% continual based on DOE evaluation of the Compressed Air Challenge, section 2.1.5 Facility Operating Schedules

4.7.5 Efficient Refrigerated Compressed Air Dryer

DESCRIPTION

An air dryer is an essential component in a compressed air system that prevents condensate from being deposited in the compressed air supply lines of a facility. If the warm, saturated compressed air is supplied directly into the plant, excess condensate will form in the compressed air supply lines. Uncontrolled condensate can damage demand-side tools and process equipment. Secondly, in an oil-flooded rotary screw compressor, the residual oil from compression can be carried along the supply lines potentially damaging process equipment. Industries that use compressed air for processes make use of various types of dryers including refrigerated dryers (both cycling and non-cycling). For this measure, three types of refrigerated air dryers will be considered: thermal mass, variable speed and digital scroll. All of these technologies offer better part load performance compared to non-cycling refrigerated dryers, thereby offering energy savings during periods when the dryer is not operating at peak capacity.

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

A new, high efficiency thermal mass dryer, variable speed dryer, or digital scroll dryer.

DEFINITION OF BASELINE EQUIPMENT

A standard non-cycling refrigerated compressed air dryer of comparable capacity.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure life is 10 years[731].

DEEMED MEASURE COST

The incremental capital cost for this measure is $6 per CFM.[732]

LOADSHAPE

Loadshape C35 – Industrial Process

COINCIDENCE FACTOR

The coincidence factor equals 0.95

[731] State of Wisconsin Public Service Commission, Focus on Energy Evaluation, Business Programs: Measure Life Study, August 25, 2009.

[732] Analysis of material cost between cycling and non-cycling dryers according to prices from Grainger. Cost provided is the average incremental cost when comparing non-cycling and cycling dryers of the same CFM capacity. http://www.grainger.com/category/refrigerated-compressed-air-dryers/compressed-air-treatment/pneumatics/ecatalog/N-kk5?bc=y

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = P_s \times (EC50_{baseline} - EC50_{efficient}) \times HOURS \times CFM$$

Where:

P_s = Full flow specific power of the dryer

= 0.007 kW/CFM[733] (for both baseline and efficient equipment)

$EC50_{baseline}$ = Energy consumption ratio of baseline dryer at 50%[734] inlet load capacity as compared to fully loaded operating conditions.[735]

= 0.843

$ECF50_{efficient}$ = Energy consumption ratio of efficient dryer at 50% inlet load capacity as compared to fully loaded operating conditions.

= Dependent on efficient dryer type, refer to the following table[736]:

Dryer Type	$EC50_{efficient}$
Thermal-Mass	0.729
VSD	0.501
Digital Scroll	0.551

HOURS = Compressed air system pressurized hours, depending on shift. If unknown, use weighted average. This value is the weighted average of facility owner responses from the DOE evaluation of the Compressed Air Challenge. Facility owners with compressed air systems were surveyed detailing the number of shifts their facilities operated.

Shift	Hours	Distribution of Facilities by Hours of Operation[737]	Weighted Hours
Single Shift 7 AM – 3 PM, weekdays, minus some holidays and scheduled down time	1,976	16%	316
Two Shifts	3,952	23%	909

[733] Compressed Air Challenge: Compressed Air Best Practice; “Cycling Air Dryers – Are Savings Significant?” Fox, Timothy J. and Marshall, Ron. http://www.compressedairchallenge.org/library/articles/2011-11-CABP.pdf
[734] Engineering judgement, based on the assumption that on average, compressed air systems will operate at 50% capacity.
[735] Compressed Air Challenge: Compressed Air Best Practice; “Cycling Air Dryers – Are Savings Significant?” Fox, Timothy J. and Marshall, Ron. http://www.compressedairchallenge.org/library/articles/2011-11-CABP.pdf
[736] Compressed Air Challenge: Compressed Air Best Practice; “Cycling Air Dryers – Are Savings Significant?” Fox, Timothy J. and Marshall, Ron. http://www.compressedairchallenge.org/library/articles/2011-11-CABP.pdf
[737] DOE evaluation of the Compressed Air Challenge, section 2.1.5 Facility Operating Schedules.

Shift	Hours	Distribution of Facilities by Hours of Operation[737]	Weighted Hours
7AM – 11 PM, weekdays, minus some holidays and scheduled down time			
Three Shifts 24 hours per day, weekdays, minus some holidays and scheduled down time	5,928	25%	1,482
Four Shifts or Continual Operation 24 hours per day, 7 days a week minus some holidays and scheduled down time	8,320	36%	2,995
		Total weighted average	5,702

CFM = Cubic feet per minute, rate of airflow through the dryer.

= Assume 50% of actual rated capacity.

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ΔkWh / HOURS * CF

Where:

CF = 0.95

NATURAL GAS ENERGY SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-CPA-CADR-V01-160601

4.8 Miscellaneous End Use

4.8.1 Pump Optimization

DESCRIPTION

Pump improvements can be done to optimize the design and control of centrifugal water pumping systems, including water solutions with freeze protection up to 15% concentration by volume. Other fluid and gas pumps cannot use this measure calculation. The measurement of energy and demand savings for commercial and industrial applications will vary with the type of pumping technology, operating hours, efficiency, and existing and proposed controls. Depending on the specific application slowing the pump, trimming or replacing the impeller may be suitable options for improving pumping efficiency. Pumps up to 40 HP are allowed to use this energy savings calculation. Larger motors should use a custom calculation (which may result in larger savings that this measure would claim).

DEFINITION OF EFFICIENT EQUIPMENT

In order for this characterization to apply, the efficient equipment is proven to be an optimized centrifugal pumping system meeting the applicable program efficiency requirements:

- Pump balancing valves no more than 15% throttled
- Balancing valves on at least one load 100% open.

DEFINITION OF BASELINE EQUIPMENT

In order for this characterization to apply, the baseline equipment is assumed to be the existing pumping system including existing controls and sequence of operations.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 10 years[738]

DEEMED MEASURE COST

The incremental capital cost for this measure can vary considerably depending upon the strategy employed to achieve the required efficiency levels and should be determined on a site-specific basis.

DEEMED O&M COST ADJUSTMENTS

N/A

COINCIDENCE FACTOR

The summer peak coincidence factor for this measure is assumed to be 38%[739]

[738] Martin, N. et al., Emerging Energy-Efficient Industrial Technologies: New York State Edition, American Council for an Energy Efficient Economy (ACEEE), March 2001 (as stated in the OH State TRM, page 269)

[739] Summer Peak Coincidence Factor has been preserved from the “Technical Reference Manual” (TRM) for Ohio Senate Bill 221 Energy Efficiency and Conservation Program and 09-512-GE-UNC,” October 15, 2009. This is likely a conservative estimate, but is recommended for further study (as stated in the OH State TRM, page 269)

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$\Delta kWh = (HP_{motor} * 0.746 * LF / \eta_{motor}) * HOURS * ESF$

Where:

HP_{motor} = Installed nameplate motor horsepower

= Actual

0.746 = Conversion factor from horse-power to kW (kW/hp)

LF / η_{motor} = Combined as a single factor since efficiency is a function of load

= 0.65 [740]

Where:

LF = Load Factor; Ratio of the peak running load to the nameplate rating of the motor

η_{motor} = Motor efficiency at pump operating conditions

HOURS = Annual operating hours of the pump

= Actual

ESF = Energy Savings Factor; assume a value of 15%[741].

[740] "Measured Loading of Energy Efficient Motors - the Missing Link in Engineering Estimates of Savings," ACEEE 1994 Summer Study Conference, Asilomar, CA.

[741] Published estimates of typical pumping efficiency improvements range from 5 to 40%. For analysis purposes, assume 15%. United States Industrial Electric Motor Systems Market Opportunities Assessment December 2002, Table E-7, Page 18, https://www1.eere.energy.gov/manufacturing/tech_assistance/pdfs/mtrmkt.pdf

Summer Coincident Peak Demand Savings

$$\Delta kW = (HP_{motor} * 0.746 * (LF / \eta_{motor})) * (ESF) * CF$$

Where:

CF = Summer Coincident Peak Factor for measure

= 0.38[742]

NATURAL GAS ENERGY SAVINGS

N/A

Water Impact Descriptions and Calculation

N/A

Deemed O&M Cost Adjustment Calculation

N/A

Measure Code: CI-MSC-PMPO-V01-150601

[742] Summer Peak Coincidence Factor has been preserved from the "Technical Reference Manual" (TRM) for Ohio Senate Bill 221 Energy Efficiency and Conservation Program and 09-512-GE-UNC," October 15, 2009. This is likely a conservative estimate, but is recommended for further study (as stated in the OH State TRM, page 269)

4.8.2 Roof Insulation for C&I Facilities

Description

Energy and demand saving are realized through reductions in the building cooling and heating loads. This measure was developed to be applicable to the following program types: RF and NC.

If applied to other program types, the measure savings should be verified.

Definition of Efficient Equipment

The efficient condition is above code and should be determined by the program.

Definition of Baseline Equipment

The retrofit baseline condition is adopted from Ohio Energy Technical Reference Manual and expanded to cover all type of commercial buildings in the state of Illinois as follows.

For retrofits, the R-value for the entire assembly:

Building Type	Retrofit Assembly R-Value
Assembly	13.5
Assisted Living	13.5
College	13.5
Convenience Store	13.5
Elementary School	13.5
Garage	13.5
Grocery	13.5
Healthcare Clinic	13.5
High School	13.5
Hospital	13.5
Hotel/Motel	13.5
Manufacturing Facility	12
MF - High Rise	13.5
MF - Mid Rise	13.5
Movie Theater	13.5
Office - High Rise	13.5
Office - Low Rise	13.5
Office - Mid Rise	13.5
Religious Building	13.5
Restaurant	13.5
Retail - Department Store	13.5
Retail - Strip Mall	13.5

Building Type	Retrofit Assembly R-Value
Warehouse	12
Unknown	13.5

For new construction use R-value from IECC 2012 or ASHRAE – 90.1 – 2010, or use IECCC 2015 or ASHRAE – 90.1 – 2013, depending on the IECC in effect on the date of the building permit (if unknown assume IECC 2015)..

R-Values: ASHRAE – 90.1 – 2010

	IL TRM Zones 1, 2, & 3 [ASHRAE/IECC Climate Zone 5 (A, B, C)]			
	Nonresidential		Semiheated	
	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value
Insulation Entirely Above Deck	0.048	R-20 c.i.	U-0.119	R-7.6 c.i.
Metal Building (Roof)	0.055	R-13.0 + R-13.0	U-0.083	R-13.0
Attic and Other	0.027	R-38.0	U-0.053	R-19.0

	IL TRM Zones 4 & 5 [ASHRAE/IECC Climate Zone 4 (A, B, C)]			
	Nonresidential		Semiheated	
	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value
Insulation Entirely Above Deck	0.048	R-20.0 c.i.	0.173	R-5.0 c.i.
Metal Building (Roof)	0.055	R-13.0 + R-13.0	0.097	R-10.0
Attic and Other	0.027	R-38.0	0.053	R-19.0

Table Notes

c.i. = continuous insulation

R-Values: ASHRAE – 90.1 – 2010

	IL TRM Zones 1, 2, & 3 [ASHRAE/IECC Climate Zone 5 (A, B, C)]			
	Nonresidential		Semiheated	
	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value
Insulation Entirely Above Deck	0.032	R-30.0 c.i.	0.063	R-15 c.i.
Metal Building (Roof)	0.037	R-19 + R-11 Ls or R-25 + R-8 Ls	0.082	R-19
Attic and Other	0.021	R-49	0.034	R-30

	IL TRM Zones 4 & 5 [ASHRAE/IECC Climate Zone 4 (A, B, C)]			
	Nonresidential		Semiheated	
	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value
Insulation Entirely Above Deck	0.032	R-30.0 c.i.	0.093	R-10 c.i.
Metal Building (Roof)	0.037	R-19 + R-11 Ls or R-25 + R-8 Ls	0.082	R-19
Attic and Other	0.021	R-49	0.034	R-30

Table Notes

c.i. = continuous insulation

Ls = linear system, a continuous vapor barrier liner installed below the purlins and uninterrupted by framing members

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure expected useful life (EUL) is assumed to be 20 years per DEER 2008. This is consistent with SDG&E's 9th Year Measure Retrofit Study (1996 & 1997 Residential Weatherization Programs), CPUC's Energy Efficiency Policy Manual v.2, and GDS's Measure Life Report Residential and Commercial/Industrial Lighting and HVAC Measures (June 2007).

DEEMED MEASURE COST

Per the W017 Itron California Measure Cost Study[743], the material cost for R-30 insulation is $0.59 per square foot. The installation cost is $0.81 per square foot. The total measure cost, therefore, is $1.40 per square foot of insulation installed. However, the actual cost should be used when available.

LOADSHAPE

Loadshape C03: Commercial Cooling

COINCIDENCE FACTOR

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

= 91.3% [744]

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

= 47.8% [745]

Algorithm

[743] Measure costs are from the W017 Itron California Measure Cost Study, accessed via http://www.energydataweb.com/cpuc/search.aspx. The data is provided in a file named "MCS Results Matrix – Volume I".

[744] 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.

[745] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year

Calculation of Energy Savings

Electric Energy Savings

Electric energy savings is calculated as the sum of energy saved when cooling the building and energy saved when heating the building

$$\Delta kWh = \Delta kWh\_cooling + \Delta kWh\_heating$$

If central cooling, the electric energy saved in annual cooling due to the added insulation is

$$\Delta kWh\_cooling = ((1/R\_existing) - (1/R\_new)) * Area * EFLH_{cooling} * \Delta T_{AVG,cooling} / 1{,}000 / \eta\_cooling$$

Where:

R_existing = Roof heat loss coefficient with existing insulation [(hr-^{o}F-ft^{2})/Btu]

R_new = Roof heat loss coefficienty with new insulation [(hr-^{o}F-ft^{2})/Btu]

Area = Area of the roof surface in square feet. Assume 1000 sq ft for planning.

$EFLH_{cooling}$ = Equivalent Full Load Hours for Cooling [hr] are provided in Section 4.4, HVAC end use

$\Delta T_{AVG,cooling}$ = Average temperature difference [^{o}F] during cooling season between outdoor air temperature and assumed 75^{o}F indoor air temperature

Climate Zone (City based upon)	$OA_{AVG,cooling}$ [°F][746]	$\Delta T_{AVG,cooling}$ [°F]
1 (Rockford)	81	6
2 (Chicago)	81	6
3 (Springfield)	81	6
4 (Belleville)	82	7
5 (Marion)	82	7

1,000 = Conversion from Btu to kBtu

η_cooling = Seasonal energy efficiency ratio (SEER) of cooling system (kBtu/kWh). Use actual if possible, if unknown and for planning purposes assume the following:

Year Equipment was Installed	SEER estimate
Before 2006	10
After 2006	13

If the building is heated with electric heat (resistance or heat pump), the electric energy saved in annual heating

[746] National Solar Radiation Data Base -- 1991- 2005 Update: Typical Meteorological Year 3 http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/by_state_and_city.html

due to the added insulation is

$$\Delta kWh\_heating = [(1/R\_existing) - (1/R\_new)] * Area * EFLH_{heating} * \Delta T_{AVG,heating} / 3{,}412 / \eta\_heating$$

Where:

$EFLH_{heating}$ = Equivalent Full Load Hours for Heating [hr] are provided in Section 4.4, HVAC end use

$\Delta T_{AVG,heating}$ = Average temperature difference [^oF] during heating season between outdoor air temperature and assumed 55^oF heating base temperature

Climate Zone (City based upon)	$OA_{AVG,heating}$ [°F][747]	$\Delta T_{AVG,heating}$ [°F]
1 (Rockford)	32	23
2 (Chicago)	34	21
3 (Springfield)	35	20
4 (Belleville)	36	19
5 (Marion)	39	16

3,142 = Conversion from Btu to kWh.

η_heating = Efficiency of heating system. Use actual efficiency. If not available refer to default table below.

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

If the building is heated with a gas furnace, there will be some electric savings in heating the building attributed to extra insulation since the furnace fans will run less.

$$\Delta kWh\_heating = \Delta Therms * Fe * 29.3$$

Where:

ΔTherms = Gas savings calculated with equation below.

Fe = Percentage of heating energy consumed by fans, assume 3.14%

29.3 = Conversion from therms to kWh

[747] National Solar Radiation Data Base -- 1991- 2005 Update: Typical Meteorological Year 3 http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/by_state_and_city.html

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = (\Delta kWh\_cooling / EFLH\_cooling) * CF$$

Where:

$EFLH_{cooling}$ = Equivalent full load hours of air conditioning are provided in Section 4.4, HVAC end use

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

= 91.3% [748]

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

= 47.8% [749]

NATURAL GAS SAVINGS

If building uses a gas furnace, the savings resulting from the insulation is calculated with the following formula.

$$\Delta Therms = ((1/R\_existing) - (1/R\_new)) * Area * EFLH_{heating} * \Delta T_{AVG,heating} / 100,000 / \eta\_heat$$

Where:

R_existing = Roof heat loss coefficient with existing insulation [(hr-^{o}F-ft^{2})/Btu]

R_new = Roof heat loss coefficienty with new insulation [(hr-^{o}F-ft^{2})/Btu]

Area = Area of the roof surface in square feet. Assume 1000 sq ft for planning.

$EFLH_{heating}$ = Equvalent Full Load Hours for Heating are provided in Section 4.4, HVAC end use

$\Delta T_{AVG,heating}$ = Average temperature difference [^{o}F] during heating season (see above)

100,000 = Conversion from BTUs to Therms

η_heat = Efficiency of existing furnace. Assume 0.78 for planning purposes.

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

[748] 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.

[749] 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

MEASURE CODE: CI-MSC-RINS-V02-160601

4.8.3 Computer Power Management Software

DESCRIPTION

Computer power management software is installed on a network of computers. This is software which monitors and records computer and monitor usage, as well as allows centralized control of computer power management settings.

DEFINITION OF EFFICIENT EQUIPMENT

The efficient equipment is defined by the requirements listed below:

- Allow centralized control and override of computer power management settings of workstations which include both a computer monitor and CPU (i.e. a desktop or laptop computer on a distributed network)
- Be able to control on/off/sleep states on both the CPU and monitor according to the Network Administrator-defined schedules and apply power management policies to network groups
- Have capability to allow networked workstations to be remotely wakened from power-saving mode (e.g. for system maintenance or power/setting adjustments)
- Have capability to detect and monitor power management performance and generate energy savings reports
- Have capability to produce system reports to confirm the inventory and performance of equipment on which the software is installed.

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

DEFINITION OF BASELINE EQUIPMENT

Baseline is defined as a computer network without software enforcing the power management capabilities in existing computers and monitors.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is five years.[750]

DEEMED MEASURE COST

The deemed measure cost is $29 per networked computer, including labor.[751]

LOADSHAPE

Loadshape C21: Commercial Office Equipment.

COINCIDENCE FACTOR

NA

[750] The following reference uses 10 years, however, given the rapid changes in the technology industry, there is quite a lot of uncertainty about the measure life and a more conservative value was used (i.e. half the published measure life): Table VI.1: Dimetrosky, S., Luedtke, J. S., & Seiden, K. (2005). Surveyor Network Energy Manager: Market Progress Evaluation Report, No. 2 (Northwest Energy Efficiency Alliance report #E05-136). Portland, OR: Quantec LLC;).

[751] Work Paper WPSCNROE0003 Revision 1, Power Management Software for Networked Computers. Southern California Edison

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = Wsavings * W$$

Where:

Wsavings = annual energy savings per workstation

= 200 kWh[752] for desktops, 50 kWh for laptops[753]

= If unknown assume 161 kWh (based on 74% desktop and 26% laptop[754])

W = number of desktop or laptop workstations controlled by the power management software

SUMMER COINCIDENT PEAK DEMAND SAVINGS

NA

NATURAL GAS SAVING

NA

WATER IMPACT DESCRIPTIONS AND CALCULATION

NA

DEEMED O&M COST ADJUSTMENT CALCULATION

Assumed to be $2/unit [755]

MEASURE CODE: CI-MSC-CPMS-V01-150601

---

[752] Based on average energy savings/computer from the following sources:
South California Edison, Work Paper WPSCNROE0003 (200k Wh)
Surveyor Network Energy Manager Evaluation Report , NEEA (68, 100, and 128kWh)
Regional Technical Forum http://rtf.nwcouncil.org/measures/measure.asp?id=95 (200 kWh)
EnergySTAR Computer Power Management Savings Calculator (~190 kWh for a mix of laptop/desktop and assuming 30% are already turned off at night)
http://www.energystar.gov/ia/products/power_mgt/LowCarbonITSavingsCalc.xlsx?78c1-120e&78c1-120e
Power Management for Networked Computers: A Review of Utility Incentive Programs J. Michael Walker, Beacon Consultants Network Inc., 2009 ACEEE Summer Study on Energy Efficiency in Industry (330 kWh)

[753] Power Management for Networked Computers: A Review of Utility Incentive Programs J. Michael Walker, Beacon Consultants Network Inc., 2009 ACEEE Summer Study on Energy Efficiency in Industry

[754] Based on PY6 ComEd Computer Software Program data showing a split of 74% desktop to 26% laptop.

[755] Based on Dimetrosky, S., Luedtke, J. S., & Seiden, K. (2005). Surveyor Network Energy Manager: Market Progress Evaluation Report, No. 2 (Northwest Energy Efficiency Alliance report #E05-136). Portland, OR: Quantec LLC and review of CLEARResult document providing Qualifying Software Providers for ComEd program and their licensing fees; “Qualifying Vendor Software Comparison.pdf”.

4.8.4 Modulating Commercial Gas Clothes Dryer

DESCRIPTION

This measure relates to the installation of a two-stage modulating gas valve retrofit kit on a standard commercial non-modulating gas dryer. Commercial gas clothes dryers found in coin-operated laundromats or on-premise laundromats (hospitals, hotels, health clubs, etc.) traditionally have a single firing rate which is sized properly for highest heat required in initial drying stages but is oversized for later drying stages requiring lesser heat. This causes the burner to cycle on/off frequently, resulting in less efficient drying and wasted gas. Replacing the single stage gas valve with a two-stage gas valve allows the firing rate to adjust to the changing heat demand, thereby reducing overall gas consumption.

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

A 30 to 250 pound capacity commercial gas dryer retrofitted with a two-stage modulating gas valve kit.

DEFINITION OF BASELINE EQUIPMENT

A 30 to 250 pound capacity commercial gas dryer with no modulating capabilities.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The deemed measure life for the retrofit kit is 14 years, assumed to be equal to that of a commercial gas dryer[756].

DEEMED MEASURE COST

The full retrofit cost is assumed to be $700, including the material cost for the basic modulating gas valve retrofit kit ($600) and the associated of labor for installation ($100)[757].

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

[756] Zhang, Yanda, and Julianna Wei. *Commerical Clothes Dryers, CASE Initiative for PY2013: Title 20 Standards Development.* California Public Utilities Commission, 2013.

[757] Engineering judgement, based on observed costs during Nicor Gas pilot study. "Nicor Gas Emerging Technology Program, 1036: Commercial Dryer Modulation Retrofit Public Project Report." 2014.

Algorithm

Calculation of Savings

Electric Energy Savings

N/A

Summer Coincident Peak Demand Savings

N/A

Natural Gas Energy Savings

Note: Accurately estimating dryer energy consumption is complicated and challenging due to a variety of factors that influence cycle times and characteristics and ultimately drying energy requirements. Clothing loads can vary by weight, volume, fiber composition, physical structure, and initial water content, meaning that for any given cycle drying energy requirements can differ. Additionally, dryer settings selected by the user as well as interactions with the site's HVAC systems are known to influence dryer performance. As better information becomes available, this characterization can be modified to allow for a more site-specific estimation of savings.

$$\Delta Therms = N_{Cycles} * SF$$

Where:

N_{Cycles} = Number of dryer cycles per year. Refer to the table below if this value is not directly available.

Application	Cycles per Year
Coin- Operated Laundromats[758]	1,483
Multi-family Dryers[759]	1,074
On-Premise Laundromats[760]	3,607

SF = Savings factor

= 0.18 therms/cycle[761]

If using default cycles the savings are as follows:

Application	ΔTherms
Coin- Operated Laundromats[762]	267
Multi-family Dryers[763]	193
On-Premise Laundromats[764]	649

[758] From DOE's Federal Register Notices - found here: http://energy.gov/eere/buildings/recent-federal-register-notices
[759] Ibid.
[760] Average value for dryer cycles in healthcare facility, hotels, drycleaners and laundromats from tests conducted in Nicor Gas Emerging Technology Program's Commercial Dryer Modulation Retrofit Public Project Report.
[761] Based on Illinois weather data, and average dryer performance for laundromat (30 to 45lb) and hotel (75 to 170 lb) dryers. See GTI Analysis.xlsx for complete derivation.
[762] From DOE's Federal Register Notices - found here: http://energy.gov/eere/buildings/recent-federal-register-notices
[763] Ibid.
[764] Average value for dryer cycles in healthcare facility, hotels, drycleaners and laundromats from tests conducted in Nicor Gas Emerging Technology Program's Commercial Dryer Modulation Retrofit Public Project Report.

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

Measure Code: CI-MSC-MODD-V01-160601

Illinois Statewide Technical Reference Manual for Energy Efficiency

Version 5.0

Volume 3: Residential Measures

Final

February 11th, 2016

Effective:

June 1st, 2016

[INTENTIONALLY LEFT BLANK]

VOLUME 1: OVERVIEW AND USER GUIDE

VOLUME 2: COMMERCIAL AND INDUSTRIAL MEASURES

VOLUME 3: RESIDENTIAL MEASURES 5

5.1 Appliances End Use 5

5.1.1 ENERGY STAR Air Purifier/Cleaner 5

5.1.2 ENERGY STAR and ENERGY STAR Most Efficient Clothes Washers 8

5.1.3 ENERGY STAR Dehumidifier 15

5.1.4 ENERGY STAR Dishwasher 19

5.1.5 ENERGY STAR Freezer 24

5.1.6 ENERGY STAR and CEE Tier 2 Refrigerator 28

5.1.7 ENERGY STAR Room Air Conditioner 35

5.1.8 Refrigerator and Freezer Recycling 40

5.1.9 Room Air Conditioner Recycling 45

5.1.10 ENERGY STAR Clothes Dryer 48

5.2 Consumer Electronics End Use 52

5.2.1 Advanced Power Strip – Tier 1 52

5.2.2 Tier 2 Advanced Power Strips (APS) – Residential Audio Visual 54

5.3 HVAC End Use 58

5.3.1 Air Source Heat Pump 58

5.3.2 Boiler Pipe Insulation 66

5.3.3 Central Air Conditioning > 14.5 SEER 69

5.3.4 Duct Insulation and Sealing 75

5.3.5 Furnace Blower Motor 89

5.3.6 Gas High Efficiency Boiler 93

5.3.7 Gas High Efficiency Furnace 98

5.3.8 Ground Source Heat Pump 103

5.3.9 High Efficiency Bathroom Exhaust Fan 121

5.3.10 HVAC Tune Up (Central Air Conditioning or Air Source Heat Pump) 124

5.3.11 Programmable Thermostats 129

5.3.12 Ductless Heat Pumps 134

5.3.13 Residential Furnace Tune-Up 140

5.3.14 Boiler Reset Controls 144

5.3.15 ENERGY STAR Ceiling Fan 147

5.3.16 Advanced Thermostats 152

5.4 Hot Water End Use 160

5.4.1 Domestic Hot Water Pipe Insulation 160

5.4.2 Gas Water Heater 164

5.4.3 Heat Pump Water Heaters 168

5.4.4 Low Flow Faucet Aerators 174

5.4.5 Low Flow Showerheads 183

5.4.6 Water Heater Temperature Setback 190

5.4.7 Water Heater Wrap 194

5.4.8 Thermostatic Restrictor Shower Valve 198

5.5 Lighting End Use 205

5.5.1 ENERGY STAR Compact Fluorescent Lamp (CFL) 205

5.5.2 ENERGY STAR Specialty Compact Fluorescent Lamp (CFL) 214

5.5.3 ENERGY STAR Torchiere 226

5.5.4 Exterior Hardwired Compact Fluorescent Lamp (CFL) Fixture 231

5.5.5 Interior Hardwired Compact Fluorescent Lamp (CFL) Fixture 236

5.5.6 LED Specialty Lamps 243

5.5.7 LED Exit Signs 254

5.5.8 LED Screw Based Omnidirectional Bulbs 258

5.6 Shell End Use 267

5.6.1 Air Sealing 267

5.6.2 Basement Sidewall Insulation 278

5.6.3 Floor Insulation Above Crawlspace 286

5.6.4 Wall and Ceiling/Attic Insulation 293

VOLUME 4: CROSS-CUTTING MEASURES AND ATTACHMENTS

ATTACHMENT A: ILLINOIS STATEWIDE NET-TO-GROSS METHODOLOGIES

Volume 3: 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[1] 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[2].

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure life is assumed to be 9 years[3].

DEEMED MEASURE COST

The incremental cost for this measure is $70.[4]

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).

---

[1] Measured according to the latest ANSI/AHAM AC-1 (AC-1) Standard

[2] As defined as the average of non-ENERGY STAR products found in EPA research, 2011, ENERGY STAR Qualified Room Air Cleaner Calculator.

[3] ENERGY STAR Qualified Room Air Cleaner Calculator.

[4] Ibid

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$\Delta kWh = kWh_{Base} - kWh_{ESTAR}$

Where:

kWh_{BASE} = Baseline kWh consumption per year[5]

= see table below

kWh_{ESTAR} = ENERGY STAR kWh consumption per year[6]

= see table below

Clean Air Delivery Rate (CADR)	CADR used in calculation (midpoint)	Baseline Unit Energy Consumption (kWh/year)	ENERGY STAR Unit Energy Consumption (kWh/year)	ΔkWH
CADR 51-100	75	441	148	293
CADR 101-150	125	733	245	488
CADR 151-200	175	1025	342	683
CADR 201-250	225	1317	440	877
CADR Over 250	300	1755	586	1169

SUMMER COINCIDENT PEAK DEMAND SAVINGS

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

Where:

ΔkWh = Gross customer annual kWh savings for the measure

Hours = Average hours of use per year

= 5844 hours[7]

CF = Summer Peak Coincidence Factor for measure

= 66.7%[8]

Clean Air Delivery Rate	ΔkW
CADR 51-100	0.033
CADR 101-150	0.056
CADR 151-200	0.078

[5] ENERGY STAR Qualified Room Air Cleaner Calculator.

[6] Ibid.

[7] Consistent with ENERGY STAR Qualified Room Air Cleaner Calculator assumption of 16 hours per day (16 * 365.25 = 5844).

[8] Assumes that the purifier usage is evenly spread throughout the year, therefore coincident peak is calculated as 5844/8766 = 66.7%.

Clean Air Delivery Rate	ΔkW
CADR 201-250	0.100
CADR Over 250	0.133

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.[9]

MEASURE CODE: RS-APL-ESAP-V02-160601

[9] Some types of room air cleaners require filter replacement or periodic cleaning, but this is likely to be true for both efficient and baseline units and so no difference in cost is assumed.

5.1.2 ENERGY STAR and ENERGY STAR Most Efficient Clothes Washers

Description

This measure relates to the installation of a clothes washer meeting the ENERGY STAR, or ENERGY STAR Most Efficient minimum qualifications. Note if the DHW and dryer fuels of the installations are unknown (for example through a retail program) savings should be based on a weighted blend using RECS data (the resultant values (kWh, therms and gallons of water) are provided). The algorithms can also be used to calculate site specific savings where DHW and dryer fuels are known.

This measure was developed to be applicable to the following program types: TOS, NC.

If applied to other program types, the measure savings should be verified.

Definition of Efficient Equipment

Clothes washer must meet the ENERGY STAR or ENERGY STAR Most Efficient minimum qualifications, as required by the program.

Definition of Baseline Equipment

The baseline condition is a standard sized clothes washer meeting the minimum federal baseline as of March 2015[10].

Efficiency Level	Top loading >2.5 Cu ft	Front Loading >2.5 Cu ft
Federal Standard	1.29 IMEF, 8.4 IWF	1.84 IMEF, 4.7 IWF
ENERGY STAR	2.06 IMEF, 4.3 IWF	2.38 IMEF, 3.7 IWF
ENERGY STAR Most Efficient	2.76 IMEF, 3.5 IWF	2.74 IMEF, 3.2IWF

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 14 years[11].

Deemed Measure Cost

The incremental cost for an ENERGY STAR unit is assumed to be $65 and for an ENERGY STAR Most Efficient unit it is $210[12].

---

[10] See http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/39.

[11] 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

[12] Cost estimates are based on Navigant analysis for the Department of Energy (see CW Analysis_09092014.xls). This analysis looked at incremental cost and shipment data from manufacturers and the Association of Home Appliance Manufacturers and attempts to find the costs associated only with the efficiency improvements. The ENERGY STAR level in this analysis was made the baseline (as it is now equivalent), the CEE Tier 3 level was made ENERGY STAR and ENERGY STAR Most efficient was extrapolated based on equal rates. Note these assumptions should be reviewed as qualifying product becomes available.

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape R01 - Residential Clothes Washer

COINCIDENCE FACTOR

The coincidence factor for this measure is 3.8%[13].

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"* [14].

   The hot water and dryer savings calculated here assumes electric DHW and Dryer (this will be separated in Step 2).

IMEFsavings[15] = Capacity * (1/IMEFbase - 1/IMEFeff) * Ncycles

Where

Capacity = Clothes Washer capacity (cubic feet)

= Actual. If capacity is unknown assume 3.45 cubic feet [16]

IMEFbase = Integrated Modified Energy Factor of baseline unit

= 1.66[17]

IMEFeff = Integrated Modified Energy Factor of efficient unit

= Actual. If unknown assume average values provided below.

[13] Calculated from Itron eShapes, 8760 hourly data by end use for Missouri, as provided by Ameren.

[14] Definition provided on the Energy star website.

[15] IMEFsavings represents total kWh only when water heating and drying are 100% electric.

[16] Based on the average clothes washer volume of all units that pass the new Federal Standard on the California Energy Commission (CEC) database of Clothes Washer products accessed on 08/28/2014. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area then that should be used.

[17] Weighted average IMEF of Federal Standard rating for Front Loading and Top Loading units. Weighting is based upon the relative top v front loading percentage of available non-ENERGY STAR product in the CEC database.

Ncycles = Number of Cycles per year

= 295[18]

IMEFsavings is provided below based on deemed values[19]:

Efficiency Level	IMEF	IMEFSavings (kWh)
Federal Standard	1.66	0.0
ENERGY STAR	2.26	163
ENERGY STAR Most Efficient	2.74	242

2. Break out savings calculated in Step 1 for electric DHW and electric dryer

ΔkWh = [Capacity * 1/IMEFbase * Ncycles * (%CWbase + (%DHWbase * %Electric_DHW) + (%Dryerbase * %Electric_Dryer))] - [Capacity * 1/IMEFeff * 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[20]		
	%CW	%DHW	%Dryer
Baseline	7.6%	31.2%	61.2%
ENERGY STAR	8.1%	23.4%	68.5%
ENERGY STAR Most Efficient	13.6%	10%	76.3%

[18] 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.

[19] IMEF values are the weighted average of the new ENERGY STAR specifications. Weighting is based upon the relative top v front loading percentage of available ENERGY STAR and ENERGY STAR Most Efficient product in the CEC database. See "CW Analysis_01142016.xls" for the calculation.

[20] 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 weighted average of top loading and front loading units based on data from DOE Life-Cycle Cost and Payback Period Excel-based analytical tool. See "CW Analysis_01142016.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%[21]

%Electric_Dryer = Percentage of dryer savings assumed to be electric

Dryer fuel	%Electric_Dryer
Electric	100%
Natural Gas	0%
Unknown	36%[22]

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	Electric DHW Unknown Dryer	Gas DHW Unknown Dryer	Unknown DHW Electric Dryer	Unknown DHW Gas Dryer	Unknown DHW Unknown Dryer
ENERGY STAR	162.7	77.0	96.0	10.2	120.0	34.3	90.7	24.0	48.0
ENERGY STAR Most Efficient	242.1	88.2	149.9	-4.0	183.1	29.2	112.8	20.6	53.8

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ΔkWh/Hours * CF

Where:

ΔkWh = Energy Savings as calculated above

Hours = Assumed Run hours of Clothes Washer

[21] 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

[22] 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.

= 295 hours[23]

CF = Summer Peak Coincidence Factor for measure.

= 0.038[24]

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	Electric DHW Unknown Dryer	Gas DHW Unknown Dryer	Unknown DHW Electric Dryer	Unknown DHW Gas Dryer	Unknown DHW Unknown Dryer
ENERGY STAR	0.0210	0.0099	0.0124	0.0013	0.0155	0.0044	0.0117	0.0031	0.0062
ENERGY STAR Most Efficient	0.0312	0.0114	0.0193	-0.0005	0.0236	0.0038	0.0145	0.0027	0.0069

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/IMEFbase * Ncycles * ((%DHWbase * %Natural Gas_DHW * R_eff) + (%Dryerbase * %Gas _Dryer))) – (Capacity * 1/IMEFeff * 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[25]

%Natural Gas_DHW = Percentage of DHW savings assumed to be Natural Gas

[23] 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/)

[24] Calculated from Itron eShapes, 8760 hourly data by end use for Missouri, as provided by Ameren.

[25] 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.

DHW fuel	%Natural Gas_DHW
Electric	0%
Natural Gas	100%
Unknown	84%[26]

%Gas_Dryer = Percentage of dryer savings assumed to be Natural Gas

Dryer fuel	%Gas_Dryer
Electric	0%
Natural Gas	100%
Unknown	58%[27]

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	Electric DHW Unknown Dryer	Gas DHW Unknown Dryer	Unknown DHW Electric Dryer	Unknown DHW Gas Dryer	Unknown DHW Unknown Dryer
ENERGY STAR	0.00	3.7	2.3	6.0	1.3	5.0	3.1	5.4	4.4
ENERGY STAR Most Efficient	0.00	6.6	3.1	9.8	1.8	8.4	5.6	8.7	7.4

WATER IMPACT DESCRIPTIONS AND CALCULATION

ΔWater (gallons) = Capacity * (IWFbase - IWFeff) * Ncycles

Where

IWFbase = Integrated Water Factor of baseline clothes washer

= 5.92[28]

IWFeff = Water Factor of efficient clothes washer

[26] 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
[27] Ibid.
[28] Weighted average IWF of Federal Standard rating for Front Loading and Top Loading units. Weighting is based upon the relative top v front loading percentage of available non-ENERGY STAR product in the CEC database.

= 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	IWF[29]	ΔWater (gallons per year)
Federal Standard	5.92	0.0
ENERGY STAR	3.93	2024
ENERGY STAR Most Efficient	3.21	2760

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-APL-ESCL-V04-160601

[29] IWF values are the weighted average of the new ENERGY STAR specifications. Weighting is based upon the relative top v front loading percentage of available ENERGY STAR and ENERGY STAR Most Efficient product in the CEC database. See “CW Analysis_01142016.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 3.0 (effective 10/1/2012)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:

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 as of October 2012 is defined below:

Capacity (pints/day)	Federal Standard Criteria (L/kWh)
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[30].

Deemed Measure Cost

The assumed incremental capital cost for this measure is $60[31].

[30] EPA Research, 2012; ENERGY STAR Dehumidifier Calculator

[31] Based on extrapolating available data from the Department of Energy's Life Cycle Cost analysis spreadsheet and weighting based on volume of units available:
See 'DOE life cycle cost dehumidifier.xls' for calculation.

LOADSHAPE

Loadshape R12 - Residential - Dehumidifier

COINCIDENCE FACTOR

The coincidence factor is assumed to be 37% [32].

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = (((Avg\ Capacity * 0.473) / 24) * Hours) * (1 / (L/kWh\_Base) - 1 / (L/kWh\_Eff))$$

Where:

Avg Capacity = Average capacity of the unit (pints/day)

= Actual, if unknown assume capacity in each capacity range as provided in table below, or if capacity range unknown assume average.

0.473 = Constant to convert Pints to Liters

24 = Constant to convert Liters/day to Liters/hour

Hours = Run hours per year

= 1632 [33]

L/kWh = Liters of water per kWh consumed, as provided in tables above

Annual kWh results for each capacity class are presented below:

Capacity Range (pints/day)	Capacity Used (pints/day)	Federal Standard Criteria (≥ L/kWh)	ENERGY STAR Criteria (≥ L/kWh)	Annual kWh		
				Federal Standard	ENERGY STAR	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

[32] Assume usage is evenly distributed day vs. night, weekend vs. weekday and is used between April through the end of September (4392 possible hours). 1632 operating hours from ENERGY STAR Dehumidifier Calculator. Coincidence peak during summer peak is therefore 1632/4392 = 37.2%

[33] ENERGY STAR Dehumidifier Calculator; 24 hour operation over 68 days of the year.

Capacity Range (pints/day)	Capacity Used (pints/day)	Federal Standard Criteria (≥ L/kWh)	ENERGY STAR Criteria (≥ L/kWh)	Annual kWh		
				Federal Standard	ENERGY STAR	Savings
Average[34]						140

Summer Coincident Peak Demand Savings

ΔkW = ΔkWh/Hours * CF

Where:

Hours = Annual operating hours

= 1632 hours [35]

CF = Summer Peak Coincidence Factor for measure

= 0.37 [36]

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

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	0.032

NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

[34] The relative weighting of each product class is based on number of units on the ENERGY STAR certified list. See “Dehumidifier Calcs.xls.

[35] Based on 68 days of 24 hour operation; ENERGY STAR Dehumidifier Calculator

[36] Assume usage is evenly distributed day vs. night, weekend vs. weekday and is used between April through the end of September (4392 possible hours). 1632 operating hours from ENERGY STAR Dehumidifier Calculator. Coincidence peak during summer peak is therefore 1632/4392 = 37.2%

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-APL-ESDH-V03-160601

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. The Energy Star standard is presented in the table below:

Dishwasher Type	Maximum kWh/year	Maximum gallons/cycle
Standard (≥ 8 place settings + six serving pieces)	270	3.5
Standard with Connected Functionality[37]	283	
Compact (< 8 place settings + six serving pieces)	203	3.1

DEFINITION OF BASELINE EQUIPMENT

The Baseline reflects the minimum federal efficiency standards for dishwashers effective May 30, 2013, as presented in the table below[38].

Dishwasher Type	Maximum kWh/year	Maximum gallons/cycle
Standard	307	5.0
Compact	222	3.5

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The assumed lifetime of the measure is 13 years[39].

[37] The new ENERGY STAR specification "establishes optional connected criteria for dishwashers. ENERGY STAR certified dishwashers with connected functionality offer favorable attributes for demand response programs to consider, since their peak energy consumption is relatively high, driven by water heating. ENERGY STAR certified dishwashers with connected functionality will offer consumers new convenience and energy-saving features, such as alerts for cycle completion and/or recommended maintenance, as well as feedback on the energy use of the product". See 'ENERGY STAR Residential Dishwasher Final Version 6.0 Cover Memo.pdf'. Calculated as per Version 6.0 specification; "ENERGY STAR Residential Dishwasher Version 6.0 Final Program Requirements.pdf". Note that the potential for demand response and additional peak savings from units with Connected Functionality have not been explored. This could be a potential addition in a future version.

[38] http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/67

[39] Koomey, Jonathan et al. (Lawrence Berkeley National Lab), Projected Regional Impacts of Appliance Efficiency Standards for the U.S. Residential Sector, February 1998.

Deemed Measure Cost

The incremental cost for this measure is $50[40].

Loadshape

Loadshape R02 - Residential Dish Washer

Coincidence Factor

The coincidence factor is assumed to be 2.6%[41].

Algorithm

Calculation of Savings

Electric Energy Savings

$$\Delta kWh^{42} = ((kWh_{Base} - kWh_{ESTAR}) * (\%kWh\_op + (\%kWh\_heat * \%Electric\_DHW)))$$

Where:

kWh_{BASE} = Baseline kWh consumption per year

Dishwasher Type	Maximum kWh/year
Standard	307
Compact	222

kWh_{ESTAR} = ENERGY STAR kWh annual consumption

Dishwasher Type	Maximum kWh/year
Standard	270
Standard with Connected Functionality	283
Compact	203

%kWh_op = Percentage of dishwasher energy consumption used for unit operation

= 1 - 56%[43]

= 44%

%kWh_heat = Percentage of dishwasher energy consumption used for water heating

[40] Estimate based on review of Energy Star stakeholder documents
[41] Calculated from Itron eShapes, 8760 hourly data by end use for Missouri, as provided by Ameren.
[42] 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.
[43] ENERGY STAR Dishwasher Calculator (http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDishwasher.xls)

= 56%[44]

%Electric_DHW = Percentage of DHW savings assumed to be electric

DHW fuel	%Electric_DHW
Electric	100%
Natural Gas	0%
Unknown	16%[45]

Dishwasher Type	ΔkWh		
	With Electric DHW	With Gas DHW	With Unknown DHW
ENERGY STAR Standard	37.0	16.3	19.6
ENERGY STAR Standard with Connected Functionality	24.0	10.6	12.7
ENERGY STAR Compact	19.0	8.4	10.1

SUMMER COINCIDENT PEAK DEMAND SAVINGS[46]

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

Where:

Hours = Annual operating hours[47]

= 252 hours

CF = Summer Peak Coincidence Factor

= 2.6% [48]

Dishwasher Type	ΔkW		
	With Electric DHW	With Gas DHW	With Unknown DHW

[44] Ibid.

[45] 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.

[46] Note that the potential for demand response and additional peak savings from units with Connected Functionality have not been explored. This could be a potential addition in a future version.

[47] 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/

[48] End use data from Ameren representing the average DW load during peak hours/peak load.

ENERGY STAR Standard	0.0038	0.0017	0.0020
ENERGY STAR Standard with Connected Functionality	0.0025	0.0011	0.0013
ENERGY STAR Compact	0.0020	0.0009	0.0010

NATURAL GAS SAVINGS

$$\Delta \text{ Therm} = (kWh_{Base} - kWh_{ESTAR}) * \%kWh\_heat * \%Natural\ Gas\_DHW * R\_eff * 0.03413$$

Where

%kWh_heat = % of dishwasher energy used for water heating

= 56%

%Natural Gas_DHW = Percentage of DHW savings assumed to be Natural Gas

DHW fuel	%Natural Gas_DHW
Electric	0%
Natural Gas	100%
Unknown	84%[49]

R_eff = Recovery efficiency factor

= 1.26[50]

0.03413 = factor to convert from kWh to Therm

Dishwasher Type	ΔTherms		
	With Electric DHW	With Gas DHW	With Unknown DHW
ENERGY STAR Standard	0.00	0.89	0.75
ENERGY STAR Standard with Connected Functionality	0.00	0.58	0.49
ENERGY STAR Compact	0.00	0.46	0.38

WATER IMPACT DESCRIPTIONS AND CALCULATION

$$\Delta Water = Water_{Base} - Water_{EFF}$$

[49] 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.

[50] 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.

Where

$Water_{Base}$ = water consumption of conventional unit

Dishwasher Type	$Water_{Base}$ (gallons) [51]
Standard	840
Compact	588

$Water_{EFF}$ = annual water consumption of efficient unit:

Dishwasher Type	$Water_{EFF}$ (gallons) [52]
Standard	588
Compact	521

Dishwasher Type	ΔWater (gallons) [53]
Standard	252
Compact	67

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-APL-ESDI-V03-160601

[51] Assuming maximum allowed from specifications 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/

[52] Assuming maximum allowed from specifications 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/

[53] Assuming maximum allowed from specifications 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[54]	ENERGY STAR Maximum Energy Usage in kWh/year[55]	Federal Baseline Maximum Energy Usage in kWh/year[56]	ENERGY STAR Maximum Energy Usage in kWh/year[57]
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:

[54] http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/43
[55] http://www.energystar.gov/ia/products/appliances/refrig/NAECA_calculation.xls?c827-f746
[56] http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/43
[57]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[58].

DEEMED MEASURE COST

The incremental cost for this measure is $35[59].

LOADSHAPE

Loadshape R04 - Residential Freezer

COINCIDENCE FACTOR

The summer peak coincidence factor for this measure is assumed to be 95%[60].

[58] Energy Star Freezer Calculator; http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Consumer_Residential_Freezer_Sav_Calc.xls?570a-f000
[59] 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.
[60] Based on eShapes Residential Freezer load data as provided by Ameren.

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.

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:

$$\Delta kWh = (5.57*(7.75*1.73)+193.7) - (5.01*(7.75*1.73)+174.3)$$

$$= 268.4 - 241.5$$

$$= 26.9 \text{ kWh}$$

If volume is unknown, use the following default values:

Product Category	Volume Used[61]	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

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

Where:

ΔkWh = Gross customer annual kWh savings for the measure

[61] Volume is based on ENERGY STAR Calculator assumption of 16.14 ft^3 average volume, converted to Adjusted volume by multiplying by 1.73.

Hours = Full Load hours per year

= 5890[62]

CF = Summer Peak Coincident Factor

= 0.95 [63]

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

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-APL-ESFR-V02-140601

[62] Calculated from eShapes Residential Freezer load data as provided by Ameren by dividing total annual load by the maximum kW in any one hour.

[63] Based on eShapes Residential Freezer load data as provided by Ameren.

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[64]	ENERGY STAR Maximum Energy Usage in kWh/year[65]	Federal Baseline Maximum Energy Usage in kWh/year[66]	ENERGY STAR Maximum Energy Usage in kWh/year[67]
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 without through-the-door ice service		4.91*AV+507.5	3.928*AV+406	8.51AV + 297.8	7.66 * AV + 268.0

[64] http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/43
[65] http://www.energystar.gov/ia/products/appliances/refrig/NAECA_calculation.xls?c827-f746
[66] http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/43
[67] 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[64]	ENERGY STAR Maximum Energy Usage in kWh/year[65]	Federal Baseline Maximum Energy Usage in kWh/year[66]	ENERGY STAR Maximum Energy Usage in kWh/year[67]
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.[68]

Remaining life of existing equipment is assumed to be 4 years[69]

DEEMED MEASURE COST

Time of Sale: The incremental cost for this measure is assumed to be $40[70] for an ENERGY STAR unit and $140[71] 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[72].

The avoided replacement cost (after 4 years) of a baseline replacement refrigerator is $413[73].

LOADSHAPE

Loadshape R05 - Residential Refrigerator

COINCIDENCE FACTOR

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

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS:

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

68 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

69 Standard assumption of one third of effective useful life.

70 From ENERGY STAR calculator linked above.

71 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

72 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.

73 Calculated using incremental cost from Time of Sale measure and applying inflation rate of 1.91%.

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[74]:

Assumptions prior to standard changes on September 1st, 2014:

Product Category	Existing Unit UEC_{EXIST} [75]	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
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-	1241.0	666.3	533.0	499.7	707.9	741.3	133.3	166.6

74 Volume is based on the ENERGY STAR calculator average assumption of 14.75 ft^3 fresh volume and 6.76 ft^3 freezer volume.
75 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} [75]	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
mounted freezer with through-the-door ice service								

Assumptions after standard changes on September 1st, 2014:

Product Category	Existing Unit UEC_{EXIST} [76]	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

[76] 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} [76]	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
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

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = (ΔkWh/8766) * TAF * LSAF

Where:

TAF = Temperature Adjustment Factor

= 1.25[77]

LSAF = Load Shape Adjustment Factor

= 1.057 [78]

If volume is unknown, use the following defaults:

[77] 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 have 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)

[78] 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)

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-V04-160601

5.1.7 ENERGY STAR Room Air Conditioner

DESCRIPTION

This measure relates to:

a) Time of Sale the purchase and installation of a room air conditioning unit that meets ENERGY STAR version 4.0 which is effective October 26th 2015), in place of a baseline unit. The baseline is based on the Federal Standard effective June 1st, 2014.

Product Type and Class (Btu/hr)		Federal Standard with louvered sides (CEER) [79]	Federal Standard without louvered sides (CEER)	ENERGY STAR v4.0 with louvered sides (CEER) [80]	ENERGY STAR v4.0 without louvered sides (CEER)
Without Reverse Cycle	< 8,000	11.0	10.0	11.5	10.5
	8,000 to 10,999	10.9	9.6	11.4	10.1
	11,000 to 13,999	10.9	9.5	11.4	10.0
	14,000 to 19,999	10.7	9.3	11.2	9.7
	20,000 to 24,999	9.4	9.4	9.8	9.8
	>=25,000	9.0	9.4	9.4	9.8
With Reverse Cycle	<14,000	9.8	9.3	10.3	9.7
	14,000 to 19,999	9.8	8.7	10.3	9.1
	>=20,000	9.3	8.7	9.7	9.1
Casement only		9.5		10.0	
Casement-Slider		10.4		10.8	

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.

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 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.

---

[79] See DOE's Appliance and Equipment Standards for Room AC; https://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/41

[80] ENERGY STAR Version 4.0 Room Air Conditioners Program Requirements

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 version 4.0 (effective October 26th 2015)[81] efficiency standards presented above.

Definition of Baseline Equipment

Time of Sale: the baseline assumption is a new room air conditioning unit that meets the Federal Standard (effective June 1st, 2014)[82] 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[83].

Remaining life of existing equipment is assumed to be 4 years[84]

Deemed Measure Cost

Time of Sale: The incremental cost for this measure is assumed to be $40 for a ENERGY STAR unit[85].

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 ENERGY STAR unit[86].

The avoided replacement cost (after 4 years) of a baseline replacement unit is $432.[87]

Loadshape

Loadshape R08 - Residential Cooling

Coincidence Factor

The coincidence factor for this measure is assumed to be 0.3[88].

---

[81] ENERGY STAR Version 4.0 Room Air Conditioners Program Requirements
[82] See DOE's Appliance and Equipment Standards for Room AC; https://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/41
[83] 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
[84] Standard assumption of one third of effective useful life.
[85] Incremental cost based on field study conducted by Efficiency Vermont.
[86] Based on IL PHA Efficient Living Program Data for 810 replaced units showing $416 per unit plus $32 average recycling/removal cost.
[87] Estimate based upon Time of Sale incremental costs and applying inflation rate of 1.91%.
[88] 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

Time of Sale: ΔkWh = (FLH_{RoomAC} * Btu/H * (1/CEERbase - 1/CEERee))/1000

Early Replacment:

ΔkWh for remaining life of existing unit (1st 4 years) = (FLH_{RoomAC} * Btu/H * (1/(EERexist/1.01) - 1/CEERee))/1000

ΔkWh for remaining measure life (next 8 years) = (FLH_{RoomAC} * Btu/H * (1/CEERbase - 1/CEERee))/1000

Where:

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

= dependent on location[89]:

Climate Zone (City based upon)	FLH_{RoomAC}
1 (Rockford)	220
2 (Chicago)	210
3 (Springfield)	319
4 (Belleville)	428
5 (Marion)	374
Weighted Average[90]	248

Btu/H = Size of rebated unit

= Actual. If unknown assume 8500 Btu/hr[91]

EERexist =Efficiency of existing unit

= Actual. If unknown assume 7.7[92]

1.01 = Factor to convert EER to CEER (CEER includes standby and off power consumption)[93].

[89] 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) 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 Volume 1, Section 3.7 providing the appropriate city to use for each county of Illinois.

[90] Weighted based on number of residential occupied housing units in each zone.

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

[92] Based on Nexus Market Research Inc, RLW Analytics, December 2005; "Impact, Process, and Market Study of the Connecticut Appliance Retirement Program: Overall Report."

[93] Since the existing unit will be rated in EER, this factor is used to appropriately compare with the new CEER rating. Version 3.0

CEERbase = Combined Energy Efficiency Ratio of baseline unit

= As provided in tables above

CEERee = Combined Energy Efficiency Ratio of ENERGY STAR unit

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

Time of Sale:

For example for an 8,500 Btu/H capacity unit, with louvered sides, in an unknown location:

$\Delta kWH_{CEE\ TIER\ 1}$ = (248 * 8500 * (1/10.9 – 1/11.4)) / 1000

= 8.5 kWh

Early Replacement:

A 7.7EER, 9000Btu/h unit is removed from a home in Springfield and replaced with an ENERGY STAR unit with louvered sides:

ΔkWh for remaining life of existing unit (1^{st} 4 years) = (319 * 9000 * (1/(7.7/1.01) - 1/11.4))/1000

= 124.7 kWh

ΔkWh for remaining measure life (next 8 years) = (319 * 9000 * (1/10.9 - 1/11.4))/1000

= 11.6 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

Time of Sale: ΔkW = Btu/H * ((1/(CEERbase *1.01) - 1/(CEERee * 1.01)))/1000) * CF

Early Replacement: ΔkW = Btu/H * ((1/EERexist - 1/(CEERee * 1.01)))/1000) * CF

Where:

CF = Summer Peak Coincidence Factor for measure

= 0.3[94]

1.01 = Factor to convert CEER to EER (CEER includes standby and off power consumption)[95].

Other variable as defined above

of the ENERGY STAR specification provided equivalent EER and CEER ratings and for the most popular size band the EER rating is approximately 1% higher than the CEER. See 'ENERGY STAR Version 3.0 Room Air Conditioners Program Requirements'.

[94] Consistent with coincidence factors found in: RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008

[95] Since the new CEER rating includes standby and off power consumption, for peak calculations it is more appropriate to apply the EER rating, but it appears as though new units will only be rated with a CEER rating. Version 3.0 of the ENERGY STAR specification provided equivalent EER and CEER ratings and for the most popular size band the EER rating is approximately 1% higher than the CEER. See 'ENERGY STAR Version 3.0 Room Air Conditioners Program Requirements'.

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/(10.9 * 1.01) – 1/(11.4*1.01))) / 1000 * 0.3

= 0.010 kW

Early Replacement:

A 7.7 EER, 9000Btu/h unit is removed from a home in Springfield and replaced with an ENERGY STAR unit with louvered sides:

ΔkW for remaining life of existing unit (1st 4 years) = (9000 * (1/7.7 - 1/(11.4 * 1.01)))/1000 * 0.3

= 0.12 kW

ΔkW for remaining measure life (next 8 years) = (9000 * (1/(10.9 * 1.01) - 1/(11.4 * 1.01)))/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-V05-160601

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 [96].

Deemed Measure Cost

Measure cost includes the customer's value placed on their lost amenity, any customer transaction costs, and the cost of pickup and recycling of the refrigerator/freezer and should be based on actual costs of running the program. The payment (bounty) a Program Administrator makes to the customer serves as a proxy for the value the customer places on their lost amenity and any customer transaction costs. If unknown assume $170[97] per unit.

[96] KEMA "Residential refrigerator recycling ninth year retention study", 2004

[97] The $170 default assumption is based on $120 cost of pickup and recycling per unit and $50 proxy for customer transaction costs and value customer places on their lost amenity. $120 is cost of pickup and recycling based on similar Efficiency Vermont program. $50 is bounty, based on Ameren and ComEd program offerings as of 7/27/15.

LOADSHAPE

Loadshape R05 - Residential Refrigerator

COINCIDENCE FACTOR

The coincidence factor is assumed to be 0.00012.

Algorithm

CALCULATION OF SAVINGS

ENERGY SAVINGS[98]

Refrigerators:

Energy savings for refrigerators are based upon a linear regression model using the following coefficients[99]:

Independent Variable Description	Estimate Coefficient
Intercept	83.324
Age (years)	3.678
Pre-1990 (=1 if manufactured pre-1990)	485.037
Size (cubic feet)	27.149
Dummy: Side-by-Side (= 1 if side-by-side)	406.779
Dummy: Primary Usage Type (in absence of the program) (= 1 if primary unit)	161.857
Interaction: Located in Unconditioned Space x CDD/365.25	15.366
Interaction: Located in Unconditioned Space x HDD/365.25	-11.067

ΔkWh = [83.32 + (Age * 3.68) + (Pre-1990 * 485.04) + (Size * 27.15) + (Side-by-side * 406.78) + (Proportion of Primary Appliances * 161.86) + (CDD/365.25 * unconditioned * 15.37) + (HDD/365.25 *unconditioned *-11.07)] * 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

[98] 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.

[99] Energy savings are based on an average 30-year TMY temperature of 51.1 degrees. Coefficients provided in July 30, 2014 memo from Cadmus: "Appliance Recycling Update no single door July 30 2014".

Side-by-side = Side-by-side dummy (= 1 if side-by-side, 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[100]:

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

Interaction: Located in Unconditioned Space x HDD/365.25

(=1 * HDD/365.25 if in unconditioned space)

HDD = Heating Degree Days

= Dependent on location:[101]

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[102]. For illustration purposes, this example uses 0.93.[103]

[100] National Climatic Data Center, calculated from 1981-2010 climate normals with a base temp of 65°F.

[101] National Climatic Data Center, calculated from 1981-2010 climate normals with a base temp of 65°F.

[102] 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.

[103] Most recent refrigerator part-use factor from Ameren Illinois PY5 evaluation.

For example, the program averages for AIC's ARP in PY4 produce the following equation:

ΔkWh = [83.32 + (22.81 * 3.68) + (0.45 * 485.04) + (18.82 * 27.15) + (0.17 * 406.78) + (0.34 * 161.86) + (1.29 * 15.37) + (6.49 * -11.07)] * 0.93

= 969 * 0.93

= 900.9 kWh

Freezers:

Energy savings for freezers are based upon a linear regression model using the following coefficients[104]:

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	9.778
Interaction: Located in Unconditioned Space x HDD/365.25	-12.755

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

[104] 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".

program year shall be used[105]. . For illustration purposes, the example uses 0.85.[106]

> 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/8766 * 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[107]

> For example, the program averages for AIC's ARP in PY4 produce the following equation:
>
> ΔkW = 806/8766 * 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-V06-160601

[105] 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.

[106] Most recent freezer part-use factor from Ameren Illinois Company PY5 evaluation.

[107] 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[108].

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%[109].

[108] A third of assumed measure life for Room AC.

[109] 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[110]:

Climate Zone (City based upon)	FLH_{RoomAC}
1 (Rockford)	220
2 (Chicago)	210
3 (Springfield)	319
4 (Belleville)	428
5 (Marion)	374
Weighted Average[111]	248

Btu/H = Size of retired unit

= Actual. If unknown assume 8500 Btu/hr [112]

EERexist = Efficiency of existing unit

= 7.7[113]

110 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 Volume 1, Section 3.7 providing the appropriate city to use for each county of Illinois.

111 Weighted based on number of residential occupied housing units in each zone.

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

113 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[114]

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

[114] 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)

5.1.10 ENERGY STAR Clothes Dryer

Description

This measure relates to the installation of a residential clothes dryer meeting the ENERGY STAR criteria. ENERGY STAR qualified clothes dryers save energy through a combination of more efficient drying and reduced runtime of the drying cycle. More efficient drying is achieved through increased insulation, modifying operating conditions such as air flow and/or heat input rate, improving air circulation through better drum design or booster fans, and improving efficiency of motors. Reducing the runtime of dryers through automatic termination by temperature and moisture sensors is believed to have the greatest potential for reducing energy use in clothes dryers[115]. ENERGY STAR provides criteria for both gas and electric clothes dryers.

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

Definition of Efficient Equipment

Clothes dryer must meet the ENERGY STAR criteria, as required by the program.

Definition of Baseline Equipment

The baseline condition is a clothes dryer meeting the minimum federal requirements for units manufactured on or after January 1, 2015.

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 14 years[116].

Deemed Measure Cost

The incremental cost for an ENERGY STAR clothes dryer is assumed to be $152[117]

Loadshape

N/A

Coincidence Factor

The coincidence factor for this measure is 3.8%[118].

[115] ENERGY STAR Market & Industry Scoping Report. Residential Clothes Dryers. Table 8. November 2011. http://www.energystar.gov/ia/products/downloads/ENERGY_STAR_Scoping_Report_Residential_Clothes_Dryers.pdf
[116] Based on an average estimated range of 12-16 years. ENERGY STAR Market & Industry Scoping Report. Residential Clothes Dryers. November 2011. http://www.energystar.gov/ia/products/downloads/ENERGY_STAR_Scoping_Report_Residential_Clothes_Dryers.pdf
[117] Based on the difference in installed cost for an efficient dryer ($716) and standard dryer ($564). http://www.aceee.org/files/proceedings/2012/data/papers/0193-000286.pdf
[118] Based on coincidence factor of 3.8% for clothes washers

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS

ΔkWh = (Load/CEFbase – Load/CEFeff) * Ncycles * %Electric

Where:

Load = The average total weight (lbs) of clothes per drying cycle. If dryer size is unknown, assume standard.

Dryer Size	Load (lbs)[119]
Standard	8.45
Compact	3

CEFbase = Combined energy factor (CEF) (lbs/kWh) of the baseline unit is based on existing federal standards energy factor and adjusted to CEF as performed in the ENERGY STAR analysis[120]. If product class unknown, assume electric, standard.

Product Class	CEF (lbs/kWh)
Vented Electric, Standard (≥ 4.4 ft^3)	3.11
Vented Electric, Compact (120V) (< 4.4 ft^3)	3.01
Vented Electric, Compact (240V) (<4.4 ft^3)	2.73
Ventless Electric, Compact (240V) (<4.4 ft^3)	2.13
Vented Gas	2.84[121]

CEFeff = CEF (lbs/kWh) of the ENERGY STAR unit based on ENERGY STAR requirements.[122] If product class unknown, assume electric, standard.

Product Class	CEF (lbs/kWh)
Vented or Ventless Electric, Standard (≥ 4.4 ft^3)	3.93
Vented or Ventless Electric, Compact (120V) (< 4.4 ft^3)	3.80
Vented Electric, Compact (240V) (< 4.4 ft^3)	3.45
Ventless Electric, Compact (240V) (< 4.4 ft^3)	2.68
Vented Gas	3.48[123]

Ncycles = Number of dryer cycles per year. Use actual data if available. If unknown, use 283 cycles

[119] Based on ENERGY STAR test procedures. https://www.energystar.gov/index.cfm?c=clothesdry.pr_crit_clothes_dryers
[120] ENERGY STAR Draft 2 Version 1.0 Clothes Dryers Data and Analysis
[121] Federal standards report CEF for gas clothes dryers in terms of lbs/kWh. To determine gas savings, this number is later converted to therms.
[122] ENERGY STAR Clothes Dryers Key Product Criteria. https://www.energystar.gov/index.cfm?c=clothesdry.pr_crit_clothes_dryers
[123] Federal standards report CEF for gas clothes dryers in terms of lbs/kWh. To determine gas savings, this number is later converted to therms.

per year.[124]

%Electric = The percent of overall savings coming from electricity

= 100% for electric dryers, 16% for gas dryers[125]

EXAMPLE

Time of Sale: For example, a standard, vented, electric clothes dryer:

ΔkWh = ((8.45/3.11 – 8.45/3.93) * 283 * 100%)

= 160 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ΔkWh/Hours * CF

Where:

ΔkWh = Energy Savings as calculated above

Hours = Annual run hours of clothes dryer. Use actual data if available. If unknown, use 283 hours per year.[126]

CF = Summer Peak Coincidence Factor for measure

= 3.8%[127]

EXAMPLE

Time of Sale: For example, a standard, vented, electric clothes dryer:

ΔkW = 160/283 * 3.8%

= 0.0215 kW

NATURAL GAS SAVINGS

Natural gas savings only apply to ENERGY STAR vented gas clothes dryers.

ΔTherm = (Load/EFbase – Load/CEFeff) * Ncycles * Therm_convert * %Gas

Where:

[124] Appendix D to Subpart B of Part 430 – Uniform Test Method for Measuring the Energy Consumption of Dryers.
[125] %Electric accounts for the fact that some of the savings on gas dryers comes from electricity (motors, controls, etc). 16% was determined using a ratio of the electric to total savings from gas dryers given by ENERGY STAR Draft 2 Version 1.0 Clothes Dryers Data and Analysis.
[126] ENERGY STAR qualified dryers have a maximum test cycle time of 80 minutes. Assume one hour per dryer cycle.
[127] Based on coincidence factor of 3.8% for clothes washers.

Therm_convert = Conversion factor from kWh to Therm

= 0.03413

%Gas = Percent of overall savings coming from gas

= 0% for electric units and 84% for gas units[128]

EXAMPLE

Time of Sale: For example, a standard, vented, gas clothes dryer:

ΔTherm = (8.45/2.84 – 8.45/3.48) * 283 * 0.03413 * 0.84

= 4.44 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-APL-ESDR-V01-150601

[128] %Gas accounts for the fact that some of the savings on gas dryers comes from electricity (motors, controls, etc). 84% was determined using a ratio of the gas to total savings from gas dryers given by ENERGY STAR Draft 2 Version 1.0 Clothes Dryers Data and Analysis.

5.2 Consumer Electronics End Use

5.2.1 Advanced Power Strip – Tier 1

DESCRIPTION

This measure relates to Advanced Power Strips – Tier 1 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 advanced power 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 advanced power strip is 4 years[129].

DEEMED MEASURE COST

The incremental cost of a advanced power strip over a standard power strip with surge protection is assumed to be $16 for a 5-plug and $26 for a 7-plug[130].

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%[131].

Algorithm

[129] David Rogers, Power Smart Engineering, October 2008; "Smart Strip electrical savings and usability", p22.
[130] Price survey performed in NYSERDA Measure Characterization for Advanced Power Strips, p4
[131] Efficiency Vermont coincidence factor for advanced power 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.

Calculation of Savings

Electric Energy Savings

$\Delta kWh_{5\text{-}Plug}$ = 56.5 kWh [132]

$\Delta kWh_{7\text{-}Plug}$ = 103 kWh [133]

Summer Coincident Peak Demand Savings

ΔkW = ΔkWh / Hours * CF

Where:

Hours = Annual number of hours during which the controlled standby loads are turned off by the Advanced power Strip.

= 7,129 [134]

CF = Summer Peak Coincidence Factor for measure

= 0.8 [135]

$\Delta kW_{5\text{-}Plug}$ = 56.5 / 7129 * 0.8

= 0.00634 kW

$\Delta kW_{7\text{-}Plug}$ = 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-V02-160601

[132] NYSERDA Measure Characterization for Advanced Power Strips. Study based on review of:
Smart Strip Electrical Savings and Usability, Power Smart Engineering, October 27, 2008.
Final Field Research Report, Ecos Consulting, October 31, 2006. Prepared for California Energy Commission's PIER Program.
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.
2005 Intrusive Residential Standby Survey Report, Energy Efficient Strategies, March, 2006.
Smart Strip Portfolio of the Future, Navigant Consulting for San Diego G&E, March 31, 2009.

[133] Ibid.

[134] Average of hours for controlled TV and computer from; NYSERDA Measure Characterization for Advanced Power Strips

[135] Efficiency Vermont coincidence factor for advanced power 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.

5.2.2 Tier 2 Advanced Power Strips (APS) – Residential Audio Visual

Description

This measure relates to the installation of Tier 2 Advanced Power Strips for household audio visual environments (Tier 2 AV APS). Tier 2 AV APS are multi-plug power strips that remove power from audio visual equipment through intelligent control and monitoring strategies.

By utilizing advanced control strategies such as true RMS (Root Mean Square) power sensing and/or external sensors[136]; both active power loads and standby power loads of controlled devices are managed by Tier 2 AV APS devices. Monitoring and controlling both active and standby power loads of controlled devices will reduce the overall load of a centralized group of electrical equipment (i.e. the home entertainment center). This more intelligent sensing and control process has been demonstrated to deliver increased energy savings and demand reduction compared with 'Tier 1 Advanced Power Strips'.

The Tier 2 APS market is a relatively new and developing one. With several new Tier 2 APS products coming to market, it is important that energy savings are clearly demonstrated through independent field trials. The IL Technical Advisory Committee have developed a protocol whereby product manufacturers must submit independent field trial evidence of the Energy Reduction Percentage of their particular product either to the TRM Administrator for consideration during the TRM update process (August – December), or engage with a Program Administrator's independent evaluation team to review at other times. The product will be assigned a Product Class (A-H) corresponding to the proven savings and all products in a class will claim consistent savings. The IL TRM Administrator will maintain a list of eligible product and class on the IL TRM Sharepoint site. If a mid-year review has taken place, supporting information should be posted on the Sharepoint site such that other program administrators can review.

Due to the inherent variance day to day and week to week for hours of use of AV systems, it is critical that field trial studies effectively address the variability in usage patterns. There is significant discussion in the EM&V and academic domain on the optimal methodology for controlling for these factors and in submitting evidence of energy savings, it is critical that it is demonstrated that these issues are adequately addressed.

This measure was developed to be applicable to the following program types: DI. If applied to other program delivery types, the installation characteristics including the number of AV devices under control and an appropriate in service rate should be verified through evaluation.

Current evaluation is limited to Direct Install applications. Through a Direct Install program it can be assured that the APS is appropriately set up and the customer is knowledgeable about its function and benefit. It is encouraged that additional implementation strategies are evaluated to provide an indication of whether the units are appropriately set up, used with AV equipment and that the customer is knowledgeable about its function and benefit. This will then facilitate a basis for broadening out the deployment methods of the APS technology category beyond Direct Install.

Definition of Efficient Equipment

The efficient case is the use of a Tier 2 AV APS in a residential AV (home entertainment) environment that includes control of at least 2 AV devices with one being the television[137].

Only Tier 2 AV APS products that have independent demonstrated energy savings via field trials are eligible.

[136] Tier 2 AV APS identify when people are not engaged with their AV equipment and then remove power, for example a TV and its peripheral devices that are unintentionally left on when a person leaves the house or for instance where someone falls asleep while watching television.

[137] Given this requirement, an AV environment consisting of a television and DVD player or a TV and home theater would be eligible for a Tier 2 AV APS installation.

The minimum product specifications for Tier 2 AV APS are:

Safety & longevity

- Product and installation instructions shall comply with 2012 International Fire Code and 2000 NFPA 101 Life Safety Code (IL Fire Code).
- Third party tested to all applicable UL Standards.
- Contains a resettable circuit breaker
- Incorporates power switching electromechanical relays rated for 100,000 switching cycles at full 15 amp load (equivalent to more than 10 years of use).

Energy efficiency functionality

- Calculates real power as the time average of the instantaneous power, where instantaneous power is the product of instantaneous voltage and current.
- Delivers a warning when the countdown timer begins before an active power down event and maintains the warning until countdown is concluded or reset by use of the remote or other specified signal
- Uses an automatically adjustable power switching threshold.

DEFINITION OF BASELINE EQUIPMENT

The assumed baseline equipment is a standard power strip or wall socket that does not control loads of connected AV equipment.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The default deemed lifetime value for Tier 2 AV APS is assumed to be 7 years[138].

DEEMED MEASURE COST

Direct Installation: The actual installed cost (including labor) of the new Tier 2 AV APS equipment should be used.

LOADSHAPE

Loadshape R13 - Residential Standby Losses – Entertainment

COINCIDENCE FACTOR

The summer peak coincidence factor for this measure is assumed to be 80%[139]

[138] There is little evaluation to base a lifetime estimate upon. Based on review of assumptions from other jurisdictions and the relative treatment of In Service Rates and persistence, an estimate of 7 years was agreed by the Technical Advisory Committee, but further evaluation is recommended.

[139] In the absence of empirical evaluation data, this was based on assumptions of the typical run pattern for televisions and computers in homes.

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS

$\Delta kWh = ERP * BaselineEnergy_{AV} * ISR$

Where:

ERP = Energy Reduction Percentage of qualifying Tier2 AV APS product range as provided below

$BaselineEnergy_{AV}$ = 600 kWh[140]

Product Class	Field trial ERP range	ERP used	ΔkWh
A	55 – 60%	55%	330
B	50 – 54%	50%	300
C	45 – 49%	45%	270
D	40 – 44%	40%	240
E	35 – 39%	35%	210
F	30 – 34%	30%	180
G	25 – 29%	25%	150
H	20 – 24%	20%	120

ISR = In Service Rate

= 0.70[141]

SUMMER COINCIDENT PEAK DEMAND SAVINGS

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

Where:

ΔkWh = Energy savings as calculated above

Hours = Annual number of hours during which the APS provides savings.

= 4,380 [142]

CF = Summer Peak Coincidence Factor for measure

= 0.8 [143]

[140] Figure is rounded down from 603kWh and assumes average annualized energy consumption reported by NYSERDA (NYSERDA 2011. "*Advanced Power Strip Research Report*", Table 3.2 p. 30) is applicable to households in Illinois.

[141] Based on two Australian study results (one showing 28% and the other 33%). This factor would benefit from more localized EM&V.

[142] This is estimate based on assumption that approximately half of savings are during active hours (assumed to be 5.3 hrs/day, 1936 per year (NYSERDA 2011. "*Advanced Power Strip Research Report*")) and half during standby hours (8760-1936 = 6824 hours). The weighted average is 4380.

[143] In the absence of empirical evaluation data, this was based on assumptions of the typical run pattern for televisions and computers in homes.

Product Class Range	ΔkW
A	0.060
B	0.055
C	0.049
D	0.044
E	0.038
F	0.033
G	0.027
H	0.022

NATURAL GAS SAVINGS

N/A[144]

WATER AND OTHER NON-ENERGY IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-CEL-APS2-V01-160601

[144] Interactive effects of Tier 2 APS on space conditioning loads has not yet been adequately studied.

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:

   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.

   Early Replacement determination will be based on meeting the following conditions:
   - The existing unit is operational when replaced, or
   - The existing unit requires minor repairs (<$276 per ton)[145].
   - All other conditions will be considered Time of Sale.

   The Baseline SEER of the existing unit replaced:
   - If the SEER of the existing unit is known and <=10, the Baseline SEER is the actual SEER value of the unit replaced. If the SEER is >10, the Baseline SEER = 14.
   - If the SEER of the existing unit is unknown use assumptions in variable list below (SEER_exist and HSPF_exist).
   - If the operational status or repair cost of the existing unit is unknown, use time of sale assumptions.

   A weighted average early replacement rate is provided for use when the actual baseline early replacement rates are unknown.[146]

Deemed Early Replacement Rates For ASHP

	Deemed Early Replacement Rate
Early Replacement Rate for ASHP participants	7%

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.

---

[145] The Technical Advisory Committee agreed that if the cost of repair is less than 20% of the new baseline replacement cost it can be considered early replacement. Note the non-inflated cost is used as this would be a cost consideration in the program year.

[146] Based upon research from “Home Energy Efficiency Rebate Program GPY2 Evaluation Report” which outlines early replacement rates for both primary and secondary central air cooling (CAC) and residential furnaces. This is used as a reasonable proxy for ASHP installations since ASHP specific data is not available. Report presented to Nicor Gas Company February 27, 2014, available at http://www.ilsag.info/evaluation-documents.html.

DEFINITION OF BASELINE EQUIPMENT

A new residential sized (<= 65,000 Btu/hr) air source heat pump meeting federal standards.

The baseline for the Time of Sale measure is based on the current Federal Standard efficiency level as of January 1st 2015; 14 SEER and 8.2HSPF.

The baseline for the early replacement measure is the efficiency of the existing equipment for the assumed remaining useful life of the unit and the new baseline as defined above for the remainder of the measure life.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 18 years.[147]

Remaining life of existing ASHP/CAC equipment is assumed to be 6 years[148] and 18 years for electric resistance.

DEEMED MEASURE COST

Time of sale: The incremental capital cost for this measure is dependent on the efficiency and capacity of the new unit[149]. Note these costs are per ton of unit capacity:

Efficiency (SEER)	Incremental Cost per Ton of Capacity ($/ton)
15	$137
16	$274
17	$411
18	$548

Early replacement: The full install cost for this measure is the actual cost of removing the existing unit and installing the new one. If this is unknown, assume the following (note these costs are per ton of unit capacity)[150]:

Efficiency (SEER)	Full Retrofit Cost (including labor) per Ton of Capacity ($/ton)
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 $1,518 per ton of capacity[151]. This cost should be discounted to present value using the utilities' discount rate.

---

[147] 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

[148] Assumed to be one third of effective useful life

[149] Based on costs derived from DEER 2008 Database Technology and Measure Cost Data (www.deeresources.com).

[150] Ibid. See 'ASHP_Revised DEER Measure Cost Summary.xls' for calculation.

[151] Ibid. $1381 per ton inflated using rate of 1.91%.

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.

$CF_{SSP\ SF}$ = Summer System Peak Coincidence Factor for Heat Pumps in single-family homes (during utility peak hour)

= 72%[152]

$CF_{PJM\ SF}$ = PJM Summer Peak Coincidence Factor for Heat Pumps in single-family homes (average during PJM peak period)

= 46.6%[153]

$CF_{SSP,\ MF}$ = Summer System Peak Coincidence Factor for Heat Pumps in multi-family homes (during system peak hour)

= 67%[154]

$CF_{PJM,\ MF}$ = PJM Summer Peak Coincidence Factor for Heat Pumps in multi-family homes (average during peak period)

= 28.5%

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[155]:

ΔkWH for remaining life of existing unit (1st 6 years for replacing an ASHP, 18 years for replacing electric resistance):

= ((FLH_cooling * Capacity_cooling * (1/SEER_exist - 1/SEER_ee)) / 1000) + ((FLH_heat *

[152] 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)'.
[153] 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.
[154] Multifamily coincidence factors both from; *All-Electric Homes PY6 Metering Results: Multifamily HVAC Systems*, Cadmus, October 2015
[155] 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_exist - 1/HSFP_ee)) / 1000)

ΔkWH for remaining measure life (next 12 years if replacing an ASHP):

= ((FLH_cooling * Capacity_cooling * (1/SEER_base - 1/SEER_ee)) / 1000) + ((FLH_heat * Capacity_heating * (1/HSPF_base - 1/HSFP_ee)) / 1000)

Where:

FLH_cooling = Full load hours of air conditioning

= dependent on location:

Climate Zone (City based upon)	FLH_cooling (single family) [156]	FLH_cooling (general multi family) [157]	FLH_cooling (weatherized multi family) [158]
1 (Rockford)	512	467	299
2 (Chicago)	570	506	324
3 (Springfield)	730	663	425
4 (Belleville)	1,035	940	603
5 (Marion)	903	820	526
Weighted Average[159]	629	564	362

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[160]
Air Source Heat Pump	9.12
Central AC	8.60
No central cooling[161]	Make '1/SEER_exist' = 0

[156] Full load hours for Chicago, Moline and Rockford are provided in "Final Evaluation Report: Central Air Conditioning Efficiency Services (CACES), 2010, Navigant Consulting", 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 Volume 1, Section 3.7 providing the appropriate city to use for each county of Illinois.

[157] Ibid.

[158] *All-Electric Homes PY6 Metering Results: Multifamily HVAC Systems*, Cadmus, October 2015. The multifamily units within this study had undergone significant shell improvements (air sealing and insulation) and therefore this set of assumptions is only appropriate for units that have recently participated in a weatherization or other shell program. Note that the FLHcool where recalculated based on existing efficiencies consistent with the TRM rather than from the metering study.

[159] Weighted based on number of occupied residential housing units in each zone.

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

[161] 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.

SEER_base = Seasonal Energy Efficiency Ratio of baseline Air Source Heat Pump (kBtu/kWh)

= 14 [162]

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 and home type:

Climate Zone (City based upon)	FLH_heat (single family and general multi family)[163]	FLH heat (weatherized multi family)[164]
1 (Rockford)	1,969	748
2 (Chicago)	1,840	699
3 (Springfield)	1,754	667
4 (Belleville)	1,266	481
5 (Marion)	1,288	489
Weighted Average[165]	1,821	692

Capacity_heating = Heating Capacity of Air Source Heat Pump (Btu/hr)

= Actual (1 ton = 12,000Btu/hr)

HSPF_exist =Heating System Performance Factor[166] of existing heating system (kBtu/kWh)

= Use actual HSPF rating where it is possible to measure or reasonably estimate. If not available use:

Existing Heating System	HSPF_exist
Air Source Heat Pump	5.44 [167]

[162] Based on Minimum Federal Standard effective 1/1/2015; http://www.gpo.gov/fdsys/pkg/CFR-2012-title10-vol3/pdf/CFR-2012-title10-vol3-sec430-32.pdf.

[163] 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 Volume 1, Section 3.7 providing the appropriate city to use for each county of Illinois.

[164] *All-Electric Homes PY6 Metering Results: Multifamily HVAC Systems*, Cadmus, October 2015.

[165] Weighted based on number of occupied residential housing units in each zone.

[166] 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

[167] 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

Existing Heating System	HSPF_exist
Electric Resistance	3.41[168]

HSPF_base =Heating System Performance Factor of baseline Air Source Heat Pump (kBtu/kWh)

= 8.2 [169]

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 a single family home in Marion:

ΔkWh = ((903 * 36,000 * (1/14 - 1/15)) / 1000) + ((1,288 * 36,000 * (1/8.2 - 1/9)) / 1000)

= 657 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 a single family home 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 * (1/14 - 1/15)) / 1000) + ((1,288 * 36,000 * (1/8.2 - 1/9)) / 1000)

= 657 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

Time of sale:

ΔkW = (Capacity_cooling * (1/EER_base - 1/EER_ee)) / 1000) * CF

Early replacement[170]:

ΔkW for remaining life of existing unit (1st 6 years for replacing an ASHP, 18 years for replacing electric resistance):

equipment in Ameren PY3-PY4. This estimation methodology appears to provide a result within 10% of actual HSPF.

[168] Electric resistance has a COP of 1.0 which equals 1/0.293 = 3.41 HSPF.

[169] Based on Minimum Federal Standard effective 1/1/2015; http://www.gpo.gov/fdsys/pkg/CFR-2012-title10-vol3/pdf/CFR-2012-title10-vol3-sec430-32.pdf

[170] 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))/1000 * CF);

ΔkW for remaining measure life (next 12 years if replacing an ASHP):

= ((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 = $(-0.02 * SEER\_exist^2) + (1.12 * SEER\_exist)$ [171]

If SEER or EER rating unavailable use:

Existing Cooling System	EER_exist[172]
Air Source Heat Pump	8.55
Central AC	8.15
No central cooling[173]	Make '1/EER_exist' = 0

EER_base = Energy Efficiency Ratio of baseline Air Source Heat Pump (kBtu/hr / kW)

= 11.8 [174]

EER_ee = Energy Efficiency Ratio of efficient Air Source Heat Pump (kBtu/hr / kW)

= Actual, If not provided convert SEER to EER using this formula:[175]

= $(-0.02 * SEER\_ee^2) + (1.12 * SEER\_ee)$

$CF_{SSP\ SF}$ = Summer System Peak Coincidence Factor for Heat Pumps in single-family homes (during system peak hour)

= 72%%[176]

$CF_{PJM\ SF}$ = PJM Summer Peak Coincidence Factor for Heat Pumps in single-family homes (average during peak period)

= 46.6%[177]

$CF_{SSP,\ MF}$ = Summer System Peak Coincidence Factor for Heat Pumps in multi-family homes (during

171 From Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder.

172 Average nameplate efficiencies of all Early Replacement qualifying equipment in Ameren PY3-PY4.

173 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.

174 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.

175 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.

176 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)'.

177 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.

system peak hour)

= 67%[178]

$CF_{PJM, MF}$ = PJM Summer Peak Coincidence Factor for Heat Pumps in multi-family homes (average during peak period)

= 28.5%[35]

Time of Sale:

For example, a three ton, 15 SEER, 12EER, 9 HSPF Air Source Heat Pump installed in single-family home in Marion:

ΔkW_{SSP} = ((36,000 * (1/11.8 – 1/12)) / 1000) * 0.72

= 0.037 kW

ΔkW_{PJM} = ((36,000 * (1/11.8 – 1/12)) / 1000) * 0.466

= 0.024 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 single-family home 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 * (1/11.8 – 1/12)) / 1000) * 0.72

= 0.037 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-V06-160601

[178] *All-Electric Homes PY6 Metering Results: Multifamily HVAC Systems*, Cadmus, October 2015

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[179].

DEEMED MEASURE COST

The measure cost including material and installation is assumed to be $3 per linear foot[180].

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS SAVINGS

$$\Delta Therm = (((1/R_{exist} * C_{exist}) - (1/R_{new} * C_{new})) * FLH\_heat * L * \Delta T) / \eta Boiler / 100,000$$

Where:

R_{exist} = Pipe heat loss coefficient of uninsulated pipe (existing) [(hr-°F-ft^2)/Btu]

[179] 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

[180] Consistent with DEER 2008 Database Technology and Measure Cost Data (www.deeresources.com).

= 0.5[181]

R_{new} = Pipe heat loss coefficient of insulated pipe (new) [(hr-°F-ft²)/Btu]

= Actual (0.5 + R value of insulation)

FLH_heat = Full load hours of heating

= Dependent on location[182]:

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[183]	1,821

L = Length of boiler pipe in unconditioned space covered by pipe wrap (ft)

= Actual

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 of pipe (in)] + ([Thickness of Insulation (in)]*2)) * π/12)

= Actual

ΔT = Average temperature difference between circulated heated water and unconditioned space air temperature (°F) [184]

Pipes in unconditioned basement:

[181] 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.

[182] 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 Volume 1, Section 3.7 providing the appropriate city to use for each county of Illinois.

[183] Weighted based on number of occupied residential housing units in each zone.

[184] 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).

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[185]	125	85

ηBoiler = Efficiency of boiler

= 0.819 [186]

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-V02-160601

[185] Weighted based on number of occupied residential housing units in each zone.
[186] Average efficiency of boiler units found in Ameren PY3-PY4 data.

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:
   Early Replacement determination will be based on meeting the following conditions:
   - The existing unit is operational when replaced, or
   - The existing unit requires minor repairs (<$190 per ton)[187].
   - All other conditions will be considered Time of Sale.

   The Baseline SEER of the existing Central Air Conditioning unit replaced:
   - If the SEER of the existing unit is known and <=10, the Baseline SEER is the actual SEER value of the unit replaced. If the SEER is >10, the Baseline SEER = 13.
   - If the SEER of the existing unit is unknown, use assumptions in variable list below (SEER_exist).
   - If the operational status or repair cost of the existing unit is unknown, use time of sale assumptions.

   A weighted average early replacement rate is provided for use when the actual baseline early replacement rate is unknown[188].

Deemed Early Replacement Rates For CAC Units in Combined System Replacement (CSR) Projects

Replacement Scenario for the CAC Unit	Deemed Early Replacement Rate
Early Replacement Rate for a CAC unit when the CAC unit is the Primary unit in a CSR project	14%
Early Replacement Rate for a CAC unit when the CAC unit is the Secondary unit in a CSR project	40%

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.

[187] The Technical Advisory Committee agreed that if the cost of repair is less than 20% of the new baseline replacement cost it can be considered early replacement. Note the non-inflated cost is used as this would be a cost consideration in the program year.

[188] Based upon research from “Home Energy Efficiency Rebate Program GPY2 Evaluation Report” which outlines early replacement rates for both primary and secondary central air cooling (CAC) and residential funaces. The unit (furnace or CAC unit) that initially caused the customer to contact a trade ally is defined as the “primary unit”. The furnace or CAC unit that was also replaced but did not initially prompt the customer to contact a trade ally is defined as the “secondary unit”. This evaluation used different criteria for early replacement due to the availability of data after the fact; cost of any repairs < $550 and age of unit < 20 years. Report presented to Nicor Gas Company February 27, 2014, available at http://www.ilsag.info/evaluation-documents.html.

DEFINITION OF EFFICIENT EQUIPMENT

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

DEFINITION OF BASELINE EQUIPMENT

The baseline for the Time of Sale measure is based on the current Federal Standard efficiency level; 13 SEER and 11 EER.

The baseline for the early replacement measure is the efficiency of the existing equipment for the assumed remaining useful life of the unit and the new baseline as defined above[189] for the remainder of the measure life.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 18 years [190].

Remaining life of existing equipment is assumed to be 6 years[191].

DEEMED MEASURE COST

Time of sale: The incremental capital cost for this measure is dependent on efficiency. Assumed incremental costs are provided below[192]:

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 full install cost for this measure is the actual cost of removing the existing unit and installing the new one. If this is unknown, assume $3,413[193].

Assumed deferred cost (after 6 years) of replacing existing equipment with new baseline unit is assumed to be

[189] Baseline SEER and EER should be updated when new minimum federal standards become effective.
[190] 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).
[191] Assumed to be one third of effective useful life
[192] DEER 2008 Database Technology and Measure Cost Data (www.deeresources.com)
[193] 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).

$3,140[194]. This cost should be discounted to present value using the utilities' discount rate.

LOADSHAPE

Loadshape R08 - Residential Cooling

COINCIDENCE FACTOR

The summer peak coincidence factor for cooling is provided in two different ways below. The first is used to estimate peak savings during the utility peak hour and is most indicative of actual peak benefits, and the second represents the *average* savings over the defined summer peak period, and is presented so that savings can be bid into PJM's Forward Capacity Market.

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)
= 68%[195]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)
= 46.6%[196]

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

Time of sale:

ΔkWH = (FLHcool * Btu/hr * (1/SEERbase - 1/SEERee))/1000

Early replacement[197]:

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)

---

194 Based on 3 ton initial cost estimate for a conventional unit from ENERGY STAR Central AC calculator, $2,857, and applying inflation rate of 1.91% (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.

195 Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.

196 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.

197 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[198]:

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[199]	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[200]

SEERbase = Seasonal Energy Efficiency Ratio of baseline unit (kBtu/kWh)

= 13[201]

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[202].

SEERee = Seasonal Energy Efficiency Ratio of ENERGY STAR unit (kBtu/kWh)

= Actual installed or 14.5 if unknown

198 Full load hours for Chicago, Moline and Rockford are provided in "Final Evaluation Report: Central Air Conditioning Efficiency Services (CACES), 2010, Navigant Consulting", 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 Volume 1, Section 3.7 providing the appropriate city to use for each county of Illinois.

199 Weighted based on number of residential occupied housing units in each zone.

200 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.

201 Based on Minimum Federal Standard; http://www1.eere.energy.gov/buildings/appliance_standards/residential/residential_cac_hp.html.

202 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.

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

Therefore savings adjustment of 26% (180/702) after 6 years.

SUMMER COINCIDENT PEAK DEMAND SAVINGS

Time of sale:

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

Early replacement[203]:

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 [204]

EERexist = EER Efficiency of existing unit

= Actual EER of unit should be used, if EER is unknown, use 9.2[205]

[203] 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).

[204] The federal Standard does not currently include an EER component. The value is approximated based on the SEER standard (13) and equals EER 11.2. To perform this calculation we are using this formula: (-0.02 * SEER2) + (1.12 * SEER) (from Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder).

[205] Based on SEER of 10,0, using formula above to give 9.2 EER.

EER_{ee} = 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%[206]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)

= 46.6%[207]

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

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-V06-160601

[206] Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.

[207] 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.

5.3.4 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; which can be found on the Energy Conservatory website (As of Oct 2014: http://www.energyconservatory.com/sites/default/files/documents/mod_3-4_dg700_-_new_flow_rings_-_cr_-_tpt_-_no_fr_switch_manual_ce_0.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 or semi-conditioned space in the home. A non-conditioned space is defined as a space outside of the thermal envelope of the building that is not intentionally heated for occupancy (crawl space, roof attic, etc). A semi-conditioned space is defined as a space within the thermal envelop that is not intentionally heated for occupancy (unfinished basement)[208].

Definition of Baseline Equipment

The existing baseline condition is leaky duct work within the unconditioned or semi-conditioned space in the home.

Deemed Lifetime of Efficient Equipment

The assumed lifetime of this measure is 20 years[209].

Deemed Measure Cost

The actual duct sealing measure cost should be used.

[208] Definition matches Regain factor discussed in Home Energy Services Impact Evaluation, prepared for the Massachusetts Residential Retrofit and Low Income Program Area Evaluation, Cadmus Group, Inc., August 2012

[209] 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%[210]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)

= 46.6%[211]

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 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)

---

[210] Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.

[211] 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.

Where:

0.64 = Converts CFM50 to CFM25[212]

SLF = Supply Loss Factor

= % leaks sealed located in Supply ducts * 1 [213]

Default = 0.5[214]

RLF = Return Loss Factor

= % leaks sealed located in Return ducts * 0.5[215]

Default = 0.25[216]

c) Calculate Electric Energy Savings:

$\Delta kWh = \Delta kWh_{cooling} + \Delta kWh_{Fan}$

$\Delta kWh_{cooling}$ = ((ΔCFM25$_{DL}$/ ((CapacityCool/12,000) * 400)) * FLHcool * CapacityCool * TRFcool) / 1000 / ηCool

ΔkWh_{Fan} = (ΔTherms * F_e * 29.3)

Where:

$\Delta CFM25_{DL}$ = Duct leakage reduction in CFM25

= calculated above

CapacityCool = Capacity of Air Cooling system (Btu/hr)

=Actual

12,000 = Converts Btu/H capacity to tons

[212] 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).

[213] 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

[214] Assumes 50% of leaks are in supply ducts.

[215] 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

[216] Assumes 50% of leaks are in return ducts.

400 = Converts capacity in tons to CFM (400CFM / ton)[217]

FLHcool = Full load cooling hours

= Dependent on location as below[218]:

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 Average219	629	564

TRFcool = Thermal Regain Factor for cooling by space type

= 1.0 for Unconditioned Spaces

= 0.0 for Semi-Conditioned Spaces[220]

1000 = Converts Btu to kBtu

ηCool = Efficiency (SEER) of Air Conditioning equipment (kBtu/kWh)

= Actual. If unknown assume the following[221]:

Age of Equipment	SEER Estimate
Before 2006	10
After 2006 - 2014	13
Central AC After 1/1/2015	13
Heat Pump After 1/1/2015	14

[217] This conversion is an industry rule of thumb; e.g. see http://www.hvacsalesandsupply.com/Linked%20Documents/Tech%20Tips/61-Why%20400%20CFM%20per%20ton.pdf

[218] 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 Volume 1, Section 3.7 providing the appropriate city to use for each county of Illinois.

[219] Weighted based on number of occupied residential housing units in each zone.

[220] Thermal regain (i.e. the potential for conditioned air escaping from ducts not being lost to the atmosphere) 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.

[221] 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.

ΔTherms = Therm savings as calculated in Natural Gas Savings

F_e = Furnace Fan energy consumption as a percentage of annual fuel consumption

= 3.14%[222]

29.3 = kWh per therm

For example, duct sealing in unconditioned space a single family house in Springfield with a 36,000 Btu/H, SEER 11 central air conditioning, an 80% AFUE, 105,000 Btu/H natural gas furnace and the following blower door test results:

Before: $CFM50_{Whole\ House}$ = 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 * 1) / 1000 / 11] + (212 * 0.0314 * 29.3)

= 237 + 195

= 432 kWh

<u>Heating savings for homes with electric heat:</u>

$\Delta kWh_{heating}$ = ((ΔCFM25$_{DL}$ /((OutputCapacityHeat/12,000) * 400)) * FLHheat * OutputCapacityHeat *

[222] 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.

TRFheat) / ηHeat / 3412

Where:

OutputCapacityHeat = Heating output capacity (Btu/hr) of electric heat

=Actual

FLHheat = Full load heating hours

= Dependent on location as below[223]:

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[224]	1,821

TRFheat = Thermal Regain Factor for heating by space type

= 0.40 for Semi-Conditioned Spaces

= 1.0 for Unconditioned Spaces[225]

ηHeat = Efficiency in COP of Heating equipment

= Actual. If not available use[226]:

System Type	Age of Equipment	HSPF Estimate	COP Estimate
Heat Pump	Before 2006	6.8	2.00
	After 2006 - 2014	7.7	2.26
	2015 on	8.2	2.40

[223] 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.
[224] Weighted based on number of occupied residential housing units in each zone.
[225] Thermal regain (i.e. the potential for conditioned air escaping from ducts not being lost to the atmosphere) 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.
[226] 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.

System Type	Age of Equipment	HSPF Estimate	COP Estimate
Resistance	N/A	N/A	1.00

3412 = Converts Btu to kWh

For example, duct sealing in unconditioned space 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 * 1) / 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"

$\Delta kWh = ((((DE_{after} - DE_{before}) / DE_{after}) * FLHcool * CapacityCool * TRFcool)/1000 / \eta Cool) + (\Delta Therms * F_e * 29.3)$

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[227]:

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[228]	629	564

[227] 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 Volume 1, Section 3.7 providing the appropriate city to use for each county of Illinois.

[228] Weighted based on number of occupied residential housing units in each zone.

CapacityCool = Capacity of Air Cooling system (Btu/hr)

=Actual

TRFcool = Thermal Regain Factor for cooling by space type

= 1.0 for Unconditioned Spaces

= 0.0 for Semi-Conditioned Spaces[229]

1000 = Converts Btu to kBtu

ηCool = Efficiency (SEER) of Air Conditioning equipment (kBtu/kWh)

= Actual. If unknown assume[230]:

Age of Equipment	SEER Estimate
Before 2006	10
After 2006 - 2014	13
Central AC After 1/1/2015	13
Heat Pump After 1/1/2015	14

For example, duct sealing in unconditioned space in a single family house in Springfield, with 36,000 Btu/H SEER 11 central air conditioning, an 80% AFUE, 105,000 Btu/H natural gas furnace and the following duct evaluation results:

DE_{before} = 0.85

DE_{after} = 0.92

Energy Savings:

$\Delta kWh_{cooling}$ = ((((0.92 – 0.85)/0.92) * 730 * 36,000 * 1) / 1000 / 11) + (212 * 0.0314 * 29.3)

= 182 + 195

= 377 kWh

Heating savings for homes with electric heat:

$\Delta kWh_{heating} = ((DE_{after} – DE_{before})/ DE_{after})) * FLHheat * OutputCapacityHeat * TRFheat) / \eta Heat / 3412$

Where:

OutputCapacityHeat = Heating output capacity (Btu/hr) of the electric heat

[229] 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.

[230] 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.

=Actual

FLHheat = Full load heating hours

= Dependent on location as below[231]:

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[232]	1,821

TRFheat = Thermal Regain Factor for heating by space type

= 0.40 for Semi-Conditioned Spaces

= 1.0 for Unconditioned Spaces[233]

COP = Coefficient of Performance of electric heating system[234]

= Actual. If not available use[235]:

System Type	Age of Equipment	HSPF Estimate	COP Estimate
Heat Pump	Before 2006	6.8	2.00
	After 2006 - 2014	7.7	2.26
	2015 on	8.2	2.40
Resistance	N/A	N/A	1.00

[231] 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.
[232] Weighted based on number of occupied residential housing units in each zone.
[233] 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.
[234] Note that the HSPF of a heat pump is equal to the COP * 3.413.
[235] 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, duct sealing in unconditioned space 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) * 1,754 * 36,000 * 1) / 2.5) / 3412

= 563 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$\Delta kW = \Delta kWh_{cooling} / FLHcool * CF$

Where:

FLHcool = Full load cooling hours:

= Dependent on location as below[236]:

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[237]	629	564

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)

= 68%[238]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)

= 46.6%[239]

[236] 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 Volume 1, Section 3.7 providing the appropriate city to use for each county of Illinois.

[237] Weighted based on number of occupied residential housing units in each zone.

[238] Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.

[239] 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

For homes with Natural Gas Heating:

Methodology 1: Modified Blower Door Subtraction

ΔTherm = $(((\Delta CFM25_{DL} / (InputCapacityHeat * 0.0123)) * FLHheat * InputCapacityHeat * TRFheat * (\eta Equipment / \eta System)) / 100,000$

Where:

$\Delta CFM25_{DL}$ = Duct leakage reduction in CFM25

InputCapacityHeat = Heating input capacity (Btu/hr)

=Actual

0.0123 = Conversion of Capacity to CFM (0.0123CFM / Btu/hr)[240]

FLHheat = Full load heating hours

=Dependent on location as below[241]:

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[242]	1,821

TRFheat = Thermal Regain Factor for heating by space type

= 0.40 for Semi-Conditioned Spaces

= 1.0 for Unconditioned Spaces[243]

[240] 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.

[241] 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.

[242] Weighted based on number of occupied residential housing units in each zone.

[243] 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.

100,000 = Converts Btu to therms

ηEquipment = Heating Equipment Efficiency

= Actual[244]. If not available use 83%[245]

ηSystem = Pre duct sealing Heating System Efficiency (Equipment Efficiency * Pre Distribution Efficiency)[246]

= Actual. If not available use 70%[247]

---

[244] The Equipment Efficiency can be obtained either by recording the AFUE of the unit, or performing a steady state efficiency test.
If there are more than one heating systems, the weighted (by consumption) average efficiency should be used.
If the heating system or distribution is being upgraded within a package of measures together with the insulation upgrade, the new average heating system efficiency should be used.

[245] 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) = 0.829

[246] 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.

[247] Estimated as follows: 0.829 * (1-0.15) = 0.70

For example, duct sealing in unconditioned space in a house in Springfield with an 80% AFUE, 105,000 Btu/H (input capacity) natural gas furnace and the following blower door test results:

Before: $CFM50_{Whole\ House}$ = 4800 CFM50

$CFM50_{Envelope\ Only}$ = 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:

Pre Distribution Efficiency = 1 – (387/4800) = 92%

ηSystem = 80% * 92% = 74%

ΔTherm = ((119/ (105,000 * 0.0123)) * 1,754 * 105,000 * 1 *(0.8/0.74)) / 100,000

= 183 therms

Methodology 2: Evaluation of Distribution Efficiency

$$\Delta Therm = ((DE_{after} - DE_{before}) / DE_{after})) * FLHheat * InputCapacityHeat * TRFheat * (\eta Equipment / \eta System)) / 100{,}000$$

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 unconditioned space in a house in Springfield an 80% AFUE, 105,000 Btu/H (input capacity) natural gas furnace and the following duct evaluation results:

DE_{after} = 0.92

DE_{before} = 0.85

Energy Savings:

ηSystem = 80% * 85% = 68%

ΔTherm = ((0.92 – 0.85)/0.92) * 1,754 * 105,000 * 1 * (0.8/0.68)) / 100,000

= 164 therm

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HVC-DINS-V06-160601

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[248].

Deemed Measure Cost

The capital cost for this measure is assumed to be $97[249].

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)

[248] 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
[249] 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

= 68%[250]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)

= 46.6%[251]

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[252]

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[253]

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 +263 + 51

= 732 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = Cooling Savings / FLH_cooling * CF

Where:

FLH_cooling = Full load hours of air conditioning

[250] Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.

[251] 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.

[252] 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.

[253] The weighted average value is based on assumption that 75% of homes installing BPM furnace blower motors have Central AC. 66% of IL housing units have CAC and 66% have gas furnaces. It is logical these two groups overlap to a large extent (like the 95% in the FOE study above).

= Dependent on location[254]:

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[255]	629

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)

= 68%[256]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)

= 46.6%[257]

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[258] = - Heating Savings * 0.03412/ AFUE

Where:

0.03412 = Converts kWh to therms

AFUE = Efficiency of the Furnace

= Actual. If unknown assume 95%[259] if in new furnace or 64.4 AFUE% [260] if in existing furnace

[254] Full load hours for Chicago, Moline and Rockford are provided in "Final Evaluation Report: Central Air Conditioning Efficiency Services (CACES), 2010, Navigant Consulting", 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 Volume 1, Section 3.7 providing the appropriate city to use for each county of Illinois.

[255] Weighted based on number of occupied residential housing units in each zone.

[256] Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.

[257] 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.

[258] The blower fan is in the heating duct so all, or very nearly all, of its waste heat is delivered to the conditioned space. Negative value since this measure will increase the heating load due to reduced waste heat.

[259] Minimum ENERGY STAR efficiency after 2.1.2012.

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

Using defaults:

For new Furnace = - (418 * 0.03412) / 0.95

= - 15.0 therms

For existing Furnace = - (418 * 0.03412) / 0.644

= - 22.1 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HVC-FBMT-V03-150601

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:
   Early Replacement determination will be based on meeting the following conditions:
   - The existing unit is operational when replaced, or
   - The existing unit requires minor repairs (<$709)[261].
   - All other conditions will be considered Time of Sale.

   The Baseline AFUE of the existing unit replaced:
   - If the AFUE of the existing unit is known and <=75%, the Baseline AFUE is the actual AFUE value of the unit replaced. If the AFUE is >75%, the Baseline AFUE = 82%.
   - If the AFUE of the existing unit is unknown, use assumptions in variable list below (AFUE(exist)).
   - If the operational status or repair cost of the existing unit is unknown, use time of sale assumptions.

   A weighted average early replacement rate is provided for use when the actual baseline early replacement rates are unknown[262].

Deemed Early Replacement Rates For Boilers

	Deemed Early Replacement Rate
Early Replacement Rate for Boiler participants	7%

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).

[261] The Technical Advisory Committee agreed that if the cost of repair is less than 20% of the new baseline replacement cost it can be considered early replacement. Note the non-inflated cost is used as this would be a cost consideration in the program year.

[262] Based upon research from "Home Energy Efficiency Rebate Program GPY2 Evaluation Report" which outlines early replacement rates for both primary and secondary central air cooling (CAC) and residential furnaces. This is used as a reasonable proxy for boiler installations since boiler specific data is not available. Report presented to Nicor Gas Company February 27, 2014, available at http://www.ilsag.info/evaluation-documents.html.

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 is 82% AFUE.

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[263].

Early replacement: Remaining life of existing equipment is assumed to be 8 years[264].

DEEMED MEASURE COST

Time of sale: The incremental install cost for this measure is dependent on tier[265]:

Measure Type	Installation Cost	Incremental Install Cost
AFUE 82%	$3543	n/a
AFUE 85% (Energy Star Minimum)	$4268	$725
AFUE 90%	$4815	$1,272
AFUE 95%	$5328	$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 $4,045[266]. This cost should be discounted to present value using the utilities' discount rate.

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

263 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

264 Assumed to be one third of effective useful life

265 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.

266 $3543 inflated using 1.91% rate.

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 * HF * (1/AFUE(base) - 1/AFUE(eff))

Early replacement[267]:

ΔTherms for remaining life of existing unit (1st 8 years):

= Gas_Boiler_Load * HF * (1/AFUE(exist) - 1/AFUE(eff)))

ΔTherms for remaining measure life (next 17 years):

= Gas_Boiler_Load * HF * (1/AFUE(base) - 1/AFUE(eff)))

Where:

Gas_Boiler_Load[268] = Estimate of annual household Load for gas boiler heated single-family homes. If location is unknown, assume the average below[269].

= or Actual if informed by site-specific load calculations, ACCA Manual J or equivalent[270].

Climate Zone (City based upon)	Gas_Boiler Load (therms)
1 (Rockford)	1275
2 (Chicago)	1218

[267] 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).

[268] 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)

[269] Values are based on household heating consumption values and inferred average AFUE results from Table 3-4, Program Sample Analysis, *Nicor R29 Res Rebate Evaluation Report 092611_REV FINAL to Nicor*). Adjusting to a statewide average using relative HDD values to adjust for the evaluation results focus on northern region. Values for individual cities are then calculated by comparing average HDD to the individual city's HDD.

[270] The Air Conditioning Contractors of America Manual J, Residential Load Calculation 8th Edition produces equipment sizing loads for Single Family, Multi-single, and Condominiums using input characteristics of the home. A best practice for equipment selection and installation of Heating and Air Conditioning, load calculations should be completed by contractors during the selection process and may be readily available for program data purposes.

Climate Zone (City based upon)	Gas_Boiler Load (therms)
3 (Springfield)	1043
4 (Belleville)	805
5 (Marion)	819
Average	1158

HF = Household factor, to adjust heating consumption for non-single-family households.

Household Type	HF
Single-Family	100%
Multi-Family	65%[271]
Actual	Custom[272]

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% [273].

AFUE(base) = Baseline Boiler Annual Fuel Utilization Efficiency Rating

= 82%

AFUE(eff) = Efficent Boiler Annual Fuel Utilization Efficiency Rating

= Actual. If unknown, use defaults dependent[274] on tier as listed below:

Measure Type	AFUE(eff)
ENERGY STAR®	87.5%
AFUE 90%	92.5%
AFUE 95%	95%

[271] 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

[272] Program-specific household factors may be utilized on the basis of sufficiently validated program evaluations.

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

[274] 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

ΔTherms = 1043 * (1/0.82 - 1/0.875)

= 80.0 Therms

Early Replacement:

For example, an existing function boiler with unknown efficiency is replaced with an ENERGY STAR boiler purchased and installed in Springfield.

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-V05-160601

5.3.7 Gas High Efficiency Furnace

DESCRIPTION

High efficiency furnace features may include improved heat exchangers and modulating multi-stage burners.

This measure characterizes:

a) Time of sale:
   a. The installation of a new high efficiency, gas-fired condensing furnace in a residential location. This could relate to the replacement of an existing unit at the end of its useful life, or the installation of a new system in a new home.

b) Early Replacement:
   Early Replacement determination will be based on meeting the following conditions:
   - The existing unit is operational when replaced, or
   - The existing unit requires minor repairs (<$528)[275].
   - All other conditions will be considered Time of Sale.

   The Baseline AFUE of the existing unit replaced:
   - If the AFUE of the existing unit is known and <=75%, the Baseline AFUE is the actual AFUE value of the unit replaced. If the AFUE is >75%, the Baseline AFUE = 80%.
   - If the AFUE of the existing unit is unknown, use assumptions in variable list below (AFUE(exist)).
   - If the operational status or repair cost of the existing unit is unknown, use time of sale assumptions.

   A weighted average early replacement rate is provided for use when the actual baseline early replacement rate is unknown[276].

Deemed Early Replacement Rates For Furnaces

Replacement Scenario for the Furnace	Deemed Early Replacement Rate
Early Replacement Rate for Furnace-only participants	7%
Early Replacement Rate for a furnace when the furnace is the Primary unit in a Combined System Replacement (CSR) project	14%
Early Replacement Rate for a furnace when the furnace is the Secondary unit in a CSR project	46%

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.

[275] The Technical Advisory Committee agreed that if the cost of repair is less than 20% of the new baseline replacement cost it can be considered early replacement. Note the non-inflated cost is used as this would be a cost consideration in the program year.

[276] Based upon research from "Home Energy Efficiency Rebate Program GPY2 Evaluation Report" which outlines early replacement rates for both primary and secondary central air cooling (CAC) and residential funaces. The unit (furnace or CAC unit) that initially caused the customer to contact a trade ally is defined as the "primary unit". The furnace or CAC unit that was also replaced but did not initially prompt the customer to contact a trade ally is defined as the "secondary unit". This evaluation used different criteria for early replacement due to the availability of data after the fact; cost of any repairs < $550 and age of unit < 20 years. Report presented to Nicor Gas Company February 27, 2014, available at http://www.ilsag.info/evaluation-documents.html.

DEFINITION OF EFFICIENT EQUIPMENT

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: The current Federal Standard for gas furnaces is an AFUE rating of 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. 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[277].

For early replacement: Remaining life of existing equipment is assumed to be 6 years[278].

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[279]:

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 90% baseline unit is assumed to be $2903[280]. This cost should be discounted to present value using the utility's discount rate.

[277] 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

[278] Assumed to be one third of effective useful life

[279] 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.

[280] $2641 inflated using 1.91% rate.

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

Electrical energy savings from the more fan-efficient (typically using brushless permanent magnet (BPM) blower motor) should also be claimed, please refer to "Furnace Blower Motor" characterization for details.

SUMMER COINCIDENT PEAK DEMAND SAVINGS

If the blower motor is also used for cooling, coincident peak demand savings should also be claimed, please refer to "Furnace Blower Motor" characterization for savings details.

NATURAL GAS SAVINGS

Time of Sale:

ΔTherms = Gas_Furnace_Heating_Load * HF * (1/AFUE(base) - 1/AFUE(eff))

Early replacement[281]:

ΔTherms for remaining life of existing unit (1st 6 years):

= Gas_Furnace_Heating_Load * HF * (1/AFUE(exist) - 1/AFUE(eff)))

ΔTherms for remaining measure life (next 14 years):

= Gas_Furnace_Heating_Load * HF * (1/AFUE(base) - 1/AFUE(eff)))

Where:

Gas_Furnace_Heating_Load

= Estimate of annual household heating load [282] for gas furnace heated single-family homes. If location is unknown, assume the average below[283].

= Actual if informed by site-specific load calculations, ACCA Manual J or equivalent[284].

---

[281] 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).

[282] Heating load is used to describe the household heating need, which is equal to (gas consumption * AFUE)

[283] 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.

[284] 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

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%[285]
Actual	Custom[286]

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% [287].

AFUE(base) = Baseline Furnace Annual Fuel Utilization Efficiency Rating

= Dependent on program type as listed below[288]:

Program Year	AFUE(base)
Time of Sale	80%
Early Replacement [289]	90%

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

= Actual. If unknown, assume 95%[290]

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.

[285] 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

[286] Program-specific household factors may be utilized on the basis of sufficiently validated program evaluations.

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

[288] 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.

[289] We estimate that the new baseline unit that could be purchased in the year the existing unit would have needed replacing is 90%.

[290] Minimum ENERGY STAR efficiency after 2.1.2012.

Time of Sale:

For example, a 95% AFUE furnace near Rockford:

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:

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-V06-160601

5.3.8 Ground Source Heat Pump

DESCRIPTION

This measure characterizes the installation of a Ground Source Heat Pump under the following scenarios:

a) New Construction:
   a. The installation of a new residential sized Ground Source Heat Pump system meeting ENERGY STAR efficiency standards presented below in a new home.
   b. Note the baseline in this case should be determined via EM&V and the algorithms are provided to allow savings to be calculated from any baseline condition.

b) Time of Sale:
   a. The planned installation of a new residential sized Ground Source Heat Pump system meeting ENERGY STAR efficiency standards presented below to replace an existing system(s) that does not meet the criteria for early replacement described in section c below.
   b. Note the baseline in this case is an equivalent replacement system to that which exists currently in the home. The calculation of savings is dependent on whether an incentive for the installation has been provided by both a gas and electric utility, just an electric utility or just a gas utility.
   c. Additional DHW savings are calculated based upon the fuel and efficiency of the existing unit.

c) Early Replacement/Retrofit:
   a. The early removal of functioning either electric or gas space heating and/or cooling systems from service, prior to the natural end of life, and replacement with a new high efficiency Ground Source Heat Pump system.
   b. Note the baseline in this case is the existing equipment being replaced. The calculation of savings is dependent on whether an incentive for the installation has been provided by both a gas and electric utility, just an electric utility or just a gas utility.
   c. Additional DHW savings are calculated based upon the fuel and efficiency of the existing unit.
   d. Early Replacement determination will be based on meeting the following conditions:
      - The existing unit is operational when replaced, or
      - The existing unit requires minor repairs, defined as costing less than[291]:

Existing System	Maximum repair cost
Air Source Heat Pump	$276 per ton
Central Air Conditioner	$190 per ton
Boiler	$709
Furnace	$528
Ground Source Heat Pump	<$249 per ton

      - All other conditions will be considered Time of Sale.

   The Baseline efficiency of the existing unit replaced:
      - If the efficiency of the existing unit is less than the maximum shown below, the Baseline efficiency is the actual efficiency value of the unit replaced. If the efficiency is greater than the maximum, the Baseline efficiency is shown in the "New Baseline" column below:

[291] The Technical Advisory Committee agreed that if the cost of repair is less than 20% of the new baseline replacement cost it can be considered early replacement.

Existing System	Maximum efficiency for Actual	New Baseline
Air Source Heat Pump	10 SEER	14 SEER
Central Air Conditioner	10 SEER	13 SEER
Boiler	75% AFUE	82% AFUE
Furnace	75% AFUE	80% AFUE
Ground Source Heat Pump	10 SEER	13 SEER

- If the efficiency of the existing unit is unknown, use assumptions in variable list below (SEER, HSPF or AFUE exist).
- If the operational status or repair cost of the existing unit is unknown use time of sale assumptions.

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 below:

ENERGY STAR Requirements (Effective January 1, 2012)

Product Type	Cooling EER	Heating COP
Water-to-air		
Closed Loop	17.1	3.6
Open Loop	21.1	4.1
Water-to-Water		
Closed Loop	16.1	3.1
Open Loop	20.1	3.5
DGX	16	3.6

DEFINITION OF BASELINE EQUIPMENT

For these products, baseline equipment includes Air Conditioning, Space Heating and Water Heating.

New Construction:

To calculate savings with an electric baseline, the baseline equipment is assumed to be an Air Source Heat Pump meeting the Federal Standard efficiency level; 14 SEER, 8.2 HSPF and 11.8[292] EER and a Federal Standard electric hot water heater.

To calculate savings with a furnace/central AC baseline, the baseline equipment is assumed to be an 80% AFUE

[292] 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.

Furnace and central AC meeting the Federal Standard efficiency level; 13 SEER, 11 EER. If a gas water heater, the Federal Standard baseline is calculated as follows[293]; for <=55 gallon tanks = 0.675 – (0.0015 * storage size in gallons) and for tanks >55 gallon = 0.8012 – (0.00078 * storage size in gallons). For a 40-gallon storage water heater this would be 0.615 EF.

Time of Sale: The baseline for this measure is a new replacement unit of the same system type as the existing unit, meeting the baselines provided below.

Unit Type	Efficiency Standard
ASHP	14 SEER, 11.8 EER, 8.2 HSPF
Gas Furnace	80% AFUE
Gas Boiler	82% AFUE
Central AC	13 SEER, 11 EER

Early replacement / Retrofit: The baseline for this measure is the efficiency of the *existing* heating, cooling and hot water equipment for the assumed remaining useful life of the existing unit and a new baseline heating and cooling system for the remainder of the measure life (as provided in table above except for Gas Furnace where new baseline assumption is 90% due to pending standard change).

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 25 years[294].

For early replacement, the remaining life of existing equipment is assumed to be 8 years[295].

Deemed Measure Cost

New Construction and Time of Sale: The actual installed cost of the Ground Source Heat Pump should be used (default of $3957 per ton[296]), minus the assumed installation cost of the baseline equipment ($1381 per ton for ASHP[297] or $2011 for a new baseline 80% AFUE furnace or $3543 for a new 82% AFUE boiler[298] and $2,857[299] for new baseline Central AC replacement).

Early Replacement: The full installation cost of the Ground Source Heat Pump should be used (default provided

[293] Minimum Federal Standard as of 4/1/2015; http://www.gpo.gov/fdsys/pkg/CFR-2012-title10-vol3/pdf/CFR-2012-title10-vol3-sec430-32.pdf

[294] System life of indoor components as per DOE estimate http://energy.gov/energysaver/articles/geothermal-heat-pumps. The ground loop has a much longer life, but the compressor and other mechanical components are the same as an ASHP. http://neep.org/uploads/EMV%20Forum/EMV%20Studies/measure_life_GDS%5B1%5D.pdf

[295] Assumed to be one third of effective useful life

[296] Based on data provided in 'Results of HomE geothermal and air source heat pump rebate incentives documented by IL electric cooperatives'.

[297] Based on data provided on Home Advisor website, providing national average ASHP cost based on 2465 cost submittals. http://www.homeadvisor.com/cost/heating-and-cooling/install-a-heat-pump/

[298] Furnace and boiler costs are based on data provided in Appendix E of the Appliance Standards Technical Support Documents including equipment cost and installation labor (http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/fb_fr_tsd/appendix_e.pdf). Where efficiency ratings are not provided, the values are interpolated from those that are.

[299] 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.

above). The assumed deferred cost (after 8 years) of replacing existing equipment with a new baseline unit is assumed to be $1,518 per ton for a new baseline Air Source Heat Pump, or $2,903 for a new baseline 90% AFUE furnace or $4,045 for a new 82% AFUE boiler and $3,140 for new baseline Central AC replacement[300]. This future cost should be discounted to present value using the utilities' discount rate.

LOADSHAPE

Loadshape R08 - Residential Cooling (if replacing gas heat and central AC)

Loadshape R09 - Residential Electric Space Heat (if replacing electric heat with no cooling)

Loadshape R10 - Residential Electric Heating and Cooling (if replacing ASHP)

COINCIDENCE FACTOR

The summer peak coincidence factor for cooling is provided in two different ways below. The first is used to estimate peak savings during the utility peak hour and is most indicative of actual peak benefits, and the second represents the *average* savings over the defined summer peak period, and is presented so that savings can be bid into PJM's Forward Capacity Market.

CF_{SSP} = Summer System Peak Coincidence Factor for Heat Pumps (during utility peak hour)

= 72%%[301]

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

= 46.6%[302]

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

New Construction and Time of Sale (non-fuel switch only):

ΔkWh = [Cooling savings] + [Heating savings] + [DHW savings]

$= [(FLHcool * Capacity\_cooling * (1/SEER_{base} – (1/EER_{PL})/1000] + [Elecheat * FLHheat * Capacity\_heating * (1/HSPF_{base} – (1/COP_{PL} * 3.412)))/1000] + [ElecDHW * \%DHWDisplaced * (((1/EF_{ELEC}) * GPD * Household * 365.25 * \gamma Water * (T_{OUT} – T_{IN}) * 1.0) / 3412)]$

New Construction and Time of Sale (fuel switch only):

If measure is supported by gas utility only, ΔkWH = 0

If measure is supported by gas and electric utility or electric utility only, electric utility claim savings calculated below:

ΔkWh = [Cooling savings] + [Heating savings from base ASHP to GSHP] + [DHW savings]

$= [(FLHcool * Capacity\_cooling * (1/SEER_{base} – (1/EER_{PL})/1000] + [FLHheat * Capacity\_heating * (1/HSPF_{ASHP} – (1/COP_{PL} * 3.412)))/1000] + [ElecDHW * \%DHWDisplaced * (((1/EF_{ELEC}) * GPD * Household * 365.25 * \gamma Water * (T_{OUT} – T_{IN}) * 1.0) /$

[300] All baseline replacement costs are consistent with their respective measures and include inflation rate of 1.91%.
[301] 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)'. http://www.icc.illinois.gov/downloads/public/edocket/368522.pdf
[302] 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.

3412)]

Early replacement (non-fuel switch only)[303]:

ΔkWH for remaining life of existing unit (1st 8 years):

= [Cooling savings] + [Heating savings] + [DHW savings]

= [(FLHcool * Capacity_cooling * (1/SEERexist – (1/EER_{PL})/1000] + [ElecHeat * (FLHheat * Capacity_heating * (1/HSPFexist) – (1/COP_{PL} * 3.412)))/1000] + [ElecDHW * %DHWDisplaced * (((1/ EF_{ELEC}) * GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0) / 3412)]

ΔkWH for remaining measure life (next 17 years):

= [(FLHcool * Capacity_cooling * (1/SEERbase – (1/EER_{PL})/1000] + [ElecHeat * (FLHheat * Capacity_heating * (1/HSPFbase) – (1/COP_{PL} * 3.412)))/1000] + [ElecDHW * %DHWDisplaced * (((1/ EF_{ELEC}) * GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0) / 3412)]

Early replacement - fuel switch only (see illustrative examples after Natural Gas section):

If measure is supported by gas utility only, ΔkWH = 0

If measure is supported by gas and electric utility or electric utility only, electric utility claim savings calculated below:

ΔkWh for remaining life of existing unit (1st 8 years):

= [Cooling savings] + [Heating savings from base ASHP to GSHP] + [DHW savings]

= [(FLHcool * Capacity_cooling * (1/SEERexist – (1/EER_{PL})/1000] + [(FLHheat * Capacity_heating * (1/$HSPF_{ASHP}$ – (1/COP_{PL} * 3.412)))/1000] + [ElecDHW * %DHWDisplaced * (((1/ EF_{ELEC}) * GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0) / 3412)]

ΔkWh for remaining measure life (next 17 years):

= [Cooling savings] + [Heating savings from base ASHP to GSHP] + [DHW savings]

= [(FLHcool * Capacity_cooling * (1/$SEER_{base}$ – (1/EER_{PL})/1000] + [(FLHheat * Capacity_heating * (1/$HSPF_{ASHP}$ – (1/COP_{PL} * 3.412)))/1000] + [ElecDHW * %DHWDisplaced * (((1/ EF_{ELEC}) * GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0) / 3412)]

Where:

FLHcool = Full load cooling hours

Dependent on location as below[304]:

[303] 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).

[304] 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 Volume 1, Section 3.7 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[305]	629	564

Capacity_cooling = Cooling Capacity of Ground Source Heat Pump (Btu/hr)

= Actual (1 ton = 12,000Btu/hr)

SEERbase = SEER Efficiency of new replacement baseline unit

Existing Cooling System	SEERbase
Air Source Heat Pump	14[306]
Central AC	13[307]
No central cooling	13[308]

SEERexist = SEER Efficiency of existing cooling unit

= Use actual SEER rating where it is possible to measure or reasonably estimate, if unknown assume default provided below:

Existing Cooling System	SEER_exist
Air Source Heat Pump	9.12[309]
Central AC	8.60[310]
No central cooling	13 [311]

$SEER_{ASHP}$ = SEER Efficiency of new baseline Air Source Heat Pump unit (for fuel switch)

= 14 [312]

305 Weighted based on number of occupied residential housing units in each zone.
306 Minimum Federal Standard as of 1/1/2015; http://www.gpo.gov/fdsys/pkg/CFR-2012-title10-vol3/pdf/CFR-2012-title10-vol3-sec430-32.pdf
307 Minimum Federal Standard; Federal Register, Vol. 66, No. 14, Monday, January 22, 2001/Rules and Regulations, p. 7170-7200.
308 Assumes that the decision to replace existing systems includes desire to add cooling.
309 Average nameplate efficiencies of all Early Replacement qualifying equipment in Ameren PY3-PY4.
310 Ibid.
311 Assumes that the decision to replace existing systems includes desire to add cooling.
312 Minimum Federal Standard as of 1/1/2015; http://www.gpo.gov/fdsys/pkg/CFR-2012-title10-vol3/pdf/CFR-2012-title10-vol3-sec430-32.pdf

EER_{PL} = Part Load EER Efficiency of efficient GSHP unit[313]

= Actual installed

ElecHeat = 1 if existing building is electrically heated

= 0 if existing building is not electrically heated

FLHheat = Full load heating hours

Dependent on location as below[314]:

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[315]	1,821

Capacity_heating = Heating Capacity of Ground Source Heat Pump (Btu/hr)

= Actual (1 ton = 12,000Btu/hr)

$HSPF_{base}$ =Heating System Performance Factor of new replacement baseline heating system (kBtu/kWh)

Existing Heating System	HSPF_base
Air Source Heat Pump	8.2
Electric Resistance	3.41[316]

HSPF_exist =Heating System Performance Factor of existing heating system (kBtu/kWh)

= Use actual HSPF rating where it is possible to measure or reasonably estimate. If unknown assume default:

Existing Heating System	HSPF_exist
Air Source Heat Pump	5.44
Electric Resistance	3.41

313 As per conversations with David Buss territory manager for Connor Co, the SEER and COP ratings of an ASHP equate most appropriately with the part load EER and COP of a GSHP.
314 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 Volume 1, Section 3.7 providing the appropriate city to use for each county of Illinois.
315 Weighted based on number of occupied residential housing units in each zone.
316 Electric resistance has a COP of 1.0 which equals 1/0.293 = 3.41 HSPF.

$HSPF_{ASHP}$ =Heating Season Performance Factor for new ASHP baseline unit (for fuel switch)

=8.2 [317]

COP_{PL} = Part Load Coefficient of Performance of efficient unit[318]

= Actual Installed

3.412 = Constant to convert the COP of the unit to the Heating Season Performance Factor (HSPF).

ElecDHW = 1 if existing DHW is electrically heated

= 0 if existing DHW is not electrically heated

%DHWDisplaced = Percentage of total DHW load that the GSHP will provide

= Actual if known

= If unknown and if desuperheater installed assume 44%[319]

= 0% if no desuperheater installed

EF_{ELEC} = Energy Factor (efficiency) of electric water heater

= Actual. If unknown or for new construction assume federal standard[320]:

For <=55 gallons: 0.96 – (0.0003 * rated volume in gallons)

For >55 gallons: 2.057 – (0.00113 * rated volume in gallons)

GPD = Gallons Per Day of hot water use per person

= 45.5 gallons hot water per day per household/2.59 people per household[321]

= 17.6

Household = Average number of people per household

Household Unit Type	Household
Single-Family - Deemed	2.56[322]
Custom	Actual Occupancy or Number of Bedrooms[323]

365.25 = Days per year

γWater = Specific weight of water

[317] Minimum Federal Standard as of 1/1/2015; http://www.gpo.gov/fdsys/pkg/CFR-2012-title10-vol3/pdf/CFR-2012-title10-vol3-sec430-32.pdf

[318] As per conversations with David Buss territory manager for Connor Co, the SEER and COP ratings of an ASHP equate most appropriately with the part load EER and COP of a GSHP.

[319] Assumes that the desuperheater can provide two thirds of hot water needs for eight months of the year (2/3 * 2/3 = 44%). Based on input from Doug Dougherty, Geothermal Exchange Organization.

[320] Minimum Federal Standard as of 4/1/2015; http://www.gpo.gov/fdsys/pkg/CFR-2012-title10-vol3/pdf/CFR-2012-title10-vol3-sec430-32.pdf

[321] Deoreo, B., and P. Mayer. Residential End Uses of Water Study Update. Forthcoming. ©2015 Water Research Foundation. Reprinted With Permission.

[322] 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

[323] 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.

	= 8.33 pounds per gallon
T_{OUT}	= Tank temperature
	= 125°F
T_{IN}	= Incoming water temperature from well or municiplal system
	= 54°F[324]
1.0	= Heat Capacity of water (1 Btu/lb*°F)
3412	= Conversion from Btu to kWh

Illustrative Examples

New Construction using ASHP baseline:

For example, a 3 ton unit with Part Load EER rating of 19 and Part Load COP of 4.4 with desuperheater is installed with a 50 gallon electric water heater in single family house in Springfield:

ΔkWh = [(FLHcool * Capacity_cooling * (1/$SEER_{base}$ – (1/EER_{PL})/1000] + [(FLHheat * Capacity_heating * (1/HSPFbase – (1/COP_{PL} * 3.412)))/1000] + [ElecDHW * %DHWDisplaced * (((1/ $EF_{ELEC\ EXIST}$) * GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0) / 3412)]

ΔkWh = [(730 * 36,000 * (1/14 – 1/19)) / 1000] + [(1754* 36,000 * (1/8.2 – 1/ (4.4*3.412))) / 1000] + [1 * 0.44 * (((1/0.945) * 17.6 * 2.56 *365.25 * 8.33 * (125-54) * 1)/3412)]

= 494 + 3494 + 1328

= 5316 kWh

Early Replacement – non-fuel switch (see example after Natural gas section for Fuel switch):

For example, a 3 ton unit with Part Load EER rating of 19 and Part Load COP of 4.4 with desuperheater is installed in single family house in Springfield with a 50 gallon electric water heater replacing an existing working Air Source Heat Pump with unknown efficiency ratings:

ΔkWH for remaining life of existing unit (1st 8 years):

= [(730 * 36,000 * (1/9.12 - 1/19)) / 1000] + [(1754 * 36,000 * (1/5.44 - 1/(4.4 * 3.412))) / 1000] + [0.44 * 1 * (((1/0.945) * 17.6 * 2.56 *365.25 * 8.33 * (125-54) * 1)/3412)]

= 1498 + 7401 + 1328

= 10,227 kWh

ΔkWH for remaining measure life (next 17 years):

= [(730 * 36,000 * (1/14 – 1/28)) / 1000] + [(1967 * 36,000 * (1/8.2 – 1/ (4.4 * 3.412)) / 1000] + [0.44 * 1 * (((1/0.945) * 17.6 * 2.56 *365.25 * 8.33 * (125-54) * 1)/3412)]

= 494 + 3494 + 1328

= 5316 kWh

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

SUMMER COINCIDENT PEAK DEMAND SAVINGS

New Construction and Time of Sale:

$\Delta kW = (Capacity\_cooling * (1/EERbase - 1/EER_{FL}))/1000) * CF$

Early replacement:

ΔkW for remaining life of existing unit (1st 8 years):

$= (Capacity\_cooling * (1/EERexist - 1/EER_{FL}))/1000) * CF$

ΔkW for remaining measure life (next 17 years):

$= (Capacity\_cooling * (1/EERbase - 1/EER_{FL}))/1000) * CF$

Where:

EERbase = EER Efficiency of new replacement unit

Existing Cooling System	EER_base
Air Source Heat Pump	11.8[325]
Central AC	11 [326]
No central cooling	11[327]

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:

$EERexist = (-0.02 * SEERexist^2) + (1.12 * SEERexist)$ [328]

If SEER rating unavailable use:

Existing Cooling System	EER_exist
Air Source Heat Pump	8.55
Central AC	8.15[330]
No central cooling	11 [331]

EER_{FL} = Full Load EER Efficiency of ENERGY STAR GSHP unit [332]

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)

[325] The Federal Standard does not include an EER requirement, so it is approximated with the conversion formula from Wassmer, M. 2003 thesis refererenced below.
[326] Minimum Federal Standard; Federal Register, Vol. 66, No. 14, Monday, January 22, 2001/Rules and Regulations, p. 7170-7200.
[327] Assumes that the decision to replace existing systems includes desire to add cooling.
[328] From Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder.
[329] Average nameplate efficiencies of all Early Replacement qualifying equipment in Ameren PY3-PY4.
[330] Ibid.
[331] Assumes that the decision to replace existing systems includes desire to add cooling.
[332] As per conversations with David Buss territory manager for Connor Co, the EER rating of an ASHP equate most appropriately with the full load EER of a GSHP.

= 72%%[333]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)

= 46.6%[334]

New Construction or Time of Sale:

For example, a 3 ton unit with Full Load EER rating of 19:

ΔkW_{SSP} = ((36,000 * (1/11.8 – 1/19))/1000) * 0.72

= 0.83 kW

ΔkW_{PJM} = ((36,000 * (1/11 – 1/19))/1000) * 0.466

= 0.54 kW

Early Replacement:

For example, a 3 ton Full Load 19 EER replaces an existing working Air Source Heat Pump with unknown efficiency ratings in Marion:

ΔkW_{SSP} for remaining life of existing unit (1st 8 years):

= ((36,000 * (1/8.55 – 1/19))/1000) * 0.72

= 1.67 kW

ΔkW_{SSP} for remaining measure life (next 17 years):

= ((36,000 * (1/11.8 – 1/19))/1000) * 0.72

= 0.83 kW

ΔkW_{PJM} for remaining life of existing unit (1st 8 years):

= ((36,000 * (1/8.55 – 1/19))/1000) * 0.466

= 1.08 kW

ΔkW_{PJM} for remaining measure life (next 17 years):

= ((36,000 * (1/11.8 – 1/19))/1000) * 0.466

= 0.54 kW

[333] 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)'. http://www.icc.illinois.gov/downloads/public/edocket/368522.pdf

[334] 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

New Construction and Time of Sale with baseline gas heat and/or hot water:

If measure is supported by gas utility only, gas utility claim savings calculated below:

ΔTherms = [Heating Savings] + [DHW Savings]

= [Replaced gas consumption – therm equivalent of GSHP source kWh] + [DHW Savings]

= [(1 – ElecHeat) * ((Gas_Heating_Load/AFUEbase) – (kWhtoTherm * FLHheat * Capacity_heating * 1/COP_{PL})/1000)] + [(1 – ElecDHW) * %DHWDisplaced * (1/ $EF_{GAS\ EXIST}$ * GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0) / 100,000)]

If measure is supported by electric utility only, ΔTherms = 0

If measure is supported by gas and electric utility, gas utility claim savings calculated below, (electric savings is provided in Electric Energy Savings section):

ΔTherms = [Heating Savings] + [DHW Savings]

= [Replaced gas consumption – therm equivalent of base ASHP source kWh] + [DHW Savings]

= [(1 – ElecHeat) * ((Gas_Heating_Load/AFUEbase) – (kWhtoTherm * FLHheat * Capacity_heating * 1/($HSPF_{ASHP}$/3.412))/1000)] + [(1 – ElecDHW) * %DHWDisplaced * (1/ $EF_{GAS\ EXIST}$ * GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0) / 100,000)]

Early replacement for homes with existing gas heat and/or hot water:

If measure is supported by gas utility only, gas utility claim savings calculated below:

ΔTherms for remaining life of existing unit (1st 8 years):

= [Heating Savings] + [DHW Savings]

= [Replaced gas consumption – therm equivalent of GSHP source kWh] + [DHW Savings]

= [(1 – ElecHeat) * ((Gas_Heating_Load/AFUEexist) – (kWhtoTherm * FLHheat * Capacity_heating * 1/(COP_{PL} * 3.412))/1000)] + [(1 – ElecDHW) * %DHWDisplaced * (1/ $EF_{GAS\ EXIST}$ * GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0) / 100,000)]

ΔTherms for remaining measure life (next 17 years):

= [(1 – ElecHeat) * ((Gas_Heating_Load/AFUEbaseER) – (kWhtoTherm * FLHheat * Capacity_heating * 1//(COP_{PL} * 3.412))/1000)] + [(1 – ElecDHW) * %DHWDisplaced * (1/ $EF_{GAS\ EXIST}$ * GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0) / 100,000)]

If measure is supported by electric utility only, ΔTherms = 0

If measure is supported by gas and electric utility, gas utility claim savings calculated below:

ΔTherms for remaining life of existing unit (1st 8 years):

ΔTherms = [Heating Savings] + [DHW Savings]

= [Replaced gas consumption – therm equivalent of base ASHP source kWh] + [DHW Savings]

= [(1 – ElecHeat) * ((Gas_Heating_Load/AFUEexist) – (kWhtoTherm * FLHheat * Capacity_heating * 1/$HSPF_{ASHP}$)/1000)] + [(1 – ElecDHW) * %DHWDisplaced * (1/ $EF_{GAS\ EXIST}$ * GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0) / 100,000)]

ΔTherms for remaining measure life (next 17 years):

= [(1 – ElecHeat) * ((Gas_Heating_Load/AFUEbaseER) – (kWhtoTherm * FLHheat *

Capacity_heating * 1/$HSPF_{ASHP}$)/1000)] + [(1 – ElecDHW) * %DHWDisplaced * (1/ $EF_{GAS\ EXIST}$ * GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0) / 100,000)]

Where:

ElecHeat = 1 if existing building is electrically heated

= 0 if existing building is not electrically heated

Gas_Heating_Load

= Estimate of annual household heating load [335] for gas furnace heated single-family homes. If location is unknown, assume the average below.

= Actual if informed by site-specific load calculations, ACCA Manual J or equivalent[336].

Climate Zone (City based upon)	Gas_Heating_Load if Furnace (therms) [337]	Gas_Heating_Load if Boiler (therms) [338]
1 (Rockford)	873	1275
2 (Chicago)	834	1218
3 (Springfield)	714	1043
4 (Belleville)	551	805
5 (Marion)	561	819
Average	793	1158

AFUEbase = Baseline Annual Fuel Utilization Efficiency Rating

= 80% if furnace and 82% if boiler.

AFUEexist = Existing Annual Fuel Utilization Efficiency Rating

= Use actual AFUE rating where it is possible to measure or reasonably estimate.

If unknown, assume 64.4% if furnace and 61.6% [339] if boiler.

AFUEbaseER = Baseline Annual Fuel Utilization Efficiency Rating for early replacement measure

---

[335] Heating load is used to describe the household heating need, which is equal to (gas consumption * AFUE)

[336] The Air Conditioning Contractors of America Manual J, Residential Load Calculation 8th Edition produces equipment sizing loads for Single Family, Multi-single, and Condominiums using input characteristics of the home. A best practice for equipment selection and installation of Heating and Air Conditioning, load calculations are commonly completed by contractors during the selection process and may be readily available for program data purposes.

[337] 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.

[338] Boiler consumption values are informed by an evaluation which did not identify any fraction of heating load due to domestic hot water (DHW) provided by the boiler. Thus these values are an average of both homes with boilers only providing heat, and homes with boilers that also provide DHW. Values are based on household heating consumption values and inferred average AFUE results from Table 3-4, Program Sample Analysis, *Nicor R29 Res Rebate Evaluation Report 092611_REV FINAL to Nicor*). Adjusting to a statewide average using relative HDD values to adjust for the evaluation results focus on northern region. Values for individual cities are then calculated by comparing average HDD to the individual city's HDD.

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

= 90%[340] if furnace and 82% if boiler.

kWhtoTherm = Converts source kWh to Therms

= H_{grid} / 100000

H_{grid} = Heat rate of the grid in btu/kWh based on the average fossil heat rate for the EPA eGRID subregion and includes a factor that takes into account T&D losses.

For systems operating less than 6,500 hrs per year:

Use the Non-baseload heat rate provided by EPA eGRID for RFC West region for ComEd territory (including independent providers connected to RFC West), and SERC Midwest region for Ameren territory (including independent providers connected to SERC Midwest)[341]. Also include any line losses.

For systems operating more than 6,500 hrs per year:

Use the All Fossil Average heat rate provided by EPA eGRID for RFC West region for ComEd territory, and SERC Midwest region for Ameren territory. Also include any line losses.

3.412 = Converts HSPF to COP

$EF_{GAS\ EXIST}$ = Energy Factor (efficiency) of existing gas water heater

= Actual. If unknown assume federal standard[342]:

For <=55 gallons: 0.675 – (0.0015 * tank_size)

For > 55 gallons 0.8012 – (0.00078 * tank size)

= If tank size unknown assume 40 gallons and EF_Baseline of 0.615

All other variables provided above

[340] Assumes that Federal Standard will have been increased to 90% by the time the existing unit would have to have been replaced.

[341] Refer to EPA eGRID data http://www.epa.gov/chp/documents/fuel_and_co2_savings.pdf, page 24 and http://www.epa.gov/cleanenergy/documents/egridzips/eGRID_9th_edition_V1-0_year_2010_Summary_Tables.pdf, page 9. Current values are:

- Non-Baseload RFC West: 9,811 Btu/kWh * (1 + Line Losses)
- Non-Baseload SERC Midwest: 10,511 Btu/kWh * (1 + Line Losses)
- All Fossil Average RFC West: 10,038 Btu/kWh * (1 + Line Losses)
- All Fossil Average SERC Midwest: 10,364 Btu/kWh * (1 + Line Losses)

[342] Minimum Federal Standard as of 4/1/2015; http://www.gpo.gov/fdsys/pkg/CFR-2012-title10-vol3/pdf/CFR-2012-title10-vol3-sec430-32.pdf

Illustrative Examples *[for illustrative purposes a Heat Rate of 10,000 Btu/kWh is used]*

New construction using gas furnace and central AC baseline, *supported by Gas utility only*:

For example, a 3 ton unit with Part Load EER rating of 19 and Part Load COP of 4.4 in single family house in Springfield with a 40 gallon gas water heater is installed in place of a natural gas furnace and 3 ton Central AC unit:

ΔkWH = 0

ΔTherms = [Heating Savings] + [DHW Savings]

= [Replaced gas consumption – therm equivalent of GSHP source kWh] + [DHW Savings]

= [(1 – ElecHeat) * ((Gas_Heating_Load/AFUEbase) – (kWhtoTherm * FLHheat * Capacity_heating * 1/(COP_{PL} * 3.412)/1000)] + [(1 – ElecDHW) * %DHWDisplaced * (1/ $EF_{GAS\ EXIST}$ * GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0) / 100,000)]

= [(1-0) * ((714/0.80) – (10000/100000 * 1754 * 36,000 * 1/(4.4 * 3.412))/1000)] + [(1 – 0) * (0.44 * (1/ 0.615 * 17.6 * 2.56 *365.25 * 8.33 * (125-54) * 1) / 100,000)]

= 472 + 70

= 542 therms

Early Replacement fuel switch, *supported by gas and electric utility*:

For example, a 3 ton unit with Part Load EER rating of 19 and Part Load COP of 4.4 in single family house in Springfield with a 40 gallon gas water heater replaces an existing working natural gas furnace and 3 ton Central AC unit with unknown efficiency ratings:

ΔkWh for remaining life of existing unit (1st 8 years):

= [Cooling savings] + [Heating savings from base ASHP to GSHP] + [DHW savings]

= [(FLHcool * Capacity_cooling * (1/SEERexist – (1/EER_{PL})/1000] + [(FLHheat * Capacity_heating * (1/$HSPF_{ASHP}$ – (1/COP_{PL} * 3.412)))/1000] + [ElecDHW * %DHWDisplaced * (((1/ EF_{ELEC}) * GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0) / 3412)]

= [(730* 36,000 * (1/8.6 - 1/19)) / 1000] + [(1754 * 36,000 * (1/8.2 - 1/(4.4 * 3.412))) / 1000] + [0 * 0.44 * (((1/0.904) * 17.6 * 2.56 *365.25 * 8.33 * (125-54) * 1)/3412)]

= 1673 + 3494 + 0

= 5167 kWh

Continued on next page.

Illustrative Example continued

ΔkWh for remaining measure life (next 17 years):

= [Cooling savings] + [Heating savings] + [DHW savings]

= [(FLHcool * Capacity_cooling * (1/$SEER_{base}$ – (1/EER_{PL})/1000] + [(FLHheat * Capacity_heating * (1/$HSPF_{ASHP}$ – (1/COP_{PL} * 3.412)))/1000] + [ElecDHW * %DHWDisplaced * (((1/ EF_{ELEC}) * GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0) /3412)]

= [(730 * 36,000 * (1/13 – 1/19)) / 1000] + [1754 * 36,000 * (1/8.2 – 1/ (4.4 *3.412)) / 1000] + [0 * 0.44 * (((1/0.904) * 17.6 * 2.56 *365.25 * 8.33 * (125-54) *1)/3412)]

= 638 + 3494 + 0

= 4132 kWh

ΔTherms for remaining life of existing unit (1st 8 years):

= [Heating Savings] + [DHW Savings]

= [Replaced gas consumption – therm equivalent of base ASHP source kWh] + [DHW Savings]

= [(1 – ElecHeat) * ((Gas_Heating_Load/AFUEexist) – (kWhtoTherm * FLHheat * Capacity_heating * 1/$HSPF_{ASHP}$)/1000)] + [(1 – ElecDHW) * %DHWDisplaced * (1/ $EF_{GAS\ EXIST}$ * GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0) / 100,000)]

= [(1-0) * ((714/0.644) – (10000/100000 * 1754 * 36,000 * 1/8.2)/1000)] + [(1 – 0) * (0.44 * (1/ 0.615 * 17.6 * 2.56 *365.25 * 8.33 * (125-54) * 1) / 100,000)]

= 339 + 70

= 408 therms

ΔTherms for remaining measure life (next 17 years):

= [(1 – ElecHeat) * ((Gas_Heating_Load/AFUEbaseER) – (kWhtoTherm * FLHheat * Capacity_heating * 1/$HSPF_{ASHP}$)/1000)] + [(1 – ElecDHW) * %DHWDisplaced * (1/ $EF_{GAS\ EXIST}$ * GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0) / 100,000)]

= [(1-0) * ((714/0.9) – (10000/100000 * 1754 * 36,000 * 1/8.2)/1000)] + [(1 – 0) * (0.44 * (1/ 0.615 * 17.6 * 2.56 *365.25 * 8.33 * (125-54) * 1) / 100,000)]

= 23 + 70

= 93 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

COST EFFECTIVENESS SCREENING AND LOAD REDUCTION FORECASTING WHEN FUEL SWITCHING

This measure can involve fuel switching from gas to electric.

For the purposes of forecasting load reductions due to fuel switch GSHP projects per Section 16-111.5B, changes in site energy use at the customer's meter (using ΔkWh algorithm below) adjusted for utility line losses (at-the-busbar savings), customer switching estimates, NTG, and any other adjustment factors deemed appropriate, should be used.

The inputs to cost effectiveness screening should reflect the actual impacts on the electric and fuel consumption at the customer meter and, for fuel switching measures, this will not match the output of the calculation/allocation methodology presented in the "Electric Energy Savings" and "Natural Gas Savings" sections above. Therefore in addition to the calculation of savings claimed, the following values should be used to assess the cost effectiveness of the measure.

ΔTherms = [Heating Consumption Replaced[343]] + [DHW Savings if gas]

= [(1 – ElecHeat) * ((Gas_Heating_Load/AFUEbase)] + [(1 – ElecDHW) * %DHWDisplaced * (1/ $EF_{GAS\ EXIST}$ * GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0) / 100,000)]

ΔkWh = - [GSHP heating consumption] + [Cooling savings[344]] + [DHW savings if electric]

= - [(FLHheat * Capacity_heating * (1/COP_{PL} * 3.412))/1000] + [(FLHcool * Capacity_cooling * (1/SEERbase - 1/EER_{PL}))/1000] + [ElecDHW * %DHWDisplaced * ((1/EF_{ELEC} * GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0) / 3412)]

[343] Note AFUEbase in the algorithm should be replaced with AFUEexist for early replacement measures.
[344] Note SEERbase in the algorithm should be replaced with SEERexist for early replacement measures.

Illustrative Example of Cost Effectiveness Inputs for Fuel Switching

For example, a 3 ton unit with Part Load EER rating of 19 and Part Load COP of 4.4 in single family house in Springfield with a 40 gallon gas water heater replaces an existing working natural gas furnace and 3 ton Central AC unit with unknown efficiency ratings. [Note the calculation provides the annual savings for the first 8 years of the measure life, an additional calculation (not shown) would be required to calculated the annual savings for the remaining life (years 9-25)]:

ΔTherms = [(1 – ElecHeat) * ((Gas_Heating_Load/AFUEexist)] + [(1 – ElecDHW) * %DHWDisplaced * (1/ $EF_{GAS\ EXIST}$ * GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0) / 100,000)]

= [(1-0) * (714/0.644)] + [((1 – 0) * 0.44 * (1/ 0.615 * 17.6 * 2.56 *365.25 * 8.33 * (125-54) * 1) / 100,000)]

= 1109 + 70

= 1179 therms

ΔkWh = - [(FLHheat * Capacity_heating * (1/COP_{PL} * 3.412))/1000] + [(FLHcool * Capacity_cooling * (1/SEERexist - 1/EER_{PL}))/1000] + [ElecDHW * %DHWDisplaced * (((1/EF_{ELEC}) * GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0) / 3412)]

= - [(1754 * 36,000 * (1/(4.4 * 3.412)))/ 1000] + [(730 * 36,000 * (1/8.6 - 1/19))/ 1000)] + [0 * 0.44 * (((1/0.904) * 17.6 * 2.56 *365.25 * 8.33 * (125-54) * 1)/3412)]

= -4206 + 1673 + 0

= -2533 kWh

MEASURE CODE: RS-HVC-GSHP-V06-160601

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 [345]) exhaust-only ventilation fan, quiet (< 2.0 sones) Continuous operation in accordance with recommended ventilation rate indicated by ASHRAE 62.2[346]

Definition of Baseline Equipment

New standard efficiency (average CFM/Watt of 3.1[347]) exhaust-only ventilation fan, quiet (< 2.0 sones) operating in accordance with recommended ventilation rate indicated by ASHRAE 62.2 [348]

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 19 years[349].

Deemed Measure Cost

Incremental cost per installed fan is $43.50 for quiet, efficient fans[350].

Loadshape

Loadshape R11 - Residential Ventilation

Coincidence Factor

The summer Peak Coincidence Factor is assumed to be 100% because the fan runs continuously.

---

[345] 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.

[346] Bi-level controls may be used by efficient fans larger than 50 CFM

[347] 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.

[348] On/off cycling controls may be required of baseline fans larger than 50CFM.

[349] 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.

[350] VEIC analysis using cost data collected from wholesale vendor; http://www.westsidewholesale.com/ .

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[351]

$\eta_{BASELINE}$ = Average efficacy for baseline fan

= 3.1 CFM/Watt[352]

$\eta_{EFFCIENT}$ = Average efficacy for efficient fan

= 8.3 CFM/Watt[353]

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

$\Delta kW = (CFM * (1/\eta_{BASELINE} - 1/\eta_{EFFICIENT})/1000) * CF$

Where:

CF = Summer Peak Coincidence Factor

= 1.0 (continuous operation)

Other variables as defined above

$\Delta kW = (50 * (1/3.1 – 1/8.3)/1000) * 1.0$

$= 0.0101$ kW

NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

[351] 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.
[352] 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.
[353] 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.

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[354].

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[355].

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)

= 68%[356]

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

= 72%%[357]

[354] Based on VEIC professional judgment.

[355] 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.

[356] Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.

[357] 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)'.

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)

= 46.6%[358]

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:[359]

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[360]	629	564

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 [361]

MFe = Maintenance energy savings factor

= 0.05[362]

[358] 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.
[359] 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 Volume 1, Section 3.7 providing the appropriate city to use for each county of Illinois.
[360] Weighted based on number of occupied residential housing units in each zone.
[361] 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.
[362] Energy Center of Wisconsin, May 2008; “Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research.”

$SEER_{ASHP}$ = SEER Efficiency of existing air source heat pump unit receiving maintenence

= Actual. If unknown assume 10 SEER [363]

FLHheat = Full load heating hours

Dependent on location:[364]

Climate Zone (City based upon)	FLHheat
1 (Rockford)	2208
2 (Chicago)	2064
3 (Springfield)	1967
4 (Belleville)	1420
5 (Marion)	1445
Weighted Average[365]	1821

Capacity_heating = Heating cpacity of equipment in Btu/hr (note 1 ton = 12,000 Btu/hr)

= Actual

$HSPF_{ASHP}$ = Heating Season Performance Factor of existing air source heat pump unit receiving maintenence

= Actual. If unknown assume 6.8 HSPF [366]

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

[363] 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.

[364] 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 Volume 1, Section 3.7 providing the appropriate city to use for each county of Illinois.

[365] Weighted based on number of occupied residential housing units in each zone.

[366] 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.

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 [367]

MFd = Maintenance demand savings factor

= 0.02 [368]

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)

= 68%[369]

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

= 72%%[370]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C and Heat Pumps (average during peak period)

= 46.6%[371]

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.

---

367 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.

368 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.

369 Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.

370 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)'.

371 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.

MEASURE CODE: RS-HVC-TUNE-V03-160601

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[372]. 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[373] based upon equipment life only[374]. For the purposes of claiming savings for a new programmable thermostat, this is reduced by a 50% persistence factor to give final measures life of 5 years. For reprogramming, this is reduced further to give a measure life of 2 years.

Deemed Measure Cost

Actual material and labor costs should be used if the implementation method allows. If unknown (e.g. through a

---

[372] 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'.

[373] Table 1, HVAC Controls, Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007

[374] 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.

retail program) the capital cost for the new installation measure is assumed to be $30[375]. 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[376] = %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%[377]

Elec_Heating_ Consumption

= Estimate of annual household heating consumption for electrically heated single-family homes[378]. If location and heating type is unknown, assume 15,678 kWh[379]

Climate Zone	Electric Resistance	Electric Heat Pump

[375] 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.
[376] Note the second part of the algorithm relates to furnace fan savings if the heating system is Natural Gas.
[377] 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.
[378] 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.
[379] 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.

(City based upon)	Elec_Heating_ Consumption (kWh)	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%[380]

HF = Household factor, to adjust heating consumption for non-single-family households.

Household Type	HF
Single-Family	100%
Multi-Family	65%[381]
Actual	Custom[382]

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%[383]

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

[380] 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.

[381] 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

[382] Program-specific household factors may be utilized on the basis of sufficiently validated program evaluations.

[383]"Programmable Thermostats. Report to KeySpan Energy Delivery on Energy Savings and Cost Effectiveness," GDS Associates, Marietta, GA. 2002GDS

consumption

= 3.14%[384]

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%
Natural Gas	100%
Unknown	87%[385]

Gas_Heating_Consumption

= Estimate of annual household heating consumption for gas heated single-family homes. If location is unknown, assume the average below[386].

Climate Zone (City based upon)	Gas_Heating_ Consumption (therms)
1 (Rockford)	1,052
2 (Chicago)	1,005

[384] 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.

[385] 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.

[386] 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.

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

5.3.12 Ductless Heat Pumps

Description

This measure is designed to calculate electric savings for supplementing existing electric HVAC systems with ductless mini-split heat pumps (DMSHPs). DMSHPs save energy in heating mode because they provide heat more efficiently than electric resistance heat and central ASHP systems. Additionally, DMSHPs use less fan energy to move heat and don't incur heat loss through a duct distribution system. Often DMSHPs are installed in addition to (do not replace) existing heating equipment because at extreme cold conditions, many DMSHPs cannot provide enough heating capacity, although cold-climate heat pumps can continue to perform at sub-zero temperatures.

For cooling, the proposed savings calculations are aligned with those of typical replacement systems. DMSHPs save energy in cooling mode because they provide cooling capacity more efficiently than other types of unitary cooling equipment. A DMSHP installed in a home with a central ASHP system will save energy by offsetting some of the cooling energy of the ASHP. 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.[387]

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 program minimum efficiency requirements.

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.

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 18 years[388].

Deemed Measure Cost

The incremental cost for this measure is provided below:

Unit Size	Incremental Cost[389]
1-Ton	$3,000

[387] 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.

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

Unit Size	Incremental Cost[389]
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 metering data for 40 DMSHPs in Ameren Illinois service territory[390].

CF_{SSP} = Summer System Peak Coincidence Factor for DMSHP (during utility peak hour)

= 43.1%%[391]

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

= 28.0%[392]

---

[390] *All-Electric Homes PY6 Metering Results: Multifamily HVAC Systems*, Cadmus, October 2015

[391] 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)'.

[392] 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

$\Delta kWh = \Delta kWh_{heat} + \Delta kWh_{cool}$

$\Delta kWh_{heat} = (Capacity_{heat} * EFLH_{heat} * (1/HSPF_{exist} - 1/HSPF_{ee})) / 1000$

$\Delta kWh_{cool} = (Capacity_{cool} * EFLH_{cool} * (1/SEER_{exist} - 1/SEER_{ee})) / 1000$

Where:

$Capacity_{heat}$ = Heating capacity of the ductless heat pump unit in Btu/hr

= Actual

$EFLH_{heat}$ = Equivalent Full Load Hours for heating. Depends on location. See table below

Climate Zone (City based upon)	$EFLH_{heat}$[393]
1 (Rockford)	1,520
2 (Chicago)	1,421
3 (Springfield)	1,347
4 (Belleville)	977
5 (Marion)	994
Weighted Average	1,406

$HSPF_{exist}$ = HSPF rating of existing equipment (kbtu/kwh)

Existing Equipment Type	$HSPF_{exist}$
Electric resistance heating	3.412[394]
Air Source Heat Pump	5.44[395]

[393] *All-Electric Homes PY6 Metering Results: Multifamily HVAC Systems*, Cadmus, October 2015. FLH values are based on metering of multi-family units that were used as the primary heating source to the whole home, and in buildings that had received weatherization improvements. A DMSHP installed in a single-family home may be used more sporadically, especially if the DMSHP serves only a room, and buildings that have not been weatherized may require longer hours. Additional evaluation is recommended to refine the EFLH assumptions for the general population.

[394] Electric resistance has a COP of 1.0 which equals 1/0.293 = 3.41 HSPF.

[395] 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.

$HSPF_{ee}$ = HSPF rating of new equipment (kbtu/kwh)

= Actual installed

$Capacity_{cool}$ = the cooling capacity of the ductless heat pump unit in Btu/hr[396].

= Actual installed

$SEER_{ee}$ = SEER rating of new equipment (kbtu/kwh)

= Actual installed[397]

$SEER_{exist}$ = SEER rating of existing equipment (kbtu/kwh)

= Use actual value. If unknown, see table below

Existing Cooling System	SEER_exist[398]
Air Source Heat Pump	9.12
Central AC	8.60
Room AC	8.0[399]
No existing cooling[400]	Make '1/SEER_exist' = 0

$EFLH_{cool}$ = Equivalent Full Load Hours for cooling. Depends on location. See table below[401].

Climate Zone (City based upon)	$EFLH_{cool}$
1 (Rockford)	323
2 (Chicago)	308
3 (Springfield)	468
4 (Belleville)	629
5 (Marion)	549
Weighted	364

[396] 1 Ton = 12 kBtu/hr

[397] Note that if only an EER rating is available, use the following conversion equation; EER_base = (-0.02 * SEER_base^2) + (1.12 * SEER). From Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder.

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

[399] Estimated by converting the EER assumption using the conversion equation; EER_base = (-0.02 * SEER_base^2) + (1.12 * SEER). From Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder.

[400] If there is no existing cooling in place but the incentive encourages installation of a new DMSHP with cooling, the added cooling load should be subtracted from any heating benefit.

[401] *All-Electric Homes PY6 Metering Results: Multifamily HVAC Systems*, Cadmus, October 2015. FLH values are based on metering of multi-family units, and in buildings that had received weatherization improvements.Additional evaluation is recommended to refine the EFLH assumptions for the general population.

Climate Zone (City based upon)	$EFLH_{cool}$
Average[402]	

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 of unknown efficiency, savings are:

ΔkWh_{heat} = (18000 * 1421 * (1/3.412 – 1/8))/1000 = 4,299 kWh

ΔkWh_{cool} = (18000 * 308 *(1/8.0 – 1/14)) /1000 = 297 kWh

ΔkWh = 4,299 + 297 = 4,596 kWh

Summer Coincident Peak Demand Savings

$\Delta kW = (Capacity_{cool} * (1/EER_{exist} - 1/EER_{ee})) / 1000) * CF$

Where:

EER_{exist} = Energy Efficiency Ratio of existing cooling system (kBtu/hr / kW)

= Use actual EER rating otherwise:

Existing Cooling System	EER_exist
Air Source Heat Pump	8.55[403]
Central AC	8.15[404]
Room AC	7.7[405]
No existing cooling[406]	Make '1/EER_exist' = 0

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: [407]

$= (-0.02 * SEER^2) + (1.12 * SEER)$

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

= 43.1%%[408]

---

402 Weighted based on number of residential occupied housing units in each zone.
403 Average nameplate efficiencies of all Early Replacement qualifying equipment in Ameren PY3-PY4.
404 Average nameplate efficiencies of all Early Replacement qualifying equipment in Ameren PY3-PY4.
405 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."
406 If there is no central cooling in place but the incentive encourages installation of a new DMSHP with cooling, the added cooling load should be subtracted from any heating benefit.
407 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.
408 Based on analysis of metering results from 24 heat pumps in Ameren Illinois service territory in PY5 coincident with AIC's

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

= 28.0%[409]

NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HVC-DHP-V04-160601

2010 system peak; 'Impact and Process Evaluation of Ameren Illinois Company's Residential HVAC Program (PY5)'.

[409] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.

5.3.13 Residential Furnace Tune-Up

Description

This measure is for a natural gas Residential furnace that provides space heating. The tune-up will improve furnace performance by inspecting, cleaning and adjusting the furnace and appurtenances for correct and efficient operation. Additional savings maybe realized through a complete system tune-up.

This measure was developed to be applicable to the following program types: Residential.

If applied to other program types, the measure savings should be verified.

Definition of Efficient Equipment

To qualify for this measure an approved technician must complete the tune-up requirements[410] listed below:

- Measure combustion efficiency using an electronic flue gas analyzer
- Check and clean blower assembly and components per manufacturer's recommendations
- Where applicable Lubricate motor and inspect and replace fan belt if required
- Inspect for gas leaks
- Clean burner per manufacturer's recommendations and adjust as needed
- Check ignition system and safety systems and clean and adjust as needed
- Check and clean heat exchanger per manufacturer's recommendations
- Inspect exhaust/flue for proper attachment and operation
- Inspect control box, wiring and controls for proper connections and performance
- Check air filter and clean or replace per manufacturer's
- Inspect duct work connected to furnace for leaks or blockages
- Measure temperature rise and adjust flow as needed
- Check for correct line and load volts/amps
- Check thermostat operation is per manufacturer's recommendations(if adjustments made, refer to 'Residential Programmable Thermostat' measure for savings estimate)
- Perform Carbon Monoxide test and adjust heating system until results are within standard industry acceptable limits

Definition of Baseline Equipment

The baseline is furnace assumed not to have had a tune-up in the past 2 years.

Deemed Lifetime of Efficient Equipment

The measure life for the tune up is 2 years.[411]

Deemed Measure Cost

The incremental cost for this measure should be the actual cost of tune up.

[410] American Standard Maintenance for Indoor Units: http://www.americanstandardair.com/owner-support/maintenance.html
[411]Act on Energy Commercial Technical Reference Manual No. 2010-4, 9.2.3 Gas Forced-Air Furnace Tune-up.

Deemed O&M Cost Adjustments

There are no expected O&M savings associated with this measure.

Loadshape

Loadshape R09 - Residential Electric Space Heat

Coincidence Factor

N/A

Algorithms

Calculation of Energy Savings

Electric Energy Savings

$$\Delta kWh = \Delta Therms * F_e * 29.3$$

Where:

ΔTherms = as calculated below

F_e = Furnace Fan energy consumption as a percentage of annual fuel consumption

= 3.14%[412]

29.3 = kWh per therm

Summer Coincident Peak Demand Savings

N/A

Natural Gas Savings

$$\Delta therms = (Gas\_Furnace\_Heating\_Load * HF * (1/ Effbefore - 1/ (Effbefore + Ei)))$$

Where:

Gas_Furnace_Heating_Load = Estimate of annual household heating load[413] for gas furnace heated

[412] 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.

[413] Heating load is used to describe the household heating need, which is equal to (gas consumption * AFUE)

single-family homes. If location is unknown, assume the average below[414].

= Actual if informed by site-specific load calculations, ACCA Manual J or equivalent[415].

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%[416]
Actual	Custom[417]

Effbefore = Efficiency of the furnace before the tune-up

= Actual

Note: Contractors should select a mid-level firing rate that appropriately represents the average building operating condition over the course of the heating season and take readings at a consistent firing rate for pre and post tune-up.

EI = Efficiency Improvement of the furnace tune-up measure

= Actual

[414] 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.

[415] 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.

[416] 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

[417] Program-specific household factors may be utilized on the basis of sufficiently validated program evaluations.

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HVC-FTUN-V02-160601

5.3.14 Boiler Reset Controls

DESCRIPTION

This measure relates to improving system efficiency by adding controls to residential heating boilers to vary the boiler entering water temperature relative to heating load as a function of the outdoor air temperature to save energy. The water can be run a little cooler during fall and spring, and a little hotter during the coldest parts of the winter. A boiler reset control has two temperature sensors - one outside the house and one in the boiler water. As the outdoor temperature goes up and down, the control adjusts the water temperature setting to the lowest setting that is meeting the house heating demand. There are also limits in the controls to keep a boiler from operating outside of its safe performance range.[418]

This measure was developed to be applicable to the following program types: RF.

DEFINITION OF EFFICIENT EQUIPMENT

Natural gas single family residential customer adding boiler reset controls capable of resetting the boiler supply water temperature in an inverse fashion with outdoor air temperature. The system must be set so that the minimum temperature is not more than 10 degrees above manufacturer's recommended minimum return temperature. This boiler reset measure is limited to existing condensing boilers serving a single family residence. Boiler reset controls for non-condensing boilers in single family residences should be implemented as a custom measure, and the cost-effectiveness should be confirmed.

DEFINITION OF BASELINE EQUIPMENT

Existing condensing boiler in a single family residential setting without boiler reset controls.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The life of this measure is 20 years[419]

DEEMED MEASURE COST

The cost of this measure is $612[420]

LOADSHAPE

NA

COINCIDENCE FACTOR

NA

---

[418] Energy Solutions Center, a consortium of natural gas utilities, equipment manufacturers and vendors. Boiler Reset Control, accessed at http://naturalgasefficiency.org/residential/Boiler_Reset_Control.htm
[419]CLEAResultreferences the Brooklyn Union Gas Company, High Efficiency Heating and Water and Controls, Gas Energy Efficiency Program Implementation Plan.
[420] Nexant. Questar DSM Market Characterization Report. August 9, 2006.

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS

NA

SUMMER COINCIDENT PEAK DEMAND SAVINGS

NA

NATURAL GAS SAVINGS

ΔTherms = Gas_Boiler_Load * (1/AFUE) * Savings Factor

Where:

Gas_Boiler_Load[421]

= Estimate of annual household Load for gas boiler heated single-family homes. If location is unknown, assume the average below[422].

= or Actual if informed by site-specific load calculations, ACCA Manual J or equivalent[423].

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 = Existing Condensing Boiler Annual Fuel Utilization Efficiency Rating

[421] 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)

[422] Values are based on household heating consumption values and inferred average AFUE results from Table 3-4, Program Sample Analysis, *Nicor R29 Res Rebate Evaluation Report 092611_REV FINAL to Nicor*). Adjusting to a statewide average using relative HDD values to adjust for the evaluation results focus on northern region. Values for individual cities are then calculated by comparing average HDD to the individual city's HDD.

[423] 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.

= Actual.

SF = Savings Factor, 5%[424]

EXAMPLE

For example, boiler reset controls on a 92.5 AFUE boiler at a household in Rockford, IL

ΔTherms = 1275 * (1/0.925) * 0.05

= 69 Therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

NA

DEEMED O&M COST ADJUSTMENT CALCULATION

NA

MEASURE CODE: RS-HVC-BREC-V01-150601

[424] Energy Solutions Center, a consortium of natural gas utilities, equipment manufacturers and vendors. Boiler Reset Control, accessed at http://naturalgasefficiency.org/residential/Boiler_Reset_Control.htm

5.3.15 ENERGY STAR Ceiling Fan

DESCRIPTION

A ceiling fan/light unit meeting the efficiency specifications of ENERGY STAR is installed in place of a model meeting the federal standard. ENERGY STAR qualified ceiling fan/light combination units are over 60% more efficient than conventional fan/light units, and use improved motors and blade designs[425].

Due to the savings from this measure being derived from more efficient ventilation and more efficient lighting, and the loadshape and measure life for each component being very different, the savings are split in to the component parts and should be claimed together. Lighting savings should be estimated utilizing the 5.5.1 ENERGY STAR Compact Fluorescent Lamp measure.

This measure was developed to be applicable to the following program types: TOS, NC, RF.

If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

The efficient equipment is defined as an ENERGY STAR certified ceiling fan with integral CFL bulbs.

DEFINITION OF BASELINE EQUIPMENT

The baseline equipment is assumed to be a standard fan with efficient incandescent or halogen light bulbs. Production of 100W, standard efficacy incandescent lamps ended in 2012 followed by restrictions on 75W in 2013 and 60W and 40W in 2014, due to the Energy Independence and Security Act of 2007 (EISA). Finally, a provision in the EISA regulations requires that by January 1, 2020, all lamps meet efficiency criteria of at least 45 lumens per watt, in essence making the baseline equivalent to a current day CFL. Therefore the measure life (number of years that savings should be claimed) for the lighting portion of the savings should be reduced once the assumed lifetime of the bulb exceeds 2020. Due to expected delay in clearing retail inventory and to account for the operating life of a halogen incandescent potentially spanning over 2020, this shift is assumed not to occur until mid-2020.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The fan savings measure life is assumed to be 10 years.[2]

The lighting savings measure life is assumed to be 5 years for lighting savings, see 5.5.1 ENERGY STAR Compact Fluorescent Lamp measure.

DEEMED MEASURE COST

Incremental cost of unit is $46.[426]

LOADSHAPE

R06 - Residential Indoor Lighting

R11 - Residential Ventilation

[425] http://www.energystar.gov/products/certified-products/detail/ceiling-fans
[426] ENERGY STAR Ceiling Fan Savings Calculator
http://www.energystar.gov/buildings/sites/default/uploads/files/light_fixture_ceiling_fan_calculator.xlsx?8178-e52c

COINCIDENCE FACTOR

The summer peak coincidence factor for the ventilation savings is assumed to be 30%.[427]

For lighting savings, see 5.5.1 ENERGY STAR Compact Fluorescent Lamp measure.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$\Delta kWh = \Delta kWh_{fan} + \Delta kWh_{Light}$

$\Delta kWh_{fan} = [Days * FanHours * ((\%Low_{base} * WattsLow_{base}) + (\%Med_{base} * WattsMed_{base}) + (\%High_{base} * WattsHigh_{base}))/1000] - [Days * FanHours * ((\%Low_{ES} * WattsLow_{ES}) + (\%Med_{ES} * WattsMed_{ES}) + (\%High_{ES} * WattsHigh_{ES}))/1000]$

ΔkWh_{light} = see 5.5.1 ENERGY STAR Compact Fluorescent Lamp measure.

Where[428]:

Days = Days used per year

= Actual. If unknown use 365.25 days/year

FanHours = Daily Fan "On Hours"

= Actual. If unknown use 3 hours

$\%Low_{base}$ = Percent of time spent at Low speed of baseline

= 40%

$WattsLow_{base}$ = Fan wattage at Low speed of baseline

= Actual. If unknown use 15 watts

$\%Med_{base}$ = Percent of time spent at Medium speed of baseline

= 40%

$WattsMed_{base}$ = Fan wattage at Medium speed of baseline

= Actual. If unknown use 34 watts

$\%High_{base}$ = Percent of time spent at High speed of baseline

= 20%

[427] Assuming that the CF same as a Room AC. 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)

[428] All fan default assumptions are based upon assumptions provided in the ENERGY STAR Ceiling Fan Savings Calculator; http://www.energystar.gov/buildings/sites/default/uploads/files/light_fixture_ceiling_fan_calculator.xlsx?8178-e52c

$WattsHigh_{base}$ = Fan wattage at High speed of baseline

= Actual. If unknown use 67 watts

%LowES = Percent of time spent at Low speed of ENERGY STAR

= 40%

$WattsLow_{ES}$ = Fan wattage at Low speed of ENERGY STAR

= Actual. If unknown use 6 watts

$\%Med_{ES}$ = Percent of time spent at Medium speed of ENERGY STAR

= 40%

$WattsMed_{ES}$ = Fan wattage at Medium speed of ENERGY STAR

= Actual. If unknown use 23 watts

$\%High_{ES}$ = Percent of time spent at High speed of ENERGY STAR

= 20%

$WattsHigh_{ES}$ = Fan wattage at High speed of ENERGY STAR

= Actual. If unknown use 56 watts

For ease of reference, the fan assumptions are provided below in table form:

	Low Speed	Medium Speed	High Speed
Percent of Time at Given Speed	40%	40%	20%
Conventional Unit Wattage	15	34	67
ENERGY STAR Unit Wattage	6	23	56
ΔW	9	11	11

If the lighting WattsBase and WattsEE is unknown, assume the following

WattsBase = 3 x 43 = 129 W

WattsEE = 1 x 42 = 42 W

EXAMPLE

For example, a ceiling fan with three 43W bulb light fixtures, replaced with an ES ceiling fan with one 42W bulb light fixture, the savings are:

ΔkWh_{fan} = [365.25*3*((0.4*15)+(0.4*34)+(0.2*67))/1000] – [365.25*3*((0.4*6)+(0.4*23)+(0.2*56))/1000]

= 36.2 – 25.0 = 11.2 kWh

ΔkWh_{light} =((129 – 42)/1000) *759 * 1.06

= 70.0 kWh

ΔkWh = 11.2 + 70

=81.2 kWh

Using the default assumptions provided above, the deemed savings is 81.2 kWh.

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$\Delta kW = \Delta kW_{Fan} + \Delta kW_{light}$

$\Delta kW_{Fan} = ((WattsHigh_{base} - WattsHigh_{ES})/1000) * CF_{fan}$

ΔkW_{Light} = see 5.5.1 ENERGY STAR Compact Fluorescent Lamp measure.

Where:

CF_{fan} = Summer Peak coincidence factor for ventilation savings

= 30%[429]

CF_{light} = Summer Peak coincidence factor for lighting savings

= 7.1%[430]

[429] Assuming that the CF same as a Room AC. 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)

[430] Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.

EXAMPLE

For example a ceiling fan with three 43W bulb light fixtures, replaced with an ES ceiling fan with one 42W bulb light fixture, the savings are:

ΔkW_{fan} = ((67-56)/1000) * 0.3

=0.0033 kW

ΔkW_{light} =((129 – 42)/1000) * 1.11 * 0.071

= 0.0068 kW

ΔkW = 0.0033 + 0.0068

= 0.010 kW

Using the default assumptions provided above, the deemed savings is 0.010kW.

NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

See 5.5.1 ENERGY STAR Compact Fluorescent Lamp measure for bulb replacement costs.

MEASURE CODE: RS-HVC-CFAN-V01-150601

5.3.16 Advanced Thermostats

Description

This measure characterizes the household energy savings from the installation of a new thermostat(s) for reduced heating and cooling consumption through a configurable schedule of temperature setpoints (like a programmable thermostat) *and* automatic variations to that schedule to better match HVAC system runtimes to meet occupant comfort needs. These schedules may be defaults, established through user interaction, and be changed manually at the device or remotely through a web or mobile app. Automatic variations to that schedule could be driven by local sensors and software algorithms, and/or through connectivity to an internet software service. Data triggers to automatic schedule changes might include, for example: occupancy/activity detection, arrival & departure of conditioned spaces, optimization based on historical or population-specific trends, weather data and forecasts.[431] This class of products and services are relatively new, diverse, and rapidly changing. Generally, the savings expected for this measure aren't yet established at the level of individual features, but rather at the system level and how it performs overall. Like programmable thermostats, it is not suitable to assume that heating and cooling savings follow a similar pattern of usage and savings opportunity, and so here too this measure treats these savings independently. Note that it is a very active area of ongoing study to better map features to savings value, and establish standards of performance measurement based on field data so that a standard of efficiency can be developed.[432] That work is not yet complete but does inform the treatment of some aspects of this characterization and recommendations. Energy savings are applicable at the household level; all thermostats controlling household heat should be programmable and installation of multiple advanced thermostats per home does not accrue additional savings.

Note that though these devices and service could potentially be used as part of a demand response program, the costs, delivery, impacts, and other aspects of DR-specific program delivery are not included in this characterization at this time, though they could be added in the future.

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 or programmable thermostat, with one that has the default enabled capability—or the capability to automatically—establish a schedule of temperature setpoints according to driving device inputs above and beyond basic time and temperature data of conventional programmable thermostats. As summarized in the description, this category of products and services is broad and rapidly advancing in regards to their capability, usability, and sophistication, but at a minimum must be capable of two-way communication[433] and exceed the typical performance of manual and conventional programmable thermostats through the automatic or default capabilities described above.

Definition of Baseline Equipment

The baseline is either the actual type (manual or programmable) if it is known,[434] or an assumed mix of these two

[431] For example, the capabilities of products and added services that use ultrasound, infrared, or geofencing sensor systems, automatically develop individual models of home's thermal properties through user interaction, and optimize system operation based on equipment type and performance traits based on weather forecasts demonstrate the type of automatic schedule change functionality that apply to this measure characterization.

[432] The ENERGY STAR program discontinued its support for basic programmable thermostats effective 12/31/09, and is presently developing a new specification for 'Residential Climate Controls'.

[433] This measure recognizes that field data may be available, through this 2-way communication capability, to better inform characterization of efficiency criteria and savings calculations. It is recommended that program implementations incorporate this data into their planning and operation activities to improve understanding of the measure to manage risks and enhance savings results.

[434] If the actual thermostat is programmable and it is found to be used in override mode or otherwise effectively being operated like a manual thermostat, then the baseline may be considered to be a manual thermostat

types based upon information available from evaluations or surveys that represent the population of program participants. This mix may vary by program, but as a default, 44% programmable and 56% manual thermostats may be assumed[435].

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life for advanced thermostats is assumed to be similar to that of a programmable thermostat 10 years[436] based upon equipment life only.[437]

DEEMED MEASURE COST

For DI and other programs for which installation services are provided, the actual material, labor, and other costs should be used. For retail, Bring Your Own Thermostat (BYOT) programs[438], or other program types actual costs are still preferable[439] but if unknown then the average incremental cost for the new installation measure is assumed to be $175[440].

LOADSHAPE

ΔkWh → Loadshape R10 - Residential Electric Heating and Cooling
$\Delta kWh_{heating}$ → Loadshape R09 - Residential Electric Space Heat
$\Delta kWh_{cooling}$ → Loadshape R08 - Residential Cooling

COINCIDENCE FACTOR

In the absence of conclusive results from empirical studies on peak savings, the TAC agreed to a temporary assumption of 50% of the cooling coincidence factor, acknowledging that while the savings from the advanced Thermostat will track with the cooling load, the impact during peak periods may be lower. This is an assumption that could use future evaluation to improve these estimates.

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)
= 34%[441]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)
= 23.3%[442]

---

[435] Based on Opinion Dynamics Corporation, "ComEd Residential Saturation/End Use, Market Penetration & Behavioral Study", Appendix 3: Detailed Mail Survey Results, p34, April 2013.

[436] Table 1, HVAC Controls, Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007

[437] Future evaluation is strongly encouraged to inform the persistence of savings to further refine measure life assumption. As this characterization depends heavily upon a number of savings studies that only lasted a single year or less, the longer term impacts should be assessed.

[438] In contrast to program designs that utilize program affiliated contractors or other trade ally partners that support customer participation through thermostat distribution, installation and other services , BYOT programs enroll customers *after* the time of purchase through online rebate and program integration sign-ups.

[439] Including any one-time software integration or annual software maintenance, and or individual device energy feature fees.

[440] Market prices vary considerably in this category, generally increasing with thermostat capability and sophistication. The core suite of functions required by this measure's eligibility criteria are available on units readily available in the market roughly in the range of $200 and $250, excluding the availability of any wholesale or volume discounts. The assumed incremental cost is based on the middle of this range ($225) minus a cost of $50 for the baseline equipment blend of manual and programmable thermostats. Note that any add-on energy service costs, which may include one-time setup and/or annual per device costs are not included in this assumption.

[441] Assumes 50% of the cooling coincidence factor (based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory).

[442] Assumes 50% of the cooling coincidence factor (based on analysis of Itron eShape data for Missouri, calibrated to Illinois

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

ΔkWh[443] $= \Delta kWh_{heating} + \Delta kWh_{cooling}$

$\Delta kWh_{heating}$ = %ElectricHeat * Elec_Heating_Consumption * Heating_Reduction * HF * Eff_ISR + (ΔTherms * F_e * 29.3)

ΔkWh_{cool} = %AC * ((FLH * Btu/hr * 1/SEER)/1000) * Cooling_Reduction * Eff_ISR

Where:

%ElectricHeat = Percentage of heating savings assumed to be electric

Heating fuel	%ElectricHeat
Electric	100%
Natural Gas	0%
Unknown	13%[444]

Elec_Heating_Consumption

= Estimate of annual household heating consumption for electrically heated single-family homes[445]. If location and heating type is unknown, assume 15,678 kWh[446]

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

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.)

443 Electrical savings are a function of both heating and cooling energy usage reductions. For heating this is a function of the percent of electric heat (heat pumps) and fan savings in the case of a natural gas furnace.

444 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.

445 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.

446 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.

Heating_Reduction = Assumed percentage reduction in total household heating energy consumption due to advanced thermostat

Existing Thermostat Type	Heating_Reduction[447]
Manual	8.8%
Programmable	5.6%
Unknown (Blended)	7.4%

HF = Household factor, to adjust heating consumption for non-single-family households.

Household Type	HF
Single-Family	100%
Multi-Family	65%[448]
Actual	Custom[449]

Eff_ISR = Effective In-Service Rate, the percentage of thermostats installed and configured effectively for 2-way communication. Note that retrospective adjustments should be made during evaluation verification activities through the use of a realization rate if the program design does not ensure that each advanced thermostat is actually installed and/or if the evaluation determines that the advanced thermostat is not actually installed in the Program Administrator's service territory.

Program Delivery	Eff_ISR
Direct Install	100%
Other	100%[450]

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%[451]

29.3 = kWh per therm

%AC = Fraction of customers with thermostat-controlled air-conditioning

---

[447] These values represent adjusted baseline savings values (8.8% for manual, and 5.6% for programmable thermostats) as presented in Navigant's PowerPoint on Impact Analysis from Preliminary Gas savings findings (slide 28 of 'IL SAG Smart Thermostat Preliminary Gas Impact Findings 2015-12-08 to IL SAG.ppt'). These values are used as the basis for the weighted average savings value when the type of existing thermostat is not known. Using the default assumption of 56% manual and 44% programmable as described in the baseline definition section above the 7.4% savings value is equal to the sum of proportional savings for manual and programmable thermostats: 8.8% * 0.56 + 5.6% * 0.44. Further evaluation and regular review of this key assumption is encouraged.

[448] 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

[449] Program-specific household factors may be utilized on the basis of sufficiently validated program evaluations.

[450] As a function of the method for determining savings impact of these devices, in-service rate effects are already incorporated into the savings value for heating_reduction above.

[451] 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.

Thermostat control of air conditioning?	%AC
Yes	100%
No	0%
Unknown	66%[452]
Unknown Multi-Family	46% [453]
Unknown Single Family	87%[454]

FLH = Estimate of annual household full load cooling hours for air conditioning equipment based on location and home type. If location and cooling type are unknown, assume the weighted average.

Climate zone (city based upon)	FLH (single family) [455]	FLH (general multifamily) [456]	FLH_cooling (weatherized multi family) [457]
1 (Rockford)	512	467	243
2 (Chicago)	570	506	263
3 (Springfield)	730	663	345
4 (Belleville)	1035	940	489
5 (Marion)	903	820	426
Weighted average[458]	629	564	293

Btu/hr = Size of AC unit[459]. (Note: One refrigeration ton is equal to 12,000 Btu/hr.)

Program Delivery	Btu/hr
Direct Install (Single Family known, or MF)	Actual
Unknown (Single family home only)	33,600

SEER = the cooling equipment's Seasonal Energy Efficiency Ratio rating (kBtu/kWh)

= Use actual SEER rating where it is possible to measure or reasonably estimate.

[452] 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;
[453] Based on Opinion Dynamics Corporation, "ComEd Residential Saturation/End Use, Market Penetration & Behavioral Study", Appendix 3: Detailed Mail Survey Results, April 2013.
[454] Ibid.
[455] Full load hours for Chicago, Moline and Rockford are provided in "Final Evaluation Report: Central Air Conditioning Efficiency Services (CACES), 2010, Navigant Consulting", 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 Volume 1, Section 3.7 providing the appropriate city to use for each county of Illinois.
[456] Ibid.
[457] *All-Electric Homes PY6 Metering Results: Multifamily HVAC Systems*, Cadmus, October 2015
[458] Weighted based on number of residential occupied housing units in each zone.
[459] 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.

Cooling System	SEER[460]
Air Source Heat Pump	9.12
Central AC	8.60

1/1000 = kBtu per Btu

Cooling_Reduction = Assumed percentage reduction in total household cooling energy consumption due to installation of advanced thermostat

= Deemed % Cooling Reduction Value set forth in the 'Deemed Cooling Reduction for Advanced Thermostats' Memorandum available at: http://www.icc.illinois.gov/Electricity/programs/TRM.aspx; If unavailable use[461]:

= 8.0%[462]

For example, an advanced thermostat replacing a programmable thermostat directly installed in an electric resistance heated, single-family home in Springfield with advanced thermostat-controlled air conditioning of a system of unknown size and seasonal efficiency rating:

$\Delta kWH = \Delta kWh_{heating} + \Delta kWh_{cooling}$

$= 1 * 20{,}928 * 5.6\% * 100\% * 100\% + (0 * 0.0314 * 29.3) + 100\% * ((730 * 33{,}600 * (1/9.12))/1000) * 8\% * 100\%$

= 1,172kWh + 215 kWh

= 1,387 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$\Delta kW = (Cooling\_Reduction * Btu/hr * (1/EER))/1000 * EFF\_ISR * CF$

Where:

EER = 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:

---

460 Average nameplate efficiencies of all Early Replacement qualifying equipment in Ameren PY3-PY4.

461 The 'Deemed Cooling Reduction for Advanced Thermostats' Memorandum will be prepared by the ComEd evaluator, based upon consideration of the Illinois Navigant Advanced Thermostat study, stakeholder input and any data from other relevant and defensible evaluation studies. If the ComEd evaluator submits their memo by March 1st 2016, the TAC will have 10 business days to reach consensus concerning the deemed cooling reduction % value and if agreement is reached the ICC Staff will post the finalized memo on the ICC's website on the IL-TRM webpage. If the recommendation is not provided by March 1st 2016 or if consensus is not reached, the default 8% should be used effective June 1, 2016.

462 This assumption is based upon the review of many evaluations from other regions in the US (see Navigant workpaper "Illinois Statewide TRM Workpaper_RES_Smart Thermostats_2015 11 02.docx" and VEIC summary "Studies informing the Illinois TRM Savings Characterization for Advanced Thermostats.docx"). These sources, are from different regions, products, and program delivery designs, but collectively form a sound basis, and directional guidance for the existence and magnitude of cooling savings. Because cooling savings are more volatile than those for heating due to variables in control behaviors, population, and product factors, conservatism is warranted and 8% is considered a conservative estimate based upon the array of results from these studies. Further evaluation and regular review of this key assumption is encouraged.

EER = (-0.02 * SEER_exist^2) + (1.12 * SEER_exist) [463]

If SEER or EER rating unavailable use:

Cooling System	EER[464]
Air Source Heat Pump	8.55
Central AC	8.15

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)
= 34%[465]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)
= 23.3%[466]

For example, an advanced thermostat replacing a programmable thermostat directly installed in an electric resistance heated, single-family home in Springfield with advanced thermostat-controlled air conditioning of a system of unknown size and seasonal efficiency rating:

ΔkW_{SSP} = 8% * 33,600 * (1/8.15))/1000) * 100% * 34%

= 0.11 kW

ΔkW_{PJM} = 8% * 33,600 * (1/8.15))/1000) * 100% * 23.3%

= 0.077 kW

NATURAL GAS ENERGY SAVINGS

ΔTherms = %FossilHeat * Gas_Heating_Consumption * Heating_Reduction * HF * Eff_ISR

Where:

%FossilHeat = Percentage of heating savings assumed to be Natural Gas

Heating fuel	%FossilHeat
Electric	0%
Natural Gas	100%
Unknown	87%[467]

Gas_Heating_Consumption

= Estimate of annual household heating consumption for gas heated single-family homes.

[463] From Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder.

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

[465] Assumes 50% of the cooling coincidence factor (based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.)

[466] Assumes 50% of the cooling coincidence factor (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.)

[467] 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.

If location is unknown, assume the average below[468].

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

Other variables as provided above

For example, an advanced thermostat replacing a programmable thermostat directly-installed in a gas heated single-family home in Chicago:

ΔTherms = 1.0 * 1005 * 5.6% * 100% * 100%

= 56.28 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HVC-ADTH-V01-160601

[468] Values are based on adjusting the average household heating consumption (849 therms) for Chicago based on 'Table 3-4, Program Sample Analysis, Nicor R29 Res Rebate Evaluation Report 092611_REV FINAL to Nicor', calculating inferred heating load by dividing by average efficiency of new in program units in the study (94.4%) and then applying 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). 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.

5.4 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[469].

DEEMED MEASURE COST

The measure cost including material and installation is assumed to be $3 per linear foot[470].

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.

[469] 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

[470] Consistent with DEER 2008 Database Technology and Measure Cost Data (www.deeresources.com).

Algorithm

Calculation of Savings

Electric Energy Savings

For electric DHW systems:

$$\Delta kWh = ((1/Rexist - 1/Rnew) * (L * C) * \Delta T * 8{,}766) / \eta DHW / 3413$$

Where:

Rexist = Pipe heat loss coefficient of uninsulated pipe (existing) [(hr-°F-ft)/Btu]

= 1.0[471]

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 [472]

8,766 = Hours per year

ηDHW = Recovery efficiency of electric hot water heater

= 0.98 [473]

3412 = Conversion from Btu to kWh

For example, insulating 5 feet of 0.75" pipe with R-5 wrap:

$$\Delta kWh = ((1/Rexist - 1/Rnew) * (L * C) * \Delta T * 8{,}766) / \eta DHW / 3412$$

$$= ((1/1 - 1/(1+5) * (5 * 0.196) * 60 * 8766) / 0.98 / 3412$$

$$= 128 \text{ kWh}$$

If inputs above are not available the following default per 3ft R-5 length can be used for up to 6 ft length on the hot pipe and 3 ft on the cold pipe.

$$\Delta kWh = ((1/Rexist - 1/Rnew) * (L * C) * \Delta T * 8{,}766) / \eta DHW / 3412$$

$$= ((1/1 - 1/(1+5)) * (3 * 0.196) * 60 * 8766) / 0.98 / 3412$$

$$= 77.1 \text{ kWh per 3ft length}$$

471 Navigant Consulting Inc., April 2009; "Measures and Assumptions for Demand Side Management (DSM) Planning; Appendix C Substantiation Sheets", p77.

472 Assumes 125°F water leaving the hot water tank and average temperature of basement of 65°F.

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

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = \Delta kWh / 8766$$

Where:

ΔkWh = kWh savings from pipe wrap installation

8766 = Number of hours in a year (since savings are assumed to be constant over year).

For example, insulating 5 feet of 0.75” pipe with R-5 wrap:

$$\Delta kW = 128/8766$$
$$= 0.015kW$$

If inputs above are not available the following default per 3ft R-4 length can be used for up to 6 ft length on the hot pipe and 3 ft on the cold pipe.

$$\Delta kW = 77.1/8766$$
$$= 0.0088\ kW$$

NATURAL GAS SAVINGS

For Natural Gas DHW systems:

$$\Delta Therm = ((1/Rexist – 1/Rnew) * (L * C) * \Delta T * 8,766) / \eta DHW /100,000$$

Where:

ηDHW = Recovery efficiency of gas hot water heater

= 0.78 [474]

Other variables as defined above

For example, insulating 5 feet of 0.75” pipe with R-5 wrap:

$$\Delta Therm = ((1/1– 1/(1+5)) * (5 * 0.196) * 60 * 8766) / 0.78 / 100,000$$
$$= 5.51\ therms$$

If inputs above are not available the following default per 3ft R-4 length can be used for up to 6ft length on the hot pipe and 3ft on the cold pipe.

$$\Delta Therm = ((1/Rexist – 1/Rnew) * (L * C) * \Delta T * 8,766) / \eta DHW / 100,000$$
$$= ((1/1– 1/(1+5)) * (3 * 0.196) * 60 * 8766) / 0.78 /100,000$$
$$= 3.30\ therms\ per\ 3ft\ length$$

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

[474] 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%

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HWE-PINS-V02-150601

5.4.2 Gas Water Heater

DESCRIPTION

This measure characterizes:

a) Time of sale or new construction:
The purchase and installation of a new efficient gas-fired water heater, in place of a Federal Standard unit in a residential setting. Savings are provided for power-vented, condensing storage, and whole-house tankless units meeting specific EF criteria.

b) Early replacement:
The early removal of an existing functioning natural gas water heater from service, prior to its natural end of life, and replacement with a new high efficiency unit. Savings are calculated between existing unit and efficient unit consumption during the remaining life of the existing unit, and between new baseline unit and efficient unit consumption for the remainder of the measure life.

This measure was developed to be applicable to the following program types: TOS, NC, EREP.

If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the efficient equipment must be a water heater rated with the following minimum efficiency ratings:

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

Time of Sale or New Construction: The baseline condition is assumed to be a standard gas storage water heater of the same capacity as the efficient unit, rated at the federal minimum. For 20 to 55 gallon tanks the Federal Standard is calculated as 0.675 – (0.0015 * storage size in gallons) and for tanks 55 - 100 gallon 0.8012 – (0.00078 * storage size in gallons)[475]. For a 40-gallon storage water heater this would be 0.615 EF.

Early replacement: The baseline for this measure is the efficiency of the existing equipment for the assumed remaining useful life of the unit and a new baseline unit for the remainder of the measure life.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 13 years.[476]

---

[475] Minimum Federal Standard as of 4/1/2015;
http://www.gpo.gov/fdsys/pkg/CFR-2012-title10-vol3/pdf/CFR-2012-title10-vol3-sec430-32.pdf

[476] 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.

For early replacement: Remaining life of existing equipment is assumed to be 4 years[477].

DEEMED MEASURE COST

Time of Sale or New Construction:

The incremental capital cost for this measure is dependent on the type of water heater as listed below[478].

Early Replacement: The full installed cost is provided in the table below. The assumed deferred cost (after 4 years) of replacing existing equipment with a new baseline unit is assumed to be $650[479]. This cost should be discounted to present value using the utility's discount rate.

Water heater Type	Incremental Cost	Full Install Cost
Gas Storage	$400	$1014
Condensing gas storage	$685	$1299
Tankless whole-house unit	$605	$1219

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

Time of Sale or New Construction:

$$\Delta Therms = (1/ EF_{BASE} - 1/EF_{EFFICIENT}) * (GPD * Household * 365.25 * \gamma Water * (T_{OUT} – T_{IN}) * 1.0)/100,000$$

Early replacement[480]:

[477] Assumed to be one third of effective useful life
[478] 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)
[479] The deemed install cost of a Gas Storage heater is based upon DCEO Efficient Living Program Data for a sample size of 157 gas water heaters, and applying inflation rate of 1.91%.
[480] 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

ΔTherms for remaining life of existing unit (1st 4 years):

$= (1/ EF_{EXISTING} - 1/EF_{EFFICIENT}) * (GPD * Household * 365.25 * \gamma Water * (T_{OUT} – T_{IN}) * 1.0)/100,000$

ΔTherms for remaining measure life (next 9 years):

$= (1/ EF_{BASE} - 1/EF_{EFFICIENT}) * (GPD * Household * 365.25 * \gamma Water * (T_{OUT} – T_{IN}) * 1.0)/100,000$

Where:

EF_Baseline = Energy Factor rating for baseline equipment

For <=55 gallons: 0.675 – (0.0015 * tank_size)

For > 55 gallons: 0.8012 – (0.00078 * tank size)

= If tank size unknown assume 40 gallons and EF_Baseline of 0.615

EF_Efficient = Energy Factor Rating for efficient equipment

= Actual. If Tankless whole-house multiply rated efficiency by 0.91[481]. 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

EF_Existing = Energy Factor rating for existing equipment

= Use actual EF rating where it is possible to measure or reasonably estimate.

= if unknown assume 0.52 [482]

GPD = Gallons Per Day of hot water use per person

= 45.5 gallons hot water per day per household/2.59 people per household[483]

= 17.6

Household = Average number of people per household

Household Unit Type	Household
Single-Family - Deemed	2.56[484]

be the (new base to efficient savings)/(existing to efficient savings).

481 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.

482 Based on DCEO Efficient Living Program Data for a sample size of 157 gas water heaters.

483 Deoreo, B., and P. Mayer. Residential End Uses of Water Study Update. Forthcoming. ©2015 Water Research Foundation. Reprinted With Permission.

484 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

Household Unit Type	Household
Multi-Family - Deemed	2.1[485]
Custom	Actual Occupancy or Number of Bedrooms[486]

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[487]

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 = (1/0.615 - 1/0.8) * (17.6 * 2.56 * 365.25* 8.33 * (125 – 54) * 1) / 100,000

= 36.6 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HWE-GWHT-V06-160601

485 Navigant, ComEd PY3 Multi-Family Home Energy Savings Program Evaluation Report Final, May 16, 2012.

486 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.

487 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[488]:

For <=55 gallons: 0.96 – (0.0003 * rated volume in gallons)

For >55 gallons: 2.057 – (0.00113 * rated volume in gallons)

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 13 years.[489]

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.[490]

LOADSHAPE

Loadshape R03 - Residential Electric DHW

COINCIDENCE FACTOR

The summer Peak Coincidence Factor is assumed to be 12%.[491]

---

488 Minimum Federal Standard as of 4/1/2015; http://www.gpo.gov/fdsys/pkg/CFR-2012-title10-vol3/pdf/CFR-2012-title10-vol3-sec430-32.pdf

489 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

490 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

491 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[492]:

For <=55 gallons: 0.96 – (0.0003 * rated volume in gallons)

For >55 gallons: 2.057 – (0.00113 * rated volume in gallons)

= 0.945 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[493]

= 17.6

Household = Average number of people per household

Household Unit Type	Household
Single-Family - Deemed	2.56[494]
Multi-Family - Deemed	2.1[495]
Custom	Actual Occupancy or Number of Bedrooms[496]

365.25 = Days per year

γWater = Specific weight of water

[492] Minimum Federal Standard as of 1/1/2015; http://www.gpo.gov/fdsys/pkg/CFR-2012-title10-vol3/pdf/CFR-2012-title10-vol3-sec430-32.pdf

[493] Deoreo, B., and P. Mayer. Residential End Uses of Water Study Update. Forthcoming. ©2015 Water Research Foundation. Reprinted With Permission.

[494] 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

[495] Navigant, ComEd PY3 Multi-Family Home Energy Savings Program Evaluation Report Final, May 16, 2012.

[496] 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.

= 8.33 pounds per gallon

T_{OUT} = Tank temperature

= 125°F

T_{IN} = Incoming water temperature from well or municiple system

= 54°F[497]

1.0 = Heat Capacity of water (1 Btu/lb*°F)

3412 = Conversion from Btu to kWh

kWh_cooling[498] = Cooling savings from conversion of heat in home to water heat

$=(((((GPD * Household * 365.25 * \gamma Water * (T_{OUT} - T_{IN}) * 1.0) / 3412) - ((1/ EF_{NEW} * GPD * Household * 365.25 * \gamma Water * (T_{OUT} - T_{IN}) * 1.0) / 3412)) * LF * 27\%) / COP_{COOL}) * LM$

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[499]

COP_{COOL} = COP of central air conditioning

= Actual, if unknown, assume 3.08 (10.5 SEER / 3.412)

LM = Latent multiplier to account for latent cooling demand

= 1.33 [500]

kWh_heating = Heating cost from conversion of heat in home to water heat (dependent on heating fuel)

---

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

[498] 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.

[499] 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).

[500] 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

$= (((((GPD * Household * 365.25 * \gamma Water * (T_{OUT} – T_{IN}) * 1.0) / 3412) –$

$((1/ EF_{NEW} * GPD * Household * 365.25 * \gamma Water * (T_{OUT} – T_{IN}) * 1.0) / 3412)) * LF * 49\%) / COP_{HEAT}) * (1 - \%NaturalGas)$

Where:

49% = Portion of reduced waste heat that results in increased heating load[501]

COP_{HEAT} = COP of electric heating system

= actual. If not available use[502]:

System Type	Age of Equipment	HSPF Estimate	COP_{HEAT} (COP Estimate)
Heat Pump	Before 2006	6.8	2.00
	After 2006 - 2014	7.7	2.26
	2015 on	8.2	2.40
Resistance	N/A	N/A	1.00
Unknown[503]	N/A	N/A	1.39

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 / 0.945 – 1 / 2.0) * 17.6 * 2.56 * 365.25* 8.33 * (125 – 54)] / 3412 + 166.3 - 0

= 1759 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ΔkWh / Hours * CF

Where:

Hours = Full load hours of water heater

= 2533 [504]

[501] 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).

[502] 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.

[503] Calculation assumes 35% Heat Pump and 65% Resistance, which is based upon data from Energy Information Administration, 2009 Residential Energy Consumption Survey, see “HC6.9 Space Heating in Midwest Region.xls”, using average for East North Central Region. Average efficiency of heat pump is based on assumption that 50% are units from before 2006 and 50% from 2006-2014. Program or evaluation data should be used to improve this assumption if available.

[504] Full load hours assumption based on Efficiency Vermont analysis of Itron eShapes.

CF = Summer Peak Coincidence Factor for measure

= 0.12 [505]

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 = 1759 / 2533 * 0.12 = 0.083 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) * %NaturalGas

Where:

ΔTherms = Heating cost from conversion of heat in home to water heat for homes with Natural Gas heat.[506]

0.03412 = conversion factor (therms per kWh)

ηHeat = Efficiency of heating system

= Actual.[507] If not available use 70%.[508]

%NaturalGas = Factor dependent on heating fuel:

Heating System	%NaturalGas
Electric resistance or heat pump	0%

[505] 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

[506] This is the additional energy consumption required to replace the heat removed from the home during the heating season by the heat pump water heater. kWh_heating (electric resistance) is that additional heating energy for a home with electric resistance heat (COP 1.0). This formula converts the additional heating kWh for an electric resistance home to the MMBtu required in a Natural Gas heated home, applying the relative efficiencies.

[507] 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.

[508] 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

Heating System	%NaturalGas
Natural Gas	100%
Unknown heating fuel[509]	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 = -((((17.6 * 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)

= - 34.1 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HWE-HPWH-V05-160601

[509] 2010 American Community Survey.

5.4.4 Low Flow Faucet Aerators

This measure relates to the installation of a low flow faucet aerator in a household kitchen or bath faucet fixture.

This measure may be used for units provided through Efficiency Kit's however the in service rate for such measures should be derived through evaluation results specifically for this implementation methodology.

This measure was developed to be applicable to the following program types: TOS, NC, RF, DI, KITS.

If applied to other program types, the measure savings should be verified.

Definition of Efficient Equipment

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

Definition of Baseline Equipment

The baseline condition is assumed to be a standard bathroom faucet aerator rated at 2.25 GPM or greater, or a standard kitchen faucet aerator rated at 2.75 GPM or greater. Average measured flow rates are used in the algorithm and are lower, reflecting the penetration of previously installed low flow fixtures (and therefore the freerider rate for this measure should be 0), use of the faucet at less than full flow, debris buildup, and lower water system pressure than fixtures are rated at.

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 9 years.[510]

Deemed Measure Cost

The incremental cost for this measure is $8[511] 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%.[512]

[510] 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"

[511] 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)

[512] Calculated as follows: Assume 18% aerator use takes place during peak hours (based on: http://www.aquacraft.com/sites/default/files/pub/DeOreo-%282001%29-Disaggregated-Hot-Water-Use-in-Single-Family-Homes-Using-Flow-Trace-Analysis.pdf) There are 65 days in the summer peak period, so the percentage of total annual aerator use in peak period is 0.18*65/365 = 3.21%. The number of hours of recovery during peak periods is therefore assumed to be 3.21% *180 = 5.8 hours of recovery during peak period where 180 equals the average annual electric DHW recovery hours for faucet use including SF and MF homes. There are 260 hours in the peak period so the probability you will see savings during the peak period is 5.8/260 = 0.022

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

Note these savings are *per* faucet retrofitted[513] (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%[514]

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[515] or custom based on metering studies[516] or if measured during DI:

= Measured full throttle flow * 0.83 throttling factor[517]

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

= 0.94[518] or custom based on metering studies[519] or if measured during DI:

[513] This algorithm calculates the amount of energy saved per aerator by determining the fraction of water consumption savings for the upgraded fixture.

[514] 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

[515] Deoreo, B., and P. Mayer. Residential End Uses of Water Study Update. Forthcoming. ©2015 Water Research Foundation. Reprinted With Permission.

[516] 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.

[517] 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

[518] 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.

[519] 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.

= Rated full throttle flow * 0.95 throttling factor[520]

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[521]
Bathroom	1.6[522]
If location unknown (total for household): Single-Family	9.0[523]
If location unknown (total for household): Multi-Family	6.9[524]

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:

Faucet Type	L_low (min/person/day)
Kitchen	4.5[525]
Bathroom	1.6[526]
If location unknown (total for household): Single-Family	9.0[527]
If location unknown (total for household): Multi-Family	6.9[528]

Household = Average number of people per household

Household Unit Type	Household
Single-Family - Deemed	2.56[529]

[520] 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
[521] 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.
[522] Ibid.
[523] One kitchen faucet plus 2.83 bathroom faucets. Based on findings from a 2009 ComEd residential survey of 140 sites, provided by Cadmus.
[524] One kitchen faucet plus 1.5 bathroom faucets. Based on findings from a 2009 ComEd residential survey of 140 sites, provided by Cadmus.
[525] Cadmus and Opinion Dynamics Showerhead and Faucet Aerator Meter Study Memorandum dated June 2013, directed to Michigan Evaluation Working Group.
[526] Ibid.
[527] One kitchen faucet plus 2.83 bathroom faucets. Based on findings from a 2009 ComEd residential survey of 140 sites, provided by Cadmus.
[528] One kitchen faucet plus 1.5 bathroom faucets. Based on findings from a 2009 ComEd residential survey of 140 sites, provided by Cadmus.
[529] ComEd Energy Efficiency/ Demand Response Plan: Plan Year 2 (6/1/2009-5/31/2010) Evaluation Report: All Electric Single

Household Unit Type	Household
Multi-Family - Deemed	2.1[530]
Custom	Actual Occupancy or Number of Bedrooms[531]

365.25 = Days in a year, on average.

DF = Drain Factor

Faucet Type	Drain Factor[532]
Kitchen	75%
Bath	90%
Unknown	79.5%

FPH = Faucets Per Household

Faucet Type	FPH
Kitchen Faucets Per Home (KFPH)	1
Bathroom Faucets Per Home (BFPH): Single-Family	2.83[533]
Bathroom Faucets Per Home (BFPH): Multi-Family	1.5[534]
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)

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

[530] Navigant, ComEd PY3 Multi-Family Home Energy Savings Program Evaluation Report Final, May 16, 2012.

[531] 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.

[532] 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.

[533] Based on findings from a 2009 ComEd residential survey of 140 sites, provided by Cadmus.

[534] Ibid.

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[535]

SupplyTemp = Assumed temperature of water entering house

= 54.1F [536]

RE_electric = Recovery efficiency of electric water heater

= 98% [537]

3412 = Converts Btu to kWh (btu/kWh)

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

Selection	ISR
Direct Install - Single Family	0.95[538]
Direct Install – Multi Family Kitchen	0.91[539]
Direct Install – Multi Family Bathroom	0.95[540]
Efficiency Kit Bathroom Aerator	0.63[541]
Efficiency Kit Kitchen Aerator	0.60[542]
Distributed School Efficiency Kit Aerator	To be determined through evaluation

535 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.

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

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

538 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

539 Navigant, ComEd-Nicor Gas EPY4/GPY1 Multi-Family Home Energy Savings Program Evaluation Report DRAFT 2013-01-28

540 Ibid.

541 From Navigant memo, "Nicor Gas energySMART Energy Saving Kits Program In Service Rate and Process Analysis", August 28, 2015.

542 Ibid.

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

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[543] / 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[544]

[543] 54.5% is the proportion of hot 120F water mixed with 54.1F supply water to give 90F mixed faucet water.

[544] Calculated as follows: Assume 18% aerator use takes place during peak hours (based on:

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:

%FossilDHW = proportion of water heating supplied by Natural Gas heating

DHW fuel	%Fossil_DHW
Electric	0%
Natural Gas	100%
Unknown	84%[545]

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[546]

= 67% For MF homes[547]

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

Other variables as defined above.

---

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

[545] 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

[546] 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%.

[547] 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 * 9.0 – 0.94 * 9.0) * 2.56 * 365.25 * 0.795) /3.83) * 0.00394 * 0.95

= 2.94 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-V05-160601

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.[548]

Deemed Measure Cost

The incremental cost for this measure is $12[549] or program actual.

For low flow showerheads provided in Efficiency Kits, the actual program delivery costs should be utilized.

Loadshape

Loadshape R03 - Residential Electric DHW

Coincidence Factor

The coincidence factor for this measure is assumed to be 2.78%.[550]

---

[548] 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"

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

[550] 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

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%[551]

GPM_base = Flow rate of the baseline showerhead

Program	GPM_base
Direct-install	2.67[552]
Retrofit, Efficiency Kits, NC or TOS	2.35[553]

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[554]

[551] 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
[552] Based on measured data from Ameren IL EM&V of Direct-Install program. Program targets showers that are rated 2.5 GPM or above.
[553] 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.
[554] 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.

L_base = Shower length in minutes with baseline showerhead

= 7.8 min[555]

L_low = Shower length in minutes with low-flow showerhead

= 7.8 min[556]

Household = Average number of people per household

Household Unit Type[557]	Household
Single-Family - Deemed	2.56[558]
Multi-Family - Deemed	2.1[559]
Custom	Actual Occupancy or Number of Bedrooms[560]

SPCD = Showers Per Capita Per Day

= 0.6[561]

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[562]
Multi-Family	1.3[563]
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

[555] 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.
[556] Ibid.
[557] If household type is unknown, as may be the case for time of sale measures, then single family deemed value shall be used.
[558] 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
[559] ComEd PY3 Multi-Family Evaluation Report REVISED DRAFT v5 2011-12-08.docx
[560] 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.
[561] Cadmus and Opinion Dynamics Showerhead and Faucet Aerator Meter Study Memorandum dated June 2013, directed to Michigan Evaluation Working Group.
[562] Based on findings from a 2009 ComEd residential survey of 140 sites, provided by Cadmus.
[563] Ibid.

8.33 = Specific weight of water (lbs/gallon)

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

ShowerTemp = Assumed temperature of water

= 101F [564]

SupplyTemp = Assumed temperature of water entering house

= 54.1F [565]

RE_electric = Recovery efficiency of electric water heater

= 98% [566]

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[567]
Direct Install – Multi Family	0.95[568]
Efficiency Kits--One showerhead kit	0.65[569]
Efficiency Kits—Two showerhead kit	0.67[570]
Distributed School Efficiency Kit showerhead	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:

$$\Delta kWh = 1.0 * ((2.67 * 7.8 – 1.5 * 7.8) * 2.56 * 0.6 * 365.25 / 1.79) * 0.117 * 0.98$$

$$= 328 \text{ kWh}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

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

Where:

[564] Cadmus and Opinion Dynamics Showerhead and Faucet Aerator Meter Study Memorandum dated June 2013, directed to Michigan Evaluation Working Group.
[565] US DOE Building America Program. Building America Analysis Spreadsheet. For Chicago, IL http://www1.eere.energy.gov/buildings/building_america/analysis_spreadsheets.html.
[566] Electric water heaters have recovery efficiency of 98%: http://www.ahridirectory.org/ahridirectory/pages/home.aspx
[567] 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.
[568] Navigant, ComEd-Nicor Gas EPY4/GPY1 Multi-Family Home Energy Savings Program Evaluation Report FINAL 2013-06-05
[569] From Navigant memo, "Nicor Gas energySMART Energy Saving Kits Program In Service Rate and Process Analysis", August 28, 2015.
[570] Ibid

ΔkWh = calculated value above

Hours = Annual electric DHW recovery hours for showerhead use

= ((GPM_base * L_base) * Household * SPCD * 365.25) * 0.712[571] / GPH

= 302 for SF Direct Install; 248 for MF Direct Install

= 266 for SF Retrofit, Efficiency Kits, NC and TOS; 218 for MF Retrofit, Efficiency Kits, NC and TOS

GPH = Gallons per hour recovery of electric water heater calculated for 65.9F 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[572]

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%[573]

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

571 71.2% is the proportion of hot 120F water mixed with 54.1F supply water to give 101F shower water.

572 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

573 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

= 0.00583 Therm/gal for MF homes

RE_gas = Recovery efficiency of gas water heater

= 78% For SF homes[574]

= 67% For MF homes[575]

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

[574] 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%.

[575] 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-V04-160601

5.4.6 Water Heater Temperature Setback

Description

This measure was developed to be applicable to the following program types: NC, RF, DI, KITS.

If applied to other program types, the measure savings should be verified.

Definition of Efficient Equipment

High efficiency is a hot water tank with the thermostat reduced to no lower than 120 degrees.

Definition of Baseline Equipment

The baseline condition is a hot water tank with a thermostat setting that is higher than 120 degrees, typically systems with settings of 130 degrees or higher. Note if there are more than one DHW tanks in the home at or higher than 130 degrees and they are all turned down, then the savings per tank can be multiplied by the number of tanks.

Deemed Lifetime of Efficient Equipment

The assumed lifetime of the measure is 2 years.

Deemed Measure Cost

The incremental cost of a setback is assumed to be $5 for contractor time, or no cost if the measure is self-installed.

Loadshape

Loadshape R03 - Residential Electric DHW

Coincidence Factor

The summer peak coincidence factor for this measure is assumed to be 1.

Algorithm

Calculation of Savings

Electric Energy Savings

For homes with electric DHW tanks:

ΔkWh[576] = (U * A * (Tpre – Tpost) * Hours) / (3412 * RE_electric)

Where:

U = Overall heat transfer coefficient of tank (Btu/Hr-°F-ft^2).

= Actual if known. If unknown assume R-12, U = 0.083

A = Surface area of storage tank (square feet)

= Actual if known. If unknown use table below based on capacity of tank. If capacity unknown assume 50 gal tank; A = 24.99ft^2

Capacity (gal)	A (ft^2)[577]
30	19.16
40	23.18
50	24.99
80	31.84

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

Hours = Number of hours in a year (since savings are assumed to be constant over year).

[576] Note this algorithm provides savings only from reduction in standby losses. The TAC considered avoided energy from not heating the water to the higher temperature but determined that dishwashers are likely to boost the temperature within the unit (roughly canceling out any savings), faucet and shower use is likely to be at the same temperature so there would need to be more lower temperature hot water being used (cancelling any savings) and clothes washers will only see savings if the water from the tank is taken without any temperature control. It was felt the potential impact was too small to be characterized.

[577] 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.

= 8766

3412 = Conversion from Btu to kWh

RE_electric = Recovery efficiency of electric hot water heater

= 0.98 [578]

A deemed savings assumption, where site specific assumptions are not available would be as follows:

ΔkWh = (U * A * (Tpre – Tpost) * Hours) / (3412 * RE_electric)

= (((0.083 * 24.99) * (135 – 120) * 8766) / (3412 * 0.98)

= 81.6 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW **=** ΔkWh / Hours * CF

Where:

Hours = 8766

CF = Summer Peak Coincidence Factor for measure

= 1

A deemed savings assumption, where site specific assumptions are not available would be as follows:

ΔkW = (81.6/ 8766) * 1

ΔkW default = 0.00931 kW

NATURAL GAS SAVINGS

For homes with gas water heaters:

ΔTherms = (U * A * (Tpre – Tpost) * Hours) / (100,000 * RE_gas)

Where

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

RE_gas = Recovery efficiency of gas water heater

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

= 78% For SF homes[579]

= 67% For MF homes[580]

A deemed savings assumption, where site specific assumptions are not available would be as follows:

For Single Family homes:

ΔTherms = (U * A * (Tpre – Tpost) * Hours) / (RE_gas)

= (((0.083 * 24.99) * (135 – 120) * 8766) / (100,000 * 0.78)

= 3.5 Therms

For Multi Family homes:

ΔTherms = (U * A * (Tpre – Tpost) * Hours) / (RE_gas)

= (((0.083 * 24.99) * (135 – 120) * 8766) / (100,000 * 0.67)

= 4.1 Therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HWE-TMPS-V04-150601

579 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%.

580 Water heating in multi-family buildings is often provided by a larger central boiler. This suggests that the average recovery efficiency is somewhere between a typical central boiler efficiency of 0.59 and the 0.75 for single family homes. An average efficiency of 0.67 is used for this analysis as a default for multi-family buildings.

5.4.7 Water Heater Wrap

Description

This measure relates to a Tank Wrap or insulation "blanket" that is wrapped around the outside of a hot water tank to reduce stand-by losses. This measure applies only for homes that have an electric water heater that is not already well insulated. Generally this can be determined based upon the appearance of the tank.[581]

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[582].

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.

[581] Visually determine whether it is insulated by foam (newer, rigid, and more effective) or fiberglass (older, gives to gently pressure, and not as effective)

[582] This estimate assumes the tank wrap is installed on an existing unit with 5 years remaining life.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

For electric DHW systems:

$$\Delta kWh = ((A_{base} / Rbase – A_{insul} / R_{insul}) * \Delta T * Hours) / (3412 * \eta DHW)$$

Where:

R_{base} = Overall thermal resistance coefficient prior to adding tank wrap (Hr-°F-ft^2/BTU).

R_{insul} = Overall thermal resistance coefficient after addition of tank wrap (Hr-°F-ft^2/BTU).

A_{base} = Surface area of storage tank prior to adding tank wrap (square feet)[583]

A_{insul} = Surface area of storage tank after addition of tank wrap (square feet)[584]

ΔT = Average temperature difference between tank water and outside air temperature (°F)

= 60°F [585]

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 [586]

---

583 Area includes tank sides and top to account for typical wrap coverage.
584 Ibid.
585 Assumes 125°F water leaving the hot water tank and average temperature of basement of 65°F.
586 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)[587]	Ainsul (ft2)[588]	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

[587] 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.
[588] Assumptions from PA TRM. A_{insul} was calculated by assuming that the water heater wrap is a 2" thick fiberglass material.

Summer Coincident Peak Demand Savings

$$\Delta kW = \Delta kWh / 8766 * CF$$

Where:

ΔkWh = kWh savings from tank wrap installation

8766 = Number of hours in a year (since savings are assumed to be constant over year).

CF = Summer Coincidence Factor for this measure

= 1.0

The table above has default kW savings for various tank capacity and pre and post R-values.

Natural Gas Savings

N/A

Water Impact Descriptions and Calculation

N/A

Deemed O&M Cost Adjustment Calculation

N/A

Measure Code: RS-HWE-WRAP-V02-150601

5.4.8 Thermostatic Restrictor Shower Valve

Description

The measure is the installation of a thermostatic restrictor shower valve in a single or multi-family household. This is a valve attached to a residential showerhead which restricts hot water flow through the showerhead once the water reaches a set point (generally 95F or lower).

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

Definition of Efficient Equipment

To qualify for this measure the installed equipment must be a thermostatic restrictor shower valve installed on a residential showerhead.

Definition of Baseline Equipment

The baseline equipment is the residential showerhead without the restrictor valve installed.

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 10 years. [589]

Deemed Measure Cost

The incremental cost of the measure should be the actual program cost or $30[590] if not available.

Loadshape

Loadshape R03 - Residential Electric DHW

Coincidence Factor

The coincidence factor for this measure is assumed to be 0.22%.[591]

[589] Assumptions based on NY TRM, Pacific Gas and Electric Company Work Paper PGECODHW113, and measure life of low-flow showerhead

[590] Based on actual cost of the SS-1002CP-SB Ladybug Water-Saving Shower-Head adapter from Evolve showerheads

[591] 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 use in peak period is 0.11*65/365 = 1.96%. The number of hours of recovery during peak periods is therefore assumed to be 1.96% * 29.5 = 0.577 hours of recovery during peak period, where 29.5 equals the average annual electric DHW recovery hours for showerhead use prevented by the device including SF and MF homes with Direct Install and Retrofit/TOS measures. There are 260 hours in the peak period so the probability you will see savings during the peak period is 0.577/260 = 0.0022

Algorithm

Calculation of Energy Savings

Electric Energy Savings

ΔkWh = %ElectricDHW * ((GPM_base_S * L_showerdevice) * 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%[592]

GPM_base_S = Flow rate of the basecase showerhead, or actual if available

Program	GPM
Direct-install, device only	2.67[593]
New Construction or direct install of device and low flow showerhead	Rated or actual flow of program-installed showerhead
Retrofit or TOS	2.35[594]

L_showerdevice = Hot water waste time avoided due to thermostatic restrictor valve

= 0.89 minutes[595]

Household = Average number of people per household

Household Unit Type[596]	Household

[592] 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

[593] Based on measured data from Ameren IL EM&V of Direct-Install program. Program targets showers that are rated 2.5 GPM or above. Assumes low flow showerhead not included in direct installation.

[594] 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.

[595] Average of the following sources: ShowerStart LLC survey; "Identifying, Quantifying and Reducing Behavioral Waste in the Shower: Exploring the Savings Potential of ShowerStart", City of San Diego Water Department survey; "Water Conservation Program: ShowerStart Pilot Project White Paper", and PG&E Work Paper PGECODHW113.

[596] If household type is unknown, as may be the case for time of sale measures, then single family deemed value shall be used.

Single-Family - Deemed	2.56[597]
Multi-Family - Deemed	2.1[598]
Custom	Actual Occupancy or Number of Bedrooms[599]

SPCD = Showers Per Capita Per Day

= 0.6[600]

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[601]
Multi-Family	1.3[602]
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 [603]

[597] 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

[598] ComEd PY3 Multi-Family Evaluation Report REVISED DRAFT v5 2011-12-08.docx

[599] 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.

[600] Cadmus and Opinion Dynamics Showerhead and Faucet Aerator Meter Study Memorandum dated June 2013, directed to Michigan Evaluation Working Group.

[601] Based on findings from a 2009 ComEd residential survey of 140 sites, provided by Cadmus.

[602] Ibid.

[603] Cadmus and Opinion Dynamics Showerhead and Faucet Aerator Meter Study Memorandum dated June 2013, directed to Michigan Evaluation Working Group.

SupplyTemp = Assumed temperature of water entering house

= 54.1F [604]

RE_electric = Recovery efficiency of electric water heater

= 98% [605]

3412 = Converts Btu to kWh (btu/kWh)

ISR = In service rate of showerhead

= Dependent on program delivery method as listed in table below

Selection	ISR
Direct Install - Single Family	0.98[606]
Direct Install – Multi Family	0.95[607]
Efficiency Kits	To be determined through evaluation

EXAMPLE

For example, a direct installed valve in a single-family home with electric DHW:

ΔkWh = 1.0 * (2.67 * 0.89 * 2.56 * 0.6 * 365.25 / 1.79) * 0.117 * 0.98

= 85 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ΔkWh/Hours * CF

Where:

ΔkWh = calculated value above

Hours = Annual electric DHW recovery hours for wasted showerhead use prevented by device

= ((GPM_base_S * L_showerdevice) * Household * SPCD * 365.25) * 0.712[608] / GPH

GPH = Gallons per hour recovery of electric water heater calculated for 65.9F temp rise (120-

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

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

[606] 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.

[607] Navigant, ComEd-Nicor Gas EPY4/GPY1 Multi-Family Home Energy Savings Program Evaluation Report FINAL 2013-06-05

[608] 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

= 34.4 for SF Direct Install; 28.3 for MF Direct Install

= 30.3 for SF Retrofit and TOS; 24.8 for MF Retrofit and TOS

CF = Coincidence Factor for electric load reduction

= 0.0022[609]

EXAMPLE

For example, a direct installed thermostatic restrictor device in a single family home with electric DHW where the number of showers is not known.

ΔkW = 85.3/34.4 * 0.0022

= 0.0055 kW

NATURAL GAS SAVINGS

ΔTherms = %FossilDHW * ((GPM_base_S * L_showerdevice)* 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%[610]

[609] 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 use in peak period is 0.11*65/365 = 1.96%. The number of hours of recovery during peak periods is therefore assumed to be 1.96% * 29.5 = 0.577 hours of recovery during peak period, where 29.5 equals the average annual electric DHW recovery hours for showerhead use prevented by the device including SF and MF homes with Direct Install and Retrofit/TOS measures. There are 260 hours in the peak period so the probability you will see savings during the peak period is 0.577/260 = 0.0022

[610] 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

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

RE_gas = Recovery efficiency of gas water heater

= 78% For SF homes[611]

= 67% For MF homes[612]

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

Other variables as defined above.

EXAMPLE

For example, a direct installed thermostatic restrictor device in a gas fired DHW single family home where the number of showers is not known:

ΔTherms = 1.0 * ((2.67 * 0.89) * 2.56 * 0.6 * 365.25 / 1.79) * 0.00501 * 0.98

= 3.7 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

Δgallons = ((GPM_base_S * L_showerdevice) * Household * SPCD * 365.25 / SPH) * ISR

Variables as defined above

EXAMPLE

For example, a direct installed thermostatic restrictor device in a single family home where the number of showers is not known:

Δgallons = ((2.67 * 0.89) * 2.56 * 0.6 * 365.25 / 1.79) * 0.98

= 730 gallons

611 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%.

612 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.

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.
8	2011, Lutz, Jim. “Water and Energy Wasted During Residential Shower Events: Findings from a Pilot Field Study of Hot Water Distribution Systems”, Energy Analysis Department Lawrence Berkeley National Laboratory, September 2011.
9	2008, Water Conservation Program: ShowerStart Pilot Project White Paper, City of San Diego, CA.
10	2012, Pacific Gas and Electric Company, Work Paper PGECODHW113, Low Flow Showerhead and Thermostatic Shower Restriction Valve, Revision # 4, August 2012.
11	2008, “Simply & Cost Effectively Reducing Shower Based Warm-Up Waste: Increasing Convenience & Conservation by Attaching ShowerStart to Existing Showerheads”, ShowerStart LLC.
12	2014, New York State Record of Revision to the TRM, Case 07-M-0548, June 19, 2014.

Measure Code: RS-HWE-TRVA-V02-160601

5.5 Lighting End Use

5.5.1 ENERGY STAR Compact Fluorescent Lamp (CFL)

DESCRIPTION

A low wattage ENERGY STAR qualified compact fluorescent screw-in bulb (CFL) is installed in place of a baseline screw-in bulb.

This characterization assumes that the CFL is installed in a residential location. If the implementation strategy does not allow for the installation location to be known (e.g. an upstream retail program), a deemed split of 96% Residential and 4% Commercial assumptions should be used[613].

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[614]. For bulbs installed June 2015 – May 2016, this would be reduced to 5 years and then for every subsequent year should be reduced by one year[615].

Exterior bulbs: The expected measure life is 3.2 years[616] for bulbs installed June 2012 – May 2016. For bulbs installed June 2017-May 2018 this would be reduced to 3 years.

---

613 RES v C&I split is based on a weighted (by sales volume) average of ComEd PY4, PY5 and PY6 and Ameren PY5 and PY6 in store intercept survey results. See 'RESvCI Split_122014.xls'.

614 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.

615 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.

616 Based on using 8,000 hour rated life assumption since more switching and use outdoors. 8,000/2475 = 3.2years

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[617].

For the Direct Install measure, the full cost of $2.50 per bulb should be used, plus $5 labor cost[618] 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

COINCIDENCE FACTOR

The summer peak coincidence factor is assumed to be 7.1% for Time of Sale Residential and in-unit Multi Family bulbs, 27.3% for exterior bulbs and 8.1% for unknown[619] and 7.4% for Residential Direct Install[620].

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

ΔkWh = ((WattsBase - WattsEE) / 1000) * ISR * (1-Leakage) * Hours * WHFe

Where:

WattsBase = Based on lumens of CFL bulb and program year installed:

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

[617] Based upon pricing forecast developed by Applied Proactive Technologies Inc (APT) based on industry input and provided to Ameren.
[618] Based on 15 minutes at $20 an hour. Includes some portion of travel time to site.
[619] Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.
[620] Based on lighting logger study conducted as part of the PY5/PY6 ComEd Residential Lighting Program evaluation and excluding all logged bulbs installed in closets.

Minimum Lumens	Maximum Lumens	Incandescent Equivalent Post-EISA 2007 (WattsBase)
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.

Program		Weighted Average 1st Year In Service Rate (ISR)	2nd year Installations	3rd year Installations	Final Lifetime In Service Rate
Retail (Time of Sale)		73.2%[621]	13.4%	11.4%	98.0%[622]
Direct Install		96.9%[623]			
Efficiency Kits[624]	CFL Distribution[625]	59%	13%	11%	83%
	School Kits[626]	61%	13%	11%	86%
	Direct Mail Kits[627]	66%	14%	12%	93%

Leakage = Adjustment to account for the percentage of program bulbs that move out (and in if

[621] 1st year in service rate is based upon review of PY4-6 evaluations from ComEd and PY5-6 for Ameren (see 'IL RES Lighting ISR_122014.xls' for more information). The average first year ISR for each utility was calculated weighted by the number of bulbs in the each year's survey. This was then weighted by annual sales to give a statewide assumption.

[622] 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.

[623] 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.

[624] In Service Rates provided are for the CFL bulb within a kit only. Given the significant differences in program design and the level of education provided through Efficiency Kits programs, the evaluators should apply the ISR estimated through evaluations (either past evaluations or the current program year evaluation) of the specific Efficiency Kits program. In cases where program-specific evaluation results for an ISR are unavailable, the default ISR values for Efficiency Kits provided may be used.

[625] Free bulbs provided without request, with little or no education. Based on 'Impact and Process Evaluation of 2013 (PY6) Ameren Illinois Company Residential CFL Distribution Program', Report Table 11 and Appendix B.

[626] Kits provided free to students through school, with education program. Based on 'Impact and Process Evaluation of 2013 (PY6) Ameren Illinois Company Residential Efficiency Kits Program', table 10. Final ISR assumptions are based upon comparing with CFL Distribution First year ISR and multiplying by the CFL Distribution Final ISR value, and second and third year estimates based on same proportion of future installs.

[627] Opt-in program to receive kits via mail, with little or no education. Based on 'Impact and Process Evaluation of 2013 (PY6) Ameren Illinois Company Residential Efficiency Kits Program', table 10, as above.

deemed appropriate[628]) of the Utility Jurisdiction.

Upstream (TOS) Lighting programs and KITS = Determined through evaluation[629].

All other programs = 0

Hours = Average hours of use per year

Program Delivery	Installation Location	Hours[630]
Retail (Time of Sale) and Efficiency Kits	Residential Interior and in-unit Multi Family	759
	Exterior	2,475 [631]
	Unknown	847 [632]
Direct Install	Residential Interior and in-unit Multi Family	793
	Exterior	2,475

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 [633]
Multi family in unit	1.04 [634]
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.

628 Leakage in is only appropriate to credit to IL utility program savings if it is reasonably expected that the IL utility program marketing efforts played an important role in influencing customer to purchase the light bulbs. Furthermore, consideration that such customers might be free riders should be addressed. If leakage in is assessed, efforts should be made to ensure no double counting of savings occurs if the evaluation is estimating both leakage in and spillover savings of light bulbs.

629 Using a leakage estimate from the current program year evaluation, from past evaluation results, or a rolling average of leakage estimates from previous years.

630 Except where noted, based on lighting logger study conducted as part of the PY5/PY6 ComEd Residential Lighting Program evaluation. Direct Install value excludes all logged bulbs installed in closets.

631 Based on secondary research conducted as part of the PY5/PY6 ComEd Residential Lighting Program evaluation.

632 Assumes 5% exterior lighting, based on PYPY5/PY6 ComEd Residential Lighting Program evaluation.

633 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)

634 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

Year 1 (Purchase Year) installs: Characterized using assumptions provided above or evaluated assumptions if available.

Year 2 and 3 installs: Characterized using delta watts assumption and hours of use from the Install Year i.e. the actual deemed (or evaluated if available) assumptions active in Year 2 and 3 should be applied.

The NTG factor for the Purchase Year should be applied.

For example, for a 14W CFL (60W standard incandescent and 43W EISA qualified incandescent/halogen) purchased in 2014.

$\Delta kWH_{1st\ year\ installs}$ = ((43 - 14) / 1000) * 0.722 * 847 * 1.06

= 18.8 kWh

$\Delta kWH_{2nd\ year\ installs}$ = ((43 - 14) / 1000) * 0.139 * 847 * 1.06

= 3.6 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 * 847 * 1.06

= 3.1 kWh

HEATING PENALTY

If electric heated home (if heating fuel is unknown assume gas, see Natural Gas section):

ΔkWh[635] = - (((WattsBase - WattsEE) / 1000) * ISR * Hours * HF) / ηHeat

Where:

HF = Heating Factor or percentage of light savings that must be heated

= 49%[636] for interior or unknown location

= 0% for exterior or unheated location

ηHeat = Efficiency in COP of Heating equipment

= actual. If not available use[637]:

System Type	Age of Equipment	HSPF Estimate	ηHeat (COP Estimate)
Heat Pump	Before 2006	6.8	2.00
	2006 - 2014	7.7	2.26
	2015 on	8.2	2.40
Resistance	N/A	N/A	1.00

[635] Negative value because this is an increase in heating consumption due to the efficient lighting.
[636] 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.
[637] 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 * 759 * 0.49) / 2.0

= - 3.9 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[638]
Multi family in unit	1.07[639]
Exterior or uncooled location	1.0

CF = Summer Peak Coincidence Factor for measure.

Program Delivery	Bulb Location	CF[640]
Retail(Time of Sale)	Interior single family or Multi Family in unit	7.1%
	Exterior	27.3%
	Unknown location	8.1%
Direct Install	Residential	7.4%

Other factors as defined above

[638] 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.

[639] 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.

[640] Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation. Direct Install value is based on resut excluding all logged bulbs installed in closets.

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 * 0.071

= 0.0017 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[641] = - (((WattsBase - WattsEE) / 1000) * ISR * Hours * HF * 0.03412) / ηHeat

Where:

HF = Heating Factor or percentage of light savings that must be heated

= 49%[642] for interior or unknown location

= 0% for exterior or unheated location

0.03412 =Converts kWh to Therms

ηHeat = Efficiency of heating system

=70%[643]

For example, a14 standard CFL is purchased and installed in a home in 2014:

ΔTherms = - (((43 - 14) / 1000) * 0.722 * 759 * 0.49 * 0.03412) / 0.7

= - 0.38 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[644].

---

641 Negative value because this is an increase in heating consumption due to the efficient lighting.

642 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.

643 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

644 Based upon pricing forecast developed by Applied Proactive Technologies Inc (APT) based on industry input and provided to Ameren.

	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 5.34% are presented below. It is important to note that for cost-effectiveness screening purposes, the O&M cost adjustments should only be applied in cases where the light bulbs area actually in service and so should be multiplied by the appropriate ISR:

Location	Lumen Level	NPV of replacement costs for period			Levelized annual replacement cost savings		
		June 2015 - May 2016	June 2016 - May 2017	June 2017 - May 2018	June 2015 - May 2016	June 2016 - May 2017	June 2017 - May 2018
Residential and in-unit Multi Family	Lumens <310 or >2600 (EISA exempt)	$0.86	$0.66	$0.45	$0.19	$0.15	$0.13
	Lumens ≥ 310 and ≤ 2600 (EISA compliant)	$1.72	$1.24	$0.80	$0.39	$0.29	$0.23
Exterior	Lumens <310 or >2600 (EISA exempt)	$2.90	$2.64	$1.95	$1.00	$0.91	$0.56
	Lumens ≥ 310 and ≤ 2600 (EISA compliant)	$6.19	$5.30	$3.59	$2.14	$1.83	$1.02
Unknown	Lumens <310 or >2600 (EISA exempt)	$0.96	$0.74	$0.51	$0.22	$0.17	$0.14
	Lumens ≥ 310 and ≤ 2600 (EISA compliant)	$1.92	$1.38	$0.89	$0.43	$0.32	$0.25

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.[645] 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.

[645] 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.

MEASURE CODE: RS-LTG-ESCF-V05-160601

5.5.2 ENERGY STAR Specialty Compact Fluorescent Lamp (CFL)

Description

An ENERGY STAR qualified specialty compact fluorescent bulb is installed in place of an incandescent specialty bulb.

This characterization assumes that the specialty CFL is installed in a residential location. If the implementation strategy does not allow for the installation location to be known (e.g. an upstream retail program) a deemed split of 96% Residential and 4% Commercial assumptions should be used[646].

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[647].

Exterior bulbs: The expected measure life is 3.2 years[648] for bulbs installed June 2012 – May 2017. For bulbs installed June 2017-May 2018 this would be reduced to 3 years.

Deemed Measure Cost

For the Retail (Time of Sale) measure, the incremental capital cost for this measure is $5[649].

For the Direct Install measure, the full cost of $8.50 should be used plus $5 labor[650] 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

---

[646] RES v C&I split is based on a weighted (by sales volume) average of ComEd PY4, PY5 and PY6 and Ameren PY5 and PY6 in store intercept survey results. See 'RESvCI Split_122014.xls'.

[647] 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).

[648] Based on using 8,000 hour rated life assumption since more switching and use ourdoors. 8,000/2475 = 3.2years

[649] NEEP Residential Lighting Survey, 2011

[650] Based on 15 minutes at $20 per hour.

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[651]

Bulb Type	Peak CF
Three-way	0.078[652]
Dimmable	0.078[653]
Interior reflector (incl. dimmable)	0.091
Exterior reflector	0.273
Candelabra base and candle medium and intermediate base	0.121
Bug light	0.273
Post light (>100W)	0.273
Daylight	0.081
Plant light	0.081
Globe	0.075
Vibration or shatterproof	0.081
Standard spirals >= 2601 lumens, Residential, Multi-family in unit	0.071
Standard spirals >= 2601 lumens, unknown	0.081
Standard spirals >= 2601 lumens, exterior	0.273
Specialty - Generic	0.081

[651] Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.
[652] Based on average of bedroom, dining room, office and living room results from the lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.
[653] Ibid

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = ((WattsBase - WattsEE) / 1000) * ISR * (1-Leakage) * Hours * WHFe$$

Where:

WattsBase = Actual wattage equivalent of incandescent specialty bulb, use the tables below to obtain the incandescent bulb equivalent wattage[654]; use 60W if unknown[655]

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
	90	149	15
	150	299	25

[654] 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.

[655] 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)	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

Directional Lamps - ENERGY STAR Minimum Luminous Efficacy = 40Lm/W for lamps with rated wattages less than 20Wand 50 Lm/W for lamps with rated wattages >= 20 watts[656].

For Directional R, BR, and ER lamp types[657]:

Bulb Type	Lower Lumen Range	Upper Lumen Range	$Watts_{Base}$
R, ER, BR with medium screw bases w/ diameter >2.25" (*see exceptions below)	420	472	40
	473	524	45
	525	714	50
	715	937	65
	938	1259	75
	1260	1399	90
	1400	1739	100
	1740	2174	120
	2175	2624	150
	2625	2999	175
	3000	4500	200
***R, BR, and ER with medium**	400	449	40
	450	499	45

[656] From pg 10 of the Energy Star Specification for lamps v1.1
[657] From pg 11 of the Energy Star Specification for lamps v1.1

Bulb Type	Lower Lumen Range	Upper Lumen Range	$Watts_{Base}$
screw bases w/ diameter <=2.25"	500	649	50
	650	1199	65
***ER30, BR30, BR40, or ER40**	400	449	40
	450	499	45
	500	649	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	30

Directional lamps are exempt from EISA regulations.

For PAR, MR, and MRX Lamps Types:

For these highly focused directional lamp types, it is necessary to have Center Beam Candle Power (CBCP) and beam angle measurements to accurately estimate the equivalent baseline wattage. The formula below is based on the Energy Star Center Beam Candle Power tool.[658] If CBCP and beam angle information are not available, or if the equation below returns a negative value (or undefined), use the manufacturer's recommended baseline wattage equivalent.[659]

$$\text{Wattsbase} = 375.1 - 4.355(D) - \sqrt{227{,}800 - 937.9(D) - 0.9903(D^2) - 1479(BA) - 12.02(D * BA) + 14.69(BA^2) - 16{,}720 * \ln(CBCP)}$$

Where:

D = Bulb diameter (e.g. for PAR20 D = 20)

BA = Beam angle

CBCP = Center beam candle power

The result of the equation above should be rounded DOWN to the nearest wattage established by Energy Star:

Diameter	Permitted Wattages
16	20, 35, 40, 45, 50, 60, 75
20	50

[658] http://energystar.supportportal.com/link/portal/23002/23018/Article/32655/

[659] The Energy Star Center Beam Candle Power tool does not accurately model baseline wattages for lamps with certain bulb characteristic combinations – specifically for lamps with very high CBCP.

Diameter	Permitted Wattages
30S	40, 45, 50, 60, 75
30L	50, 75
38	40, 45, 50, 55, 60, 65, 75, 85, 90, 100, 120, 150, 250

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[660]

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)	88.0%[661]	5.4%	4.6%	98.0%[662]
Direct Install	96.9%[663]			

[660] An evaluation (Energy Efficiency / Demand Response Plan: Plan Year 2 (6/1/2009-5/31/2010) Evaluation Report: Residential Energy Star ® Lighting) 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).

[661] 1st year in service rate is based upon review of PY4-6 evaluations from ComEd and PY5-6 from Ameren (see 'IL RES Lighting ISR_122014.xls' for more information. The average first year ISR was calculated weighted by the number of bulbs in the each year's survey.

[662] 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.

[663] 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.

Program		Weighted Average 1st year In Service Rate (ISR)	2nd year Installations	3rd year Installations	Final Lifetime In Service Rate
Efficiency Kits[664]	CFL Distribution[665]	59%	13%	11%	83%
	School Kits[666]	61%	13%	11%	86%
	Direct Mail Kits[667]	66%	14%	12%	93%

Leakage = Adjustment to account for the percentage of program bulbs that move out (and in if deemed appropriate[668]) of the Utility Jurisdiction.

Upstream (TOS) Lighting programs and KITS = Determined through evaluation[669].

All other programs = 0

Hours = Average hours of use per year, varies by bulb type as presented below:[670]

Bulb Type	Annual hours of use (HOU)
Three-way	850
Dimmable	850
Interior reflector (incl. dimmable)	861
Exterior reflector	2475
Candelabra base and candle medium and intermediate base	1190
Bug light	2475
Post light (>100W)	2475
Daylight	847
Plant light	847

664 In Service Rates provided are for the bulb within a kit only. Given the significant differences in program design and the level of education provided through Efficiency Kits programs, the evaluators should apply the ISR estimated through evaluations (either past evaluations or the current program year evaluation) of the specific Efficiency Kits program. In cases where program-specific evaluation results for an ISR are unavailable, the default ISR values for Efficiency Kits provide may be used.
665 Free bulbs provided without request, with little or no education. Consistent with Standard CFL assumptions.
666 Kits provided free to students through school, with education program. Consistent with Standard CFL assumptions.
667 Opt-in program to receive kits via mail, with little or no education. Consistent with Standard CFL assumptions.
668 Leakage in is only appropriate to credit to IL utility program savings if it is reasonably expected that the IL utility program marketing efforts played an important role in influencing customer to purchase the light bulbs. Furthermore, consideration that such customers might be free riders should be addressed. If leakage in is assessed, efforts should be made to ensure no double counting of savings occurs if the evaluation is estimating both leakage in and spillover savings of light bulbs.
669 Using a leakage estimate from the current program year evaluation, from past evaluation results, or a rolling average of leakage estimates from previous years.
670 Hours of use by specialty bulb type calculated using the average hours of use in locations or rooms where each type of specialty bulb is most commonly found. Values for Reflector, Decorative and Globe are taken directly from the lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation. All other hours have been updated based on the room specific hours of use from the PY5/PY6 logger study.

Bulb Type	Annual hours of use (HOU)
Globe	639
Vibration or shatterproof	847
Standard Spiral >2601 lumens, Residential, Multi Family in-unit	759
Standard Spiral >2601 lumens, unknown	847
Standard Spiral >2601 lumens, Exterior	2475
Specialty - Generic	847

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 [671]
Multi family in unit	1.04 [672]
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.

[671] 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)

[672] 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 * 850 * 1.06

= 34.9 kWh

$\Delta kWH_{2nd\ year\ installs}$ = ((43 - 13) / 1000) * 0.085 * 850 * 1.06

= 2.3 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 * 850 * 1.06

= 1.9 kWh

Note: delta watts is equivalent to install year. Here we assume no change in hours assumption.

HEATING PENALTY

If electric heated home (if heating fuel is unknown assume gas, see Natural Gas section):

ΔkWh[673] = - (((WattsBase - WattsEE) / 1000) * ISR * Hours * HF) / ηHeat

Where:

HF = Heating Factor or percentage of light savings that must be heated

= 49%[674] for interior or unknown location

= 0% for exterior location

ηHeat = Efficiency in COP of Heating equipment

= actual. If not available use[675]:

System Type	Age of Equipment	HSPF Estimate	ηHeat (COP Estimate)
Heat Pump	Before 2006	6.8	2.00
	2006 - 2014	7.7	2.26
	2015 on	8.2	2.40
Resistance	N/A	N/A	1.00

[673] Negative value because this is an increase in heating consumption due to the efficient lighting.
[674] 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.
[675] 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 globe 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 * 639 * 0.49) / 2.0

= - 5.8 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[676]
Multi family in unit	1.07[677]
Exterior or uncooled location	1.0

CF = Summer Peak Coincidence Factor for measure. Coincidence factors by bulb types are presented below[678]

Bulb Type	Peak CF
Three-way	0.078[679]
Dimmable	0.078[680]
Interior reflector (incl. dimmable)	0.091
Exterior reflector	0.273
Candelabra base and candle medium and intermediate base	0.121
Bug light	0.273
Post light (>100W)	0.273
Daylight	0.081
Plant light	0.081

---

676 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.

677 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.

678 Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.

679 Based on average of bedroom, dining room, office and living room results from the lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.

680 Ibid

Bulb Type	Peak CF
Globe	0.075
Vibration or shatterproof	0.081
Standard Spiral >=2601 lumens, Residential, Multi-family in unit	0.071
Standard spirals >= 2601 lumens, unknown	0.081
Standard spirals >= 2601 lumens, exterior	0.273
Specialty - Generic	0.081

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 * 0.081

= 0.003 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[681] = - (((WattsBase - WattsEE) / 1000) * ISR * Hours * HF * 0.03412) / ηHeat

Where:

HF = Heating Factor or percentage of light savings that must be heated

= 49%[682] for interior or unknown location

= 0% for exterior location

0.03412 =Converts kWh to Therms

ηHeat = Efficiency of heating system

=70%[683]

[681] Negative value because this is an increase in heating consumption due to the efficient lighting.

[682] 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.

[683] 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 Globe specialty CFL replacing a 60W incandescent specialty bulb:

ΔTherms = - (((60 - 15) / 1000) * 0. 823 * 639 * 0.49 * 0.03412) / 0.7

= - 0.57 Therms

Second and third year savings should be calculated using the appropriate ISR.

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

For those bulbs types exempt from EISA the following O&M assumptions should be used: Life of the baseline bulb is assumed to be 1.32 year[684]; baseline replacement cost is assumed to be $3.5[685].

For non-exempt EISA bulb types defined above, the following O&M assumptions should be used: Life of the baseline bulb is assumed to be 1.32 year[686]; baseline replacement cost is assumed to be $5[687].

It is important to note that for cost-effectiveness screening purposes, the O&M cost adjustments should only be applied in cases where the light bulbs area actually in service and so should be multiplied by the appropriate ISR.

MEASURE CODE: **RS-LTG-ESCC-V04-160601**

[684] Assuming 1000 hour rated life for incandescent bulb: 1000/759 = 1.32
[685] NEEP Residential Lighting Survey, 2011
[686] Assuming 1000 hour rated life for halogen bulb: 1000/759 = 1.32
[687] NEEP Residential Lighting Survey, 2011

5.5.3 ENERGY STAR Torchiere

Description

A high efficiency ENERGY STAR fluorescent torchiere is purchased in place of a baseline mix of halogen and incandescent torchieres and installed in a residential setting.

This measure was developed to be applicable to the following program types: TOS, NC.

If applied to other program types, the measure savings should be verified.

Definition of Efficient Equipment

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

Definition of Baseline Equipment

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

Deemed Lifetime of Efficient Equipment

The lifetime of the measure is assumed to be 8 years[688].

Deemed Measure Cost

The incremental cost for this measure is assumed to be $5[689].

Loadshape

Loadshape R06 - Residential Indoor Lighting

Loadshape R07 - Residential Outdoor Lighting

Coincidence Factor

The summer peak coincidence factor for this measure is 7.1% for Residential and in-unit Multi Family bulbs and 8.1% for bulbs installed in unknown locations[690].

688 Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007.
689 DEER 2008 Database Technology and Measure Cost Data (www.deeresources.com) and consistent with Efficiency Vermont TRM.
690 Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

ΔkWh = ((ΔWatts) /1000) * ISR * (1-Leakage) * HOURS * WHFe

Where:

ΔWatts = Average delta watts per purchased ENERGY STAR torchiere

= 115.8 [691]

ISR = In Service Rate or percentage of units rebated that get installed.

= 0.86 [692]

Leakage = Adjustment to account for the percentage of program bulbs that move out (and in if deemed appropriate[693]) of the Utility Jurisdiction.

Upstream (TOS) Lighting programs and KITS = Determined through evaluation[694].

All other programs = 0

HOURS = Average hours of use per year

Installation Location	Hours
Residential and in-unit Multi Family	1095 (3.0 hrs per day)[695]

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 [696]

[691] 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)

[692] 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

[693] Leakage in is only appropriate to credit to IL utility program savings if it is reasonably expected that the IL utility program marketing efforts played an important role in influencing customer to purchase the light bulbs. Furthermore, consideration that such customers might be free riders should be addressed. If leakage in is assessed, efforts should be made to ensure no double counting of savings occurs if the evaluation is estimating both leakage in and spillover savings of light bulbs.

[694] Using a leakage estimate from the current program year evaluation, from past evaluation results, or a rolling average of leakage estimates from previous years.

[695] 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)

[696] 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)

Bulb Location	WHFe
Multi family in unit	1.04 [697]
Exterior or uncooled location	1.0

For single family buildings:

$\Delta kWh = (115.8 /1000) * 0.86 * 1095 * 1.06$

$= 116$ kWh

For multi family in unit:

$\Delta kWh = (115.8 /1000) * 0.86 * 1095 * 1.04$

$= 113$ kWh

HEATING PENALTY

If electric heated home (if heating fuel is unknown assume gas, see Natural Gas section):

ΔkWh[698] $= - ((\Delta Watts) /1000) * ISR * HOURS * HF) / \eta Heat$

Where:

HF = Heating Factor or percentage of light savings that must be heated

= 49%[699] for interior or unknown location

ηHeat = Efficiency in COP of Heating equipment

= Actual. If not available use defaults provided below[700]:

System Type	Age of Equipment	HSPF Estimate	ηHeat (COP Estimate)
Heat Pump	Before 2006	6.8	2.00
	2006 - 2014	7.7	2.26
	2015 on	8.2	2.40
Resistance	N/A	N/A	1.00

[697] 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

[698] Negative value because this is an increase in heating consumption due to the efficient lighting.

[699] 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.

[700] These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Heat Pumps was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate.

For example, an ES torchiere installed in a house with a newer heat pump:

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[701]
Multi family in unit	1.07[702]
Exterior or uncooled location	1.0

CF = Summer Peak Coincidence Factor for measure

Bulb Location	CF[703]
Interior single family or Multi family in unit	7.1%
Unknown location	8.1%

For single family and multi-family in unit buildings:

ΔkW = (115.8 / 1000) * 0.86 * 1.11 * 0.071

= 0.008kW

For unknown location:

ΔkW = (115.8 / 1000) * 0.86 * 1.07 * 0.081

= 0.009 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:

[701] 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.

[702] 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.

[703] Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.

$\Delta Therms_{WH}$ = 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% [704]

ηHeat = average heating system efficiency

= 70% [705]

$\Delta Therms_{WH}$ = - ((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[706] for residential and multifamily in unit. Baseline bulb cost replacement is assumed to be $6.[707]

It is important to note that for cost-effectiveness screening purposes, the O&M cost adjustments should only be applied in cases where the light bulbs area actually in service and so should be multiplied by the appropriate ISR.

MEASURE CODE: RS-LTG-ESTO-V03-160601

---

[704] 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.

[705] 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

[706] Based on VEIC assumption of baseline bulb (mix of incandescent and halogen) average rated life of 2000 hours, 2000/1095 = 1.83 years.

[707] 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[708]. 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[709].

DEEMED MEASURE COST

The incremental cost for an exterior fixture is assumed to be $32[710].

LOADSHAPE

Loadshape R07 - Residential Outdoor Lighting

---

[708] 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.

[709] 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.

710 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)

COINCIDENCE FACTOR

The summer peak coincidence factor is assumed to be 27.3%[711].

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = ((WattsBase - WattsEE) / 1000) * ISR * (1-Leakage) * Hours$$

Where:

WattsBase = Based on lumens of CFL bulb and program year purchased:

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

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%[712]	5.7%	4.8%	98.0%[713]

[711] Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.
[712] 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.
[713] 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

Program	Weighted Average 1st year In Service Rate (ISR)	2nd year Installations	3rd year Installations	Final Lifetime In Service Rate
Direct Install	96.9[714]			

Leakage = Adjustment to account for the percentage of program bulbs that move out (and in if deemed appropriate[715]) of the Utility Jurisdiction.

Upstream (TOS) Lighting programs and KITS = Determined through evaluation[716].

All other programs = 0

Hours = Average hours of use per year

=2475 (6.78 hrs per day)[717]

DEFERRED INSTALLS

As presented above, the characterization assumes that a percentage of bulbs purchased are not installed until Year 2 and Year 3 (see ISR assumption above). The Illinois Technical Advisory Committee has determined the following methodology for calculating the savings of these future installs.

Year 1 (Purchase Year) installs: Characterized using assumptions provided above or evaluated assumptions if available.

Year 2 and 3 installs: Characterized using delta watts assumption and hours of use from the Install Year i.e. the actual deemed (or evaluated if available) assumptions active in Year 2 and 3 should be applied.

The NTG factor for the Purchase Year should be applied.

For example, for a 2 x 14W pin based CFL fixture (43W EISA qualified incandescent/halogen) purchased in 2014.

$\Delta kWH_{1st\ year\ installs}$ = ((86 - 28) / 1000) * 0.875 * 2475

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.

[714] 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.

[715] Leakage in is only appropriate to credit to IL utility program savings if it is reasonably expected that the IL utility program marketing efforts played an important role in influencing customer to purchase the light bulbs. Furthermore, consideration that such customers might be free riders should be addressed. If leakage in is assessed, efforts should be made to ensure no double counting of savings occurs if the evaluation is estimating both leakage in and spillover savings of light bulbs.

[716] Using a leakage estimate from the current program year evaluation, from past evaluation results, or a rolling average of leakage estimates from previous years.

[717] Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.

= 125.6 kWh

$\Delta kWH_{2nd\ year\ installs}$ = ((86 - 28) / 1000) * 0.057 * 2475

= 8.2 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 * 2475

= 6.9 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ((WattsBase - WattsEE) / 1 000) * ISR * CF

Where:

CF = Summer Peak Coincidence Factor for measure.

= 27.3%[718]

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 * 0.273

= 0.0142 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

DEEMED O&M COST ADJUSTMENT CALCULATION

Bulb replacement costs assumed in the O&M calculations are provided below[719].

	Std Inc.	EISA Compliant Halogen
2014	$0.34	$1.25
2015	$0.34	$0.90

718 Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.
719 Based upon pricing forecast developed by Applied Proactive Technologies Inc (APT) based on industry input and provided to Ameren.

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 5.34% are presented below. It is important to note that for cost-effectiveness screening purposes, the O&M cost adjustments should only be applied in cases where the light bulbs area actually in service and so should be multiplied by the appropriate ISR:

Lumen Level	NPV of replacement costs for period			Levelized annual replacement cost savings		
	June 2015 - May 2016	June 2016 - May 2017	June 2017 - May 2018	June 2015 - May 2016	June 2016 - May 2017	June 2017 - May 2018
Lumens <310 or >2600 (non-EISA compliant)	$3.29	$2.64	$1.95	$0.65	$0.61	$0.56
Lumens ≥ 310 and ≤ 2600 (EISA compliant)	$6.88	$5.16	$3.59	$1.37	$1.20	$1.02
Efficient bulb CFL	$1.10	$0.50	$0 - No replacement bulb within measure life	$0.26	$0.14	$0 - No replacement bulb within measure life

For halogen bulbs, we assume the same replacement cycle as incandescent bulbs.[720] The replacement cycle is based on the location of the lamp and varies based on the hours of use for that location. Both incandescent and halogen lamps are assumed to last for 1,000 hours before needing replacement, CFLs in Residential and in-unit multifamily assume 8000 hours and multifamily common areas assume 10,000 (longer run hours and less switching leads to longer lamp life).

MEASURE CODE: RS-LRG-EFOX-V05-160601

[720] 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.

5.5.5 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[721]. 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[722].

Deemed Measure Cost

The incremental cost for an interior fixture is assumed to be $32[723].

Loadshape

Loadshape R06 - Residential Indoor Lighting

---

721 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.

722 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.

723 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)

COINCIDENCE FACTOR

The summer peak coincidence factor is assumed to be 7.1%[724] for Residential and in-unit Multi Family bulbs.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

ΔkWh = ((WattsBase - WattsEE) / 1000) * ISR * (1-Leakage) * Hours * WHFe

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

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%[725]	5.7%	4.8%	98.0%[726]

[724] Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.
[725] 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.
[726] 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

Program	Weighted Average 1st year In Service Rate (ISR)	2nd year Installations	3rd year Installations	Final Lifetime In Service Rate
Direct Install	96.9[727]			

Leakage = Adjustment to account for the percentage of program bulbs that move out (and in if deemed appropriate[728]) of the Utility Jurisdiction.

Upstream (TOS) Lighting programs and KITS = Determined through evaluation[729].

All other programs = 0

Hours = Average hours of use per year

Installation Location	Hours
Residential and in-unit Multi Family	759 [730]

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 [731]
Multi family in unit	1.04 [732]

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.

727 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.

728 Leakage in is only appropriate to credit to IL utility program savings if it is reasonably expected that the IL utility program marketing efforts played an important role in influencing customer to purchase the light bulbs. Furthermore, consideration that such customers might be free riders should be addressed. If leakage in is assessed, efforts should be made to ensure no double counting of savings occurs if the evaluation is estimating both leakage in and spillover savings of light bulbs.

729 Using a leakage estimate from the current program year evaluation, from past evaluation results, or a rolling average of leakage estimates from previous years.

730 Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.

731 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)

732 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

DEFERRED INSTALLS

As presented above, the characterization assumes that a percentage of bulbs purchased are not installed until Year 2 and Year 3 (see ISR assumption above). The Illinois Technical Advisory Committee has determined the following methodology for calculating the savings of these future installs.

Year 1 (Purchase Year) installs: Characterized using assumptions provided above or evaluated assumptions if available.

Year 2 and 3 installs: Characterized using delta watts assumption and hours of use from the Install Year i.e. the actual deemed (or evaluated if available) assumptions active in Year 2 and 3 should be applied.

The NTG factor for the Purchase Year should be applied.

For example, for a 2 x 14W pin based CFL fixture (43W EISA qualified incandescent/halogen) purchased in 2013.

$\Delta kWH_{1st\ year\ installs}$ = ((86 - 28) / 1000) * 0.875 * 759 * 1.06

= 40.8 kWh

$\Delta kWH_{2nd\ year\ installs}$ = ((86 - 28) / 1000) * 0.057 * 759 * 1.06

= 2.7 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 * 759 * 1.06

= 2.2 kWh

HEATING PENALTY

If electric heated building:

ΔkWh[733] = - (((WattsBase - WattsEE) / 1000) * ISR * Hours * HF) / ηHeat

Where:

HF = Heating Factor or percentage of light savings that must be heated

= 49%[734] for interior or unknown location

= 0% for unheated location

ηHeat = Efficiency in COP of Heating equipment

= actual. If not available use[735]:

System Type	Age of Equipment	HSPF Estimate	ηHeat (COP Estimate)
Heat Pump	Before 2006	6.8	2.00
	2006 -2014	7.7	2.26
	2015 on	8.2	2.40

[733] Negative value because this is an increase in heating consumption due to the efficient lighting.
[734] 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.
[735] 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.

Resistance	N/A	N/A	1.00

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 * 759 * 0.49) / 2.0

= - 9.4 kWh

Second and third year install savings should be calculated using the appropriate ISR and the delta watts and hours from the install year.

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[736]
Multi family in unit	1.07[737]
Exterior or uncooled location	1.0

CF = Summer Peak Coincidence Factor for measure.

Bulb Location	CF[738]
Interior single family or unknown location	7.1%
Multi family in unit	7.1%

Other factors as defined above

[736] 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.

[737] 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 .

[738] Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.

For example, a 14W pin-based CFL fixture is purchased in 2013:

$\Delta kW_{1st\ year}$ = ((86- 28) / 1000) * 0.875 * 1.11 * 0.071

= 0.004 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[739] = - (((WattsBase - WattsEE) / 1000) * ISR * Hours * HF * 0.03412) / ηHeat

Where:

HF = Heating Factor or percentage of light savings that must be heated

= 49%[740] for interior or unknown location

= 0% for unheated location

0.03412 =Converts kWh to Therms

ηHeat = Efficiency of heating system

=70%[741]

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 * 759 * 0.49 * 0.03412) / 0.7

= - 0.9 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[742].

---

[739] Negative value because this is an increase in heating consumption due to the efficient lighting.

[740] 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.

[741] 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

[742] Based upon pricing forecast developed by Applied Proactive Technologies Inc (APT) based on industry input and provided to Ameren.

	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 5.34% are presented below. It is important to note that for cost-effectiveness screening purposes, the O&M cost adjustments should only be applied in cases where the light bulbs area actually in service and so should be multiplied by the appropriate ISR:

Location	Lumen Level	NPV of replacement costs for period			Levelized annual replacement cost savings		
		June 2015 - May 2016	June 2016 - May 2017	June 2017 - May 2018	June 2015 - May 2016	June 2016 - May 2017	June 2017 - May 2018
Residential and in-unit Multi Family	Lumens <310 or >2600 (non-EISA compliant)	$0.86	$0.66	$0.45	$0.20	$0.19	$0.17
	Lumens ≥ 310 and ≤ 2600 (EISA compliant)	$1.72	$1.24	$0.80	$0.40	$0.35	$0.30
	Efficient bulb CFL	$0 - No replacement bulb within measure life			$0 - No replacement bulb within measure life		

For halogen bulbs, we assume the same replacement cycle as incandescent bulbs.[743] The replacement cycle is based on the location of the lamp and varies based on the hours of use for that location. Both incandescent and halogen lamps are assumed to last for 1,000 hours before needing replacement, CFLs in Residential and in-unit multi family assume 8000 hours

MEASURE CODE: RS-LTG-IFIX-V05-160601

[743] 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 Specialty Lamps

Description

This measure describes savings from a variety of specialty LED lamp types (including globe, decorative and downlights). 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) a deemed split of 96% Residential and 4% Commercial assumptions should be used[744].

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

While LED rated lives are often 25,000 – 50,000 hours, all installations are assumed to be 10 years[745] except for recessed downlight and track lights at 15 years[746]

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[747]:

Bulb Type	LED Wattage	LED	Incandescent	Incremental Cost
Directional Lamps	< 20W	$22.42	$6.31	$16.11
	≥20W	$70.78		$64.47
Recessed downlight luminaries	All	$94.00	$4.00	$90.00
Track lights	All	$60.00	$4.00	$56.00
Decorative and Globe	<15W	$12.76	$3.92	$8.84
	≥15	$25.00		$21.08

[744] RES v C&I split is based on a weighted (by sales volume) average of ComEd PY4, PY5 and PY6 and Ameren PY5 and PY6 in store intercept survey results. See 'RESvCI Split_122014.xls'.
[745] 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.
[746] Limited by persistence. NEEP EMV Emerging Technologies Research Report (December 2011)
[747] LED lamp costs are based on VEIC review of a year's worth of LED sales data through VEIC implemented programs and the retail cost averaged (see 2015 LED Sales Review.xls) and of price reports provided to Efficiency Vermont by a number of manufacturers and retailers. Baseline cost based on "2010-2012 WA017 Ex Ante Measure Cost Study Draft Report", Itron, February 28, 2014.

LOADSHAPE

Loadshape R06 - Residential Indoor Lighting

Loadshape R07 - Residential Outdoor Lighting

COINCIDENCE FACTOR

Unlike standard lamps that could be installed in any room, certain types of specialty lamps are more likely to be found in specific rooms, which affects the coincident peak factor. Coincidence factors by bulb types are presented below[748]

Bulb Type	Peak CF
Three-way	0.078[749]
Dimmable	0.078[750]
Interior reflector (incl. dimmable)	0.091
Exterior reflector	0.273
Unknown reflector	0.094
Candelabra base and candle medium and intermediate base	0.121
Bug light	0.273
Post light (>100W)	0.273
Daylight	0.081
Plant light	0.081
Globe	0.075
Vibration or shatterproof	0.081
Standard Spiral >=2601 lumens, Residential, Multi-family in unit	0.071
Standard spirals >= 2601 lumens, unknown	0.081
Standard spirals >= 2601 lumens, exterior	0.273
Specialty - Generic	0.081

[748] Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.
[749] Based on average of bedroom, dining room, office and living room results from the lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.
[750] Ibid

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

ΔkWh = ((WattsBase - WattsEE) / 1000) * ISR * (1-Leakage) * Hours * WHFe

Where:

$Watts_{base}$ = Input wattage of the existing or baseline system. Reference the table below for default values.

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 (Shapes B, BA, C, CA, DC, F, G, medium and intermediate bases less than 750 lumens)	70	89	10
	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

Bulb Type	Lower Lumen Range	Upper Lumen Range	WattsBase
	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

Directional Lamps -

For Directional R, BR, and ER lamp types[751]:

Bulb Type	Lower Lumen Range	Upper Lumen Range	$Watts_{Base}$
R, ER, BR with medium screw bases w/ diameter >2.25" (*see exceptions below)	420	472	40
	473	524	45
	525	714	50
	715	937	65
	938	1259	75
	1260	1399	90
	1400	1739	100
	1740	2174	120
	2175	2624	150
	2625	2999	175
	3000	4500	200
***R, BR, and ER with medium screw bases w/ diameter <=2.25"**	400	449	40
	450	499	45
	500	649	50
	650	1199	65
***ER30, BR30, BR40, or ER40**	400	449	40
	450	499	45
	500	649	50
***BR30, BR40, or ER40**	650	1419	65
***R20**	400	449	40

751 From pg 11 of the Energy Star Specification for lamps v1.1

Bulb Type	Lower Lumen Range	Upper Lumen Range	$Watts_{Base}$
	450	719	45
***All reflector lamps below lumen ranges specified above**	200	299	20
	300	399	30

Directional lamps are exempt from EISA regulations.

For PAR, MR, and MRX Lamps Types:

For these highly focused directional lamp types, it is necessary to have Center Beam Candle Power (CBCP) and beam angle measurements to accurately estimate the equivalent baseline wattage. The formula below is based on the Energy Star Center Beam Candle Power tool.[752] If CBCP and beam angle information are not available or if the equation below returns a negative value (or undefined), use the manufacturer's recommended baseline wattage equivalent.[753]

$$\text{Wattsbase} =$$

$$375.1 - 4.355(D) - \sqrt{227{,}800 - 937.9(D) - 0.9903(D^2) - 1479(BA) - 12.02(D * BA) + 14.69(BA^2) - 16{,}720 * \ln(CBCP)}$$

Where:

D = Bulb diameter (e.g. for PAR20 D = 20)

BA = Beam angle

CBCP = Center beam candle power

The result of the equation above should be rounded DOWN to the nearest wattage established by Energy Star:

Diameter	Permitted Wattages
16	20, 35, 40, 45, 50, 60, 75
20	50
30S	40, 45, 50, 60, 75
30L	50, 75
38	40, 45, 50, 55, 60, 65, 75, 85, 90, 100, 120, 150, 250

EISA non-exempt bulb types:

[752] http://energystar.supportportal.com/link/portal/23002/23018/Article/32655/

[753] The Energy Star Center Beam Candle Power tool does not accurately model baseline wattages for lamps with certain bulb characteristic combinations – specifically for lamps with very high CBCP.

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

$Watts_{EE}$ = Actual wattage of LED purchased / installed. ISR = In Service Rate or the percentage of units rebated that get installed

Program	Bulb Type	ISR
Retail (Time of Sale)	Recessed downlight luminaries and Track Lights	100%[754]
	All other lamps	95%
Direct Install	All lamps	96.9%[755]

Leakage = Adjustment to account for the percentage of program bulbs that move out (and in if deemed appropriate[756]) of the Utility Jurisdiction.

Upstream (TOS) Lighting programs and KITS = Determined through evaluation[757].

All other programs = 0

Hours = Average hours of use per year [758]

[754] NEEP EMV Emerging Technologies Research Report (December 2011)

[755] 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.

[756] Leakage in is only appropriate to credit to IL utility program savings if it is reasonably expected that the IL utility program marketing efforts played an important role in influencing customer to purchase the light bulbs. Furthermore, consideration that such customers might be free riders should be addressed. If leakage in is assessed, efforts should be made to ensure no double counting of savings occurs if the evaluation is estimating both leakage in and spillover savings of light bulbs.

[757] Using a leakage estimate from the current program year evaluation, from past evaluation results, or a rolling average of leakage estimates from previous years.

[758] Hours of use by specialty bulb type calculated using the average hours of use in locations or rooms where each type of specialty bulb is most commonly found. Values for Reflector, Decorative and Globe are taken directly from the lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation. All other hours have been updated based on the room specific hours of use from the PY5/PY6 logger study.

Bulb Type	Annual hours of use (HOU)
Three-way	850
Dimmable	850
Interior reflector (incl. dimmable)	861
Exterior reflector	2475
Unknown reflector	891
Candelabra base and candle medium and intermediate base	1190
Bug light	2475
Post light (>100W)	2475
Daylight	847
Plant light	847
Globe	639
Vibration or shatterproof	847
Standard Spiral >2601 lumens, Residential, Multi Family in-unit	759
Standard Spiral >2601 lumens, unknown	847
Standard Spiral >2601 lumens, Exterior	2475
Specialty – Generic Interior	847
Specialty – Generic Exterior	2475

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 [759]
Multi family in unit	1.04 [760]

[759] 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)

[760] 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

Bulb Location	WHFe
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 * 861 * 1.06

= 27.7 kWh

HEATING PENALTY

If electric heated home (if heating fuel is unknown assume gas, see Natural Gas section):

ΔkWh[761] = - (((WattsBase - WattsEE) / 1000) * ISR * Hours * HF) / ηHeat

Where:

HF = Heating Factor or percentage of light savings that must be heated

= 49%[762] for interior or unknown location

= 0% for exterior location

ηHeat = Efficiency in COP of Heating equipment

= Actual. If not available use:[763]

System Type	Age of Equipment	HSPF Estimate	ηHeat (COP Estimate)
Heat Pump	Before 2006	6.8	2.00
	After 2006 - 2014	7.7	2.26
	2015 on	8.2	2.40
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 * 861 * 0.49) / 2.26

= - 5.67 kWh

[761] Negative value because this is an increase in heating consumption due to the efficient lighting.
[762] 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.
[763] 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

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[764]
Multi family in unit	1.07[765]
Exterior or uncooled location	1.0

CF = Summer Peak Coincidence Factor for measure, see above for values. [766]

Bulb Type	Peak CF
Three-way	0.078[767]
Dimmable	0.078[768]
Interior reflector (incl. dimmable)	0.091
Exterior reflector	0.273
Unknown reflector	0.094
Candelabra base and candle medium and intermediate base	0.121
Bug light	0.273
Post light (>100W)	0.273
Daylight	0.081
Plant light	0.081
Globe	0.075
Vibration or shatterproof	0.081
Standard Spiral >=2601 lumens, Residential, Multi-family in unit	0.071
Standard spirals >= 2601 lumens, unknown	0.081

[764] 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.

[765] 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.

[766] Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.

[767] Based on average of bedroom, dining room, office and living room results from the lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.

[768] Ibid

Bulb Type	Peak CF
Standard spirals >= 2601 lumens, exterior	0.273
Specialty - Generic	0.081

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* 0.091

= 0.0031 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

Where:

HF = Heating factor, or percentage of lighting savings that must be replaced by heating system.

= 49% [769] for interior or unknown location

= 0% for exterior location

0.03412 = Converts kWh to Therms

ηHeat = Average heating system efficiency.

= 0.70 [770]

Other factors as defined above

[769] Average result from REMRate modeling of several different configurations and IL locations of homes

[770] 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 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 * 861 * 0.49* 0.03412) / 0.70

= - 0.63 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

For those bulbs types exempt from EISA (except for reflectors) the following O&M assumptions should be used: Life of the baseline bulb is assumed to be 1.32 year[771]; baseline replacement cost is assumed to be $3.5[772].

For reflectors the life of the baseline bulb and the cost of its replacement is presented in the following table:

Lamp Type	Baseline Lamp Life (hours)	Baseline Life (Single Family and in unit Multifamily - 1010 hours)	Baseline Replacement Cost
PAR20, PAR30, PAR38 screw-in lamps	2000	2.0	$4.00
MR16/PAR16 pin-based lamps	2000	2.0	$3.00
Recessed downlight luminaries	2000	2.0	$4.00
Track lights	2000	2.0	$4.00

For non-exempt EISA bulb types defined above, the following O&M assumptions should be used: Life of the baseline bulb is assumed to be 1.32 year[773]; baseline replacement cost is assumed to be $5[774].

It is important to note that for cost-effectiveness screening purposes, the O&M cost adjustments should only be applied in cases where the light bulbs area actually in service and so should be multiplied by the appropriate ISR.

MEASURE CODE: RS-LTG-LEDD-V06-160601

[771] Assuming 1000 hour rated life for incandescent bulb: 1000/759 = 1.32
[772] NEEP Residential Lighting Survey, 2011
[773] Assuming 1000 hour rated life for halogen bulb: 1000/759 = 1.32
[774] NEEP Residential Lighting Survey, 2011

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[775].

Deemed Measure Cost

The incremental cost for this measure is assumed to be $30[776].

Loadshape

Loadshape C53 - Flat

Coincidence Factor

The summer peak coincidence factor for this measure is assumed to be 100%[777].

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:

[775] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Effective/Remaining Useful Life Values", California Public Utilities Commission, December 16, 2008.
[776] NYSERDA Deemed Savings Database, Labor cost assumes 25 minutes @ $18/hr.
[777] Assuming continuous operation of an LED exit sign, the Summer Peak Coincidence Factor is assumed to equal 1.0.

Baseline Type	WattsBase
Incandescent	35W[778]
Fluorescent	11W[779]
Unknown (e.g. time of sale)	11W

WattsEE = Actual wattage if known, if unknown assume 2W[780]

HOURS = Annual operating hours

= 8766

WHF_e = Waste heat factor for energy; accounts for cooling savings from efficient lighting.

= 1.04[781] for multi family buildings

Default if replacing incandescent fixture

ΔkWH = (35 – 2)/1000 * 8766 * 1.04

= 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[782] = - (((WattsBase - WattsEE) / 1000) * Hours * HF) / ηHeat

Where:

HF = Heating Factor or percentage of light savings that must be heated

= 49%[783]

---

778 Based on review of available product.

779 Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010

780 Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010

781 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

782 Negative value because this is an increase in heating consumption due to the efficient lighting.

783 This means that heating loads increase by 49% of the lighting savings. This is based on the average result from REMRate modeling of several different configurations and IL locations of homes.

ηHeat = Efficiency in COP of Heating equipment

= Actual. If not available use:[784]

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

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[785] for multi family buildings

CF = Summer Peak Coincidence Factor for measure

= 1.0

Default if incandescent fixture

ΔkW = (35 – 2)/1000 * 1.07 * 1.0

= 0.035 kW

Default if fluorescent fixture

ΔkW = (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.

---

[784] 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.

[785] 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.

Δtherms = - (((WattsBase - WattsEE) / 1000) * Hours * HF * 0.03412) / ηHeat

Where:

HF = Heating factor, or percentage of lighting savings that must be replaced by heating system.

= 49% [786]

0.03412 = Converts kWh to Therms

ηHeat = Average heating system efficiency.

= 0.70 [787]

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[788]	1.37 years[789]

MEASURE CODE: RS-LTG-LEDE-V01-120601

[786] Average result from REMRate modeling of several different configurations and IL locations of homes

[787] This has been estimated assuming that natural gas central furnace heating is typical for Illinois residences (66% of Illinois homes have a Natural Gas Furnace (based on Energy Information Administration, 2009 Residential Energy Consumption Survey: http://www.eia.gov/consumption/residential/data/2009/xls/HC6.9%20Space%20Heating%20in%20Midwest%20Region.xls))
In 2000, 24% of furnaces purchased in Illinois were condensing (based on data from GAMA, provided to Department of Energy during the federal standard setting process for residential heating equipment - see Furnace Penetration.xls). Furnaces tend to last up to 20 years and so units purchased 10 years ago provide a reasonable proxy for the current mix of furnaces in the State. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows:
(0.24*0.92) + (0.76*0.8) * (1-0.15) = 0.70

[788] 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).

[789] Assumes a lamp life of 12,000 hours and 8766 run hours 12000/8766 = 1.37 years.

5.5.8 LED Screw Based Omnidirectional Bulbs

DESCRIPTION

This characterization provides savings assumptions for LED Screw Based Omnidirectional (e.g. A-Type lamps) lamps within the residential and multifamily sectors. This characterization assumes that the LED lamp or fixture is installed in a residential location. Where the implementation strategy does not allow for the installation location to be known (e.g. an upstream retail program) evaluation data could be used to determine an appropriate residential v commercial split. If this is not available, it is recommended to use this residential characterization for all installs in unknown locations to be appropriately conservative in savings assumptions.

This measure was developed to be applicable to the following program types: TOS, NC, RF, KITS.

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

13.7 years (exterior) to 26 years (residential home), however all installations are capped at 10 years[790].

DEEMED MEASURE COST

Wherever possible, actual incremental costs should be used. Refer to reference table “Residential LED component Cost & Lifetime” for defaults.

LOADSHAPE

Loadshape R06 – Residential Indoor Lighting

Loadshape R07 – Residential Outdoor Lighting

COINCIDENCE FACTOR

The summer peak coincidence factor is assumed to be 7.1% for Residential and in-unit Multi Family bulbs, 27.3% for exterior bulbs and 8.1% for unknown[791].

[790] 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.
[791] Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = ((Watts_{base} - Watts_{EE})/1000) * ISR * (1-Leakage) * Hours * WHF_e$$

Where:

$Watts_{base}$ = Input wattage of the existing or baseline system. Reference the "LED New and Baseline Assumptions" table for default values.

$Watts_{EE}$ = Actual wattage of LED purchased / installed. If unknown, use default provided below:

LED New and Baseline Assumptions Table

Minimum Lumens	Maximum Lumens	Lumens used to calculate LED Wattage (midpoint)	LED Wattage [792] (WattsEE)	Baseline 2014-2019 (WattsBase)	Delta Watts 2014-2019 (WattsEE)	Baseline Post EISA 2020 requirement[793] (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

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)	95%[794]	1.6%	1.4%	98.0%[795]

---

[792] 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.

[793] Calculated as 45lm/W for all EISA non-exempt bulbs.

[794] 1st year in service rate is based upon analysis of ComEd PY7 intercept data.

[795] 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:

Direct Install		96.9%[796]			
Efficiency Kits[797]	CFL Distribution[798]	59%	13%	11%	83%
	School Kits[799]	61%	13%	11%	86%
	Direct Mail Kits[800]	66%	14%	12%	93%

Leakage = Adjustment to account for the percentage of program bulbs that move out (and in if deemed appropriate[801]) of the Utility Jurisdiction.

Upstream (TOS) Lighting programs and KITS = Determined through evaluation[802].

All other programs = 0

Hours = Average hours of use per year

'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.

796 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.

797 In Service Rates provided are for the bulb within a kit only. Given the significant differences in program design and the level of education provided through Efficiency Kits programs, the evaluators should apply the ISR estimated through evaluations (either past evaluations or the current program year evaluation) of the specific Efficiency Kits program. In cases where program-specific evaluation results for an ISR are unavailable, the default ISR values for Efficiency Kits provide may be used.

798 Free bulbs provided without request, with little or no education. Consistent with Standard CFL assumptions.

799 Kits provided free to students through school, with education program. Consistent with Standard CFL assumptions.

800 Opt-in program to receive kits via mail, with little or no education. Consistent with Standard CFL assumptions.

801 Leakage in is only appropriate to credit to IL utility program savings if it is reasonably expected that the IL utility program marketing efforts played an important role in influencing customer to purchase the light bulbs. Furthermore, consideration that such customers might be free riders should be addressed. If leakage in is assessed, efforts should be made to ensure no double counting of savings occurs if the evaluation is estimating both leakage in and spillover savings of light bulbs.

802 Using a leakage estimate from the current program year evaluation, from past evaluation results, or a rolling average of leakage estimates from previous years.

Installation Location	Hours[803]
Residential and in-unit Multi Family	759
Exterior	2475
Unknown	847

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 [804]
Multi family in unit	1.04 [805]
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%

803 Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.
804 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)
805 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

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
750	1049	16.4	26.6	3.6	13.5%
310	749	9.6	19.4	2.1	10.8%

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:

ΔkWH = ((29-8 /1000) * 847 * 1.06 * 0.92

= 17.3 kWh

This value should be claimed for six years, i.e. June 2014 – May 2020, but from May 2020 until the end of the measure life for that same bulb, savings should be reduced to (17.3 * 0.108 =) 1.9 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)*847*1.06*0.92

= 17.3 kWh

$\Delta kWH_{2nd\ year\ installs}$ = ((29-8/1000)*847*1.06*0.032

= 0.6 kWh

Note: Here we assume no change in hours assumption. NTG value from Purchase year applied.

HEATING PENALTY

If electric heated home (if heating fuel is unknown assume gas, see Natural Gas section):

ΔkWh[806] = - (((WattsBase - WattsEE) / 1000) * ISR * Hours * HF) / ηHeat

Where:

HF = Heating Factor or percentage of light savings that must be heated

= 49%[807] for interior or unknown location

= 0% for exterior or unheated location

ηHeat = Efficiency in COP of Heating equipment

= actual. If not available use[808]:

System Type	Age of Equipment	HSPF Estimate	ηHeat (COP Estimate)
Heat Pump	Before 2006	6.8	2.00
	After 2006 - 2014	7.7	2.26
	2015 on	8.2	2.40
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 * 759 * 0.49) / 2.0

= - 3.6 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:

WHFd = Waste heat factor for demand to account for cooling savings from efficient lighting.

Bulb Location	WHFd

806 Negative value because this is an increase in heating consumption due to the efficient lighting.
807 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.
808 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.

Interior single family or unknown location	1.11[809]
Multi family in unit	1.07[810]
Exterior or uncooled location	1.0

CF = Summer Peak Coincidence Factor for measure.

Bulb Location	CF[811]
Interior single family or unknown location or Multi family in unit	7.1%
Exterior	27.3%
Unknown	8.1%

Other factors as defined above

For the same 8 W LED that is installed in a single family interior location in 2014, the demand savings are:

ΔkW = ((29-8) / 1000) * 0.92* 1.11 * 0.071

= 0.0015 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.

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

Where:

HF = Heating factor, or percentage of lighting savings that must be replaced by heating system.

= 49% [812] for interior or unknown location

= 0% for exterior location

0.03412 = Converts kWh to Therms

ηHeat = Average heating system efficiency.

809 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.

810 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.

811 Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluations.

812 Average result from REMRate modeling of several different configurations and IL locations of homes

= 0.70 [813]

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[814].

	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 [815]	Measure Life in Years (capped at 10)
Residential and in-unit Multi Family	25,000	759	10
Exterior	25,000	2475	10
Unknown	25,000	847	10

The NPV for replacement lamps and annual levelized replacement costs using the statewide real discount rate of 5.34% are presented below. It is important to note that for cost-effectiveness screening purposes, the O&M cost

[813] This has been estimated assuming that natural gas central furnace heating is typical for Illinois residences (66% of Illinois homes have a Natural Gas Furnace (based on 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

[814] Based upon pricing forecast developed by Applied Proactive Technologies Inc (APT) based on industry input and provided to Ameren.

[815] Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluations.

adjustments should only be applied in cases where the light bulbs area actually in service and so should be multiplied by the appropriate ISR:

Location	Lumen Level	NPV of replacement costs for period			Levelized annual replacement cost savings		
		June 2015 - May 2016	June 2016 - May 2017	June 2017 - May 2018	June 2015 - May 2016	June 2016 - May 2017	June 2017 - May 2018
Residential and in-unit Multi Family	Lumens <310 or >2600 (non-EISA compliant)	$1.72	$1.72	$1.72	$0.23	$0.23	$0.23
	Lumens ≥ 310 and ≤ 2600 (EISA compliant)	$2.51	$2.21	$1.96	$0.33	$0.29	$0.26
Exterior	Lumens <310 or >2600 (non-EISA compliant)	$6.07	$6.07	$6.07	$0.80	$0.80	$0.80
	Lumens ≥ 310 and ≤ 2600 (EISA compliant)	$9.44	$8.31	$7.51	$1.24	$1.09	$0.99
Unknown	Lumens <310 or >2600 (non-EISA compliant)	$1.91	$1.91	$1.91	$0.25	$0.25	$0.25
	Lumens ≥ 310 and ≤ 2600 (EISA compliant)	$2.80	$2.46	$2.19	$0.37	$0.32	$0.29

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.[816] The replacement cycle is based on the location of the lamp and varies based on the hours of use for that location. Both incandescent and halogen lamps are assumed to last for 1,000 hours before needing replacement.

MEASURE CODE: RS-LTG-LEDA-V04-160601

[816] The manufacturers of the new minimally compliant EISA Halogens are using regular incandescent lamps with halogen fill gas rather than halogen infrared to meet the standard and so the component rated life is equal to the standard incandescent.

5.6 Shell End Use

5.6.1 Air Sealing

DESCRIPTION

Thermal shell air leaks are sealed through strategic use and location of air-tight materials. Leaks are detected and leakage rates measured with the assistance of a blower-door. The algorithm for this measure can be used when the program implementation does not allow for more detailed forecasting through the use of residential modeling software.

Prescriptive savings are provided for use only where a blower door test is not possible (for example in large multi family buildings).

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.[817]

DEEMED MEASURE COST

The actual capital cost for this measure should be used in screening.

LOADSHAPE

Loadshape R08 - Residential Cooling

Loadshape R09 - Residential Electric Space Heat

Loadshape R10 - Residential Electric Heating and Cooling

COINCIDENCE FACTOR

The summer peak coincidence factor for cooling is provided in two different ways below. The first is used to estimate peak savings during the utility peak hour and is most indicative of actual peak benefits, and the second represents the *average* savings over the defined summer peak period, and is presented so that savings can be bid into PJM's Forward Capacity Market.

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during utility peak hour)

[817] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007

= 68%[818]

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

= 72%%[819]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)

= 46.6%[820]

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

Methodology 1: Blower Door Test

Preferred methodology unless blower door testing is not possible.

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 location and number of stories:[821]

Climate Zone (City based upon)	N_cool (by # of stories)			
	1	1.5	2	3
1 (Rockford)	39.5	35.0	32.1	28.4
2 (Chicago)	38.9	34.4	31.6	28.0

[818] Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.
[819] 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)'.
[820] 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.
[821] N-factor is used to convert 50-pascal blower door air flows to natural air flows and is dependent on geographic location and # of stories. These were developed by applying the LBNL infiltration model (see LBNL paper 21040, *Exegisis of Proposed ASHRAE Standard 119: Air Leakage Performance for Detached Single-Family Residential Buildings*; Sherman, 1986; page v-vi, Appendix page 7-9) to the reported wind speeds and outdoor temperatures provided by the NRDC 30 year climate normals. For more information see Bruce Harley, CLEAResult "Infiltration Factor Calculations Methodology.doc".

Climate Zone (City based upon)	N_cool (by # of stories)			
	1	1.5	2	3
3 (Springfield)	41.2	36.5	33.4	29.6
4 (St Louis, MO)	40.4	35.8	32.9	29.1
5 (Paducah, KY)	43.6	38.6	35.4	31.3

60 * 24 = Converts Cubic Feet per Minute to Cubic Feet per Day

CDD = Cooling Degree Days

= Dependent on location[822]:

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 [823]

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[824]:

Age of Equipment	SEER Estimate
Before 2006	10
2006 - 2014	13
Central AC After 1/1/2015	13
Heat Pump After 1/1/2015	14

822 National Climatic Data Center, calculated from 1981-2010 climate normals with a base temp of 65°F.
823 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.
824 These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Central AC was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate.

LM = Latent multiplier to account for latent cooling demand[825]

Climate Zone (City based upon)	LM
1 (Rockford)	3.3
2 (Chicago)	3.2
3 (Springfield)	3.7
4 (St Louis, MO)	3.6
5 (Paducah, KY)	3.7

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:[826]

Climate Zone (City based upon)	N_heat (by # of stories)			
	1	1.5	2	3
1 (Rockford)	23.8	21.1	19.3	17.1
2 (Chicago)	23.9	21.1	19.4	17.2
3 (Springfield)	24.2	21.5	19.7	17.4
4 (St Louis, MO)	25.4	22.5	20.7	18.3
5 (Paducah, KY)	27.8	24.6	22.6	20.0

HDD = Heating Degree Days

= Dependent on location:[827]

Climate Zone (City based upon)	HDD 60
1 (Rockford)	5,352

[825] Derived by calculating the sensible and total loads in each hour. For more information see Bruce Harley, CLEAResult "Infiltration Factor Calculations Methodology.doc".

[826] N-factor is used to convert 50-pascal blower door air flows to natural air flows and is dependent on geographic location and # of stories. These were developed by applying the LBNL infiltration model (see LBNL paper 21040, *Exegisis of Proposed ASHRAE Standard 119: Air Leakage Performance for Detached Single-Family Residential Buildings*; Sherman, 1986; page v-vi, Appendix page 7-9) to the reported wind speeds and outdoor temperatures provided by the NRDC 30 year climate normals. For more information see Bruce Harley, CLEAResult "Infiltration Factor Calculations Methodology.doc".

[827] National Climatic Data Center, calculated from 1981-2010 climate normals with a base temp of 60°F.

Climate Zone (City based upon)	HDD 60
2 (Chicago)	5,113
3 (Springfield)	4,379
4 (Belleville)	3,378
5 (Marion)	3,438

ηHeat = Efficiency of heating system

= Actual. If not available refer to default table below[828]:

System Type	Age of Equipment	HSPF Estimate	ηHeat (Effective COP Estimate)= (HSPF/3.413)*0.85
Heat Pump	Before 2006	6.8	1.7
	2006 - 2014	7.7	1.92
	2015 on	8.2	2.40
Resistance	N/A	N/A	1

3412 = Converts Btu to kWh

For example, a 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) / 31.6) * 60 * 24 * 842 * 0.75 * 0.018) / (1000 * 10.5)) * 3.2] + [((3,400 – 2,250) / 19.4)) * 60 * 24 * 5113 * 0.018 / (1.92 * 3,412)]

= 182 + 1199

= 1,381 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%[829]

828 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.

829 F_e is not one of the AHRI certified ratings provided for residential furnaces, but can be reasonably estimated from a

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 = 109.1 * 0.0314 * 29.3

= 100 kWh

Methodology 2: Prescriptive Infiltration Reduction Measures[830]

Savings shall only be calculated via Methodology 2 if a blower door test is not feasible. Cooling savings are not quantified using Methodology 2.

$\Delta kWh\_heating = (\Delta kWh_{gasket} * n_{gasket} + \Delta kWh_{sweep} * n_{sweep} + \Delta kWh_{sealing} * lf_{sealing} + \Delta kWh_{WX} * lf_{WX}) * ADJ_{RxAirsealing}$

Where:

ΔkWh_{gasket} = Annual kWh savings from installation of air sealing gasket on an electric outlet

Climate Zone (City based upon)	ΔkWh_{gasket} / gasket	
	Electric Resistance	Heat Pump
1 (Rockford)	10.5	5.3
2 (Chicago)	10.2	5.1
3 (Springfield)	8.8	4.4
4 (Belleville)	7.0	3.5
5 (Marion)	7.2	3.6

n_{gasket} = Number of gaskets installed

ΔkWh_{sweep} =Annual kWh savings from installation of door sweep

Climate Zone (City based upon)	ΔkWh_{sweep} / sweep	
	Electric Resistance	Heat Pump
1 (Rockford)	202.4	101.2
2 (Chicago)	195.3	97.6

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.

[830] Prescriptive savings are based upon "Evaluation of the Weatherization Residential Assistance Partnership and Helps Programs (WRAP/Helps)." Middletown, CT: KEMA, 2010. Accessed July 30, 2015, (http://www.energizect.com/sites/default/files/Final%20WRAP%20%20Helps%20Report.pdf) and adjusted for relative HDD of Bridgeport/Hartford CT with the IL climate zones. See 'Rx Airsealing HDD adjustment.xls' for more information.

3 (Springfield)	169.3	84.7
4 (Belleville)	134.9	67.5
5 (Marion)	137.9	68.9

n_{sweep} = Number of sweeps installed

$\Delta kWh_{sealing}$ = Annual kWh savings from foot of caulking, sealing, or polyethlylene tape

Climate Zone (City based upon)	$\Delta kWh_{sealing}$ / ft	
	Electric Resistance	Heat Pump
1 (Rockford)	11.6	5.8
2 (Chicago)	11.2	5.6
3 (Springfield)	9.7	4.8
4 (Belleville)	7.7	3.9
5 (Marion)	7.9	3.9

$lf_{sealing}$ = linear feet of caulking, sealing, or polyethylene tape

ΔkWh_{WX} = Annual kWh savings from window weatherstripping or door weatherstripping

Climate Zone (City based upon)	ΔkWh_{WX} / ft	
	Electric Resistance	Heat Pump
1 (Rockford)	13.5	6.7
2 (Chicago)	13.0	6.5
3 (Springfield)	11.3	5.6
4 (Belleville)	9.0	4.5
5 (Marion)	9.2	4.6

lf_{WX} = Linear feet of window weatherstripping or door weatherstripping

$ADJ_{RxAirsealing}$ = Adjustment for air sealing savings to account for prescriptive estimates overclaiming savings[831].

= 80%

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = (ΔkWh_cooling / FLH_cooling) * CF

Where:

FLH_cooling = Full load hours of air conditioning

= Dependent on location[832]:

[831] Though we do not have a specific evaluation to point to, modeled savings have often been found to overclaim. Further VEIC reviewed these deemed estimates and consider them to likely be a high estimate. As such an 80% adjustment is applied, and this could be further refined with future evaluations.

[832] Full load hours for Chicago, Moline and Rockford are provided in “Final Evaluation Report: Central Air Conditioning Efficiency Services (CACES), 2010, Navigant Consulting”, p.33. An average FLH/Cooling Degree Day (from NCDC) ratio was calculated for

Climate Zone (City based upon)	Single Family	Multifamily
1 (Rockford)	512	467
2 (Chicago)	570	506
3 (Springfield)	730	663
4 (Belleville)	1,035	940
5 (Marion)	903	820

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)

= 68%[833]

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

= 72%%[834]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)

= 46.6%[835]

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} = 182 / 570 * 0.68

= 0.22 kW

ΔkW_{PJM} = 182 / 570 * 0.466

= 0.15 kW

NATURAL GAS SAVINGS

Methodology 1: Blower Door Test

Preferred methodology unless blower door testing is not possible.

If Natural Gas heating:

$$\Delta Therms = (((CFM50\_existing - CFM50\_new)/N\_heat) * 60 * 24 * HDD * 0.018) / (\eta Heat * 100{,}000)$$

Where:

N_heat = Conversion factor from leakage at 50 Pascal to leakage at natural conditions

these locations and applied to the CDD of the other locations in order to estimate FLH.

833 Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.

834 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)'.

835 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.

= Based on climate zone and building height[836]

Climate Zone (City based upon)	N_heat (by # of stories)			
	1	1.5	2	3
1 (Rockford)	23.8	21.1	19.3	17.1
2 (Chicago)	23.9	21.1	19.4	17.2
3 (Springfield)	24.2	21.5	19.7	17.4
4 (St Louis, MO)	25.4	22.5	20.7	18.3
5 (Paducah, KY)	27.8	24.6	22.6	20.0

HDD = Heating Degree Days

= dependent on location[837]:

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

ηHeat = Efficiency of heating system

= Equipment efficiency * distribution efficiency

= Actual[838]. If not available use 72%[839].

Other factors as defined above

[836] N-factor is used to convert 50-pascal blower door air flows to natural air flows and is dependent on geographic location and # of stories. These were developed by applying the LBNL infiltration model (see LBNL paper 21040, *Exegisis of Proposed ASHRAE Standard 119: Air Leakage Performance for Detached Single-Family Residential Buildings*; Sherman, 1986; page v-vi, Appendix page 7-9) to the reported wind speeds and outdoor temperatures provided by the NRDC 30 year climate normals. For more information see Bruce Harley, CLEAResult "Infiltration Factor Calculations Methodology.doc".

[837] 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..

[838] 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.

[839] Based on average Nicor PY4 nameplate efficiencies derated by 15% for distribution losses.

For example, a 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)/19.4) * 60 * 24 * 5113 * 0.018) / (0.72 * 100,000)

= 109.1 therms

Methodology 2: Prescriptive Infiltration Reduction Measures[840]

Savings shall only be calculated via Methodology 2 if a blower door test is not feasible.

$\Delta therms = (\Delta therms_{gasket} * n_{gasket} + \Delta therms_{sweep} * n_{sweep} + \Delta therms_{sealing} * lf_{sealing} + \Delta therms_{WX} * lf_{WX}) * ADJ_{RxAirsealing}$

Where:

$\Delta therms_{gasket}$ = Annual therm savings from installation of air sealing gasket on an electric outlet

Climate Zone (City based upon)	$\Delta therms_{gasket}$ / gasket Gas Heat
1 (Rockford)	0.49
2 (Chicago)	0.47
3 (Springfield)	0.41
4 (Belleville)	0.33
5 (Marion)	0.33

n_{gasket} = Number of gaskets installed

$\Delta therms_{sweep}$ = Annual therm savings from installation of door sweep

Climate Zone (City based upon)	$\Delta therms_{sweep}$ / sweep Gas Heat
1 (Rockford)	9.46
2 (Chicago)	9.13
3 (Springfield)	7.92
4 (Belleville)	6.31
5 (Marion)	6.45

n_{sweep} = Number of sweeps installed

$\Delta therms_{sealing}$ = Annual therm savings from foot of caulking, sealing, or polyethlylene tape

[840] Prescriptive savings are based upon "Evaluation of the Weatherization Residential Assistance Partnership and Helps Programs (WRAP/Helps)." Middletown, CT: KEMA, 2010. Accessed July 30, 2015, (http://www.energizect.com/sites/default/files/Final%20WRAP%20%20Helps%20Report.pdf) and adjusted for relative HDD of Bridgeport/Hartford CT with the IL climate zones. See 'Rx Airsealing HDD adjustment.xls' for more information.

Climate Zone (City based upon)	$\Delta therms_{sealing}$ / ft Gas Heat
1 (Rockford)	0.54
2 (Chicago)	0.52
3 (Springfield)	0.45
4 (Belleville)	0.36
5 (Marion)	0.37

$lf_{sealing}$ = linear feet of caulking, sealing, or polyethylene tape

$\Delta therms_{WX}$ = Annual therm savings from window weatherstripping or door weatherstripping

Climate Zone (City based upon)	$\Delta therms_{sx}$ / ft Gas Heat
1 (Rockford)	0.63
2 (Chicago)	0.61
3 (Springfield)	0.53
4 (Belleville)	0.42
5 (Marion)	0.43

lf_{WX} = Linear feet of window weatherstripping or door weatherstripping

$ADJ_{RxAirsealing}$ = Adjustment for air sealing savings to account for prescriptive estimates overclaiming savings[841].

= 80%

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-SHL-AIRS-V05-160601

[841] Though we do not have a specific evaluation to point to, modeled savings have often been found to overclaim. Further VEIC reviewed these deemed estimates and consider them to likely be a high estimate. As such an 80% adjustment is applied, and this could be further refined with future evaluations.

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.[842]

Deemed Measure Cost

The actual installed cost for this measure should be used in screening.

Deemed O&M Cost Adjustments

N/A

Loadshape

Loadshape R08 - Residential Cooling

Loadshape R09 - Residential Electric Space Heat

Loadshape R10 - Residential Electric Heating and Cooling

Coincidence Factor

The summer peak coincidence factor for cooling is provided in two different ways below. The first is used to estimate peak savings during the utility peak hour and is most indicative of actual peak benefits, and the second represents the *average* savings over the defined summer peak period, and is presented so that savings can be bid into PJM's Forward Capacity Market.

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during utility peak hour)

[842] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007

= 68%[843]

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

= 72%%[844]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)

= 46.6%[845]

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))) * $ADJ_{BasementCool}$

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[846]

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

843 Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.

844 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)'.

845 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.

846 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

= 25% if studs and cavity insulation[847]

24 = Converts hours to days

CDD = Cooling Degree Days

= Dependent on location and whether basement is conditioned:[848]

Climate Zone (City based upon)	Conditioned CDD 65	Unconditioned CDD 65[849]
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[850]	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 [851]

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:[852]

Age of Equipment	ηCool Estimate
Before 2006	10
2006 - 2014	13
Central AC After 1/1/2015	13

[847] ASHRAE, 2001, "Characterization of Framing Factors for New Low-Rise Residential Building Envelopes (904-RP)," Table 7.1
[848] National Climatic Data Center, calculated from 1981-2010 climate normals with a base temp of 65°F. There is a county mapping table in Volume 1, Section 3.7 providing the appropriate city to use for each county of Illinois.
[849] 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.
[850] Weighted based on number of occupied residential housing units in each zone.
[851] 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.
[852] 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.

Heat Pump After 1/1/2015	14

$ADJ_{BasementCool}$ = Adjustment for cooling savings from basement wall insulation to account for prescriptive engineering algorithms overclaiming savings[853].

= 80%

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)) * $ADJ_{BasementHeat}$

Where

R_old_BG = R-value value of foundation wall below grade (including thermal resistance of the earth) [854]

= 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)

[853] As demonstrated in two years of metering evaluation by Opinion Dynamics, see Memo "Results for AIC PY6 HPwES Billing Analysis", dated February 20, 2015. TAC negotiated adjustment factor is 80%.

[854] Adapted from Table 1, page 24.4, of the 1977 ASHRAE Fundamentals Handbook

HDD = Heating Degree Days

= dependent on location and whether basement is conditioned:[855]

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[856]	4,860	2,895

ηHeat = Efficiency of heating system

= Actual. If not available refer to default table below:[857]

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 - 2014	7.7	1.92
	2015 on	8.2	2.40
Resistance	N/A	N/A	1

$ADJ_{BasementHeat}$ = Adjustment for basement wall insulation to account for prescriptive engineering algorithms overclaiming savings[858].

[855] National Climatic Data Center, calculated from 1981-2010 climate normals with a base temp of 60°F for a conditioned basement and 50°F for an unconditioned basement), consistent with the findings of Belzer and Cort, Pacific Northwest National Laboratory in "Statistical Analysis of Historical State-Level Residential Energy Consumption Trends," 2004. There is a county mapping table in Volume 1, Section 3.7 providing the appropriate city to use for each county of Illinois.

[856] Weighted based on number of occupied residential housing units in each zone.

[857] 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.

[858] As demonstrated in two years of metering evaluation by Opinion Dynamics, see Memo "Results for AIC PY6 HPwES Billing Analysis", dated February 20, 2015. TAC negotiated adjustment factor is 60%.

= 60%

.

For example, a single family home in Chicago with a 20 by 25 by 7 foot R-2.25 basement, with 3 feet above grade, insulated with R-13 of interior spray foam, 10.5 SEER Central AC and 2.26 COP Heat Pump:

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)) * 0.8] + [(((((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)) * 0.6]

= (39.4 + 860.9)

= 900.3 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%[859]

29.3 = kWh per therm

For example, a single family home in Chicago with a 20 by 25 by 7 foot unconditioned basement, with 3 feet above grade, insulated with R-13 of interior spray foam, and a 70% efficient furnace (for therm calculation see Natural Gas Savings section :

= 78.3 * 0.0314 * 29.3

= 72.0 kWh

SUMMER COINCIDENT PEAK DEMAND

ΔkW = (ΔkWh_cooling / FLH_cooling) * CF

Where:

FLH_cooling = Full load hours of air conditioning

= dependent on location[860]:

[859] 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.

[860] Full load hours for Chicago, Moline and Rockford are provided in "Final Evaluation Report: Central Air Conditioning Efficiency Services (CACES), 2010, Navigant Consulting",

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[861]	629	564

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)

= 68%[862]

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

= 72%%[863]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)

= 46.6%[864]

> For example, a single family home in Chicago with a 20 by 25 by 7 foot unconditioned basement, with 3 feet above grade, insulated with R-13 of interior spray foam, 10.5 SEER Central AC and 2.26 COP Heat Pump:
>
> ΔkW_{SSP} = 39.4 / 570 * 0.68
>
> = 0.047 kW
>
> ΔkW_{PJM} = 39.4 / 570 * 0.466
>
> = 0.032 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)] * $ADJ_{BasementHeat}$

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 Volume 1, Section 3.7 providing the appropriate city to use for each county of Illinois.

861 Weighted based on number of occupied residential housing units in each zone.

862 Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.

863 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)'.

864 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.

ηHeat = Efficiency of heating system

= Equipment efficiency * distribution efficiency

= Actual. If unknown assume 72%[865]

Other factors as defined above

> For example, a single family home in Chicago with a 20 by 25 by 7 foot R-2.25 basement, with 3 feet above grade, insulated with R-13 of interior spray foam, and a 72% 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) / (0.72 * 100,067) * 0.60
>
> = 78.3 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-SHL-BINS-V07-160601

[865] Based on average Nicor PY4 nameplate efficiencies derated by 15% for distribution losses.

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.[866]

DEEMED MEASURE COST

The actual installed cost for this measure should be used in screening.

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape R08 - Residential Cooling

Loadshape R09 - Residential Electric Space Heat

Loadshape R10 - Residential Electric Heating and Cooling

COINCIDENCE FACTOR

The summer peak coincidence factor for cooling is provided in two different ways below. The first is used to estimate peak savings during the utility peak hour and is most indicative of actual peak benefits, and the second represents the *average* savings over the defined summer peak period, and is presented so that savings can be bid into PJM's Forward Capacity Market.

[866] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during utility peak hour)

= 68%[867]

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

= 72%%[868]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)

= 46.6%[869]

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))) * $ADJ_{FloorCool}$

R_old = R-value value of floor before insulation, assuming 3/4" plywood subfloor and carpet with pad

= Actual. If unknown assume 3.96 [870]

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% [871]

24 = Converts hours to days

CDD = Cooling Degree Days

[867] Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.

[868] 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)'.

[869] 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.

[870] Based on 2005 ASHRAE Handbook – Fundamentals: assuming 2x8 joists, 16" OC, ¾" subfloor, ½" carpet with rubber pad, and accounting for a still air film above and below: 1/ [(0.85 cavity share of area / (0.68 + 0.94 + 1.23 + 0.68)) + (0.15 framing share / (0.68 + 7.5" * 1.25 R/in + 0.94 + 1.23 + 0.68))] = 3.96

[871] ASHRAE, 2001, "Characterization of Framing Factors for New Low-Rise Residential Building Envelopes (904-RP)," Table 7.1

Climate Zone (City based upon)	Unconditioned CDD[872]
1 (Rockford)	263
2 (Chicago)	281
3 (Springfield)	436
4 (Belleville)	538
5 (Marion)	570
Weighted Average[873]	325

DUA = Discretionary Use Adjustment (reflects the fact that people do not always operate their AC when conditions may call for it).

= 0.75 [874]

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:[875]

Age of Equipment	ηCool Estimate
Before 2006	10
2006 - 2014	13
Central AC After 1/1/2015	13
Heat Pump After 1/1/2015	14

$ADJ_{FloorCool}$ = Adjustment for cooling savings from floor to account for prescriptive engineering algorithms overclaiming savings[876].

= 80%

ΔkWh_heating = If electric heat (resistance or heat pump), reduction in annual electric heating due to

[872] 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.

[873] Weighted based on number of occupied residential housing units in each zone.

[874] Energy Center of Wisconsin, May 2008 metering study; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research", p31.

[875] 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.

[876] As demonstrated in two years of metering evaluation by Opinion Dynamics, see Memo "Results for AIC PY6 HPwES Billing Analysis", dated February 20, 2015. TAC negotiated adjustment factor is 80%.

insulation

= ((((1/R_old - 1/(R_added + R_old)) * Area * (1-Framing_factor) * 24 * HDD)/ (3,412 * ηHeat)) * $ADJ_{FloorHeat}$

HDD = Heating Degree Days:[877]

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[878]	2,895

ηHeat = Efficiency of heating system

= Actual. If not available refer to default table below:[879]

System Type	Age of Equipment	HSPF Estimate	ηHeat (Effective COP Estimate) (HSPF/3.413)*0.85
Heat Pump	Before 2006	6.8	1.7
	2006 - 2014	7.7	1.92
	2015 on	8.2	2.40
Resistance	N/A	N/A	1

$ADJ_{FloorHeat}$ = Adjustment for floor insulation to account for prescriptive engineering algorithms overclaiming savings[880].

= 60%

Other factors as defined above

[877] 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 Volume 1, Section 3.7 providing the appropriate city to use for each county of Illinois.

[878] Weighted based on number of occupied residential housing units in each zone.

[879] 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.

[880] As demonstrated in two years of metering evaluation by Opinion Dynamics, see Memo "Results for AIC PY6 HPwES Billing Analysis", dated February 20, 2015. TAC negotiated adjustment factor is 60%.

> For example, a single family home in Chicago with a 20 by 25 footprint, insulated with R-30 spray foam above the crawlspace, a 10.5 SEER Central AC and a newer heat pump:
>
> ΔkWh = (ΔkWh_cooling + ΔkWh_heating)
>
> = ((((1/3.96 -1/(30+3.96))*(20*25)*(1-0.12)* 24 * 281*0.75)/(1000*10.5)) * 0.8 + (((1/3.96 - 1/(30+3.96))*(20*25)*(1-0.15) * 24 * 3079)/(3412*1.92)) * 0.6)
>
> = (37.8 + 641.7)
>
> = 679.5 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%[881]

29.3 = kWh per therm

> For example, a single family home in Chicago with a 20 by 25 footprint, insulated with R-30 spray foam above the crawlspace, and a 70% efficient furnace (for therm calculation see Natural Gas Savings section):
>
> ΔkWh = 60.4 * 0.0314 * 29.3
>
> = 55.6 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = (ΔkWh_cooling / FLH_cooling) * CF

Where:

FLH_cooling = Full load hours of air conditioning

= Dependent on location:[882]

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

[881] 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.

[882] Full load hours for Chicago, Moline and Rockford are provided in "Final Evaluation Report: Central Air Conditioning Efficiency Services (CACES), 2010, Navigant Consulting", 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 Volume 1, Section 3.7 providing the appropriate city to use for each county of Illinois.

Climate Zone (City based upon)	Single Family	Multifamily
Weighted Average[883]	629	564

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)

= 68%[884]

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

= 72%%[885]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)

= 46.6%[886]

For example, a single family home in Chicago with a 20 by 25 footprint, insulated with R-30 spray foam above the crawlspace, a 10.5 SEER Central AC and a newer heat pump:

ΔkW_{SSP} = 37.8 / 570 * 0.68

= 0.045 kW

ΔkW_{SSP} = 37.8 / 570 * 0.466

= 0.031 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) * $ADJ_{FloorHeat}$

Where

ηHeat = Efficiency of heating system

= Equipment efficiency * distribution efficiency

= Actual. If unknown assume 72%[887]

Other factors as defined above

883 Weighted based on number of occupied residential housing units in each zone.
884 Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.
885 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)'.
886 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.
887 Based on average Nicor PY4 nameplate efficiencies derated by 15% for distribution losses.

For example, a single family home in Chicago with a 20 by 25 footprint, insulated with R-30 spray foam above the crawlspace, and a 72% efficient furnace:

$$\Delta Therms = (1 / 3.96 – 1 /(30 + 3.96))*(20 * 25) * (1 - 0.12) * 24 * 3079) / (100,000 * 0.72) * 0.60$$

$$= 60.4 \text{ therms}$$

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-SHL-FINS-V07-160601

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.[888]

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%[889]

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

= 72%%[890]

---

[888] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007

[889] Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.

[890] 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)'.

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)

= 46.6%[891]

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)) * $ADJ_{WallAtticCool}$

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[892])

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

= 25%[893]

Framing_factor_attic = Adjustment to account for area of framing

= 7%[894]

24 = Converts hours to days

CDD = Cooling Degree Days

= dependent on location:[895]

[891] 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.

[892] 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).

[893] ASHRAE, 2001, “Characterization of Framing Factors for New Low-Rise Residential Building Envelopes (904-RP),” Table 7.1

[894] Ibid.

[895] National Climatic Data Center, Cooling Degree Days are based on a base temp of 65°F. There is a county mapping table Volume 1, Section 3.7 providing the appropriate city to use for each county of Illinois.

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[896]	947

DUA = Discretionary Use Adjustment (reflects the fact that people do not always operate their AC when conditions may call for it).

= 0.75 [897]

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:[898]

Age of Equipment	ηCool Estimate
Before 2006	10
2006 - 2014	13
Central AC After 1/1/2015	13
Heat Pump After 1/1/2015	14

$ADJ_{WallAtticCool}$ = Adjustment for cooling savings from basement wall insulation to account for prescriptive engineering algorithms overclaiming savings[899].

= 80%

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)) + (1/R_old - 1/R_attic) * A_attic * (1-Framing_factor_attic)) * 24 * HDD] / (ηHeat * 3412)) * $ADJ_{WallAtticHeat}$

[896] Weighted based on number of occupied residential housing units in each zone.

[897] 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.

[898] 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.

[899] As demonstrated in two years of metering evaluation by Opinion Dynamics, see Memo "Results for AIC PY6 HPwES Billing Analysis", dated February 20, 2015. TAC negotiated adjustment factor is 80%.

HDD = Heating Degree Days

= Dependent on location:[900]

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[901]	4,860

ηHeat = Efficiency of heating system

= Actual. If not available refer to default table below:[902]

System Type	Age of Equipment	HSPF Estimate	ηHeat (Effective COP Estimate) (HSPF/3.413)*0.85
Heat Pump	Before 2006	6.8	1.7
	2006 - 2014	7.7	1.92
	2015 on	8.2	2.40
Resistance	N/A	N/A	1

3412 = Converts Btu to kWh

$ADJ_{WallAtticHeat}$ = Adjustment for wall and attic insulation to account for prescriptive engineering algorithms overclaiming savings[903].

= 60%

[900] 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 Volume 1, Section 3.7 providing the appropriate city to use for each county of Illinois.

[901] Weighted based on number of occupied residential housing units in each zone.

[902] 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.

[903] As demonstrated in two years of metering evaluation by Opinion Dynamics, see Memo "Results for AIC PY6 HPwES Billing Analysis", dated February 20, 2015. TAC negotiated adjustment factor is 60%.

For example, a single family home in Chicago with 990 ft^2 of R-5 walls insulated to R-11 and 700 ft^2 of R-5 attic insulated to R-38, 10.5 SEER Central AC and 2.26 (1.92 including distribution losses) COP Heat Pump:

ΔkWh = (ΔkWh_cooling + ΔkWh_heating)

= (((((1/5 - 1/11) * 990 * (1-0.25)) + ((1/5 - 1/38) * 700 * (1-0.07))) * 842 * 0.75 * 24)/ (1000 * 10.5)) * 0.8) + ((((((1/5 - 1/11) * 990 * (1-0.25)) + ((1/5 - 1/38) * 700 * (1-0.07))) * 5113 * 24) / (1.92 * 3412)) * 0.6)

= 224 + 2181

= 2405 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%[904]

29.3 = kWh per therm

For example, a single family home in Chicago with 990 ft^2 of R-5 walls insulated to R-11 and 700 ft^2 of R-5 attic insulated to R-38, with a gas furnace with system efficiency of 66% (for therm calculation see Natural Gas Savings section):

ΔkWh = 216.4 * 0.0314 * 29.3

= 199.1 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:[905]

Climate Zone (City based upon)	Single Family	Multifamily
1 (Rockford)	512	467
2 (Chicago)	570	506
3 (Springfield)	730	663

904 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.

905 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 Volume 1, Section 3.7 providing the appropriate city to use for each county of Illinois.

4 (Belleville)	1,035	940
5 (Marion)	903	820
Weighted Average[906]	629	564

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)

= 68%[907]

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

72%%[908]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)

= 46.6%[909]

For example, a single family home in Chicago with 990 ft^2 of R-5 walls insulated to R-11 and 700 ft^2 of R-5 attic insulated to R-38, 10.5SEER Central AC and 2.26 COP Heat Pump:

ΔkW_{SSP} = 224 / 570 * 0.68

= 0.27 kW

ΔkW_{PJM} = 224 / 570 * 0.466

= 0.18 kW

906 Weighted based on number of occupied residential housing units in each zone.

907 Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.

908 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)'.

909 Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.

NATURAL GAS SAVINGS

If Natural Gas heating:

$$\Delta Therms = ((((1/R\_old - 1/R\_wall) * A\_wall * (1-Framing\_factor\_wall)) + ((1/R\_old - 1/R\_attic) * A\_attic * (1-Framing\_factor\_attic))) * 24 * HDD) / (\eta Heat * 100{,}067\ Btu/therm) * ADJ_{WallAtticHeat}$$

Where:

HDD = Heating Degree Days

= Dependent on location:[910]

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[911]	4,860

ηHeat = Efficiency of heating system

= Equipment efficiency * distribution efficiency

= Actual.[912] If unknown assume 72%.[913]

Other factors as defined above

For example, a single family home in Chicago with 990 ft^2 of R-5 walls insulated to R-11 and 700 ft^2 of R-5 attic insulated to R-38, with a gas furnace with system efficiency of 66%:

ΔTherms = ((((1/5 - 1/11) * 990 * (1-0.25)) + ((1/5 - 1/38) * 700 * (1-0.07))) * 24 * 5113) / (0.66 * 100,067) * 0.60

= 216.4 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

910 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 Volume 1, Section 3.7 providing the appropriate city to use for each county of Illinois.

911 Weighted based on number of occupied residential housing units in each zone.

912 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.

913 Based on average Nicor PY4 nameplate efficiencies derated by 15% for distribution losses.

Deemed O&M Cost Adjustment Calculation

N/A

Measure Code: RS-SHL-AINS-V06-160601

Illinois Statewide Technical Reference Manual for Energy Efficiency

Version 5.0

Volume 4: Cross-Cutting Measures and Attachments

Final

February 11th, 2016

Effective:

June 1st, 2016

Table of Contents

VOLUME 1: OVERVIEW AND USER GUIDE

VOLUME 2: COMMERCIAL AND INDUSTRIAL MEASURES

VOLUME 3: RESIDENTIAL MEASURES

VOLUME 4: CROSS-CUTTING MEASURES AND ATTACHMENTS

6 Cross-Cutting Measures 6

6.1 Behavior 6

6.1.1 Adjustments to Behavior Savings to Account for Persistence 6

Attachment A: Illinois Statewide Net-to-Gross Methodologies 18

1.1 Policy Context for this Information 18

1.2 Programs Currently Covered in this Document 19

1.3 Updating the IL-NTG Methods 20

1.4 Diverging from the IL-NTG Methods 20

1.5 Procedure for Non-Consensus Items 21

2 Attribution in Energy Efficiency Programs in General 22

2.1 Definitions 22

2.2 Spillover-Specific Issues 25

2.2.1 Measure Costs 25

3 Commercial, Industrial, and Public Sector Protocols 26

3.1 Core Non-Residential Protocol 28

3.1.1 Core Non-Residential Free Ridership Protocol 28

3.2 Core Non-Residential Spillover Protocol 36

3.3 Small Business Protocol 39

3.3.1 Free Ridership 39

3.4 C&I New Construction Protocol 40

3.4.1 Free Ridership 40

3.5 Study-Based Protocol 41

3.5.1 Free Ridership 41

3.6 Training and Technical Assistance Protocol 44

3.6.1 Program-Attributable Savings 44

3.6.2 Research Methods 44

4 Residential and Low Income Sector Protocols 46

4.1 Residential Cross-Cutting Approaches 48

4.1.1 Survey Design Issues 48

4.1.2 Participant Spillover 48

4.1.3 Nonparticipant Spillover Measured Through Trade Allies 50

4.1.4 Nonparticipant Spillover Measured from Customers 50
4.2 Appliance Recycling Protocol 53
4.2.1 Basic Method 54
4.2.2 Enhanced Method 58
4.3 Residential Upstream Lighting Protocol 59
4.3.1 Basic Method 60
4.3.2 Participant Spillover 63
4.3.3 Nonparticipant Spillover 63
4.4 Prescriptive Rebate (With No Audit) Protocol 64
4.4.1 Basic Method 64
4.4.2 Enhanced Method 67
4.5 Single-Family Home Energy Audit Protocol 68
4.5.1 Basic Method 68
4.6 Multifamily Protocol 72
4.6.1 Basic Method 73
4.7 Energy Saving Kits and Elementary Education Protocol 76
4.7.1 Basic Method 77
4.8 Residential New Construction Protocol 78
4.8.1 Basic Method 78
4.8.2 Participant Spillover 81
4.8.3 Builder Nonparticipant Spillover 82
5 Cross-Sector Protocols 84
5.1 Behavioral Protocol 84
5.1.1 Randomized Controlled Trials 84
5.1.2 Non-Randomized Designs 85
5.2 Code Compliance Protocol 87
5.2.1 Data Collection 87
5.2.2 Attribution Assessment 87
6 Appendix A: Overview of NTG Methods 89
6.1 Survey-Based Approaches 89
6.1.1 Self-Report Approach 89
6.1.2 Econometric/Revealed Preference Approach 90
6.2 Randomized Control Trials and Quasi-Experimental Designs 90
6.3 Deemed or Stipulated NTG Ratios 91
6.4 Common Practice Baseline Approaches 91
6.5 Market Analyses 91
6.6 Structured Expert Judgment Approaches 91

6.7 Program Theory-Driven Approach 92
6.8 Case Studies Design 92
7 Appendix B: References 94

Table of Figures

Figure 3-1. Core Free Ridership Algorithm 1 29
Figure 3-2. Core Free Ridership Algorithm 2 30
Figure 3-3. Core Free Ridership Algorithm 3 30
Figure 3-4. Small Business Free Ridership 40
Figure 3-5. Study-Based Free Ridership—Overview 42
Figure 3-6. Study-Based Free Ridership—No-Program FR Score Option #1 43
Figure 3-7. Study-Based Free Ridership—No-Program FR Score Option #2 43
Figure 4-1. NPSO Question Logic 52
Figure 4-2. Appliance Retirement Scenarios 57
Figure 4-3. Residential Upstream Lighting Free Ridership via In-Store Intercept 61
Figure 4-4. Residential Prescriptive Rebate (With No Audit) Free Ridership (Replace on Burnout) 65
Figure 4-5. Residential Prescriptive Rebate (With No Audit) Free Ridership (Early Replacement) 66
Figure 4-6. Single-Family Home Energy Audit Free Ridership—No Cost Measures 70
Figure 4-7. Single-Family Home Energy Audit Free Ridership—Discounted Measures 71
Figure 4-8. Multifamily Free Ridership for Property Managers—Non-CFL Measures 75
Figure 4-9. Multifamily Free Ridership—CFL Measures 75
Figure 4-10. Energy Saving Kits and Elementary Education Free Ridership 77
Figure 4-11. Residential New Construction Free Ridership 79

Table of Tables

Table 1-1. ICC Energy Efficiency Dockets 18
Table 2-1. Definitions 22
Table 3-1. Commercial, Industrial, and Public Sector Programs 26
Table 4-1. Residential and Low Income Programs 46
Table 4-2. Estimation of Respondents' NPSO Savings 53
Table 4-3. Calculation of Total NPSO Generated 53
Table 4-4. Net Savings Example for a Sample Population* 58
Table 4-5. Example Triangulation Weighting Approach 68
Table 4-6. IECC 2012 Building Energy Code 82

6 Cross-Cutting Measures

6.1 Behavior

6.1.1 Adjustments to Behavior Savings to Account for Persistence

DESCRIPTION

Energy efficiency program administrators are increasingly including behavior programs as part of their portfolios. These programs are characterized by various kinds of outreach, education, and customer engagement designed to motivate increases in conservation and energy management behaviors, and most commonly include participant-specific energy usage information. Savings impacts are evaluated by ex-post billing analysis comparing consumption before and after (or with and without) program intervention, and require M&V methods that include customer-specific energy usage regression analysis and randomized controlled trial experimental designs, among others (see Behavioral protocol set forth in the IL-TRM Attachment A: Illinois Statewide Net-to-Gross Methodologies for more information). As such, initial calculation of savings is treated as a custom protocol[1].

An important issue for many stakeholders is whether energy savings from behavior programs continue over time (i.e., whether they persist beyond the initial program year). Behavior programs have now been delivered for a number of years in many jurisdictions. The weight of evaluation evidence indicates that the energy-saving behaviors influenced through these programs can persist beyond the initial period of program intervention, even without continued program participation[2]. This post-treatment savings persistence has implications for calculations of first-year savings, measure life, and cost-effectiveness testing. Accounting for persistence will yield savings and cost-effectiveness estimates that more accurately reflect the true benefits of these programs. Because annual goals are based on first-year savings, programs should only count savings attributable to first-year spending. The effect of persistence of savings beyond the first year should be included in lifetime savings calculations and cost-effectiveness testing.

The protocol below was developed to outline the adjustments that should be made to account for the persistence of savings beyond the year of program delivery. This protocol is applicable to behavior programs of any type, delivered to residential or C&I customers, that has evaluated evidence of program persistence. This general protocol should be used for any type of behavior program once supportable assumptions for persistence exist as measured by multi-year, rigorous evaluation studies.

Currently, evaluations calculate a custom value on an annual basis to estimate yearly savings. Evaluators typically use a regression analysis to estimate program effects. These regression analyses provide what is called an average treatment effect on the treated (ATT) estimate of program savings. The ATT approach takes advantage of the presence of a randomly assigned control group for each cohort that received reports in the service territory. These regressions use various methods to account for household-specific usage patterns[3]. Because of the experimental design, we can assume that the treatment and control groups experienced similar historical, political, economic,

[1] The protocol outlined here assumes that adjustments to remove the effects of savings from program lift (participation in other utility programs), including legacy uplift, to account for move-outs and opt-outs, to normalize for effects of weather, and any other appropriate adjustments, have been made as part of the custom calculation of savings – this final savings value is referred to as “Measured Savings” in the calculations below.

[2] Long-Run Savings and Cost-Effectiveness of Home Energy Reports Programs, Cadmus, October 2014. Also see additional sources in the REFERENCE TABLE below.

[3] For example, a linear fixed-effects regression (LFER) model includes a household-specific intercept to account for time-invariant, household-level factors affecting energy use, and a post program regression (PPR) model uses energy use lags to account for household-specific usage in the year prior to the program.

and other events that had comparable effects on their energy use. Moreover, because these groups experienced generally similar weather conditions, it is not necessary to measure or include weather in the model specification.

However, in the case of comparing and summing savings year over year, exogenous factors, such as weather, make annual estimates non-equivalent. In particular, weather can play an important role in driving behavioral effects.[4] As such, for this framework, evaluators will adjust for effects related to weather as part of the custom inputs to this protocol. This adjustment will provide savings using a model specification that incorporates standard weather year inputs (HDD and CDD), to be used in the calculation of annual savings as well as inputs for cost effectiveness as outlined below. This input will approximate average savings for a given weather year based upon historical data.[5] This approach is consistent with how performance goals are developed, as well as other inputs for cost-effectiveness testing.

The protocol will become effective for residential Home Energy Reports (HERs)-type programs[6] as of June 1, 2017 (program year 2018) - it is provided here for program planning purposes. All ongoing programs will undergo a "reset" upon institution of this protocol[7]. Regardless of any previous history of behavior program delivery, the program year ending May 31, 2018 will be assumed to be Year 1 for all HERs-type programs underway at that time for the purpose of the incorporation of multiyear measure life/savings persistence into cost-effectiveness calculations and for the application of the adjustments to annual savings as outlined below. Should any additional new programs (referred to as "waves" in the calculations below) be established in 2018 or in subsequent years, their first year will be assumed to be Year 1 for that wave – that is, each wave is tracked separately and savings are calculated separately using the approach outlined here. All residential HERs-type programs prior to June 1, 2017 will assume a 1-year measure life; the assumptions and protocols outlined below will not be applied retrospectively to any utility programs. All other types of behavior programs will continue to use a 1-year measure life until supportable evidence exists for savings persistence, at which time this adjustment protocol can be used.

Determination of Efficient Behavior

Behavior programs focus primarily on reducing electricity and natural gas consumption through behavioral changes; this reduction is generally measured through ex-post billing analysis after program intervention. Specific energy conservation and management behaviors are not usually directly observable. The specific definition of the efficient case is part of the design of behavioral programs and is included as part of the custom saving protocol, which will include any adjustment necessary to remove effects of program-related investments in efficient equipment.

Determination of Baseline Behavior

The ideal baseline for behavior programs is the energy usage without the program intervention. Various types of experimental, quasi-experimental, and/or regression-based EM&V approaches are used to present statistically

---

[4] We acknowledge that this approach is a proxy for estimating actual savings to allow for prospective calculation of lifetime savings. However, a substantial limitation to this approach is the issue of unobserved behavioral ramp-up that is likely to occur for future waves of participants.

[5] In the future, this approach could be empirically tested by comparing actual savings calculated in future program years against standard weather year results, producing a 'realization rate' between planned and actual savings results. Standard weather years could potentially be enhanced to better reflect these differences.

[6] Residential HERs-type programs: programs that deliver Home Energy Reports to homeowners using a random control trial (RCT) experimental design. Behavior change is motivated by customer-specific usage information with individualized analysis, comparisons, and tips for energy savings.

[7] It is understood that this approach does not accurately take into account that programs have been in place prior to this date, and the fact that customers at that time will have been receiving reports for variable amounts of time, with varied associated actual savings persistence from these earlier program efforts. The difficulties of trying to "phase in" persistence adjustments to reflect this history have been recognized, and the approach outlined here has been recommended by the Illinois TAC members as a reasonable approximation.

valid approximations to this without-program baseline[8]. The specific definition of the baseline case is part of the design of behavioral programs and is included as part of the custom saving protocol.

DEEMED LIFETIME/PERSISTENCE OF SAVINGS

Evaluations in Illinois have shown that savings from residential HERs-type behavior programs can persist into the year following program delivery[9], though savings levels decay in the second year. For other residential RCT programs evaluated to date, savings have been shown to persist for at least 3 years year following program delivery[10], and industry expectations are that savings likely persist beyond that. We assume here that savings persist at some level for 5 years[11]. Savings over those 5 years are not equal, however; it is preferable that actual levels of ongoing savings should be calculated by future year as outlined below (see Application of Persistence for Cost-effectiveness) and used in cost-effectiveness and lifetime savings calculations[12]. Measure life is assumed = 1 year for other behavior program types.

DEEMED MEASURE COST

It is assumed that most behavior changes in residential settings can be accomplished with homeowner labor only and without investment in new equipment; therefore, without evidence to the contrary, measure costs in such residential programs focused on motivating changes in customer behavior may be defined as $0[13]. Costs for C&I programs may include additional staffing, software purchases, etc. Cost for such programs is therefore program specific and is determined on a custom basis.

LOADSHAPE AND COINCIDENCE FACTOR

While there is evidence from analysis of AMI data that the savings loadshape for residential HERs-type programs mirrors the whole-house electric energy load pattern, there are not yet enough data to develop a behavior-specific loadshape. Indications from several unpublished analyses[14] show that these behavior savings occur in a general

[8] See the Illinois Behavioral protocol set forth in the IL-TRM Attachment A: IL-NTG Methods for more information concerning randomized control trials and quasi-experimental evaluation methods for non-randomized designs for behavior programs.

[9] ComEd Home Energy Report Opower Program Decay Rate and Persistence Study DRAFT. Energy Efficiency/Demand Response Plan: Plan Year 7 (6/1/2014-5/31/2015). Navigant, Presented to Commonwealth Edison Company, January 29, 2016; Behavioral Energy Savings Programs: Home Energy Reports Persistence Study Part 2 – April 2015 to September 2015Nicor Behavioral Energy Savings Programs, Navigant, January 2016.

[10] Long-Run Savings and Cost-Effectiveness of Home Energy Reports Programs, Cadmus, October 2014. Also see additional sources in the REFERENCE TABLE below. Given the limited persistence studies available, we acknowledge that using an average of these studies by fuel type may be the best approximation of persistence rates. However, moving forward, the TAC will incorporate additional study values and develop the most appropriate persistence factor taking into account participant characteristics, such as the duration of exposure, the frequency of reports, baseline usage, as well as the amount of time that has persisted since receiving their final report

[11] Determined as a reasonable preliminary assumption by Illinois TAC members. This assumption should be updated as additional research is conducted on these types of programs, and additional evaluation should be undertaken to assess the reasonableness of this assumption for Illinois-specific programs.

[12] This method of applying calculated values for future year benefits is preferred. Alternatively, an effective measure life can be calculated as Effective Measure Life = Total Discounted Lifetime Savings / First Year Savings.

[13] Future evaluation of costs of behavior change is encouraged to help clarify this assumption. In addition, as noted earlier in this measure characterization, in order to ensure double counting of savings does not occur, the protocol outlined here assumes that adjustments to remove the effects of program lift have been made as part of the custom calculation of savings. In a similar manner, given the savings accounted for by other utility programs are removed from the savings claims and cost-effectiveness for the behavior program, the incremental costs associated with such utility program incentivized measures should also be excluded from the behavior program cost-effectiveness analysis, so as to help ensure double counting of costs does not occur in the utility portfolio cost-effectiveness analysis.

[14] Based on communication from Mathias Bell based on (currently unpublished) studies done by Opower, Cadmus, and LBNL.

pattern most closely approximated by the Residential Electric Heating and Cooling Loadshape (R10) than any other current residential measure loadshape; this is therefore recommended as the most reasonable approximation for use until more-specific data are available. Loadshapes and coincidence factors will need to be determined for other types of behavior programs once sufficient data are in hand.

Algorithm

CALCULATION OF SAVINGS

Throughout these protocols, Year T refers to the current reporting year for which annual savings are being determined[15].

ELECTRIC ENERGY SAVINGS

The algorithm shown below for this measure was developed to calculate the annual persistence-adjusted electric savings in to be reported in year T after adjustment to account for the proportion of the measured savings for that program year that actually reflects any persistent savings from prior years' program activities (Years T-1, T-2, T-3, and T-4)[16].

$$\Delta kWh_{T\ Adjusted} = \Delta kWh_{T\ Measured} - (\Delta kWh_{T-1\ Adjusted} * RR_{T-1,T} * PFE_1) - (\Delta kWh_{T-2\ Adjusted} * RR_{T-2,T} * PFE_2) - (\Delta kWh_{T-3\ Adjusted} * RR_{T-3,T} * PFE_3) - (\Delta kWh_{T-4\ Adjusted} * RR_{T-4,T} * PFE_4)$$

Where:

$\Delta kWh_{x\ Adjusted}$ = total program annual savings for year X after adjustments to account for persistence (calculated value)

$\Delta kWh_{x\ Measured}$ = measured kWh savings: total program savings as determined from custom calculation/billing analysis[17] of participants in program during year X (input value)

$RR_{Y,X}$ = Program retention rate in year X from year Y participation

= % of program participants in year Y that are still in program in year X (input value: calculated as # participants still in program in year X / # participants in year Y))

PFE_Z = Persistence factor - electric (deemed value)

= % savings that persist Z years after savings were initially measured, where Z is a number from 1 - 4

Also see DTE Energy: Behavior Program Measures for Submission to 2015 MEMD - Year Three Energy Savings - Demand Savings. Energy Optimization, April 15, 2014. http://www.michigan.gov/documents/mpsc/memd_2015_453673_7.pdf

[15] Calculation algorithms account for program attrition as well as persistence decay. It has been noted that there may also be a need to adjust for cross-year effects of large differences in weather conditions or economic impacts. Custom savings inputs therefore are adjusted for standard year weather. Further studies are needed to help determine the magnitude of such effects and if this is the appropriate way to account for them.

[16] This calculation should be carried out separately for each "wave" of behavior programs, where a wave is defined as a newly launched program. For simplicity, any new wave is assumed to start at the beginning of a program year (Year 1) and may include multiple different treatment types such as usage groups, report frequency, etc. For example, any wave added after 2018, will be considered Year 1 in the year they are launched.

[17] All appropriate adjustments to remove effects of participation in other utility programs, move-outs, opt-outs, to normalize for effects related to weather, and other adjustments as determined by the program experimental design, are assumed to have been made to result in this value for "measured savings". This value has been adjusted for year X weather terms.

= use table below to select the appropriate value

Electric Persistence Factors[18]

Program Type	Program Year T - record 100% of adjusted savings ($\Delta kWh_{TAdjusted}$ above)	Percent adjusted savings from Year T activities that persist 1 year after year T	Percent adjusted savings from Year T activities that persist 2 years after year T	Percent adjusted savings from Year T activities that persist 3 years after year T	Percent adjusted savings from Year T activities that persist 4 years after year T
		PFE_1	PFE_2	PFE_3	PFE_4
Residential HERs-type (RCT)	100%	82%	68%	56%	46%

[18] See REFERENCE TABLE below for sources.

Example of Adjusted Annual Savings Calculations:

Assume the following information on participation and measured savings for the following program years (all adjustments have been made to remove effects of program lift, weather, etc. within the custom savings calculations). Assume 2018 is the first year of all programs (or is the "reset" year).

	Reporting Year					
	2018	2019	2020	2021	2022	2023
Input data from program information and custom savings analysis						
# Participants (households)	120,000	109,000	103,000	99,000	94,000	90,000
kWh per participant (household)	200	250	245	250	250	265
Measured kWh savings (custom)	24,000,000	27,250,000	25,235,000	24,750,000	23,500,000	23,850,000

Calculation of Retention Rates:

For use in 2019:

$RR_{2018,\ 2019}$ = 109,000/120,000 = 0.908

For use in 2020:

$RR_{2018,\ 2020}$ = 103,000/120,000 = 0.858

$RR_{2019,\ 2020}$ = 103,000/109,000 = 0.945

For use in 2021:

$RR_{2018,\ 2021}$ = 99,000/120,000 = 0.825

$RR_{2019,\ 2021}$ = 99,000/109,000 = 0.908

$RR_{2020,\ 2021}$ = 99,000/103,000 = 0.961

For use in 2022:

$RR_{2018,\ 2022}$ = 94,000/120,000 = 0.783

$RR_{2019,\ 2022}$ = 94,000/109,000 = 0.862

$RR_{2020,\ 2022}$ = 94,000/103,000 = 0.913

$RR_{2021,\ 2022}$ = 94,000/99,000 = 0.949

For use in 2023:

$RR_{2019,\ 2023}$ = 90,000/109,000 = 0.826

$RR_{2020,\ 2023}$ = 90,000/103,000 = 0.874

$RR_{2021,\ 2023}$ = 90,000/99,000 = 0.909

$RR_{2022,\ 2023}$ = 90,000/94,000 = 0.957

Calculation of Adjusted Annual Savings:

$\Delta kWh_{2018\ Adjusted}$ = 24,000,000 kWh

$\Delta kWh_{2019\ Adjusted}$ = 27,250,000 – (24,000,000 * 0.908 * 0.82)
= 9,380,560 kWh

$\Delta kWh_{2020\ Adjusted}$ = 25,235,000 – (9,380,560 * 0.945 * 0.82) – (24,000,000 * 0.858 * 0.68)
= 3,963,444 kWh

$\Delta kWh_{2021\ Adjusted}$ = 24,750,000 – (3,963,444 * 0.961 * 0.82) – (9,380,560 * 0.908 * 0.68) – (24,000,000 * 0.825 * 0.56)
= 4,746,794 kWh

$\Delta kWh_{2022\ Adjusted}$ = 23,500,000 – (4,746,794 * 0.949 * 0.82) – (3,963,444 * 0.913 * 0.68) – (9,380,560 * 0.862 * 0.56) – (24,000,000 * 0.783 * 0.46)
= 4,172,971 kWh

$\Delta kWh_{2023\ Adjusted}$ = 23,850,000 – (4,172,971 * 0.957 * 0.82) – (4,746,794 * 0.909 * 0.68) – (3,963,444 * 0.874 * 0.56) – (9,380,560 * 0.826 * 0.46)
= 12,137,109 kWh

Apply the same approach to calculate adjusted annual kW and Therms.

SUMMER COINCIDENT PEAK DEMAND SAVINGS

Coincident peak demand savings in year T should also be adjusted to account for persistence from previous years using a similar algorithm[19].

[19] While there are no current studies that evaluate the persistence of peak savings, without more-specific information on the

If peak demand is measured directly by the custom savings analysis:

$$\Delta kW_{T\ Adjusted} = \Delta kW_{T\ Measured} - (\Delta kW_{T-1\ Adjusted} * RR_{T-1,T} * PFE_1) - (\Delta kW_{T-2\ Adjusted} * RR_{T-2,T} * PFE_2) - (\Delta kW_{T-3\ Adjusted} * RR_{T-3,T} * PFE_3) - (\Delta kW_{T-4\ Adjusted} * RR_{T-4,T} * PFE_4)$$

Where:

$\Delta kW_{X\ Adjusted}$ = total program demand savings for year X after adjustments to account for persistence (calculated value)

$\Delta kW_{X\ Measured}$ = total program demand savings as determined from custom calculation /billing analysis[20] of participants in program during year X (input value)

Other variables as defined above

If peak demand is not measured directly by the custom savings analysis, peak demand should be calculated as follows:

$$\Delta kW_{T\ Adjusted} = (\Delta kWh_{T\ Adjusted\ Summer} / \#summer\ hours) * peak\ adjustment\ factor$$

Where:

$\Delta kWh_{T\ Adjusted\ Summer}$ = average adjusted electric energy savings (calculated above) for peak summer months

$= \Delta kWh_{T\ Adjusted} * 0.42 * (3/5)$

$= \Delta kWh_{T\ Adjusted} * 0.25$

Where:

0.42 = Summer Loadshape % for May – Sept

3/5 = proportion of May-Sept hours that fall in June, July, and Aug

summer hours = # hours in June, July, and Aug

= 8760 / 4

Where: 8760 = Hours per year

peak adjustment factor = adjustment for peak k/w over average kW for these hours

= 1.5[21]

actual behaviors undertaken by program participants and their corresponding peak savings, it seems reasonable to assume that peak savings will also persist in a similar pattern; both of the approaches given assume persistence in peak savings. Further evaluation should be undertaken to clarify this point and determine appropriate peak-specific persistence values.

[20] All appropriate adjustments to remove effects of participation in other utility programs, move-outs, opt-outs, to normalize for effects related to weather, and other adjustments as determined by the program experimental design, are assumed to have been made to result in this value for "measured savings". This value has been adjusted for year X weather terms.

[21] Based on an approach used in Michigan that gives resulting values supported by evaluation claims. Also see DTE Energy: Behavior Program Measures for Submission to 2015 MEMD - Year Three Energy Savings - Demand Savings. Energy Optimization, April 15, 2014. http://www.michigan.gov/documents/mpsc/memd_2015_453673_7.pdf

NATURAL GAS ENERGY SAVINGS

The algorithm shown below for this measure was developed to calculate the annual persistence-adjusted Therm savings in to be reported in year T after adjustment to account for the proportion of the measured savings for that program year that actually reflects any persistent savings from prior years' program activities (Years T-1, T-2, T-3, and T-4).[22]

$\Delta Therms_{T\ Adjusted} = \Delta Therms_{T\ Measured} - (\Delta Therms_{T-1\ Adjusted} * RR_{T-1,T} * PFG_1) - (\Delta Therms_{T-2\ Adjusted} * RR_{T-2,T} * PFG_2) - (\Delta Therms_{T-3\ Adjusted} * RR_{T-3,T} * PFG_3) - (\Delta Therms_{T-4\ Adjusted} * RR_{T-4,T} * PFG_4)$

Where:

$\Delta Therms_{x\ Adjusted}$ = total program annual savings for year X after adjustments to account for persistence (calculated value)

$\Delta Therms_{x\ Measured}$ = total program savings as determined from custom calculation/billing analysis[23] of participants in program during year X (input value)

PFG_Z = Persistence factor - gas (deemed value)

= % savings that persist Z years after savings were initially measured, where Z is a number from 1 - 4

= use table below to select the appropriate value

Other variables as defined above

Gas Persistence Factors[24]

Program Type	Program Year T - record 100% of calculated savings ($\Delta Therms_{TAdjusted}$ above)	Percent adjusted savings from Year T activities that persist 1 year after year T	Percent adjusted savings from Year T activities that persist 2 years after year T	Percent adjusted savings from Year T activities that persist 3 years after year T	Percent adjusted savings from Year T activities that persist 4 years after year T
		PFG_1	PFG_2	PFG_3	PFG_4
Residential HERs-type (RCT)	100%	45%	20%	9%	4%

APPLICATION OF PERSISTENCE FOR COST-EFFECTIVENESS

For determination of cost effectiveness (or lifetime savings) of programs in year T, future years' savings related to the current year activities should be recorded for this measure as savings for each specific year using the table

---

[22] This calculation should be carried out separately for each "wave" of behavior programs, where a wave is defined as a newly launched program. For simplicity, any new wave is assumed to start at the beginning of a program year (Year 1) and may include multiple different treatment types such as usage groups, report frequency, etc.

[23] All appropriate adjustments to remove effects of participation in other utility programs, move-outs, opt-outs, to normalize for effects related to weather, and other adjustments as determined by the program experimental design, are assumed to have been made to result in this value for "measured savings". This value has been adjusted for year X weather terms.

[24] See REFERENCE TABLE below for sources.

below[25]. Because of the potentially confounding effects of differences in weather in future years, the savings inputs used ($\Delta kWh_{TAdjusted}$, $\Delta kW_{TAdjusted,}$ $\Delta Therms_{TAdjusted}$) for these future-year savings calculations have been developed using inputs that are provided from a custom model specification that incorporates standard weather year inputs (HDD and CDD). This input (to be provided by program evaluators) will approximate average savings for a given weather year based upon historical data.[26]

Program Year T - record 100% of adjusted annual savings as calculated above	Percent savings from Year T activities that persist 1 year after year T	Percent savings from Year T activities that persist 2 years after year T	Percent savings from Year T activities that persist 3 years after year T	Percent savings from Year T activities that persist 4 years after year T
$\Delta kWh_{TAdjusted}$ $\Delta kW_{TAdjusted}$ $\Delta Therms_{TAdjusted}$	$\Delta kWh_{TAdjusted}$ * PFE_1 $\Delta kW_{TAdjusted}$ * PFE_1 $\Delta Therms_{TAdjusted}$ * PFG_1	$\Delta kWh_{TAdjusted}$ * PFE_2 $\Delta kW_{TAdjusted}$ * PFE_2 $\Delta Therms_{TAdjusted}$ * PFG_2	$\Delta kWh_{TAdjusted}$ * PFE_3 $\Delta kW_{TAdjusted}$ * PFE_3 $\Delta Therms_{TAdjusted}$ * PFG_3	$\Delta kWh_{TAdjusted}$ * PFE_4 $\Delta kW_{TAdjusted}$ * PFE_4 $\Delta Therms_{TAdjusted}$ * PFG_4

[25] These cost-effectiveness calculations assume a retention rate of 100% after the first program year. Move-out rates and other attrition factors continue to occur and fluctuate year over year, and, to be accurate, the value of this persistence for lifetime cost and cost-effectiveness calculations should adjust for this attrition through the application of a deemed estimate. At this time, we do not have sufficient data for such an adjustment and recommend further evaluation to develop appropriate values.

[26] In the future, this approach could be empirically tested by comparing actual savings calculated in future program years against standard weather year results, producing a 'realization rate' between planned and actual savings results. Standard weather years could potentially be enhanced to better reflect these differences.

Example of Calculation of Cost-effectiveness Inputs – for Electric Savings:

Assume the same information as was used in the Example of Adjusted Annual Savings Calculations (first row below). However, within each year of calculation, evaluators will adjust custom evaluation input (e.g., $\Delta kWh_{2018WeatherAdj}$) by modeling estimated savings using the standard weather year for prospective application. Assume these custom inputs provide the values in the second row below.

	Reporting Year T					
	2018	2019	2020	2021	2022	2023
Adj. kWh savings (previously calculated) $\Delta kWh_{TAdjusted}$	24,000,000	10, 252, 240	5,116,954	5,731,923	5,024,404	11,556,551

In 2018:

2018 annual savings = $\Delta kWh_{2018\ Adjusted}$ = 24,000,000 kWh

Cost-effectiveness benefit in 2019 = $\Delta kWh_{2018\ Adjusted}$ * PFE_1 = 24,000,000 * 0.82 = 19,680,000 kWh

Cost-effectiveness benefit in 2020 = $\Delta kWh_{2018\ Adjusted}$ * PFE_2 = 24,000,000 * 0.68 = 16,320,000 kWh

Cost-effectiveness benefit in 2021 = $\Delta kWh_{2018\ Adjusted}$ * PFE_3 = 24,000,000 * 0.56 = 13,440,000 kWh

Cost-effectiveness benefit in 2022 = $\Delta kWh_{2018\ Adjusted}$ * PFE_4 = 24,000,000 * 0.46 = 11,040,000 kWh

In 2019:

2019 annual savings = $\Delta kWh_{2019\ Adjusted}$ = 10,252,240 kWh

Cost-effectiveness benefit in 2020 = $\Delta kWh_{2019\ Adjusted}$ * PFE_1 = 10,252,240 * 0.82 = 8,406,837 kWh

Cost-effectiveness benefit in 2021 = $\Delta kWh_{2019\ Adjusted}$ * PFE_2 = 10,252,240 * 0.68 = 6,971,523 kWh

Cost-effectiveness benefit in 2022 = $\Delta kWh_{2019\ Adjusted}$ * PFE_3 = 10,252,240 * 0.56 = 5,741,254 kWh

Cost-effectiveness benefit in 2023 = $\Delta kWh_{2019\ Adjusted}$ * PFE_4 = 10,252,240 * 0.46 = 4,716,030 kWh

In 2020:

2020 annual savings = $\Delta kWh_{2020\ Adjusted}$ = 5,116,954 kWh

Cost-effectiveness benefit in 2021 = $\Delta kWh_{2020\ Adjusted}$ * PFE_1 = 5,116,954 * 0.82 = 4,195,902 kWh

Cost-effectiveness benefit in 2022 = $\Delta kWh_{2020\ Adjusted}$ * PFE_2 = 5,116,954 * 0.68 = 3,479,529 kWh

Cost-effectiveness benefit in 2023 = $\Delta kWh_{2020\ Adjusted}$ * PFE_3 = 5,116,954 * 0.56 = 2,865,494 kWh

Cost-effectiveness benefit in 2024 = $\Delta kWh_{2020\ Adjusted}$ * PFE_4 = 5,116,954 * 0.46 = 2,353,799 kWh

Etc.

Apply the same approach to calculate cost-effectiveness inputs for kW and for Therms.

Water Impact Descriptions and Calculation

N/A

Deemed O&M Cost Adjustment Calculation

N/A

REFERENCE TABLE

Persistence: Reference Studies[27]							
Utility/Location	Frequency of Reports when in program	Number of Months in Program Before Terminated	Number of Post-Treatment Savings Analysis Months	Average Annual savings decay	Persistence (= 100% - decay)	Source	Electric or Gas
Upper Midwest	Monthly & quarterly	24-25	26	21%	79%	1	Electric
West Coast	Monthly & quarterly	24	29	18%	82%	1	Electric
West Coast	Monthly & quarterly	25-28	34	15%	85%	1	Electric
SMUD	Monthly & quarterly	27	12	32%	68%	1	Electric
Puget Sound Energy	Monthly & quarterly	24	36	11%	89%	1	Electric
MASS	Monthly & quarterly	26	15	33%	67%	2	Electric
Illinois (ComEd)	Bimonthly	52	12	4%	96%	3	Electric
Illinois (ComEd)	Bimonthly	30	12	2%	98%	3	Electric
Illinois (ComEd)	Bimonthly	16	12	22%	78%	3	Electric
Average Annual Electric Savings Persistence:					**82%**		
MASS	Monthly & quarterly	15	17	64%	36%	2	Gas
Illinois (Nicor)	Bimonthly	12	12	46%	54%	4	Gas
Average Annual Gas Savings Persistence:					**45%**		

Sources:
1: http://www.cadmusgroup.com/wp-content/uploads/2014/11/Cadmus_Home_Energy_Reports_Winter2014.pdf
2: http://ma-eeac.org/wordpress/wp-content/uploads/Home-Energy-Report-Savings-Decay-Analysis-Final-Report1.pdf
3:http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_5/Sources/Nicor_Gas_HER_Persistence_Study_Part_2_DRAFT_2016-01-28.pdf
4:http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_5/Sources/ComEd_HER_Opower_Persistence_and_Decay_Study_DRAFT_2016-01-28.pdf

MEASURE CODE: CC-BEH-BEHP-V01-170601

[27] These persistence studies done to date capture effects only through a limited time frame and only for the specific program characteristics of the study programs. They may not accurately represent conditions in Illinois or those for all Illinois programs. It is recommended that this protocol continue to be updated as further longer term and Illinois-specific evaluations are undertaken.

Illinois Statewide Technical Reference Manual for Energy Efficiency Version 5.0

Attachment A

Illinois Statewide Net-to-Gross Methodologies

Effective for Evaluation: June 1st, 2016

All NTG data collection and analysis activities for the program types covered by this document that start after the effective date, June 1, 2016, shall conform to the NTG methods set forth herein.

Attachment A: Illinois Statewide Net-to-Gross Methodologies

1.1 Policy Context for this Information

The Illinois Evaluation Teams (ADM Associates, Cadmus Group, Itron, Navigant Consulting, Opinion Dynamics, Ridge & Associates) are working with the Illinois Stakeholder Advisory Group (SAG) to create an Illinois Statewide Net-to-Gross (NTG) Methodologies document (IL-NTG Methods). The IL-NTG Methods document is included as an attachment to the Illinois Statewide Technical Reference Manual for Energy Efficiency (IL-TRM). Through five different dockets, the Illinois Commerce Commission (ICC) has directed the Evaluation Teams to compile and formalize standard NTG methods for use in Illinois energy efficiency (EE) evaluation, measurement, and verification (EM&V) work. The ICC EE dockets are shown in the following table.

Table 1-1. ICC Energy Efficiency Dockets

ICC Order Docket No. and Date	Program Administrator	NTG Discussion – Order Pages	ICC Link
13-0495 **(1/28/14)**	Commonwealth Edison Company (ComEd)	129-130	http://www.icc.illinois.gov/downloads/public/edocket/367591.pdf
13-0498 **(1/28/14)**	Ameren Illinois Company (Ameren)	167, 171	http://www.icc.illinois.gov/downloads/public/edocket/367603.pdf
13-0499 **(1/28/14)**	Illinois Department of Commerce & Economic Opportunity (Department of Commerce)	20, 23, 49	http://www.icc.illinois.gov/downloads/public/edocket/367581.pdf
13-0549 **(5/20/14)**	Nicor Gas Company (Nicor)	41-42, 78	http://www.icc.illinois.gov/downloads/public/edocket/378494.pdf
13-0550 **(5/20/14)**	North Shore Gas Company (North Shore Gas) and The Peoples Gas Light and Coke Company (Peoples Gas) (collectively, PG&NSG)	54-55, 66	http://www.icc.illinois.gov/downloads/public/edocket/378495.pdf

To provide clarity to the ICC directives, the relevant section on IL-NTG Methods is shown in its entirety from the Nicor Gas Order (Docket No. 13-0549). The Nicor Gas Order provides the most detail on the ICC NTG directive in comparison to the other EE orders. The Nicor language is as follows:

> The Commission believes that Staff's recommendations concerning Commission adoption of consistent statewide net-to-gross methodologies ("IL-NTG Methods") for use by the evaluators are reasonable and will aid in future evaluation of the energy efficiency programs. To help ensure the independence of the evaluators, to improve efficiency in the evaluation process, and to ensure programs across the state as delivered by the various Program Administrators can be meaningfully and consistently evaluated, the Commission hereby adopts Staff's recommendation that consistent IL-NTG Methods be established for use in the evaluations of comparable energy efficiency programs offered by different Illinois Program Administrators. The Commission notes that Section 8-104(k) of the Act encourages statewide coordination and consistency between the gas and electric energy efficiency programs and Staff's proposal would help ensure consistency in the evaluation of program performance. The Commission notes that this directive is not to create entirely "new" NTG methodologies for every energy efficiency program, but rather to assess NTG methodologies and survey instruments that have been used to evaluate energy efficiency programs offered in Illinois, and to compile the most justifiable and well-

vetted methodologies (or potentially combine certain components from the existing approaches to better represent the most justifiable and well-vetted method consistent with best practices) in an attachment to the Updated IL-TRM that would get submitted to the Commission for approval. The Commission notes that the IL-NTG Methods will be flexible and adaptable to multiple program designs and budgets and tailored to appropriately assess the specifics of each of the Program Administrators' energy efficiency programs, consistent with standard NTG methodologies adopted in other states that were filed in this proceeding. The Commission agrees with Staff that in the interest of efficiency, the current program evaluators should take the lead in compiling and formalizing standard methodologies for NTG in Illinois taking into consideration SAG input. Because the existing Plan 1 evaluators are under contract with the Company for the evaluation of the program year three energy efficiency programs, it is appropriate for these existing evaluators to work on and complete the compilation of the IL-NTG Methods over the next year. The Commission recognizes that each year considerable time may be spent vetting NTG methodologies for each program evaluation separately for each utility under the existing evaluation plan review practices; adoption of IL-NTG Methods would save on these limited evaluation resources by having a common reference document for the evaluators to use in estimating net savings for Illinois.

The Commission hereby directs the Company to require its evaluators to collaborate with the other Illinois evaluators and the SAG to use best efforts to reach consensus on the approaches used in assessing NTG in particular markets for both residential and non-residential energy efficiency programs in a manner consistent with the direction described herein. (Pages 41-42)

(16) Northern Illinois Gas Company shall require its evaluators to collaborate with the other Illinois evaluators and the SAG to reach consensus on the most defensible and well-vetted methodologies for assessing net-to-gross ratios in particular markets for both residential and non-residential energy efficiency programs in a manner consistent with the direction provided herein;

(17) ICC Staff shall file the agreed-upon consensus statewide NTG methodologies with the Commission as an attachment to the Updated IL-TRM, and if consensus is not reached on a certain component of the statewide NTG methodologies, that particular non-consensus component should be submitted in a manner consistent with the approach used for non-consensus IL-TRM Updates; (Page 78)

1.2 Programs Currently Covered in this Document

This document is intended to cover the majority of residential and non-residential programs offered in Illinois.[28] Programs covered as of the writing of this document are listed in tables at the beginning of Section 3: Commercial, Industrial, and Public Sector Protocols and Section 4: Residential and Low Income Sector Protocols. If the design of a given program changes significantly, then it may mean that the NTG protocol listed for that program in this document is no longer appropriate. If that happens, the evaluator should follow the procedures outlined below under Section 1.4: Diverging from the IL-NTG Methods.

This document will be updated over time to incorporate new programs and to reflect recommended changes to existing methodologies. All NTG data collection and analysis activities for the program types covered by this document that start after the effective date, June 1, 2016, shall conform to the NTG methods set forth herein.

[28] Evaluation reports on those programs can be found at http://www.ilsag.info/evaluation-documents.html.

1.3 Updating the IL-NTG Methods

This attachment is part of the IL-TRM and follows the timeline for updating of the IL-TRM, as specified in the IL-TRM Policy Document.[29] In general, the following will take place:

- Updates will occur annually.
- Any changes to the IL-NTG Methods document will be circulated to the full SAG, and SAG participants will have a ten business day review process.
- Updates will be discussed within the SAG and completed by March 1.
- The ICC Staff will then submit a Staff Report (with the consensus Updated IL-TRM attached) to the Commission with a request for expedited review and approval.

1.4 Diverging from the IL-NTG Methods

The NTG methods for the programs outlined in this document are partially binding. The criteria for deviating from the IL-NTG Methods document are set forth below. In all cases, the evaluators (or any interested stakeholder) submits the proposed deviation to the full SAG for a ten business day SAG review and comment period. In the event of an objection by a SAG participant, efforts may be made to see if consensus can be reached on the proposed deviation in a subsequent monthly SAG meeting. In this case, a final opportunity for SAG review and comment to the proposed deviation will be provided following the SAG meeting.

Evaluators may modify the approaches described in this document if the following three conditions have been satisfied:

1. Evaluators must explicate within the annual evaluation research plan (or another document) how specific items in the proposed modified NTG method will diverge from what is written in this document. Evaluators must justify why the divergence is appropriate.
2. Prior to the use of the modified NTG method for a particular program, evaluation teams must be in agreement on the use and execution of the modified NTG method.
3. Any objection from SAG participants regarding the proposed modified NTG method is resolved.

Evaluators may test alternative methods of estimating NTG for a particular program in addition to the NTG methods outlined in this document, if the following three conditions have been satisfied:

1. Evaluators must explicate within the annual evaluation research plan (or other document) the proposed alternative NTG method. Evaluators must explain why the proposed alternative NTG method might be superior to the NTG methods outlined in this document for the particular program. Evaluators must discuss the foundation for expecting that the proposed alternative NTG method is likely to produce meaningful results.
2. Prior to the use of the alternative NTG method for a particular program, evaluation teams must be in agreement on the key details of the approach for implementing the alternative NTG method.
3. Any objection from SAG participants regarding the proposed alternative NTG method gets resolved.

When performing alternative NTG methods for a particular program, the choice of methods may vary across the state. For example, if ComEd's evaluator chooses to test Methods 1 and 2 for a particular program, Ameren's and

[29] Policy Document for the Illinois Statewide Technical Reference Manual for Energy Efficiency. October 25, 2012. http://www.icc.illinois.gov/downloads/public/IL%20TRM%20Policy%20Document.pdf

Department of Commerce's evaluators do not also have to perform Methods 1 and 2 for a similar program.

Several sections of this attachment provide example questions that can be used to collect the data required in the NTG algorithms. Adjustments to refine specific question wording, e.g., to better reflect the design of the evaluated program, do not constitute divergence from the IL-NTG Methods.

1.5 Procedure for Non-Consensus Items

Non-consensus items that arise during the development and updating of the IL-NTG Methods document will be handled in substantially the same way as non-consensus IL-TRM Updates are addressed. The approach to be used is as follows.

- Once the Illinois NTG Working Group[30] has progressed as far as they can on the methodology, and it has been found that there is non-consensus on a specific Net-to-Gross Methods topic or procedure, the Illinois NTG Working Group shall submit to the ICC Staff and the SAG's Technical Advisory Committee (TAC) a Comparison Exhibit of Non-Consensus Net-to-Gross Methods topics/procedures within two weeks after the Illinois NTG Working Group has failed to reach consensus. The TAC will then deliberate on the issue with a goal of reaching consensus.
- If consensus does not emerge in the TAC regarding a particular Net-to-Gross Methods topic or procedure, the Comparison Exhibit of Non-Consensus NTG Methods topics/procedures is then sent to the full SAG for their deliberations and input. The SAG provides a forum where experts on all sides of the contested issue can present their expert opinions in an effort to inform parties of the contested issue and to also facilitate consensus.
- If the full SAG is unable to reach consensus, the non-consensus item will be referred to the ICC for resolution at the time of the IL-TRM Update proceeding. After receipt of the Comparison Exhibit of Non-Consensus Net-to-Gross Methods topics/procedures, the ICC Staff will submit a Staff Report to the Commission to initiate a proceeding separate from the consensus IL-TRM Update proceeding to resolve the non-consensus Net-to-Gross Methods topics/procedures.

[30] The Illinois NTG Working Group consists primarily of the subset of Evaluators deliberating on NTG methodologies; however, any interested party may participate in the Illinois NTG Working Group.

2 Attribution in Energy Efficiency Programs in General

One of the most difficult aspects of evaluation, and not just within evaluation of energy efficiency programs, is attributing results to a program. Attribution provides credible evidence that there is a causal link between the program activities and the outcomes achieved by the program. Attribution research estimates the difference between the outcomes and those that would have occurred absent the program (i.e., the counterfactual). Put in research terms, evaluators must reject the null hypothesis of no causality through probabilistic statements (e.g., "strong evidence"; "high probability"). As such, it is important to realize that the concept of the counterfactual cannot be proven with certainty. So even though the NTG ratio is a single value, conceptually it is a probabilistic statement.[31] One of the main academics within evaluation stated that there is a "…total and inevitable absence of certain knowledge [arising] from the methods social scientists use" when assessing the counterfactual. (Shadish, et al., 2002) This statement is not about poor methods, but about the counterfactual itself. Because programs work with people and are usually not a laboratory experiment that can be replicated over and over[32] to find out what actions people would have taken absent an intervention, one would need a time machine to take people back in time and not provide the program. Since time machines do not exist, evaluators have developed methods that approximate the counterfactual to the best of their ability.

2.1 Definitions

For energy efficiency programs, evaluators differentiate between savings at a "gross" and "net" level as described below in the short set of relevant definitions. These definitions are not all encompassing or meant to restrict evaluation in any way, but to provide context before additional detail is provided in later sections. Research to determine attribution occurs to allow for a better understanding of the net level of savings.

Table 2-1. Definitions

Concept	Term	Definition
Consumers	Nonparticipant	Any consumer who was eligible but did not participate in the subject efficiency program, in a given program year.
	Participant	A consumer who received a service offered through the subject efficiency program, in a given program year; also called program participant. The term "service" is used in this definition to suggest that the service can be a wide variety of inducements, including financial rebates, technical assistance, product installations, training, energy efficiency information, or other services, items, or conditions. Each evaluation plan should define "participant" as it applies to the specific evaluation.
Gross Impacts	Gross Impacts	The change in energy consumption and/or demand that results directly from program-related actions taken by participants in an energy efficiency program, regardless of why they participated.

[31] A probabilistic statement is not the same as the confidence and precision information calculated based on sampling theory.

[32] However, a small number of program designs do lend themselves to experimental or quasi-experimental designs that allow for regression analysis of net impacts.

Concept	Term	Definition
Attribution of Impacts	Net Impacts	The change in energy consumption and/or demand that is attributable to a particular energy efficiency program. This change in energy use and/or demand may include, implicitly or explicitly, consideration of factors such as free ridership, participant and nonparticipant spillover, and induced market effects. These factors may be considered in how a baseline is defined (e.g., common practice) and/or in adjustments to gross savings values.
	Net-to-Gross Ratio	A factor representing net program savings divided by gross program savings that is applied to gross program impacts to convert them into net program impacts. The factor itself may be made up of a variety of factors that create differences between gross and net savings, commonly including free riders and spillover. The factor can be estimated and applied separately to either energy or demand savings. Note that the net-to-gross ratio (NTGR) = ((1-Free Ridership) + Participant Spillover + Nonparticipant Spillover).
	Core NTGR	1-Free Ridership
	Free Rider	A program participant who would have implemented the program's measures or practices in the absence of the program. Free riders can be: (1) total, in which the participant's activity would have completely replicated the program measure; (2) partial, in which the participant's activity would have partially replicated the program measure; or (3) deferred, in which the participant's activity would have partially or completely replicated the program measure, but at a future time.
	Spillover	Reductions in energy consumption and/or demand caused by the presence of an energy efficiency program, beyond the program-claimed gross savings of the participants. There can be participant and/or nonparticipant spillover. *Participant spillover* (PSO) is the additional energy savings that occur as a result of the program's influence when a program participant independently installs incremental energy efficiency measures or applies energy-saving practices after having participated in the energy efficiency program. There are several general categories of participant spillover: • *Inside spillover* (ISO): Occurs when program participants implement additional program-induced energy efficiency measures at the program project site. • *Outside spillover* (OSO): Occurs when program participants implement program-induced efficiency measures at other sites within the Program Administrator's service territory at which program project measures were not implemented. • *Like spillover:* Occurs when program participants implement program-induced efficiency measures of the same type as those implemented through the program. Like spillover can occur at the program project sites (ISO) or at other sites within the Program Administrator's service territory (OSO). • *Unlike spillover:* Occurs when program participants implement

Concept	Term	Definition
		program-induced efficiency measures of a different type from those implemented through the program. Unlike spillover can occur at the program project sites (ISO) or at other sites within the Program Administrator's service territory (OSO). *Nonparticipant spillover* (NPSO) refers to energy savings that occur when a program nonparticipant installs energy efficiency measures or applies energy savings practices as a result of a program's influence.
Markets	Market	The commercial activity (e.g., manufacturing, distributing, buying, and selling) associated with products and services that affect energy use.
	Market Effects	A change in the structure of a market or the behavior of participants in a market that is reflective of an increase (or decrease) in the adoption of energy efficient products, services, or practices and is causally related to market interventions (e.g., programs). Examples of market effects include increased levels of awareness of energy-efficient technologies among customers and suppliers, increased availability of energy-efficient technologies through retail channels, reduced prices for energy-efficient models, build-out of energy-efficient model lines, and—the end goal— increased market shares for energy-efficient goods, services, and design practices.
	Market Assessment	An analysis that provides an assessment of how and how well a specific market or market segment is functioning with respect to the definition of well-functioning markets or with respect to other specific policy objectives. A market assessment generally includes a characterization or description of the specific market or market segments, including a description of the types and number of buyers and sellers in the market, the key actors that influence the market, the type and number of transactions that occur on an annual basis, and the extent to which market participants consider energy efficiency an important part of these transactions. This analysis may also include an assessment of whether a market has been sufficiently transformed to justify a reduction or elimination of specific program interventions (or whether continued or even increased intervention is necessary). Market assessment can be blended with strategic planning analysis to produce recommended program designs or budgets. One particular kind of market assessment effort is a baseline study, or the characterization of a market before the commencement of a specific intervention in the market for the purpose of guiding the intervention and/or assessing its effectiveness later.

Sources: State and Local Energy Efficiency Action Network. 2012. Energy Efficiency Program Impact Evaluation Guide. Prepared by Steven R. Schiller, Schiller Consulting, Inc., www.seeaction.energy.gov; Violette and Rathbun 2014. The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures, Chapter 23: Estimating Net Savings: Common Practices, http://www.nrel.gov/docs/fy14osti/62678.pdf.

2.2 Spillover-Specific Issues

Some issues related to spillover are applicable for both residential and non-residential programs and are discussed in this section.

2.2.1 Measure Costs

In order to facilitate analysis of program Total Resource Cost (TRC), estimates of the total incremental measure cost (IMC) at the program level must be developed. IMC values are available for most IL-TRM measures and can be summed to the program level. However, the IMC values for spillover measures could also be estimated and added to this total. The problem is that IMC values for spillover measures can be difficult to estimate. When the magnitude of the savings justifies the effort to estimate the total IMC for spillover measures, the following approaches should be used.

- In cases where the evaluator believes the spillover measure incremental costs are not materially different from the rebated measure incremental costs, the evaluator may multiply the IMC for the rebated measure by the spillover rate to derive the IMC for the spillover measure.
- In cases where the evaluator believes the spillover measure incremental costs are materially different from the installed measure incremental costs (e.g., installation of measures that have no efficiency levels), the evaluator should use the estimated incremental project costs as the IMC for the spillover measure.

Normally, the sample-based estimates of IMCs for spillover measures should be extrapolated to the program level using sample weights. Then the total IMCs for rebated measures and the total IMCs for spillover measures should be summed and used in the TRC calculation.

For measures characterized by the IL-TRM, measure effective useful life (EUL) estimates should be based on the IL-TRM. For measures not characterized by the IL-TRM, evaluator can use either the EUL for similar measures or best professional judgment. In either case, the evaluator must provide the rationale for their choices.

3 Commercial, Industrial, and Public Sector Protocols

The table below lists Illinois non-residential programs and the free ridership protocol applicable to each program.[33] If the design of a given program changes significantly, then it may mean that the NTG protocol listed for that program in this document is no longer appropriate. If that happens, the evaluator should follow the procedures outlined in Section 1.4: Diverging from the IL-NTG Methods. Note that the Core Non-Residential Spillover protocol described in Section 3.2 is generally applicable to most of these programs.

Table 3-1. Commercial, Industrial, and Public Sector Programs

Program Administrator	Free Ridership Protocol	Program Name
Ameren Illinois	3.1 Core Non-Residential Protocol	C&I Custom
		C&I Standard
	3.3 Small Business Protocols	Small Business Direct Install
	3.5 Study-Based Protocol	C&I Retro-Commissioning
ComEd	3.1 Core Non-Residential Protocol	BILD / Midstream
		Custom Incentive
		Savings through Efficient Products (STEP)
		Standard Incentive
	3.3 Small Business Protocol	Agricultural EE Program (CoAg)
		CLEAResult School DI
		DCV – Matrix Demand- Based Fan Control
		EE Technologies to Address Peak Load in Assisted Living and Senior Housing
		Luminaire Level Lighting Control
		Matrix K through 12 Private Schools DI
		Rural Small Business EE Kits
		Small Business Energy Services
		Small Commercial Lit Signage
		Small Commercial HVAC Tuneup
	3.4 C&I New Construction Protocol	C&I New Construction
		New Construction – Small Buildings
	3.5 Study-Based Protocol	Data Centers
		Enhanced Building Optimization Program

33 The "Free Ridership Protocol Name" in the second column of the table refers to the numbered sections in this document, e.g., "3.3 Small Business Protocol."

Program Administrator	Free Ridership Protocol	Program Name
		Industrial Systems Optimization
		Retrocommissioning
		Strategic Energy Management
	3.5 Study-Based Protocol or 5.1 Behavioral Protocol	Power TakeOff – Small Business MBCx
	5.1 Behavioral Protocol	Agentis C&I Behavioral Program
		Root3
	NTG = 1	LED Streetlighting
Department of Commerce	3.1 Core Non-Residential Protocol	Public Sector Custom
		Public Sector Custom - CHP Component
		Public Sector Natural Gas Boiler Systems Efficiency
		Public Sector Standard
		Savings through Efficient Products
	3.4 C&I New Construction Protocol	Public Sector New Construction
	3.5 Study-Based Protocol	Public Sector Retro-Commissioning
	3.6 Training and Technical Assistance Protocol	Building Operator Certification
		Energy Assessment and New Construction Design Assistance
		Performance Contracting
	5.2 Code Compliance Protocol	Building Energy Code Compliance
Nicor	N/A	Emerging Technology
	3.1 Core Non-Residential Protocol	Business Custom (Except Retro-Commissioning)
		Business Energy Efficiency Rebate
		Combined Heat and Power (CHP)
	3.3 Small Business Protocol	Small Business Energy Savings
	3.4 C&I New Construction Protocol	Business New Construction
	3.5 Study-Based Protocol	Business Custom (Retro-Commissioning component)
		Strategic Energy Management (SEM)
Peoples Gas/ North Shore Gas	3.1 Core Non-Residential Protocol	C&I Custom
		C&I Direct Install
		C&I Prescriptive
	3.3 Small Business Protocol	SB Custom
		SB Direct Install & Assessment

Program Administrator	Free Ridership Protocol	Program Name
		SB Partner Trade Ally
		SB Prescriptive
	3.4 C&I New Construction Protocol	C&I New Construction (Joint)
	3.5 Study-Based Protocol	C&I Gas Optimization
		MF Gas Optimization
		Retro-Commissioning (Joint)
All	5.2 Code Compliance Protocol	Statewide Codes Collaborative

3.1 Core Non-Residential Protocol

3.1.1 Core Non-Residential Free Ridership Protocol

Key considerations and guidelines for estimation of free ridership under this Core Non-Residential Free Ridership (FR) protocol are listed below:

- **Multiple Questions:** Evaluators will use program participant responses to multiple survey questions as inputs to the free ridership calculation algorithm. Evaluators will not use the response to a single question to establish a survey respondent as either a complete free rider or a complete non-free rider.
- **Program and Non-Program Factors:** Evaluators will administer survey questions to obtain respondent ratings on a numeric scale of the impact, influence, or importance on the decision to implement energy efficiency measures or take energy efficiency actions. A series of questions will focus on factors that the evaluator determines are a function of the program. Such program factors may, for instance, include availability of the program incentive, technical assistance from program staff, program staff recommendations, Program Administrator marketing materials, and endorsement or recommendation by Program Administrator account manager or program partner staff. Evaluators will also administer a series of questions to obtain respondent ratings, on a numeric scale of the impact, influence, or importance on the decision to implement energy efficiency measures, of different factors that the evaluator determines are not a function of the program. Such non-program factors may include, for example, previous experience with the measure, standard business or industry practice, and organizational policy or guidelines.
- **Vendor Recommendations:** Vendor recommendations may also be a program factor to the extent that such recommendations are a function of the program. Vendors include trade allies, contractors, distributors, suppliers, and other market actors involved in the selection and installation of program-incented equipment on behalf of the participant. The evaluator may administer survey questions to vendors to verify their involvement with participant projects and to obtain their ratings—on a numeric scale—of the impact, influence, or importance of the program on the decision to recommend the energy efficiency measures to the program participant.
- **Consistency Checks:** Evaluators should administer survey questions as checks on the consistency of responses associated with a core free ridership assessment methodology. Evaluators may also reference available quantitative and qualitative data, including consistency check data, to perform documented modifications to individual free ridership estimates resulting from the application of a core free ridership assessment methodology.

3.1.1.1 Core Free Ridership Scoring Algorithm

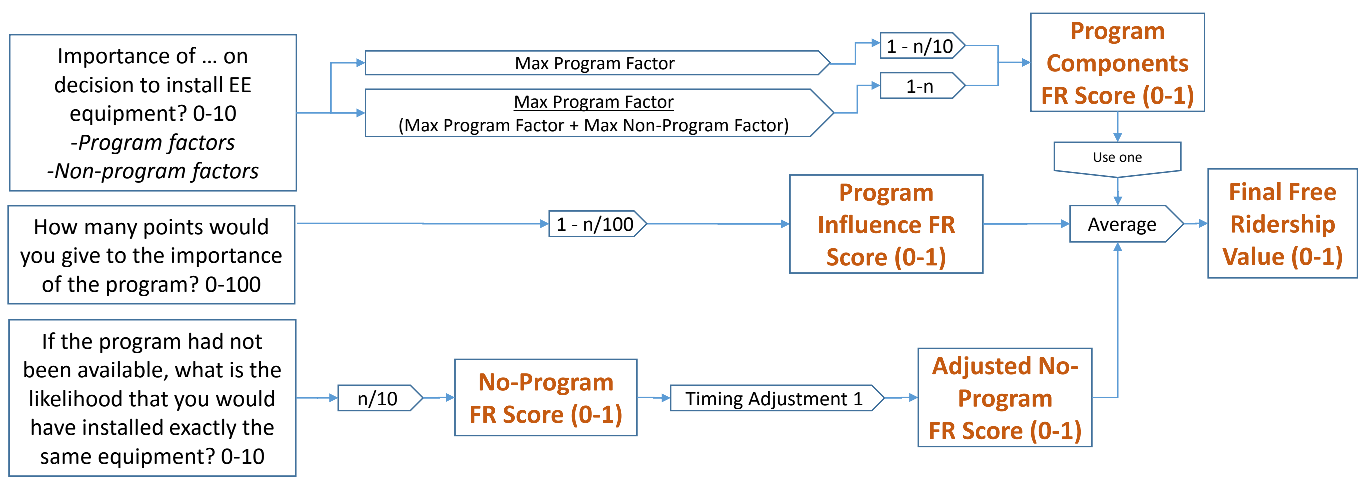
The Core Non-Residential FR protocol combines three scores that test different ways of approaching free ridership: the Program Components FR Score, the Program Influence FR Score, and the No-Program FR Score. The three scores are combined to calculate the final free ridership value. Three options for combining the three scores are shown graphically in Figure 3-1, Figure 3-2, and Figure 3-3.

This protocol designates an algorithm that includes inputs with alternative specifications. Specifically, as described below, the Program Components FR Score has two alternative specifications, and there are three alternative specifications to account for the impact of the program on project timing (referred to as "deferred free ridership"). Further, the way in which the algorithm inputs are combined and weighted varies, based on the selected specification. Evaluators will calculate free ridership using each possible combination of designated input specifications—resulting in six estimates of free ridership—and will select one of these combinations of input specifications for purposes of calculating the annual incremental energy savings for comparing to the legislated goal.[34]

Evaluators will submit participant survey and net savings analysis data to the Illinois NTG Working Group. The group will analyze these data for the purpose of further refining the protocol and potentially reducing the number of alternative algorithm input specifications.

Figure 3-1. Core Free Ridership Algorithm 1

(Program Components FR Score + Program Influence FR Score + (No-Program FR Score * Timing Adjustment 1)) / 3



[34] As defined in 220 ILCS 5/8-103 and 220 ILCS 5/8-104.

Figure 3-2. Core Free Ridership Algorithm 2

((Program Components FR Score + Program Influence FR Score + No-Program FR Score) / 3) * Timing Adjustment 2

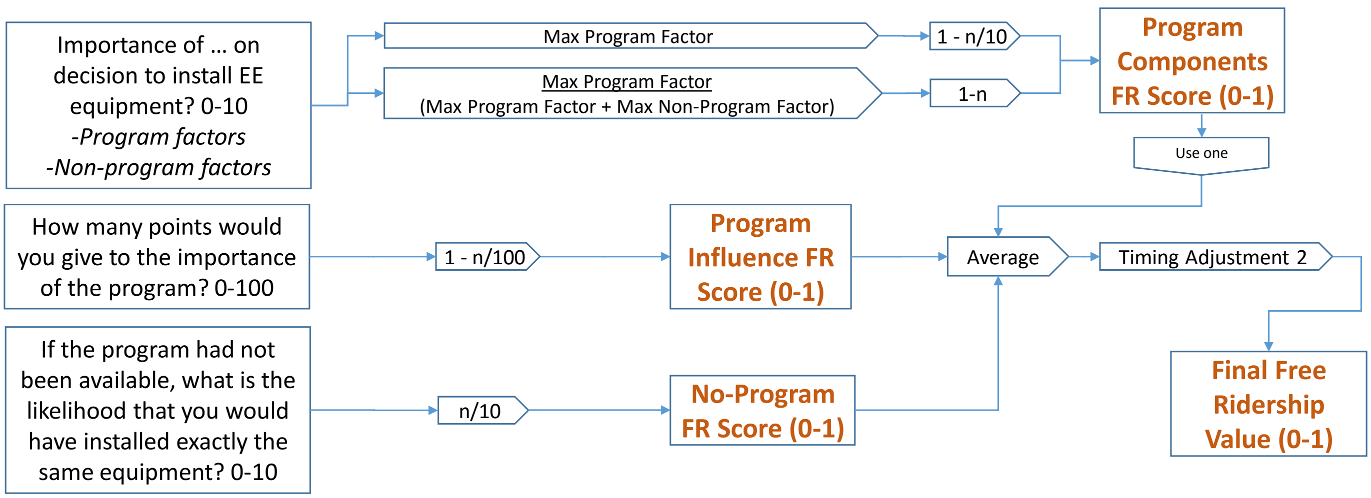
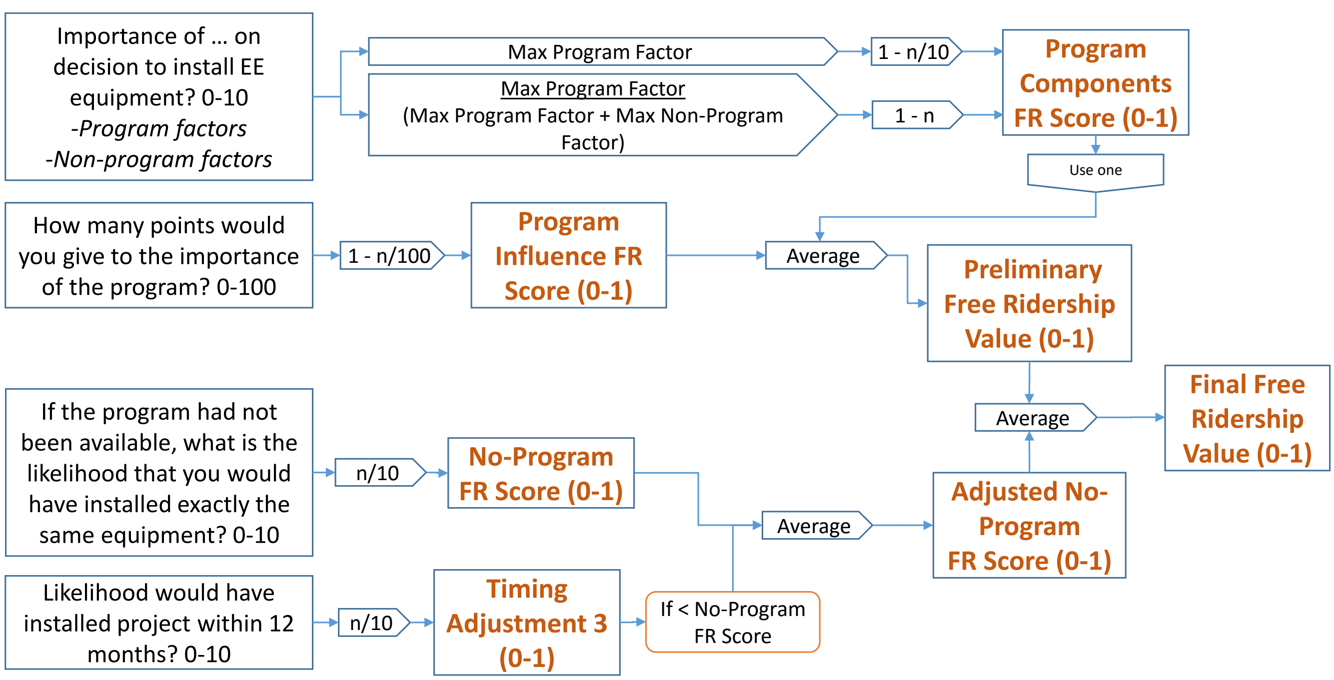


Figure 3-3. Core Free Ridership Algorithm 3

((Program Components FR Score + Program Influence FR Score) / 2 + (No-Program FR Score + Timing Adjustment 3) /2) / 2



3.1.1.1.1 Program Components FR Score

Evaluators will administer survey questions to obtain participants' rating of the importance of various factors on the decision to implement energy efficiency measures. The numeric scales shall range from 0 to 10, where 0 means "not at all important" and 10 means "extremely important". The various factors referenced in the survey will include those that the evaluator determines are program factors and non-program factors that could potentially impact the participant decision making process. A participant rating shall be obtained for each relevant program and non-program factor.

Evaluators will calculate the "Program Components FR Score" for each survey respondent in two ways (shown in the top center of the three flow charts). These scores can range from 0 (no free ridership) to 1 (full free rider).

1) Equal to 1 - ([Maximum Program Factor Rating]/10).

2) Equal to 1 - ([Maximum Program Factor Rating]/([Maximum Program Factor Rating]+[Maximum Non-Program Factor Rating])).

Evaluators may use one of the two above-referenced calculation methods to develop a Program Components FR Score to use as an input to the algorithm for calculation of program-level free ridership. Evaluators must document in EM&V reporting why the selected option was chosen. Evaluators should also test the other approach and report on the effect of their choice on the results.

Evaluation reports should list all factors considered program and non-program factors. Evaluators must document why factors were treated as program factors or non-program factors.

3.1.1.1.2 Program Influence FR Score

Evaluators will administer a survey question that asks respondents to quantify the importance of the program on the decision to implement energy efficiency measures relative to the importance or impact of non-program factors. Respondents will be asked to allocate a total of 100 points to the program and to non-program factors. The points allocated to the program by the participants are the "Program Points." Evaluators will calculate the "Program Influence FR Score" as 1 - (Program Points/100). This score can range from 0 (no free ridership) to 1 (full free rider).

3.1.1.1.3 No-Program FR Score

Evaluators will administer a counterfactual likelihood survey question to obtain respondent ratings on a 0 to 10-point numeric scale (where 0 means "not at all likely" and 10 means "extremely likely") of the likelihood of the respondent to implement the exact same energy efficiency measures in the absence of the program. Evaluators will calculate the "No-Program FR Score" as the numeric score of the likelihood of the respondent to implement specified energy efficiency measures in the absence of the program divided by 10. This score can range from 0 (no free ridership) to 1 (full free rider).

Note that under two of the three deferred free ridership specifications (see next subsection), a timing adjustment is applied to the "No-Program FR Score." Under these two specifications, the resulting score is referred to as the "Adjusted No-Program FR Score."

3.1.1.1.4 Timing and Deferred Free Ridership

Evaluators will ask about the likely timing of measure installation in the absence of the program in two different ways. This is referred to as the counterfactual timing questions since the evaluators are asking the respondent to speculate on what might have happened within particular timeframes.

The first question will present a series of date ranges (e.g., within one year, between 12 months and 2 years, etc.) and ask the respondent to pick one representing their best estimate of when the measure would have been implemented in the absence of the program. The free ridership algorithm uses the midpoint of each date range, referred to as "Number of Months Expedited" below. For respondents that report accelerated adoption due to the program, this variable can take on values from 6 to 48 months.

The second question will prompt the respondent to use a 0 to 10-point numeric scale to report the likelihood, in the absence of the program, of implementing the same measure within 12 months of when it was actually implemented. This is the "Likelihood of Implementing within One Year" in the formulas below.

Evaluators will use the Likelihood of Implementing within One Year and/or the Number of Months Expedited variables to calculate three alternative ways of accounting for deferred free ridership:

1) Calculate *Timing Adjustment 1* as equal to:

1 - (Number of Months Expedited - 6)/42

Timing Adjustment 1 is multiplied by the No-Program FR Score; it can range from 0 (full deferred free ridership) to 1 (no deferred free ridership). The application of Timing Adjustment 1 is shown in Figure 3-1.

2) Calculate *Timing Adjustment 2* as equal to:

1 - ((Number of Months Expedited - 6)/42)((10 - Likelihood of Implementing within One Year)/10)*

Timing Adjustment 2 is multiplied by the average of the Program Components FR Score, the Program Influence FR Score, and the No-Program FR Score; it can range from 0 (full deferred free ridership) to 1 (no deferred free ridership). The application of Timing Adjustment 2 is shown in Figure 3-2.

3) Calculate *Timing Adjustment 3* as equal to:

Likelihood of Implementing within One Year/10

Timing Adjustment 3 is averaged with the No-Program FR Score; it can range from 0 (full deferred free ridership) to 1 (no deferred free ridership). The application of Timing Adjustment 3 is shown in Figure 3-3.

How these timing adjustments are accounted for in the calculation of the Final FR Value is described below in the subsection “3.1.1.2 Construction of Core Free Ridership Value.”

3.1.1.1.5 Consistency Checks

Respondents may be asked one or more questions to facilitate understanding and potentially reconciling apparently inconsistent responses. Some questions may be asked of all respondents; others may be asked when previous answers appear inconsistent. Evaluators should report on the amount of inconsistency encountered and on the resolution to inform future protocol revisions. Three consistency checks are outlined below.

Program Influence/Program Components Consistency Check

A Program Influence/Program Components consistency check is triggered when the following conditions are met:

1) The number of Program Points (supporting calculation of the Program Influence FR Score) is greater than 70; and

2) no program factor is rated greater than 2.

A Program Influence/Program Components consistency check is also triggered by the following conditions being met:

1) The number of Program Points (supporting calculation of the Program Influence FR Score) is less than 30; and

2) at least one program factor is rated greater than 7. In this instance, the highest-rated program factor(s) with a rating of greater than 7 will be referenced in the consistency check question.

Program Components/No-Program Consistency Check

A Program Components/No-Program consistency check is triggered when the following conditions are met:

1) The likelihood of installing the exact same equipment without the program (supporting calculation of the No-Program FR Score) is greater than 7; and

2) at least one program factor is rated greater than 7.

A Program Components/No-Program consistency check is also triggered when the following conditions are met:

1) The likelihood of installing the exact same equipment without the program (supporting calculation of the No-Program FR Score) is less than 3; and

2) no program factor is rated greater than 2.

Timing of Installation Decision/Level of Program Attribution Consistency Check

The survey should contain a question to ask whether the respondent learned about the program after finalizing project specifications, including, where applicable, equipment efficiency level and number of units. The Timing of Installation Decision/Level of Program Attribution consistency check is triggered by the following conditions being met:

1) A respondent learned about the program after finalizing project specifications; and

2) any of the following occur:

a) the number of Program Points (supporting calculation of the Program Influence FR Score) is greater than 70;

b) the likelihood of installing the exact same equipment without the program (supporting calculation of the No-Program FR Score) is less than 3; or

c) at least one program factor is rated greater than 7.

When the Timing of Installation Decision/Level of Program Attribution consistency check is administered, if the respondent rating of the importance of the vendor on the decision to implement the project is greater than 7, then an open-ended question will be triggered to obtain information regarding the role the vendor played in the participant decision to implement the project.

3.1.1.2 Construction of Core Free Ridership Value

This protocol designates an algorithm that includes inputs with alternative specifications. Specifically, as described above, the Program Components FR Score input has two alternative specifications and the Deferred Free Ridership input has three alternative specifications. Evaluators will calculate free ridership using each possible combination of designated input specifications – resulting in six estimates of free ridership – and will select one of these combinations of input specifications for purposes of calculating the annual incremental energy savings for comparing to the legislated goal. Evaluators will present the results of all six estimates of free ridership in EM&V reporting.

Evaluators will calculate free ridership values in the following three ways in order to account for the variable ways of accounting for deferred free ridership outlined above:

1) Core FR Algorithm 1 = AVERAGE([Program Components FR Score], [Program Influence FR Score], [No-Program FR Score*Timing Adjustment 1])

2) Core FR Algorithm 2 = AVERAGE([Program Components FR Score], [Program Influence FR Score], [No-Program FR Score]) * Timing Adjustment 2

3) Core FR Algorithm 3 = AVERAGE([(Program Components FR Score + Program Influence FR Score)/2], [MINIMUM((No-Program FR Score + Timing Adjustment 3)/2, No-Program FR Score)])

For each of the three ways, the Program Components FR Score is calculated in two ways:

a) 1 - ([Maximum Program Factor Rating]/10)

b) 1 - ([Maximum Program Factor Rating]/([Maximum Program Factor Rating]+[Maximum Non-Program Factor Rating]))

The three Core FR Algorithms listed above are graphically presented in Figure 3-1, Figure 3-2, and Figure 3-3, respectively.

3.1.1.3 Vendor Influence in the Free Ridership Calculation

3.1.1.3.1 Treatment of Participant's Rating of Vendor in the Program Components FR Score of the Core FR Algorithm

The Program Components FR Score of the participant Core FR algorithm is based on participant ratings of program and non-program factors. Vendors[35] often receive a high rating for their influence on the participant's decision to install the efficient measure. To implement the Core FR algorithm, the evaluator needs to decide whether the vendor rating should be considered a program factor or a non-program factor. This section outlines three scenarios for the treatment of the participant's rating of a vendor in the Program Components FR Score of the Core FR algorithm.

Scenario #1: Vendors are automatically considered a program factor

The vendor is considered a program factor in the calculation of the Program Components FR Score in the FR algorithm if the program meets specific criteria, which could include the following:

1. Trade allies are an integral component of program delivery, as supported by program logic
2. The trade ally network consists of a limited number of Program Administrator-selected, pre-approved trade allies
3. Only trade allies can implement projects and submit applications on behalf of the customer
4. Trade allies complete signed agreements with the Program Administrator
5. Trade allies complete program-sponsored training

In these cases, the vendor is automatically considered a program factor, and no additional input from the vendor is needed regarding the customer's decision-making process related to the project. The participant's influence rating for the vendor goes directly into the Program Components FR Score algorithm as a program factor (if it is the highest rating given to any program factor).

Scenario #2: Vendors are considered a program factor if the program influenced their recommendation to implement the efficient project

For programs that have a trade ally network, but do not meet the conditions under Scenario #1 above, follow-up interviews with vendors may be used to determine if the vendor should be considered a program factor. To qualify for Scenario #2, a program's trade ally network should meet the following conditions:

1. Trade allies are registered with the program
2. Trade allies typically complete signed agreements with the Program Administrator
3. Trade allies complete program-sponsored training
4. Trade allies drive program participation, as supported by program logic

In these cases, if the size of the project warrants a greater level of effort, a follow-up interview with the vendor may be used to determine if the participant's rating of the vendor's influence should be included as a program factor. A follow-up interview is triggered under the following conditions:

1. The participant rated the influence of the vendor as 8, 9, or 10 (on a scale from 0 to 10)
2. The rating the participant gave to vendor influence is higher than any of the program factor ratings

If completed, the interview should include the following questions:

FR1a On a scale of 0 to 10 where 0 is NOT AT ALL IMPORTANT and 10 is EXTREMELY IMPORTANT, how important was the <PROGRAM>, including incentives as well as program services and information, in influencing your decision to recommend that <CUSTOMER> install the energy efficient <MEASURE> at this time?

---

[35] Vendors include trade allies, contractors, distributors, suppliers, and other market actors involved in the selection and installation of program-incented equipment on behalf of the participant.

FR1b On the same scale, how important was your firm's past participation in an incentive or study-based program sponsored by <PROGRAM ADMINISTRATOR>?

FR2 And using a 0 to 10 likelihood scale where 0 is NOT AT ALL LIKELY and 10 is EXTREMELY LIKELY, if the <PROGRAM>, including incentives as well as program services and information, had not been available, what is the likelihood that you would have recommended this specific <MEASURE> to <CUSTOMER>?

FR3a Approximately, in what percent of projects did you recommend <MEASURE> BEFORE you learned about the <PROGRAM>?

FR3b And approximately, in what percent of projects do you recommend <MEASURE> now that you have worked with the <PROGRAM>?

The interview will also include consistency checks, if the vendor provides inconsistent responses to these questions.

The vendor is viewed as a program factor and the rating the participant provided for the vendor goes into the Program Components FR Score algorithm as a program factor if, after consideration of any consistency checks:

1. The response to Q. FR1a or FR1b is 8, 9, or 10

<u>OR</u>

2. The response to Q. FR2 is 0, 1, or 2

<u>OR</u>

3. The difference between the responses to FR3b and FR3a is 80% or greater

If none of these conditions are met, the rating the participant provided for the vendor goes into the Program Components FR Score algorithm as a non-program factor.

In the event that an interview is not completed (e.g., the size of the project did not warrant a vendor interview or the vendor could not be reached), the evaluation reports should explain how the rating the participant provided for the vendor was treated. Guidelines for these situations may be added to this document in the future.

Scenario #3: Vendors are considered a non-program factor

For programs that do NOT have a trade ally network that meets the conditions under Scenario #2, vendors are considered a non-program factor. In these cases, the participant's rating of the vendor goes directly into the Program Components FR Score algorithm as a non-program factor (if it is the highest rating given to any non-program factor).

3.1.1.4 Public Sector Planning

The ICC order in Docket No. 11-0593 stated:

> All parties, including DCEO, are cautioned that, with respect to a determination regarding "free ridership," the person or entity in question should have actual energy efficiency plans before they are to be considered to be "free riders," as opposed to persons who have some goal to be met in the distant future regarding energy efficiency products and services.[36]

The NTG Working Group did not achieve consensus on an approach to address this issue and will continue to work toward consensus for a future version of this document. In the interim, evaluators may make documented adjustments to the free ridership analysis approach outlined in this section for the purpose of generating free ridership estimates that account for this order. They should present NTG results both with and without this adjustment.

[36] https://www.icc.illinois.gov/downloads/public/edocket/371251.pdf

3.2 Core Non-Residential Spillover Protocol

Spillover refers to energy savings associated with energy-efficient equipment installed by consumers who were influenced by an energy efficiency program, but without direct intervention (e.g., financial or technical assistance) from the program. Energy savings associated with spillover are not included in the Program Administrator's energy savings claim, nor are they formally tracked in the Program Administrator's databases.

To place the spillover protocols in context, we begin by defining the NTGR as:

NTGR = (1 – Free Ridership Value + PSO Rate + NPSO Rate)

Where:

PSO Rate = Participant spillover rate

NPSO Rate = Nonparticipant spillover rate

The term (1-Free Ridership) is referred to as the Core NTGR for an efficiency program.

3.2.1.1 Core Participant Spillover Protocol

The Core Participant Spillover protocol is generally applicable to most commercial, industrial, and public sector programs.

3.2.1.1.1 Research Methods

Data collection approach. An initial determination of participant spillover may be made based on self-reported findings from surveys of program participants. At a minimum, surveys collecting data pertaining to participant spillover will obtain general information on the specific measures installed and information substantiating their attribution to an energy efficiency program. Research on the specific characteristics of the energy efficient equipment installed and the baseline and operating conditions needed to estimate savings may be done in one of two ways: 1) a detailed battery of measure specific questions may be administered as part of the initial survey; or 2) a separate in-depth follow-up interview may be conducted by the engineer or analyst responsible for the energy savings calculation. In either case, an engineer or analyst will use the collected data to develop an estimate of spillover savings for each project.

Sample Frame. One target for participant spillover research may be the most recent year's program participants who have been sampled for free ridership or process surveys. In the case where a stand-alone spillover study is being conducted, the sample frame may be broader and include those whose participation occurred during the time period of two prior program years.

Because evaluated spillover energy impacts associated with the sample are being extrapolated to the program population, it is important that the sample frame be limited to participating customers for which spillover may potentially be claimed.

Sample frames should be constructed in accordance with the following guidelines:

- Self-directing customers as defined by 220 ILCS 5/8-104(m) should be excluded from the sample frame for natural gas spillover.
- Customers of municipal electric utilities should be excluded from the sample frame for electric spillover.

Timing of Data Collection. Evaluators may either administer the participant spillover module as part of a comprehensive net-to-gross survey, or they may elect to implement it separately. A follow-up in-depth interview may also be conducted by an engineer or analyst to obtain additional details needed to quantify savings. Optimally, the spillover inquiry should be timed in order to allow sufficient time for spillover to occur; at a minimum, three months after the program-incented measure is installed. Projects installed up to two years after program participation occurred may be counted as spillover, provided it can be substantiated.

3.2.1.1.2 Approach for Identifying and Quantifying Spillover

Attribution Threshold Condition. Spillover cases are identified using a threshold approach, in which certain conditions must be met in order to qualify as a spillover measure. The threshold condition for spillover is based on responses to the following two survey questions:

1. How important was your experience in the <PROGRAM> in your decision to implement this measure, using a scale of 0 to 10, where 0 is not at all important and 10 is extremely important?
2. If you had not participated in the <PROGRAM>, how likely is it that your organization would still have implemented this measure, using a 0 to 10 scale, where 0 means you definitely WOULD NOT have implemented this measure and 10 means you definitely WOULD have implemented this measure?

The response to the first question cited above is "Measure Attribution Score 1," and the response to the second question cited above is "Measure Attribution Score 2." Spillover is considered to be attributable to the program if the "Spillover Score" is greater than 7.0. The "Spillover Score" is defined as follows:

Spillover Score = (Measure Attribution Score 1 + (10 – Measure Attribution Score 2))/2

Spillover is considered to be attributable to the program if the average of the Measure Attribution Score 1 and (10 – Measure Attribution Score 2) exceeds 7.0; either the Measure Attribution Score 1 or (10 – Measure Attribution Score 2) could be below 7.0—as long as the average is greater than 7.0, the threshold is met.

If the average is greater than 7.0, 100% of the spillover savings referenced in the question are considered to be attributable to the program. If the average is not greater than 7.0, none of the spillover savings are considered to be attributable to the program.

Calculation of Spillover Measure Energy Savings. Energy savings of spillover measures shall be calculated in one of two ways.

1. Those addressed in the IL-TRM shall be calculated in accordance with the methods and algorithms specified in the IL-TRM, and shall reference the IL-TRM-defined time-of-sale or new construction baseline.
2. For measures not addressed in the IL-TRM, evaluators shall quantify savings using accepted industry-wide savings methods that conform to IPMVP or other industry protocols and documents.

Evaluators will make every effort to ensure that there is no double-counting of participant spillover energy savings across multiple sources of participant and nonparticipant spillover (such as participating customer and trade ally surveys) and will document that effort.

Measure implementation must have occurred within one year of the participant spillover study data collection effort in order to be countable as participant spillover.

For the purposes of accounting for spillover savings attributable to a program, spillover will only be quantified for measures implemented within the Program Administrator's service territory.

3.2.1.1.3 Key Participant Spillover Survey Questions

The Participant Spillover question module is designed to be a general inquiry that seeks to: (1) assess whether additional energy efficiency improvements were implemented since the rebated project was completed; (2) confirm that these measures either had not received program incentives, or that there were no plans to submit them for program incentives in the future; (3) gather basic information about the additional energy efficiency measures (e.g., their type, size, quantities, and energy efficiency rating); and (4) establish program attribution.

The basic question structure is shown below. The measure-specific questions can be repeated in order to capture multiple measures. Note that there is considerable flexibility to tailor the questions to specific types of applications and programs.

1. Since your participation in the <PROGRAM>, did you implement any ADDITIONAL energy efficiency improvements at this facility or at your other facilities within <PROGRAM ADMINISTRATOR>'s service territory that did NOT receive incentives through <PROGRAM>?

2. What measures did you implement without an incentive?

MEASURE-SPECIFIC QUESTIONS [repeated for each spillover measure][37]

1. How important was your experience in the <PROGRAM> in your decision to implement this <MEASUREX>? Please use a scale of 0 to 10, where 0 is not at all important and 10 is extremely important.
2. Can you explain how your experience with the <PROGRAM> influenced your decision to install this additional high-efficiency measure?
3. If you had not participated in the <PROGRAM>, how likely is it that your organization would still have implemented <MEASURE>? Please use a 0 to 10, scale where 0 means you definitely WOULD NOT have implemented this measure and 10 means you definitely WOULD have implemented this measure.
4. How many of <MEASURE> did you install?
5. Questions to further define the measure (as applicable):
    a. Type
    b. Efficiency
    c. Size
    d. Other attributes
6. Can you briefly explain why you decided to install this energy efficiency measure on your own, rather than going through the <PROGRAM>?

3.2.1.1.4 Reporting of Results

Evaluators will report the following information relating to participant spillover data collection and analysis in annual EM&V reporting: 1) the number of participants surveyed; 2) the number of survey respondents reporting spillover; 3) the number of survey respondents who meet the spillover attribution threshold; 4) the number of respondents for which spillover savings were actually quantified; 5) the spillover savings for each project and overall; and 6) the spillover rate. The term (1-Free Ridership) is referred to as the Core NTGR.

The annual EM&V report should also describe the means by which the participant spillover rate is calculated. Two possible approaches are:

(1) Add the participant spillover rate to each project's Core NTGR. The project-level NTGRs are then weighted by each project's ex ante or ex post (if available) gross savings as a share of the total. This savings-weighted NTGR can then be applied to the ex post gross savings of the participant population. If the sample is stratified, sampling weights must be applied before applying the NTGR to the ex post gross savings of the participant population.

(2) Estimate program spillover effects by summing overall project-level spillover estimates for the sample and dividing this sum by the total ex ante or ex post (if available) gross savings for the sample to produce the participant spillover rate. This participant spillover rate can be added to the Core NTGR for the sample to yield the NTGR. If the sample is stratified, sampling weights must be applied before applying the NTGR to the ex post gross savings of the participant population.

In both cases, the participant spillover rate must be calculated at the project level for Option 1 or at the program level for Option 2, using the following formula.

[37] Example questions to gather engineering information to support the calculation of spillover savings may be accessed here: http://www.ilsag.info/il_ntg_methods.html

$$Participant\ Spillover\ Rate = \frac{ISO + OSO\ in\ sample}{Ex\ Post\ Gross\ Impacts\ in\ sample}$$

Where:

ISO = Inside participant spillover

OSO = Outside participant spillover

3.2.1.2 Nonparticipant Spillover

The evaluation may perform research to measure nonparticipant spillover. Guidelines for the assessment of nonparticipant spillover may be added to this document in the future. Evaluators will make efforts to ensure that there is no double-counting of energy savings across multiple sources and will document those efforts.

3.3 Small Business Protocol

3.3.1 Free Ridership

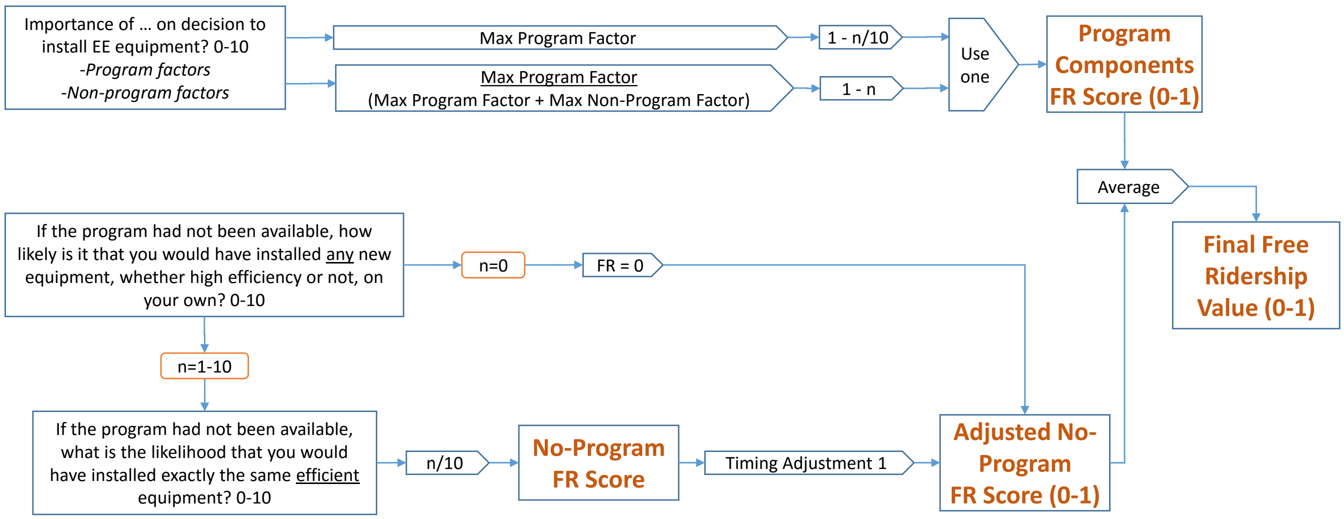
The FR algorithm for non-residential small business programs will follow the Core Non-Residential FR Protocol, with the following exceptions:

1. To reduce respondent burden, the Program Influence FR Score may be dropped from the Small Business FR algorithm. The influence of non-program factors will still be captured in the Program Components FR Score.
2. The counterfactual likelihood question (likelihood the participant would have installed the exact same energy efficiency equipment absent the program) may be preceded with a 0-10 scale question about the likelihood the participant would have installed any new equipment—either standard efficiency or high efficiency—on their own.
   a. If the participant provides a likelihood response of 0, then the No-Program FR Score for that participant is set to 0.
   b. If the participant provides a likelihood response of 1-10, then the participant is asked the same counterfactual questions (including the first timing question) as in the Core Non-Residential FR protocol.
3. To reduce respondent burden, the second question about timing (likelihood the participant would have installed the exact same energy efficiency equipment within 12 months) may be dropped. In this case, the only Deferred Free Ridership specification would be the one applying Timing Adjustment 1.

The diagram below, Figure 3-4, depicts the Small Business FR approach with exceptions 1 and 3 above implemented.

Figure 3-4. Small Business Free Ridership

(Program Components FR Score + (No-Program FR Score * Timing Adjustment 1)) / 2



Evaluators will calculate free ridership scores for small business projects as follows:

If Program Influence FR Score is dropped:

FR = AVERAGE ([Program Components FR Score], [No-Program FR Score * Timing Adjustment 1])

If Program Influence FR Score is included:

FR = AVERAGE ([Program Components FR Score], [Program Influence FR Score], [No-Program FR Score * Timing Adjustment 1])

Evaluators will develop estimates of free ridership based on the two Program Components FR Score specifications outlined in the Core Non-Residential FR protocol. Evaluators will select one of these for purposes of calculating the annual incremental energy savings for comparing to the legislated goal. Evaluators will present the results of both estimates of free ridership in EM&V reporting.

3.4 C&I New Construction Protocol

3.4.1 Free Ridership

The FR algorithm for non-residential new construction programs will follow the Core Non-Residential FR protocol, with the following exception:

- The concept of project timing and deferred free ridership is not applicable to new construction projects.[38] As a result, the various deferred free ridership specifications outlined in Figure 3-1, Figure 3-2, and Figure 3-3 will not be included in the free ridership estimation for new construction projects.

[38] New Construction programs intervene in the early phases of ongoing construction projects (i.e., after the decision to build has been made). As a result, participation in a New Construction program would not be expected to accelerate the construction of the new building.

Evaluators will calculate free ridership values for new construction projects as follows:

FR = AVERAGE ([Program Components FR Score], [Program Influence FR Score], [No-Program FR Score])

Evaluators will develop estimates of free ridership based on the two Program Components FR Score specifications outlined in the Core Non-Residential FR protocol and will select one of these for purposes of calculating the annual incremental energy savings for comparing to the legislated goal. Evaluators will present the results of both estimates of free ridership in EM&V reporting.

3.5 Study-Based Protocol

3.5.1 Free Ridership

The FR algorithm for non-residential study-based programs (See Figure 3-5) will follow the Core Non-Residential FR protocol, with the following exceptions:

- The counterfactual likelihood question (Q.4 in Figure 3-6 and Figure 3-7, below) will be preceded by five questions.[39]
- Q.1 A 0-10 scale question about the likelihood that the participant would have conducted the study absent the program will be included.

At the measure-group level, the following should be included:

- Q.2a A yes/no question to determine if the participant performs regular maintenance on the equipment treated through the program
- Q.2b If the response to Q.2a is “yes,” a yes/no question to determine if the maintenance always includes the treatment provided through the program
- Q.3a A yes/no question to determine if the participant had prior awareness of the performance issues identified through the study
- Q.3b A 0-10 scale question about the participant’s level of familiarity with the recommended actions to rectify the performance issue.

The counterfactual likelihood question (Q.4 – likelihood the participant would have taken action absent the program) and the first counterfactual timing question (used to develop Timing Adjustment 1) will be asked at the measure-group level. Measure-group level responses will be aggregated to the project level, using savings-based weights.

There will be two options for developing the No-Program FR Score:

1. The measure-group level Adjusted No-Program FR Score will be developed following Algorithm 1 of the Core Non-Residential FR approach, using responses to the counterfactual likelihood question (Q.4) and Timing Adjustment 1.
2. The measure-group level No-Program FR Scores will be assigned, based on responses to Q.1, Q.2b, Q.3a, and Q.3b, as follows:
    a. If Q.2b = Yes, then No-Program FR Score = 1. This assumes that if the participant performs regular maintenance on the treated equipment and that maintenance always includes the issue

[39] It should be noted that the question numbering in Figure 3-6 and Figure 3-7 is for reference purposes only; the additional questions do not have to immediately precede the counterfactual likelihood question.

addressed through the program, then the participant is a full free rider for that measure group for purposes of calculating the No-Program FR Score.

b. If Q.3a = No and Q1 = 0 and Q.2b ≠ Yes, then No-Program FR Score = 0. This assumes that if the participant was not aware of the performance issue and had a zero likelihood of performing the study absent the program and their maintenance practices do not always include the issue addressed through the program, then the participant is not a free rider for that measure group for purposes of calculating the No-Program FR Score since they would not have found out about the issue absent the program.

c. If Q.3b = 0 and Q1 = 0 and Q.2b ≠ Yes, then No-Program FR Score = 0. This assumes that if the participant had no familiarity with how to rectify the performance issue, had a zero likelihood of performing the study absent the program, and their maintenance practices do not always include the issue addressed through the program, then the participant is not a free rider for that measure group for purposes of calculating the No-Program FR Score since they would not have known how to address the issue absent the program.

d. For all other combinations of responses to Q.1, Q.2b, Q.3a, and Q.3b, the measure-group level Adjusted No-Program FR Scores will be developed following Algorithm 1 of the Core FR approach, using responses to the counterfactual likelihood question (Q.4) and Timing Adjustment 1.

Figure 3-5. Study-Based Free Ridership—Overview

(Program Components FR Score + Program Influence FR Score + (No-Program FR Score * Timing Adjustment 1)) / 3

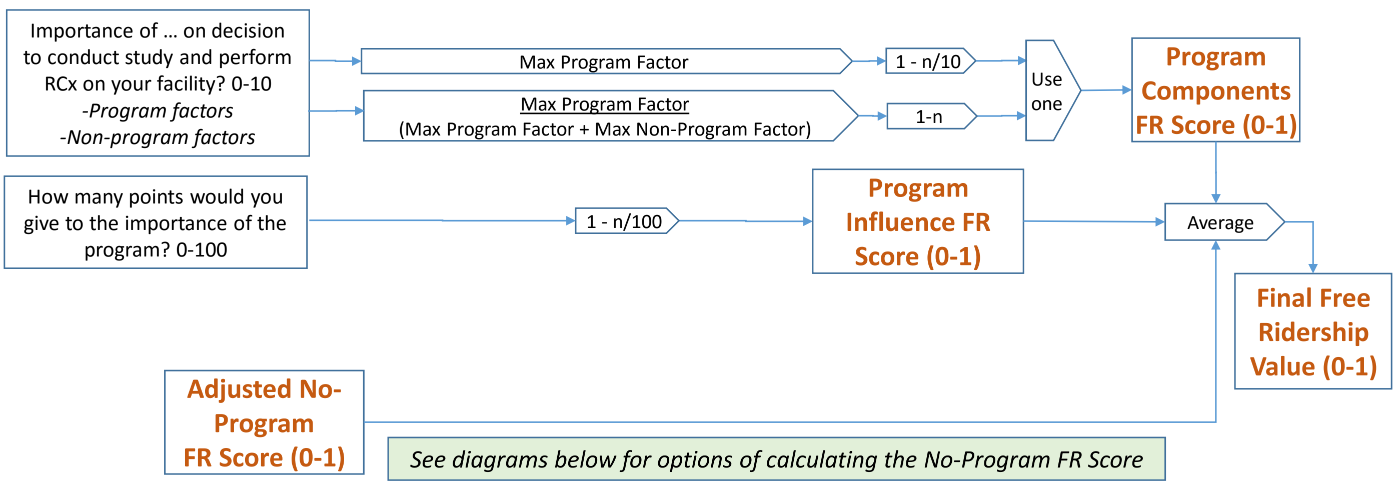


Figure 3-6. Study-Based Free Ridership—No-Program FR Score Option #1

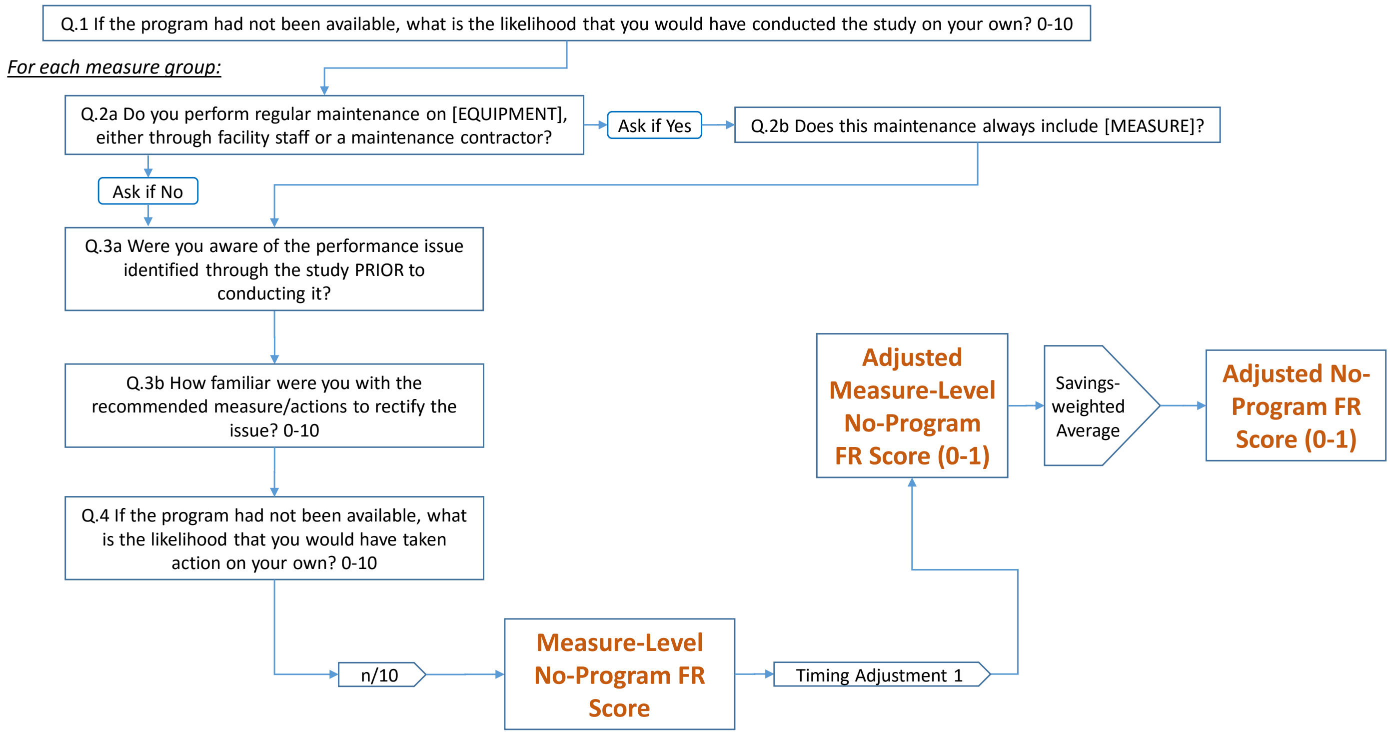
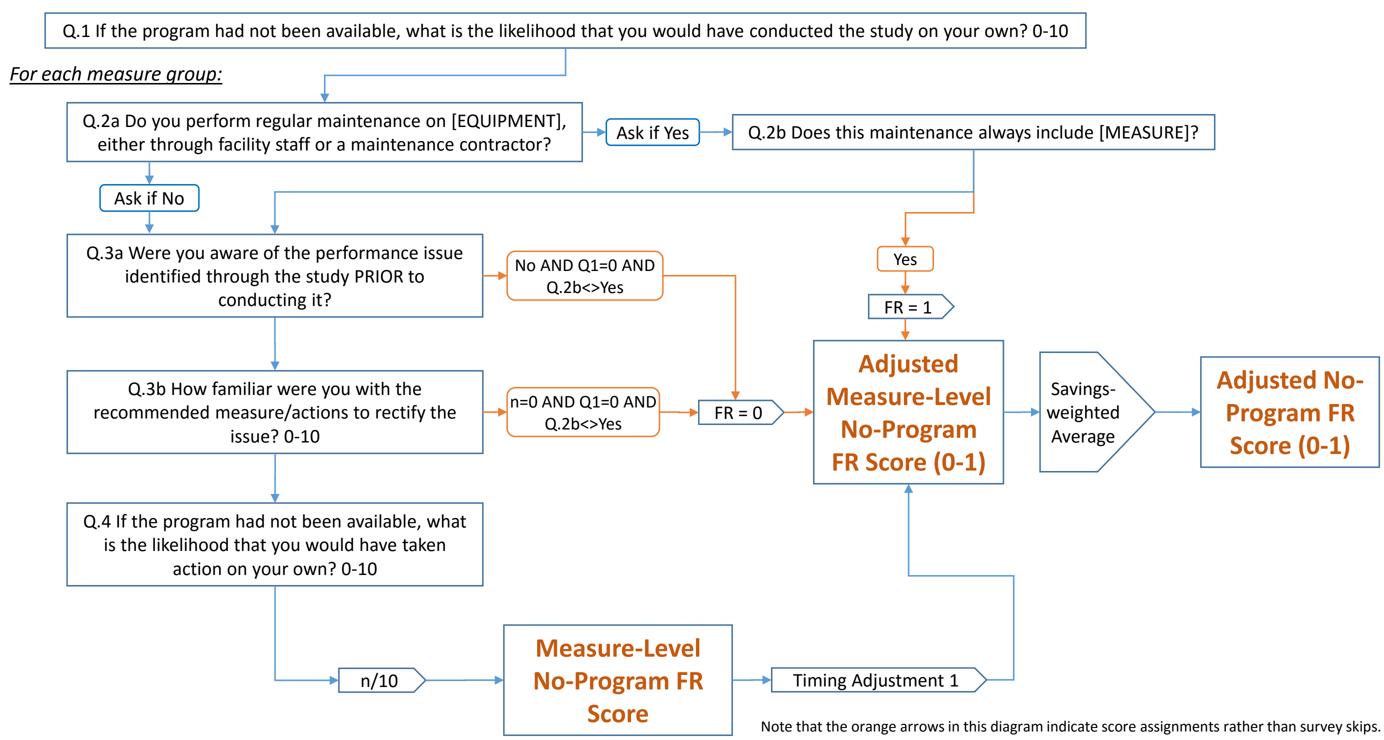


Figure 3-7. Study-Based Free Ridership—No-Program FR Score Option #2



Evaluators will calculate free ridership values for study-based programs as follows:

FR = AVERAGE ([Program Components FR Score], [Program Influence FR Score], [No-Program FR Score * Timing Adjustment 1])

Evaluators will develop estimates of free ridership based on the two No-Program FR Score options outlined above and the two Program Components FR Score specifications outlined in the Core Non-Residential FR protocol. Evaluators will select one of these for purposes of calculating the annual incremental energy savings for comparing to the legislated goal. Evaluators will present the results of both estimates of free ridership in EM&V reporting.

3.6 Training and Technical Assistance Protocol

This protocol is applicable to programs that provide training or technical assistance to encourage the adoption of energy efficiency measures in non-residential facilities, but do not provide financial incentives.

3.6.1 Program-Attributable Savings

Program-attributable savings are defined as energy savings resulting from the implementation of energy efficiency measures that were facilitated by assessment or technical assistance provided by the program and which did not receive a financial incentive through an Illinois energy efficiency program.

3.6.2 Research Methods

Data collection approach. An initial determination of program-attributable savings may be made based on self-reported findings from surveys of program participants. At a minimum, surveys collecting data pertaining to participant measure implementation will obtain general information on the specific measures installed and information substantiating their attribution to the program. Research on the specific characteristics of the energy-efficient equipment installed and the baseline and operating conditions needed to estimate savings may be done in one of two ways: 1) a detailed battery of measure specific questions may be administered as part of the initial survey; or 2) a separate in-depth follow-up interview may be conducted by the engineer or analyst responsible for the energy savings calculation. These collected data may be augmented by detailed facility and measure characteristics if provided by program staff.

3.6.2.1 Approach for Identifying and Quantifying Program-Attributable Savings

Attribution Threshold Condition. Program-attributable cases are identified using a threshold approach, in which certain conditions must be met in order to qualify as a program-attributable measure. The threshold condition for program attribution is based on responses to the following two survey questions:

1. How important was the information and/or assistance you received through the <PROGRAM NAME> in your decision to implement this measure, using a scale of 0 to 10, where 0 is NOT AT ALL IMPORTANT and 10 is EXTREMELY IMPORTANT?
2. If you had not received the information and/or assistance through the <PROGRAM>, how likely is it that your organization would still have implemented this measure, using a 0 to 10, scale where 0 means you definitely WOULD NOT have implemented this measure and 10 means you definitely WOULD have implemented this measure?

The response to the first question cited above is Measure Attribution Score 1, and the response to the second question cited above is Measure Attribution Score 2. An implemented measure is considered to be attributable to the program if the “Attribution Score” is greater than 7.0. The “Attribution Score” is defined as follows:

Attribution Score = (Measure Attribution Score 1 + (10 – Measure Attribution Score 2))/2

The implemented measure is considered attributable to the program if the average of the Measure Attribution Score 1 and (10 – Measure Attribution Score 2) exceeds 7.0; either the Measure Attribution Score 1 or (10 – Measure Attribution Score 2) could be below 7.0—as long as the average is greater than 7.0, the threshold is met.

If the Attribution Score is greater than 7.0, 100% of the measure savings referenced in the question are considered to be attributable to the program. If the Attribution Score is equal to or less than 7.0, none of the measure savings are considered to be attributable to the program.

Calculation of Attributable Measure Energy Savings. Energy savings of program-attributable measures shall be calculated in one of two ways.

1. Those addressed in the IL-TRM shall be calculated in accordance with the methods and algorithms specified in the IL-TRM, and shall reference the appropriate IL-TRM-defined Time of Sale or New Construction baseline.
2. For measures not addressed in the IL-TRM, evaluators shall quantify savings using accepted industry-wide savings methods that conform to IPMVP and other industry protocols. All calculations should be done in a transparent manner that meets annual reporting requirements. The IPMVP protocols are to be used under the following situations: 1) the measure is non-standard and/or not directly addressed by the IL-TRM; (2) the expected energy savings are large; or 3) the evaluator believes that the precision of savings estimates would be substantially improved by its application.

Evaluators will make every effort to ensure that there is no double-counting of program-attributable energy savings across multiple sources of participant and nonparticipant spillover reporting (such as participating customer and trade ally surveys).

3.6.2.2 Reporting of Results

Evaluators will report the following information relating to data collection and analysis in annual EM&V reporting: 1) the number of participants surveyed; 2) the number of participants that implemented measures during the program year; 3) the number of survey respondents who meet the attribution threshold; 4) the number of respondents for which program-attributable savings were actually quantified; 5) the program-attributable savings for each project and overall; and 6) the total program-attributable savings.

Total program-attributable savings will be calculated in one of two ways. For programs that collect data on implemented projects and associated expected energy savings, total program attributable savings will be calculated by weighting the sum of verified program-attributable savings by the ratio of total program reported savings to sampled project savings. For programs that do not report projects implemented by program participants, total program-attributable savings will be calculated by weighting the sum of verified program-attributable savings by the ratio of total program participants to sampled program participants.

4 Residential and Low Income Sector Protocols

The table below lists Illinois residential programs and the NTG protocol applicable to each program.[40] If the design of a given program changes significantly, then it may mean that the NTG protocol listed for that program in this document is no longer appropriate. If that happens, the evaluator should follow the procedures outlined in Section 1.4: Diverging from the IL-NTG Methods.

Table 4-1. Residential and Low Income Programs

Program Administrator	Free Ridership Protocol	Program Name
Ameren Illinois	4.2 Appliance Recycling Protocol	Appliance Recycling
	4.3 Residential Upstream Lighting Protocol	Upstream Lighting
	4.4 Prescriptive Rebate (With No Audit) Protocol	Heating and Cooling
	4.5 Single-Family Home Energy Audit Protocol	All Electric Homes (Single Family)
		Home Performance with Energy Star
	4.6 Multifamily Protocol	All Electric Homes (Multifamily-Major Measures)
		Multifamily (In-Unit, Common Area and Major Measures)
	4.7 Energy Saving Kits and Elementary Education Protocol	Direct Mail Kits
		School Kits
	4.8 Residential New Construction Protocol	ENERGY STAR New Homes
	5.1 Behavioral Protocol	Behavior Modification
	NTG=1†	Moderate Income
ComEd	4.2 Appliance Recycling Protocol	Fridge and Freezer Recycling
	4.3 Residential Upstream Lighting Protocol	Lighting Discounts
	4.4 Prescriptive Rebate (With No Audit) Protocol	Appliance Rebates
		Heating and Cooling Rebates
		Weatherization Rebates
	4.5 Single-Family Home Energy Audit Protocol	Home Energy Assessments
	4.6 Multifamily Protocol	Elevate Energy Multifamily All Electric (In-Unit, Common Area and Major Measures)
		Residential Multifamily
	4.7 Energy Saving Kits and Elementary	Community-based CFL Distribution

[40] The "Free Ridership Protocol Name" in the second column of the table refers to the numbered sections in this document, e.g., "4.6 Multifamily Protocol."

Program Administrator	Free Ridership Protocol	Program Name
	Education Protocol	Direct to Consumers Kits
		NTC Middle School Take Home Kits
		SuperSavers – Elementary Education Kits
	4.8 Residential New Construction Protocol	Residential New Construction
	5.1 Behavioral Protocol	Cub Energy Saver
		Home Energy Reports (Opower)
		Power Smart Reports
		Shelton Solutions Great Energy Stewards
	NTG=1†	Low-Income Kit Energy (LIKE)
	NTG=1†	Low-Income Multi-Family
Department of Commerce	4.7 Energy Saving Kits and Elementary Education Protocol	Energy Smart Schools
	NTG=1†	Affordable Housing Construction Program
	NTG=1†	Public Housing Authority Efficient Living Program
	NTG=1†	Residential Retrofit (Low Income)
Nicor	4.4 Prescriptive Rebate (With No Audit) Protocol	Home Energy Efficiency Rebates
	4.5 Single-Family Home Energy Audit Protocol	Home Energy Savings
	4.6 Multifamily Protocol	Multifamily Home Energy Savings
	4.7 Energy Saving Kits and Elementary Education Protocol	Elementary Energy Education
		Kits
	4.8 Residential New Construction Protocol	Residential New Construction
	5.1 Behavioral Protocol	Behavioral Energy Savings
Peoples Gas/ North Shore Gas	4.4 Prescriptive Rebate (With No Audit) Protocol	Home Energy Rebates
	4.5 Single-Family Home Energy Audit Protocol	Home Energy Jumpstart
	4.6 Multifamily Protocol	MF Custom
		MF Partner Trade Ally
		MF Prescriptive
		Multifamily (Direct Install)
	4.7 Energy Saving Kits and Elementary Education Protocol	Elementary Energy Education
	5.1 Behavioral Protocol	Home Energy Reports

Program Administrator	Free Ridership Protocol	Program Name
All	5.2 Code Compliance Protocol	Statewide Codes Collaborative

† The Uniform Methods Project notes that “most low-income programs are not subject to NTG analysis (that is, are deemed at 1.0).” In line with that common practice, there is general consensus among Illinois stakeholders that the Illinois low-income programs should not be subject to NTG analysis and thus the NTG ratios for low-income programs are effectively deemed at 1.0. See Violette and Rathbun (2014), Chapter 23: Estimating Net Savings: Common Practices. The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures, available electronically at http://www.nrel.gov/docs/fy14osti/62678.pdf, p. 50.

4.1 Residential Cross-Cutting Approaches

The approaches in this section can apply to more than one program type but do not supersede program-specific approaches presented in later sections.

4.1.1 Survey Design Issues

Free ridership questions should be asked near the beginning of a participant survey, before asking satisfaction questions. This should prevent participants from confusing free ridership questions with the satisfaction questions, which would result in an artificially high free ridership score, especially for participants highly satisfied with the measures.

4.1.2 Participant Spillover

Effective program marketing and outreach generates program participation and increases general energy efficiency awareness among customers. Spillover can be calculated using participant survey questions, which ask participants about energy-savings actions they have taken on their own since participating in the program. Questions should be sufficiently specific to ensure energy savings associated with spillover can be reasonably well-quantified. These may include questions about measure types or measures installed, quantities, and efficiency levels. When program implementers provide recommendations to participants and can provide data on the types of recommendations made to specific participants, evaluations should attempt to determine whether participants took the recommended actions outside of the program at sites within the program administrator’s service territory; if so, savings from those recommended actions should be attributed to the program.

To reduce the respondent’s burden, the survey should first ask participants about the influence the program had on their decision to take additional energy-saving actions on their own. In particular, the evaluation team should ask two close-ended questions to determine program influence on spillover actions. The two required questions, preceded by an optional open-ended warm-up question, are:

- OPTIONAL: Did the program influence you in any way to make these additional improvements?

1. How important was your participation in the <PROGRAM ADMINISTRATOR’S> program on your decision to make additional energy efficiency improvements on your own? [Scale from 0-10 where 0 is “not at all important” and 10 is “extremely important”]
2. If you had not participated in the <PROGRAM ADMINISTRATOR’S> program, how likely is it that you would still have implemented this measure, using a 0 to 10, scale where 0 means you definitely WOULD NOT have implemented this measure and 10 means you definitely WOULD have implemented this measure?

The response to the first required question cited above is “Measure Attribution Score 1,” and the response to the second required question cited above is “Measure Attribution Score 2.” The specific measures referenced in the question are considered to be attributable to the program if the “Spillover Score” is greater than 7.0:

Spillover Score = (Measure Attribution Score 1 + (10 – Measure Attribution Score 2))/2 > 7.0

If these conditions are met, the evaluator determines that the specific measures referenced in the question are attributable to the program; otherwise, the evaluator determines that the specific measures referenced in the question are not attributable to the program. The attribution criterion represents a threshold approach, in which energy impacts associated with measures implemented by program participants outside the program are either 100% program-attributable or 0% program-attributable.

For each measure mentioned, customers will be asked how they know the measure is more efficient than other models. If the respondent can identify the measure as ENERGY STAR or name an efficiency level that the evaluator confirms as being above the minimum federal standard, or if they identify a technology that the evaluator can confirm is above the minimum federal standard, it will count towards Participant Spillover.

Finally, depending on the measure type cited by the customer, follow-up questions should ask customers to provide reasonable information to allow the evaluator to estimate the amount of savings using IL-TRM protocols, such as quantity of appliances or the location and amount of insulation.

To calculate the spillover energy and demand savings for these actions, the appropriate version of the IL-TRM should be used. To develop the spillover rate, the total energy and demand impacts from the sampled participants who installed additional measures due to participation in the program are summed, and then this sum is divided by the total ex post sample energy and demand impacts:

$$Participant\ Spillover\ Rate\ (PSO) = \frac{Sum\ of\ Energy\ or\ Demand\ from\ Additional\ Measures\ Installed}{Sample\ Ex\ Post\ Gross\ Energy\ or\ Demand\ Impacts}$$

The equation used to adjust the Core NTGR based on participant spillover is as follows:

$$NTGR = (1 - FR + PSO)$$

4.1.2.1 Data Collection

Respondents should be drawn from a random sample of current or up to one year of previous program participants. Regardless of the participation year, spillover should be measured within the last 12 months (from the survey date), but after previous participation; the tracking database should supply this information.

4.1.2.2 Data Analysis

The following four steps calculate spillover:

1. Calculate total spillover savings for each participant installing an efficient measure not rebated through the program where the Spillover Score is greater than 7.0:

$$\text{Measure Spillover} = \text{Measure Savings} * \text{Number of Units}$$

2. Total savings associated with each program participant to calculate overall participant spillover savings.

3. $\text{Spillover Percentage Estimate} = \frac{\sum \text{Sample Spillover kWh Savings}}{\text{Sample Evaluated Program kWh Savings}}$

4.1.3 Nonparticipant Spillover Measured Through Trade Allies

In addition to participant free ridership and spillover, residential programs may create nonparticipant spillover (NPSO) through trade allies exposed to the program but not actually facilitating program participation. Rather, they promote and stock higher-efficiency equipment due to the program.[41] NPSO caused by trade allies can be determined by surveying three groups of trade allies:

- Participating trade allies that do not submit rebates or otherwise act as program agents on behalf of their customers. For this group, care should be taken to ensure spillover is not double-counted with program sales.
- "Drop out" trade allies, who participated in the program previously but have not participated in the past 12 months.
- True nonparticipating trade allies that report they were aware of the program but had never participated.

Surveys ask nonparticipating trade allies if the program influenced their sales of high-efficiency equipment to nonparticipating customers and to quantify the program's impact on their high-efficiency sales. The general questions take the following form:

- Q.1: How many <measures> did you sell in <period>?
- Q.2: How many of them were <efficiency level> or higher?
- Q.3: Had the <program> not existed, how many <measures> do you think you would have sold?

Evaluators should ensure that trade allies receive sufficient time to collect specific data and not rely on "guesses" to respond. Additional questions should be included to document how the program influenced sales of additional measures and to determine whether the responses to Question 3 should be included as NPSO. Responses should also clarify whether sales counts are specific to the utility service territory in question.

The following steps calculate the program's nonparticipant trade ally spillover percentage:

1. Compute the difference between the total reported number of high-efficiency units sold and the total that would have been sold in the program's absence to obtain the total number of spillover units for that trade ally.
2. Multiply the total net number of spillover units of each measure sold by each surveyed trade ally by the average gross unit savings for each measure type.
3. Sum the result for each contractor from the previous step, and weight the results by the ratio of the population of non-active trade allies to the sample to compute the total spillover energy over the program period.
4. Divide the spillover energy savings by program gross savings.

4.1.4 Nonparticipant Spillover Measured from Customers

The evaluation may perform research on the general population to measure nonparticipant spillover (NPSO). If so, care should be taken to ensure spillover is not double-counted with a trade-ally approach. The basic method uses a general population survey. An enhanced method for estimating spillover would use site visits to verify and gather information to estimate spillover savings in cases where significant spillover is reported by nonparticipants.

---

[41] NPSO also can arise from nonparticipating customers as a direct result of general energy efficiency education and promotion efforts. A separate protocol addresses such NPSO. Care should be taken to ensure the different approaches do not double-count NPSO.

4.1.4.1 Basic Method

4.1.4.1.1 Sampling

As spillover may be rare in the general, nonparticipating population, determining spillover will likely require a large sample of customers who have not participated in any energy efficiency programs, including a behavioral program, within the past three years. Customers will be removed from the sample frame if their account numbers can be cross-referenced against a list of program participants from the previous three years. The survey should target household members responsible for paying utility bills.

4.1.4.1.2 Measures-Specific Questions

Depending on the spillover measure type reported by the customer, follow-up questions should be included to gather sufficient information to reasonably assess the saving amount by applying the IL-TRM, understanding that assumptions must be made if IL-TRM inputs cannot be easily supplied by the participant. Such assumptions should be conservative, or, if not conservative, reasons for deviating from the conservative application should be documented. Measures that cannot be reasonably quantified within available evaluation budgets should be excluded from spillover calculations.

For measures included in the IL-TRM, savings will be assessed using the IL-TRM algorithms. Baselines for measures not in the IL-TRM will be assessed based on appliance standards and building codes, if applicable, and, if not, through engineering judgements of existing or market conditions. Engineering assumptions and analysis by the evaluator will be applied for measures not included in the IL-TRM. Key assumptions should be documented in the report.

4.1.4.2 Attribution Approach

To receive credit for energy savings, the nonparticipant must fit the following criteria: (1) be familiar with the Program Administrators energy efficiency campaign (e.g., ActOnEnergy for Ameren); and (2) indicate that some aspect of the Program Administrator's energy efficiency programs motivated their purchasing decisions. Influence will be measured on a scale of 0 to 10, where 10 is very influential and 0 is not at all influential. Savings attribution requires a Spillover Score of greater than 7.0.

Survey respondents will be asked series of questions following the logic shown in Figure 4-1. First, the customer will indicate whether they know about their Program Administrator's energy efficiency programs and/or marketing messages. Customers aware of the services will be asked a follow-up question (whether they have participated in a program in the past three years) to confirm their household qualifies as a true nonparticipant. If confirmed as a nonparticipant, the customer will be asked if they or anyone in their household made an energy efficiency improvement within the last year, and if so, what improvements they made. Responses to these questions will generate a list of potential spillover measures (shown at point "[A]" in Figure 4-1). If attribution is established as described further below, for each measure mentioned, customers will be asked how they know the measure is more efficient than other models. If the respondent can identify the measure as ENERGY STAR or name an efficiency level that the evaluator confirms as being above the minimum federal standard, or if they identify a technology that the evaluator can confirm is above the minimum federal standard, it will count towards NPSO.

To assess attribution for each spillover measure mentioned, the customer will be asked questions to be scored in two areas. Spillover may be program-attributable for those measures for which self-report data meet the following threshold condition:

$$\textit{Spillover Score} = (\textit{Attribution Score 1} + (10 - \textit{Attribution Score 2}))/2 > 7.0$$

4.1.4.2.1 Attribution Score 1

The first score, "Attribution Score 1," measures the influence level (on a scale of 0 to 10, where 10 is very influential and 0 is not at all influential) their Program Administrator had on the decision to purchase the measure.

Influence can derive from the following:

1. General information about energy efficiency provided by the Program Administrator.
2. Word-of-mouth from people installing energy-efficient equipment and receiving a rebate from the Program Administrator.
3. Personal experience with a previous Program Administrator rebate program (longer than three years ago).
4. Information from a contractor or retailer communicating about the Program Administrator's programs.

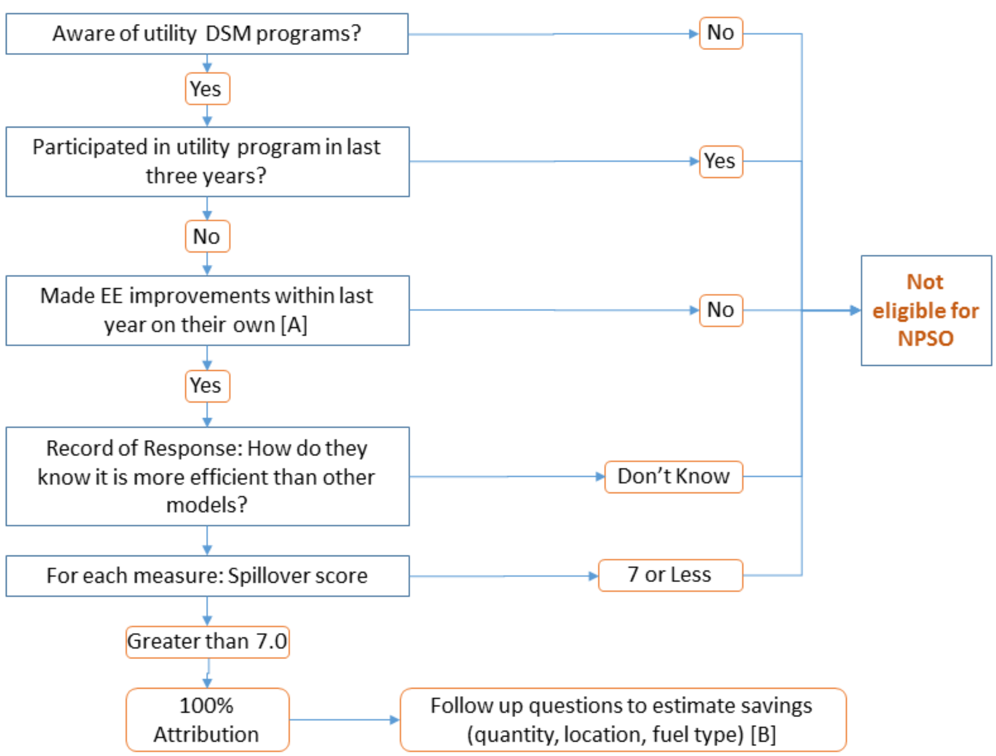
4.1.4.2.2 Attribution Score 2

The second score, "Attribution Score 2," comes from the customer's response to a single question to assess the counterfactual, asking about the likelihood (on a scale of 0 to 10, where 10 is highly likely and 0 is not at all likely) that the customer would have installed the measure had they not been influenced by the program.

The Spillover Score is then the average of the Attribution Score 1 and (10 – Attribution Score 2). If that Spillover Score is greater than 7.0, 100% of the savings are attributed to the Program Administrator for that measure.

Finally, depending on the measure type cited by the customer, follow-up questions will gather information to enable an estimate of savings (shown in the figure as [B]), such as quantity of appliances or the location of insulation.

Figure 4-1. NPSO Question Logic



4.1.4.3 Scoring

Survey respondents' answers to the NPSO questions will determine total energy and demand savings attributed to the program. Table 4-2 lists NPSO measures under column A, the Spillover Score under column B, the estimated measure savings under column C, the percentage of allocated savings under column D, and the total allocated savings under column E. Column F shows the calculated average energy savings per spillover measure, determined by dividing the total allocated savings (the sum of column E) by the number of surveyed nonparticipating customers. The table shows how kWh NPSO savings would be calculated; calculations of therm or demand savings would be accomplished in the same manner.

Table 4-2. Estimation of Respondents' NPSO Savings

A	B	C	D	E	F
Spillover Measure	Spillover Score	Measure Savings (kWh)	Allocated Savings	Total kWh Savings	Average kWh Per Surveyed Customer
Measure1	Scale of 0 to 10	Savings1	100% if [B] > 7.0	[C] x [D]	N/A
Measure2	Scale of 0 to 10	Savings2		[C] x [D]	
MeasureN	Scale of 0 to 10	SavingsN	0% if [B] ≤ 7.0	[C] x [D]	
				Sum of column E = Total kWh Savings	Total kWh Savings ÷ Number of Completed Surveys

Table 4-3 shows the process for estimating total NPSO generated by the Program Administrator during the program year (for electric savings). The savings attributed from the survey population will be extrapolated to the nonparticipating residential customer population to determine the overall NPSO savings. Then NPSO energy savings will be converted into a percentage using the total evaluated electric savings for the program year. A similar process would apply for calculating therm or demand NPSO.

Table 4-3. Calculation of Total NPSO Generated

Variable	Description	Source/Calculation
F	Average kWh Energy Savings per Surveyed Customer	Survey data and impact evaluation
J	Total Nonparticipating Residential Population	Customer database
K	NPSO MWh Energy Savings Extrapolated to Nonparticipating Population	[F × J] ÷ 1,000 kWh/MWh
S	Total Evaluated MWh Savings	Residential Portfolio Savings
G	NPSO Spillover Rate	K ÷ S

4.2 Appliance Recycling Protocol

Appliance recycling programs (ARPs) typically offer some mix of incentives and free pickups for the removal of old but operable refrigerators, freezers, or room air conditioners. These programs encourage consumers to undertake the following:

- Discontinue use of secondary or inefficient appliances;
- Relinquish appliances previously used as primary units upon their replacement (rather than keeping the old appliance as a secondary unit); and
- Prevent the continued use of old appliances in other households through direct transfers (i.e., giving it away or selling it) or indirect transfers (resale in the used appliance market).

As the program theory and logic for appliance recycling differ significantly from standard "downstream" incentive programs (which typically offer rebates for purchases of efficient products), the free ridership estimation approach also significantly differs.

The basic and enhanced methods are described next.

4.2.1 Basic Method

4.2.1.1 Free Ridership

Free ridership is based on participants' anticipated plans had the program not been available, thus classifying a free rider as a participant who would have removed the unit from service regardless of the program.

Estimating net savings for ARPs should adopt a multistep process to segment participants into different groups, each with specific attributable savings.

In general, independent of program intervention, participating appliances would have been subject to one of the following options:

1. The appliance would have been kept by the participating household.
2. The appliance would have been discarded in a way that transfers the unit to another customer for continued use.
3. The appliance would have been discarded in a way that would have permanently removed the unit from service.

Only Option 3 constitutes free ridership (the proportion of units that would have been taken off the grid absent the program). Options 1 and 2 both indicate non-free riders. However, these respondents need to be further classified to account for potential induced replacement and secondary market impacts, both described below.

4.2.1.1.1 Data Collection

A participant survey—drawn from a random sample of participants—will serve as the primary source of data collected for estimating NTG for the ARP. To determine the percentage of participants in each of the three options, evaluators will begin by asking surveyed participants about the likely fate of their recycled appliance had it not been decommissioned through the program. Responses provided by participants generally can be categorized as follows:

1. Kept the appliance.
2. Sold the appliance to a private party (either an acquaintance or through a posted advertisement).
3. Sold or gave the appliance to a used-appliance dealer.
4. Gave the appliance to a private party, such as a friend or neighbor.
5. Gave the appliance to a charity organization, such as Goodwill Industries or a church.
6. Had the appliance removed by the dealer from whom the new or replacement appliance was obtained.
7. Hauled the appliance to a landfill or recycling center.
8. Hired someone else to haul the appliance away for junking, dumping, or recycling.

Additional, follow-up questions will be included to validate the viability of all responses.

Next, evaluators will assess whether each participant's final response indicates free ridership:

- Some final responses clearly indicate free ridership, such as: "I would have taken it to the landfill or recycling center myself."
- Other responses clearly indicate no free ridership, as when the appliance would have remained active within the participating home ("I would have kept it and continued to use it") or used elsewhere within

the Program Administrator's service territory ("I would have given it to a family member, neighbor, or friend to use").

If the respondent planned to have the unit picked up by the retailer and the retailer would likely resell the unit in the secondary market, they are not a free rider. Absent retailer survey primary research described in the Enhanced Options below, the evaluators will utilize data from the most recent research conducted of the ComEd program to determine the proportion of free riders unless another metric is mutually agreed upon by the evaluators.[42]

Secondary Market Impacts

In the event that the unit would have been transferred to another household (Option 2 above), the question then becomes what purchasing decisions are made by the would-be acquirers of participating units now that these units are unavailable. Such would-be acquirers could:

1. Not purchase/acquire another unit.
2. Purchase/acquire another used unit.

Adjustments to savings based on these factors are referred to as the program's secondary market impacts.

If it is determined that the participant would have directly or indirectly (through a market actor) transferred the unit to another customer on the grid, the next question addresses what that potential acquirer did because that unit was unavailable. There are three possibilities:

A. **None of the would-be acquirers would find another unit.** That is, program participation would result in a one-for-one reduction in the total number of appliances operating on the grid. In this case, the total energy consumption of avoided transfers (participating appliances that otherwise would have been used by another customer) should be credited as savings to the program. This position is consistent with the theory that participating appliances are essentially convenience goods for would-be acquirers. (That is, the potential acquirer would have accepted the appliance had it been readily available, but because the appliance was not a necessity, the potential acquirer would not seek out an alternate unit.)

B. **All of the would-be acquirers would find another unit.** Thus, program participation has no effect on the total number of appliances operating on the grid. This position is consistent with the notion that participating appliances are necessities and that customers will always seek alternative units when participating appliances are unavailable.

C. **Some of the would-be acquirers would find another unit, while others would not.** This possibility reflects the awareness that some acquirers were in the market for an appliance and would acquire another unit, while others were not (and would only have taken the unit opportunistically).

The evaluators will assume Possibility C unless primary research within a Program Administrator's service territory to assess the secondary appliance market is undertaken as described in the Enhanced Options below. Specifically, evaluators will assume that half (0.5, the midpoint of Possibilities A and B) of the would-be acquirers of avoided transfers found an alternate unit.

Once the proportion of would-be acquirers who are assumed to find alternate units is determined, the next question is whether the alternate unit was likely to be another used appliance (similar to those recycled through the program) or, with fewer used appliances presumably available in the market due to program activity, would the customer acquire a new standard-efficiency unit instead.

---

[42] Note that such retailer interviews are being conducted annually for the ComEd ARP evaluation, and answers are used directly in the calculation of the NTG ratio in cases where: (1) the respondent planned to have the unit picked up by the retailer; and (2) the retailer was interviewed.

4.2.1.2 Induced Replacement

If, however, the unit would have been kept by the participating household, the next question is whether the appliance was replaced and, if so, whether the household would have replaced the appliance regardless of the program.

The purchase of a refrigerator in conjunction with program participation does not necessarily indicate induced replacement. (The refrigerator market is continuously replacing older refrigerators with new units, independent of any programmatic effects.) However, if a customer would have not purchased the replacement unit (put another appliance on the grid) in the absence of the program, the net program savings should reflect this fact. This is, in effect, akin to negative spillover and will be used to adjust net program savings downward.

Estimating the proportion of households induced to replace their appliance should be done through participant surveys. As an example, participants could be asked, “Would you have purchased your replacement refrigerator if the recycling program had not been offered?”

Because an incentive ranging from $35 to $50 is unlikely to be sufficient motivation for purchasing an otherwise-unplanned replacement unit (which can cost $500 to $2,000), it is critical that evaluators include a follow-up question. That question should confirm the participants’ assertions that the program alone caused them to replace their refrigerator. For example, participants could be asked, “Let me be sure I understand correctly. Are you saying that you chose to purchase a new appliance because of the appliance recycling program, or are you saying that you would have purchased the new appliance regardless of the program?”

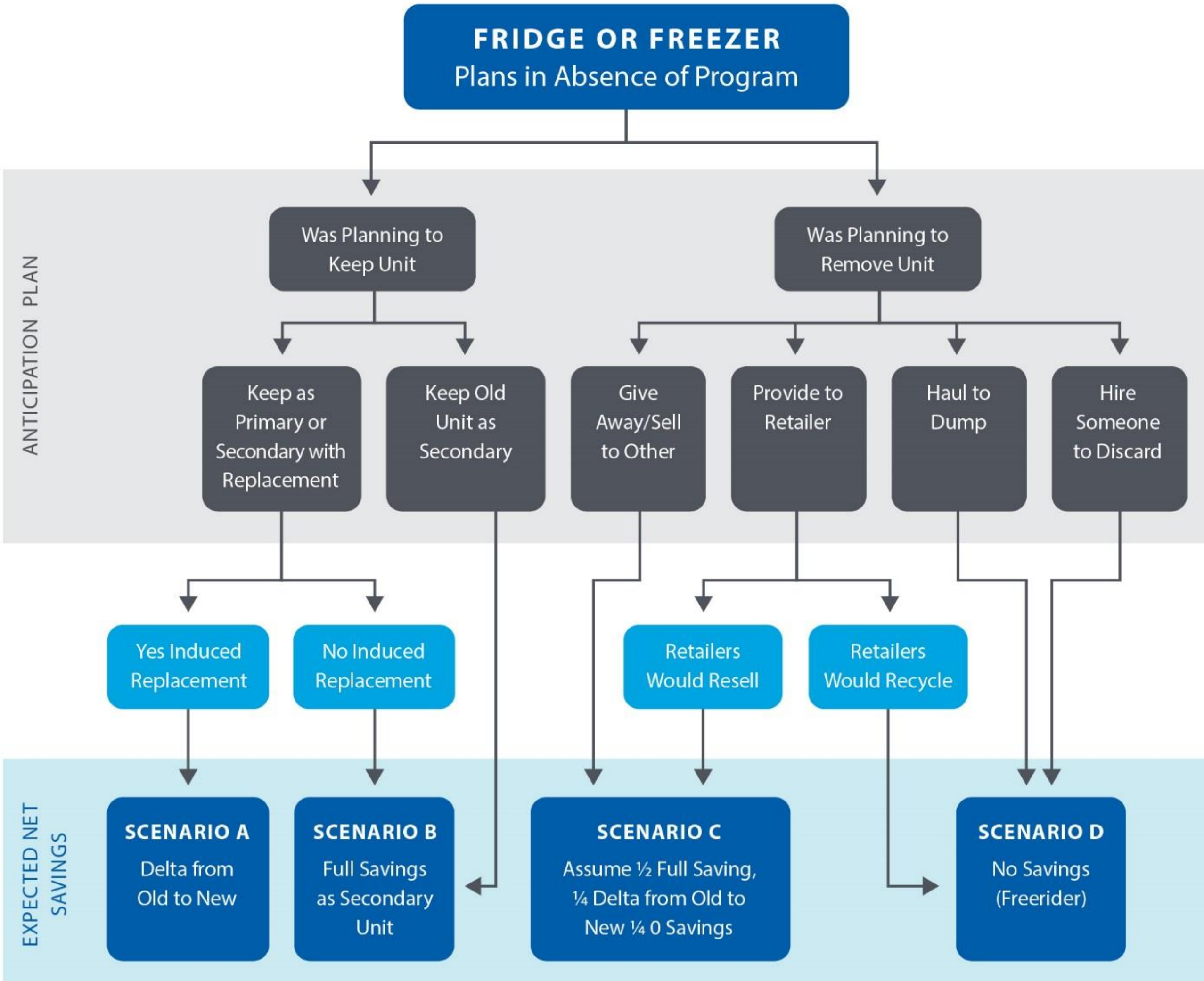
When assessing participant survey responses to calculate induced replacement, evaluators will consider the appliance recycled through the program as well as the participant’s stated intentions in the absence of the program. For example, if customers indicate they would have discarded their primary refrigerator independent of the program, it is not possible that the replacement was induced (because it is extremely unlikely the participant would live without a primary refrigerator). Induced replacement is a viable response for all other usage types and stated intention combinations.

As one might expect, previous evaluations have shown the number of induced replacements to be considerably smaller than the number of naturally occurring replacements unrelated to the program. Once the number of induced replacements is determined, this information is combined with the energy consumption replacement appliance to determine the total energy consumption induced by the program (on a per-unit basis).

4.2.1.3 Integrating Free Ridership, Secondary Market Impacts, and Induced Replacement

The flow chart shown in Figure 4-2Figure illustrates how net savings will be derived for an ARP. As shown, below, expected savings fall into four different scenarios.

Figure 4-2. Appliance Retirement Scenarios



Source: Adapted from the Pennsylvania Statewide Evaluator Common Approach for Measuring Net Savings for Appliance Retirement Programs, Guidance Memo-026, March 14, 2014.

4.2.1.4 Scoring Algorithm

Net savings will be assigned individually to each respondent, based on responses provided to the questions discussed above. Net savings will be averaged across all respondents to calculate program-level net savings. The following equation will be used:

$$FR = (free\ ridership\ and\ secondary\ market\ impacts\ \% - induced\ replacement\ \%)$$

Table 4-4 demonstrates the proportion of a sample population classified into each of the eight potential (Tertiary Classification) categories and the resulting weighted net savings.

Table 4-4. Net Savings Example for a Sample Population*

Primary Classification	Secondary Classification	Tertiary Classification	Population (%)	UEC (kWh) w/out Program	UEC (kWh) w/ Program	kWh Savings
Would have kept unit	Scenario A: Kept but Induced Replacement	Non-ES unit	3%	1,026	520	506
		ES unit	2%	1,026	404	622
	Scenario B: Kept but NO Induced Replacement	N/A	25%	1,026	0	1,026
Would have removed unit	Scenario C1: Transferred No Induced Replacement	N/A	30%	1,026	520	506
	Scenario C2: Transferred With Induced Replacement	Non-ES unit	3.5%	1,026	520	506
		ES unit	3.5%	1,026	404	622
	Scenario D: Removed from Service	Recycled/ Destroyed	20%	0	0	0
		Retailer would Recycle	13%	0	0	0
Net Savings (kWh)						475

*The percent values presented in this table serve only as examples; actual research should be conducted to determine the percentage of units falling into each of these categories. Note that UEC (Unit Energy Consumption) values presented in the table represent example values, factoring in part-use.

4.2.2 Enhanced Method

Results can be enhanced by including three additional research efforts. The basic method has defaults where primary research on enhanced approaches cannot be performed:

1. A retailer survey, to determine the quantity and/or proportion of units returned to a retailer and that the retailer would deconstruct or recycle. Through this survey, one would determine a retailer's criteria for reselling used units vs. deconstructing them, based on unit age and condition. Results from the survey and analysis would be used to determine the proportion of those who would have returned an old appliance

to the retailer that should be included in Scenario D (free riders). This research was conducted for ComEd in EPY6 evaluation and those results were applied to Ameren.

2. An appliance market assessment study to determine the size of the secondary appliance market and whether removal of participating units from the market would cause an otherwise would-be receiver to purchase an alternative used or new unit. Savings attributable to these participants are the most difficult to estimate, as the scenario attempts to estimate what the prospective buyer of a used appliance would do in the absence of finding a program-recycled unit in the marketplace (i.e., the program took the unit off the grid, so the prospective purchaser faced, in theory, a smaller supply of used appliances). It is difficult to answer this question with certainty, absent Program Administrator-specific information regarding the change in the total number of appliances (overall and used appliances specifically) that were active before and after program implementation. In some cases outside of Illinois, evaluators have conducted in-depth market research to estimate both the program's impact on the secondary market and the appropriate attribution of savings for this scenario. Although these studies are imperfect, they can provide Program Administrator-specific information related to the program's net energy impact. Where feasible, evaluators and utilities should design and implement such an approach. Unfortunately, this type of research tends to be cost-prohibitive, or the necessary data may simply be unavailable.
3. However, it is possible to estimate through nonparticipant surveys which of the disposal responses given by nonparticipants were most likely to have been to an opportunistic would-be-acquirer. Transfers that would most likely have been opportunistic are determined primarily based on the cost to the recipient. If the appliance was sold or transferred to a retailer, there would have been a cost to the recipient of that appliance. If the recipient was willing to pay for the appliance or was willing to exert the effort to visit a retail location, this suggests the recipient was actively seeking an appliance. However, if the unit were given away for free, there was little cost to the recipient and it is a reasonable proxy for the proportion of opportunistic acquirers. This proportion would replace the 50% default assumption (scenario C in Figure 4-2Figure) of would-be-acquirers that would or would not find an alternate unit.
4. A nonparticipant survey can be used to assess how nonparticipants acquire and dispose of used units. As nonparticipants do not have the same perceived response bias as participants, they can help offset some of this potential bias in estimating the true proportion of the population that would have recycled their units in program's absence. The evaluators will average the results of the nonparticipant survey with the participant survey if the nonparticipant survey is of sufficient sample size. Otherwise, results may be used for a qualitative characterization of potential bias. Though recommended, use of a nonparticipant survey need not be required, given budget and time considerations. A nonparticipant survey was completed as part of ComEd's EPY6 evaluation and used qualitatively to validate participant results.

4.3 Residential Upstream Lighting Protocol

The Illinois Residential Upstream Lighting programs to date have provided discounts on efficient lighting through retailers at the point of purchase. Such programs often remain transparent to customers purchasing incentivized lighting. Program administrators also do not know the identity of most customers purchasing the program-discounted lighting; so these customers cannot easily be contacted once they leave the store for a traditional self-report NTG evaluation survey (i.e., an after-the-fact, direct solicitation of customers regarding what they would have done in the program's absence). Similar surveys can be conducted with customers within program retailers after they have made their lighting purchasing decision but before they leave the store. For programs such as this, in store customer surveys are preferable to the traditional self-report telephone surveys that ask customers to recall their past light bulb purchases. Light bulbs are a small and relatively insignificant purchase for most people, thus the recall bias could be substantial.

Further, as upstream programs work with multiple market actors and can include wide-reaching marketing campaigns promoting energy efficiency to the general public, they tend to stimulate spillover and "market effects." As a result, estimating NTG for upstream residential lighting programs can be challenging. Multiple methods exist, each with their own strengths and weaknesses.

Ameren and ComEd implement their residential lighting programs comparably, and the evaluation teams have used a consistent primary NTG evaluation method. This section details the consensus NTG methodology, which has been used multiple times for both ComEd and Ameren and is considered the most well-vetted and defensible NTG method that has been successfully used in Illinois.

For EPY5 and EPY6, Ameren and ComEd used a customer self-report methodology to estimate NTG for their upstream residential lighting programs.[43] Customer self-report data in this method are collected during surveys conducted within program retailers with customers purchasing program bulbs (i.e., in-store intercept surveys). This method separately estimates free ridership, participant spillover, and nonparticipant spillover. Details follow on the primary data collection and scoring algorithms.

4.3.1 Basic Method

4.3.1.1 Free Ridership

Free ridership for this program is calculated as the proportion of program bulbs that would have been purchased if the program did not exist. Three alternative scenarios could occur:

1. Full Free Rider: The customer would have purchased the same quantity of efficient bulbs (CFLs or LEDs) in the program's absence.
2. Partial Free Rider: The customer would have purchased fewer efficient bulbs (CFLs or LEDs) in the program's absence.
3. Non-Free Rider: The customer would have not purchased any efficient bulbs (CFLs or LEDs) in the program's absence.

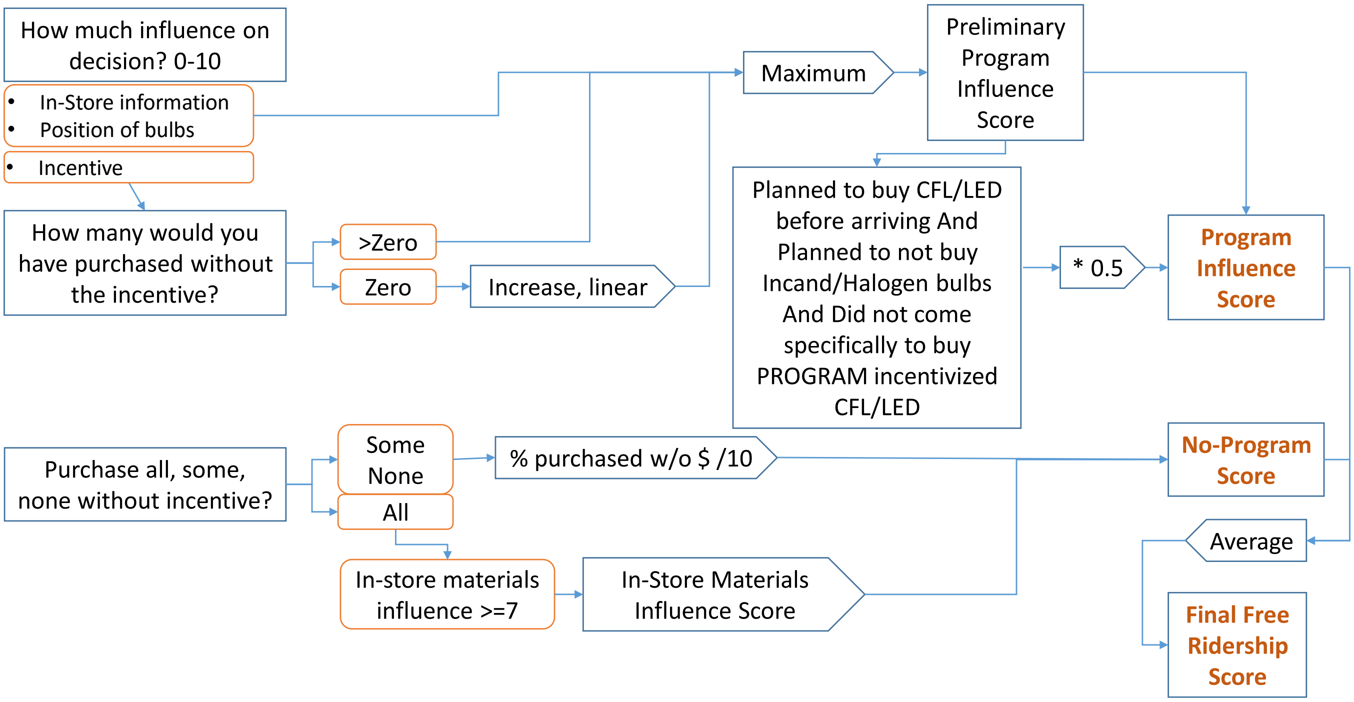
Free ridership is calculated as the average of two distinct scores: a Program Influence Score and a No-Program score. These scores are defined as follows:

1. The Program Influence Score captures the maximum level of program influence, reported by a survey respondent, of the residential lighting program on their decisions to purchase program bulbs on the day of the survey. This program influence can take a number of forms, such as: the monetary incentive provided to decrease the cost of high-efficiency bulbs; program-sponsored educational materials that explain the benefits of efficient lighting; in-store product placement of efficient bulbs; and program bulb recommendations provided by retail store personnel.
2. The No-Program Score is used to estimate how many program bulbs a survey respondent would have purchased in the absence of the residential lighting program.

Figure 4-3 illustrates the scoring algorithm for Residential Upstream Lighting Free Ridership via In-Store Intercepts.

[43] ComEd has used this method since EPY2. Ameren began using it in EPY5.

Figure 4-3. Residential Upstream Lighting Free Ridership via In-Store Intercept



4.3.1.2 Data Collection

To estimate free ridership, the evaluation teams will conduct in-store intercept surveys with customers purchasing program-discounted lighting at participating retailers. Customers are asked questions that are used to estimate a Program Influence Score and a No-Program Score for each customer and efficient bulb type purchased.

Primary Program Influence Score Questions

1. Light bulb purchasing plans for current shopping trip (Yes/No)
2. If planning to purchase bulbs:
   a. Bulb type (CFL, LED, Incandescent, Halogen)
   b. Program administrator-incentivized bulbs (Yes/No)
3. Influence of various program factors:
   a. Program incentive
   b. In-store information (printed materials or information from Program Administrator representatives or retail personnel)
   c. Positioning of discounted bulbs within the store

Primary No-Program Score Questions

1. Stated preference of light bulb purchases had the Program Administrator incentive not been available (purchase all, some, or none of efficient bulbs)
2. Quantity of light bulbs purchased absent the incentive

4.3.1.3 Scoring Algorithms

Using the data collected from program participants during the in-store intercept surveys, Program Influence and No-Program Scores are calculated for each survey respondent and then combined to estimate a respondent-specific Free Ridership Score.

4.3.1.3.1 Calculation of the Program Influence Score

Survey respondents purchasing one or more program-discounted bulbs are assigned a Preliminary Program Influence Score based on the maximum program influence level (on a 0 to 10 scale) they assigned to one or more program factors (e.g., monetary incentive/informational materials [printed or from store personnel]/product positioning). The influence level assigned to the monetary incentive should be increased for survey respondents (using a linear decreasing function)[44] who indicated that, absent the incentive, they would not have purchased any of the program bulbs they were purchasing that day.

After the Preliminary Program Influence Score is assigned, a secondary algorithm is run that adjusts the preliminary program influence based on survey data regarding the customers purchasing plans when they entered the store. Survey respondents who indicated they planned to purchase high-efficiency bulbs prior to entering the store and who had not come to the store specifically to buy Program Administrator-incentivized program bulbs, should have their Program Influence Score cut in half. This adjustment makes the final Program Influence Score reflective of their stated planned intention to purchase efficient bulbs in the program's absence.

4.3.1.3.2 Calculation of the No-Program Score

The No-Program Score is based on whether a respondent states they would have purchased all, some, or none of the program-discounted bulbs in the absence of Program Administrator incentives. Respondents reporting they would have purchased all of the efficient bulbs without the incentive should be considered free riders and receive a No-Program Score of zero. Those reporting they would have purchased none of the efficient bulbs without the incentives should be classified as non-free riders and receive a No-Program Score of 10, the maximum. Respondents reporting they would have purchased some of the efficient bulbs without the incentive should be assigned a No-Program Score between 0 and 10, reflective of the percentage of efficient bulbs they would not have purchased absent the program.

Respondents reporting they would have purchased all of the program-discounted bulbs in the program's absence, but in-store materials provided by the Program Administrator had a moderate to high influence on their decision, should have their No-Program Scores adjusted to equal the level of influence they attributed to these program-sponsored informational materials.

4.3.1.4 Calculation of Free Ridership

The Free Ridership rate is calculated as follows:

Free Ridership = 1 – (Program Influence Score + No-Program Score)/20

Using the calculated Program Influence and No-Program Scores, Free Ridership is calculated as one minus the sum of the two scores (Program Influence Score plus No-Program score), divided by 20. Dividing the sum of scores by 20 results in a ratio (between 0 and 1) that is representative of the average of the two zero to 10 scores. Subtracting this ratio from one reverses the score, thus representing the free ridership level. If either the No-Program or Program Influence Scores are missing, Free Ridership can be calculated using the single available score divided by 10. Evaluators may also reference available data to perform documented modifications to individual free ridership estimates resulting from the application of this free ridership assessment methodology.

[44] The function, adjusted monetary score = (monetary score + 10)/2, increases the monetary score using a decreasing linear function. This function results in an increase in the monetary influence score of between 0 and 5 points depending on their original monetary score (i.e., an original score of 0 would become a 5, a 5 would become a 7.5, and a 10 would remain a 10). In past Illinois evaluations, this adjustment has typically changed less than 10% of all monetary scores.

4.3.2 Participant Spillover

For this program, participant spillover results from purchases of non-discounted efficient bulbs by program bulb purchasers who are influenced by their participation in the residential lighting program to purchase additional non-discounted efficient bulbs.

4.3.2.1 Data Collection

Data collected during in-store intercept surveys with customers purchasing program bulbs should be used to estimate participant spillover. During these surveys, customers purchasing program-discounted and non-discounted efficient bulbs should be asked questions to determine whether the residential lighting program influenced their purchases of non-discounted efficient bulbs.

4.3.2.2 Scoring Algorithm

To estimate participant spillover, the number of program-influenced, non-discounted efficient bulbs purchased by program participants is divided by the total number of program bulbs purchased by these program participants. This results in the Participant Spillover Rate.

4.3.3 Nonparticipant Spillover

Nonparticipant spillover results from purchases of non-discounted efficient bulbs by customers who are not purchasing program-discounted bulbs, but report that the residential lighting program influenced their decision to purchase non-discounted efficient bulbs.

4.3.3.1 Data Collection

Data collected during in-store intercept surveys with customers purchasing efficient bulbs not discounted by the program should be used to estimate nonparticipant spillover. During these surveys, customers purchasing non-discounted efficient bulbs should be asked questions to determine whether the residential lighting program influenced their purchases of non-discounted efficient bulbs.

4.3.3.2 Scoring Algorithm

To estimate nonparticipant spillover, one must first calculate the number of program-influenced, non-discounted efficient bulbs purchased by the population of program nonparticipants surveyed. This yields a survey nonparticipant spillover rate. This rate is then extrapolated to the estimated population of nonparticipating customers to determine the estimated total quantity of non-program efficient bulbs being purchased within the utility service territory. Dividing this result by the total number of program bulbs results in the Nonparticipant Spillover Rate.

4.3.3.3 Method Advantages and Disadvantages

The in-store intercept method described above has certain advantages and disadvantages.

Advantages: This approach catches customers at their point of purchase, before they leave the store and can no longer be contacted directly. Given the interview's timing, customers can more easily recall price factors leading to their purchase choices. Also, as customers are intercepted at the store rather than surveyed by telephone, a higher cooperation rate results.

Disadvantages: Customers may not fully connect the impact that in-store education, product placement, and advertising have on their decision making. While many consumers believe they are not influenced by advertising, retailers know advertising and product placement work. Further, store intercepts typically must be coordinated with education events, and many retailers do not allow interviews to take place in their stores. Consequently, results are not based on random samples of customers purchasing program-discounted lighting throughout the year and across all participating retailers, which could bias the results.

4.4 Prescriptive Rebate (With No Audit) Protocol

Prescriptive Rebate programs typically offer predetermined rebates to residential customers for purchasing measures such as high-efficiency furnaces, clothes washers, brushless/electronically commutated motors (ECMs), boilers, boiler reset controls, water heaters, air-source heat pumps (ASHPs), ground-source heat pumps (GSHPs), central air conditioners (CACs), programmable thermostats, smart thermostats, insulation, air sealing, duct sealing, and desktop power management software. The program may require installation by a registered program ally, but it does not require a home audit (although purchases may be made in response to an audit).

These programs encourage consumers to undertake the following:

- Purchase higher-efficiency equipment than they otherwise would have, had they shopped for such equipment at the same time (replace on burnout); and
- Replace operating but inefficient equipment with higher-efficiency equipment (early replacement).

The basic method for estimating free ridership and participant spillover (See Section 4.1.2) for these programs uses a participant self-report, based on a standard battery of questions. An enhanced method may utilize trade ally surveys to provide another quantitative assessment, which may be triangulated with the basic method approach. As discussed further in Section 4.4.2, trade ally surveys may also be used to assess nonparticipant spillover.

4.4.1 Basic Method

4.4.1.1 Free Ridership

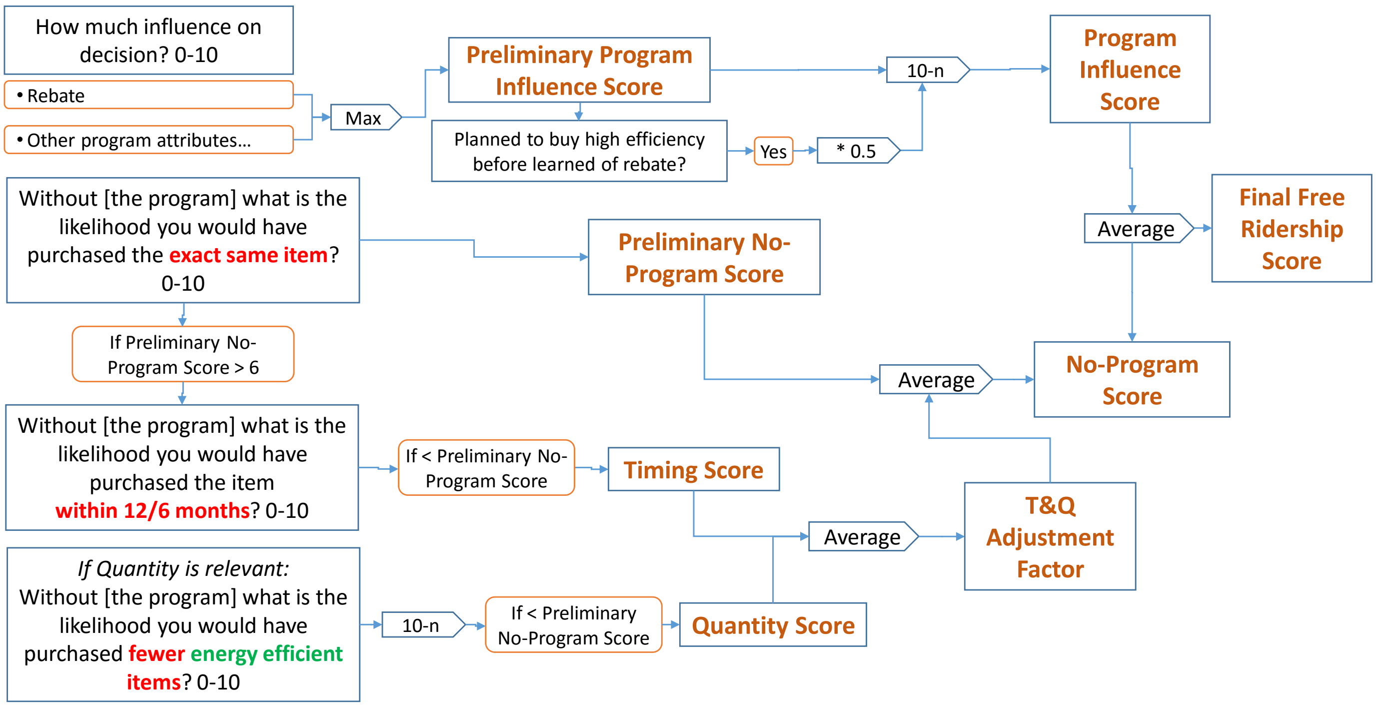
The free ridership assessment battery is brief to avoid applying an undue survey burden, yet it seeks to reduce self-report biases by including two main free ridership components:

- A Program Influence component, based on the participant’s perception of the program’s influence on the decision to carry out the energy-efficient project; and
- A No-Program component, based on the participant’s intention to carry out the energy-efficient project without program funds.

When scored, each component assesses the likelihood of free ridership on a scale of 0 to 10, with the two scores averaged and for a combined total free ridership score. For replace on burnout, adjustments are possible for timing and quantity impacts, assessed through additional questions, while for early replacement, timing is a major driver of the assessment. As different and opposing biases potentially affect the two main components, the No-Program component typically indicates higher free ridership than the Program Influence component. Therefore, combining these decreases the biases.

If the program differentiates between replace on burnout and early replacement and pays different incentives, the free ridership protocol applicable to the type of replacement should be followed. Figure 4-4 illustrates the scoring algorithm for Replace On Burnout measures, while Figure 4-5 illustrates the scoring for Early Replacement. Should the program not differentiate between replacement types, the Replace On Burnout protocol should be followed.

Figure 4-4. Residential Prescriptive Rebate (With No Audit) Free Ridership (Replace on Burnout)



4.4.1.1.1 Calculation of the Program Influence Score

Program influence is assessed by asking respondents, on a scale from 0 (not at all important) to 10 (very important), how important they found various program elements were on their decision to undertake the project the way they did. The number of elements included will vary, depending on the program's design. Logic models, program theory, and staff interviews typically inform the list of elements. Programs typically use the following elements to influence customer decision making: information; incentives or rebates; interaction with program staff (i.e., technical assistance); interaction with program proxies, such as members of a trade ally network; building audits or assessments; and financing.

In addition to asking about specific program influences, surveys ask respondents whether they planned to purchase a high-efficiency version of the product before learning of the rebate program. The Preliminary Program Influence Score is adjusted by 0.5 for those answering the question "yes."[45] Evaluators should conduct a sensitivity analysis around the use of this adjustment and present it in the report.

The Preliminary Program Influence Score equals the maximum influence rating for any program element rather than, for example, the mean influence rating. This is based on the rationale that if any given program element had a great influence on the respondent's decision, then the program itself had a great influence, even if other elements had less influence.

[45] The Illinois NTG Working Group discussed using this question to check for consistencies rather than adjusting the score. The NTG working group agreed that it is preferable not to directly ask about conflicting language with residential customers and to utilize an open ended question instead to assess possible reasons for conflicting statements. It is the experience of the NTG working group members that residential customers tend to be more impatient with these types of questions and can typically respond easier to an open-ended question about their motivations.

An inverse relationship occurs between high program influence and free ridership: the greater the program influence, the lower the free ridership. The Program Influence (PI) Score = 10 - Preliminary Program Influence Score. Should a respondent also answer that they planned to purchase a high-efficiency version of the product before learning of the program, the Preliminary Program influence Score should be multiplied by 0.5 before subtracting from 10 to compute the Program Influence Score.

4.4.1.1.2 Calculation of the No-Program Score

The No-Program (NP) Score differs slightly, depending on whether it is a Replace On Burnout measure or early replacement. For Replace On Burnout, the Preliminary No-Program (NP_p) Score is assessed using a key question that asks the respondent to gauge their likelihood of purchasing the exact same item (e.g., make, model, efficiency) had the program not existed. A respondent stating the likelihood of purchasing the same exact item as a 5 on a scale of 0 to 10 is assigned a Preliminary No-Program Score of 5.

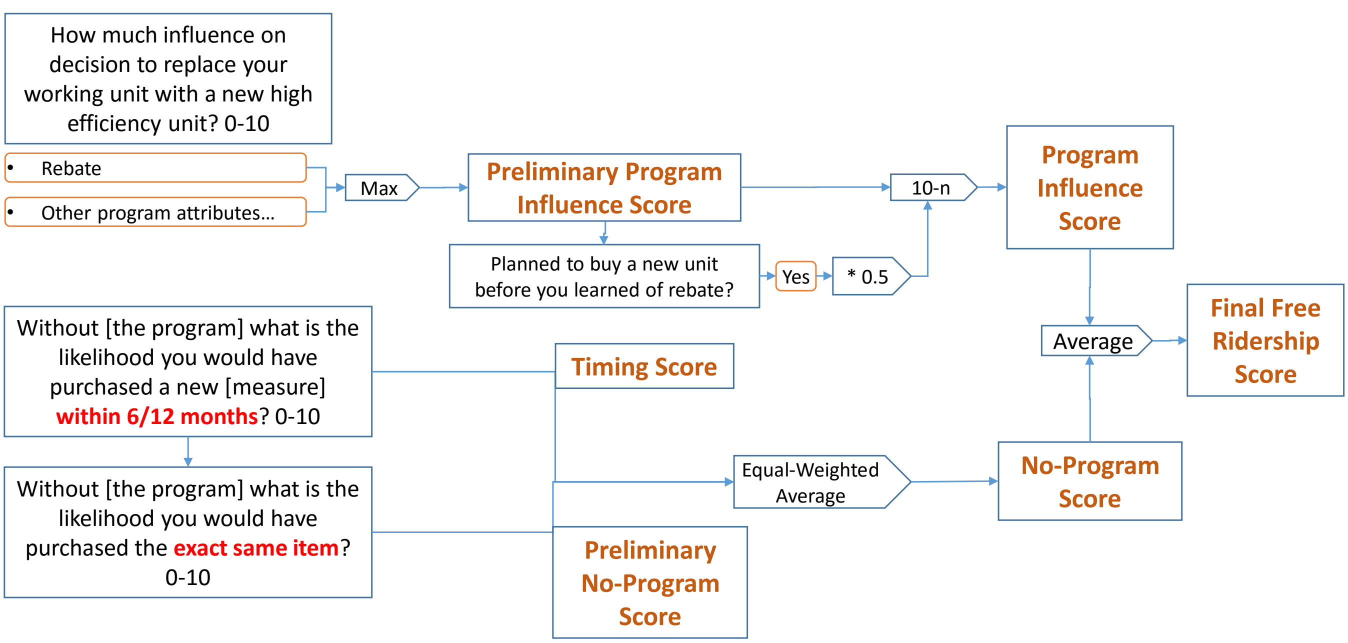
Two possible adjustments to the Preliminary No-Program Score address the possibility of the program accelerating respondents' decisions to purchase or increasing the quantity of efficient products purchased (i.e., partial free ridership) compared to actions taken in the program's absence. These adjustments are based on the responses to two additional questions.

If the Preliminary No-Program Score is greater than 6, the participant should be asked their likelihood of purchasing the same item within 12 or 6 months (12 months for a single or big ticket item and 6 months for less expensive items) for the Timing (T) Score.

If multiple quantities of an item are purchased, the respondent should be asked about the likelihood of purchasing fewer energy-efficient items. The response to this question is subtracted from 10 to compute the Quantity (Q) Score.

If either or both of these scores (timing or quantity) is less than the Preliminary No-Program Score, the T&Q Adjustment Factor (average of Timing and Quantity Scores) should be averaged in with the Preliminary No-Program Score to get the No-Program Score. The No-Program Score is averaged with the Program Influence Score to calculate the Final Free Ridership Score.

Figure 4-5. Residential Prescriptive Rebate (With No Audit) Free Ridership (Early Replacement)



For early replacement, the No-Program score is assessed by averaging the likelihood ratings from two questions:

- Likelihood of purchasing a new measure within 12 months (Timing Score); and

- Likelihood of purchasing the exact same item (Preliminary No-Program Score).

The two likelihood scores are weighted equally and result in the No-Program score, which is then averaged with the program influence score to calculate the final free ridership score.

In addition to reporting results based on the algorithms outlined above, evaluators should test two alternative methods of combining the scores and then should report the sensitivity of results to these changes. For Replace On Burnout measures, evaluators should test the following scenarios:

1. An average of Preliminary No-Program (NP_p), Timing (T), and Quantity (Q) Scores, which is then averaged with the Program Influence (PI) Score (if applicable):

$$FR = Mean\left(Mean\left(NP_p, T, Q\right)\right), PI)$$

2. Average of all four scores, PI, NP_p, T, and Q:

$$FR = Mean(PI, NP_p, T, Q)$$

Similarly, for Early Replacement measures, evaluators should test the following scenario:

- Average of Preliminary No-Program (NP_p), Timing (T), and Program Influence (PI) Score:

$$FR = Mean(PI, NP_p, T)$$

Evaluated net savings results will be based on the algorithm outlined in this protocol, but sensitivity analysis results may be used to develop suggested algorithm revisions going forward.

4.4.1.1.3 Consistency Checks

To address the possibility of conflicting responses (i.e., low intention score and high influence score), the survey should include consistency checks that, at a minimum, ask participants an open-ended question to address the program's influence. For example:

- In your own words, please tell me the influence the program had on your decision to purchase the <insert measure name>.

In this case, the evaluation analyst will assess the response to this open ended question and its consistency with the other questions, and, if warranted based on clear additional information, they will adjust the score based on expert judgement. If an inconsistency exists and the open-ended response does not resolve the inconsistency, the respondent will be removed from the calculation. All instances of this occurring should be documented in the final report. Additional consistency checks, triggered and resolved within the survey with additional questions to participants, remain optional.

Missing responses to specific questions should be treated as "missing" for that particular question, but the observation or case will be retained in the analysis. Evaluation reports should note if this affects more than 5% of the responses.

4.4.2 Enhanced Method

4.4.2.1 Free Ridership

Free ridership results may be enhanced by including additional research efforts. A trade ally survey can be conducted to assess the percentage change in sales of high-efficiency equipment resulting from the program and the percentage of efficient equipment sales rebated through the program. Though these questions avoid directly asking for total sales before and after the program, the "with program" sales volume can be calculated by dividing program tracking database counts of rebated products by the percentage of efficient products rebated through the program. The "without program" sales volume would then equal the "with program" sales volume, adjusted by the reported percentage change in equipment sales resulting from the program. Evaluators should ensure that trade allies receive sufficient time to collect specific data and not rely on "guesses" to respond. These results may be triangulated with participant survey results.

4.4.2.2 Triangulation

When multiple methods are used, evaluators may triangulate results by rating the analysis methodology and data collected using responses (rated on a scale of 0 to 10) to the following three questions:

1. All things being equal, on a scale of 0 to 10, with 0 being not at all likely and 10 being extremely likely, how likely is the approach to provide a more accurate estimate of free ridership?
2. Similarly, how valid is the data collected and the analysis performed (i.e., consider missing data, whether data collected was based on recollection or record keeping, is the analysis technique able to properly utilize the data collected)?
3. How representative is the sample (accounting for confidence and precision, and non-response or any sample frame bias)?

The weight for each method is the average score for that method divided by the sum of the scores for all methods.

Table 4-5 illustrates example scoring for two different methods, illustrating the calculated weights.

Table 4-5. Example Triangulation Weighting Approach

NTG Triangulation Data and Analysis	Method 1	Method 2
1. How likely is this approach to provide an accurate view of free ridership?	6	8
2. How valid is the data collected/analysis?	3	5
3. How representative is the sample?	8	10
Average Score	5.7	9
Weight	39%	61%

4.5 Single-Family Home Energy Audit Protocol

Single-Family Home Energy Audit programs (or energy assessment programs) seek to secure energy savings for residential customers by providing audits, direct-install measures, and incentives for additional energy efficiency opportunities. The participation process generally begins with an energy audit, performed by a program-affiliated companies or individuals; this involves an auditor assessing the customer's home to identify energy-saving opportunities. At that time, the auditor may install free instant-savings measures, such as CFLs, low-flow showerheads, and faucet aerators. Auditors also may educate customers about incentives available through the audit program (e.g., air sealing, insulation) or other Program Administrator-sponsored energy efficiency programs.

For these programs, free ridership and participant spillover (See Section 4.1.2) estimates rely on participant self-reports, gathered through surveys.

4.5.1 Basic Method

Given the multiple components of some audit programs, net impacts should be estimated using survey batteries tailored to a customer's experience (e.g., receipt of free direct-install measures and discounted or rebated measures). The following sections outline the approach for two program components, one dealing with the direct installation of free low-cost measures and a second dealing with envelope measures, such as air sealing and insulation.

4.5.1.1 No-Cost, Direct Install Measures

For free measures directly installed by program staff due to the audit, free ridership calculations should include the following components: No-Program, Timing, and Quantity.

This approach provides several important benefits, such as deriving a partial free ridership score based on the likelihood that the participant would take similar actions in the absence of the audit. For example, partial scores can be assigned to customers who planned to install the measure, but the program influenced that decision, particularly in terms of timing (e.g., the program might have accelerated the installation) or quantity (e.g., the program might have led to installation of additional program-qualified measures).

Outlines of components and their associated survey questions follow:

- **No-Program Score (NP).** This score reflects the likelihood that customers would have installed specified measures, had the program not existed. For free measures, this is based on a question asking respondents to rate the likelihood that they would have installed the exact same measures had they not received them for free through the audit (on a 0 to 10 scale, where 0 is not at all likely and 10 is extremely likely). A higher likelihood value means a higher level of free ridership (i.e., a lower attribution level for the program).

- **Timing and Quantity Adjustment Factor ($T\&Q_{ADJ}$).** This factor adjusts the No-Program Score downwards for an earlier installation of equipment and for the installation of greater equipment quantities than would have taken place in the program's absence. It is based on two questions targeting respondents who report they would likely have installed the same equipment without the program (a score greater than 6, on a scale from 0-10, on the NP question). This will only be asked of measures where the quantity is a relevant concept (e.g., lighting).

  The first question to compute the Timing (T) Score accounts for earlier installation of measures due to the program by asking respondents about their likelihood (0-10 scale) to have installed the measure within 6 or 12 months, had they not received it through the program (12 months for a single or big ticket item and 6 months for less expensive items).

  The second question to compute the Quantity (Q) Score asks respondents about the likelihood that they would have installed fewer measures or performed less weatherization without the program. The response to this question is subtracted from 10 to compute the Quantity Score, as a lower score means a greater likelihood respondents would have installed the same or a greater number of measures. Averaging the Timing and Quantity scores provides the adjustment factor, as shown in the following equation:

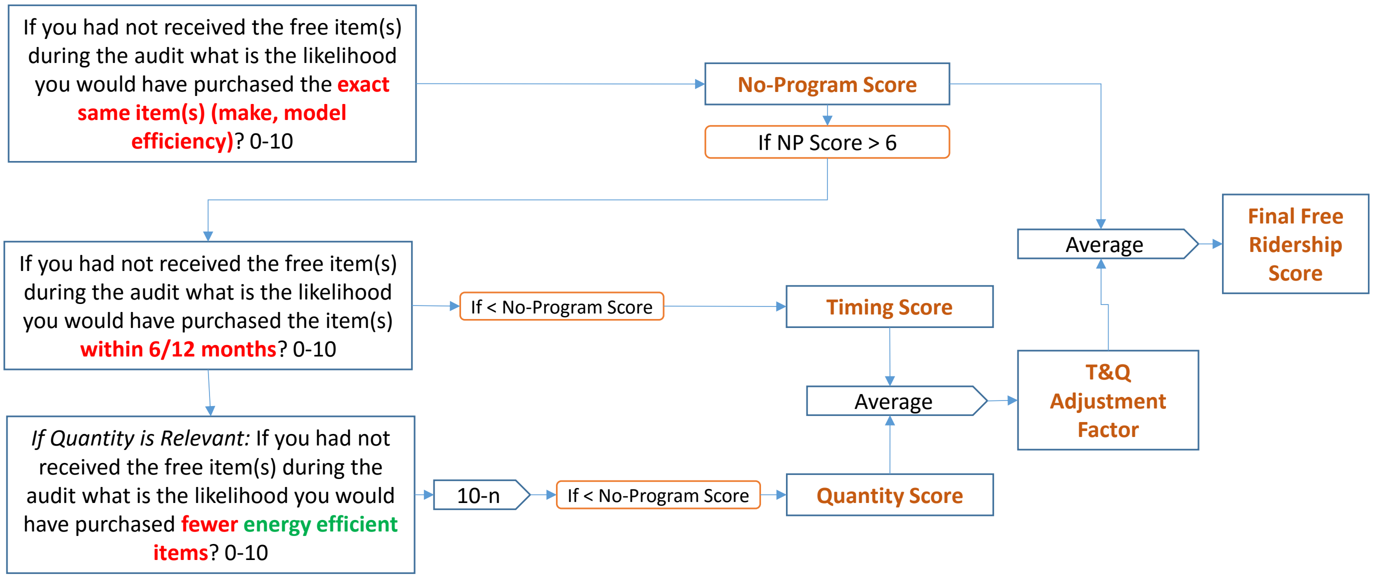
$$T\&Q_{ADJ} = Mean(T, Q)$$

Given the low cost of the measures provided through the direct-install component of most audit programs and the number of measures received per participant, efforts have been made to streamline the free ridership battery to reduce the respondent's burden. As such, the overall Final Free Ridership Score per measure can be calculated by averaging the NP Score and the Timing and Quantity Adjustment Factor, as shown in the following equation:

$$Free\ Ridership\ (FR) = Mean(NP, T\&Q_{ADJ})$$

Figure 4-6 illustrates the algorithm for no cost measures.

Figure 4-6. Single-Family Home Energy Audit Free Ridership—No Cost Measures



4.5.1.2 Rebated/Discounted Measures

Estimating NTG for rebated measures (typically for building shells) requires a more rigorous process than estimating NTG for free direct-install measures. In particular, the approach integrates an assessment of various program components that may have influenced the participant's decision to install the measures. For discounted envelope measures, the basic free ridership factor consists of the following two components:

- **Program Influence (PI).** Evaluators assess program influence by asking respondents how important various program elements were on their decisions to undertake a project as they did (on a scale from 0 to 10, where 0 is not at all important and 10 is very important). The list of program elements draws upon the program's design and theory as well as input from program staff. In addition to asking about specific program influences, surveys ask respondents whether they installed the equipment or performed a particular upgrade before learning about the program. The Preliminary Program Influence Score is adjusted by 0.5 for those answering "yes" to this question. Evaluators should conduct a sensitivity analysis around the use of this adjustment and present it in the report.

  The Preliminary Program Influence Score equals the maximum influence rating for any program element rather than, for example, the mean influence rating. This is based on the rationale that if any given program element had a great influence on the respondent's decision, then the program itself had a great influence, even if other elements had less influence.

  An inverse relationship occurs between high program influence and free ridership: the greater the program influence, the lower the free ridership. The Program Influence (PI) Score = 10 - Preliminary Program Influence Score. Should a respondent also answer that they planned to purchase a high-efficiency version of the product before learning of the program, the Preliminary Program Influence Score should be multiplied by 0.5 before subtracting from 10 to compute the Program Influence Score.

- **No-Program Score (NP).** The Preliminary No-Program (NP_p) Score reflects the likelihood that customers would have installed the specified measures in the program's absence. In general, this draws upon one question that asks respondents to rate the likelihood that they would have installed the exact same measures if not receiving them through the program (on a 0 to 10 scale, where 0 is not at all likely and 10 is extremely likely). A higher likelihood value means a higher free ridership level (i.e., a lower attribution level for the program).

  - **Timing and Quantity Adjustment Factor ($T\&Q_{ADJ}$).** This factor adjusts the Preliminary No-Program Score downwards for earlier installation of equipment and for installation of greater equipment quantities than would have taken place in the program's absence. It draws upon two survey questions asked of respondents who indicate they likely would have installed the same equipment without the program (a score greater than 6, on a scale from 0-10, on the NP question).

The first question to compute the Timing (T) Score accounts for earlier measure installation due to the program, asking respondents about the likelihood (0-10 scale) that they would have installed the measure within 6 or 12 months (12 months for a single or big ticket item and 6 months for less expensive items) had they not received it through the program.

The second question asks respondents about their likelihood to have installed fewer measures or performed less weatherization in the program's absence. Responses to this question are subtracted from 10 to compute the Quantity (Q) Score, as a lower score means a greater likelihood that they would have installed the same or a greater number of measures. This will only be asked of measures where the quantity is a relevant concept.

Averaging the Timing and Quantity Scores produces the adjustment factor, as shown in the following equation:

$$T\&Q_{ADJ} = Mean(T, Q)$$

Averaging the Timing and Quantity Adjustment Factor with the Preliminary NP Score (NP_p) calculates the final No-Program (NP) Score:

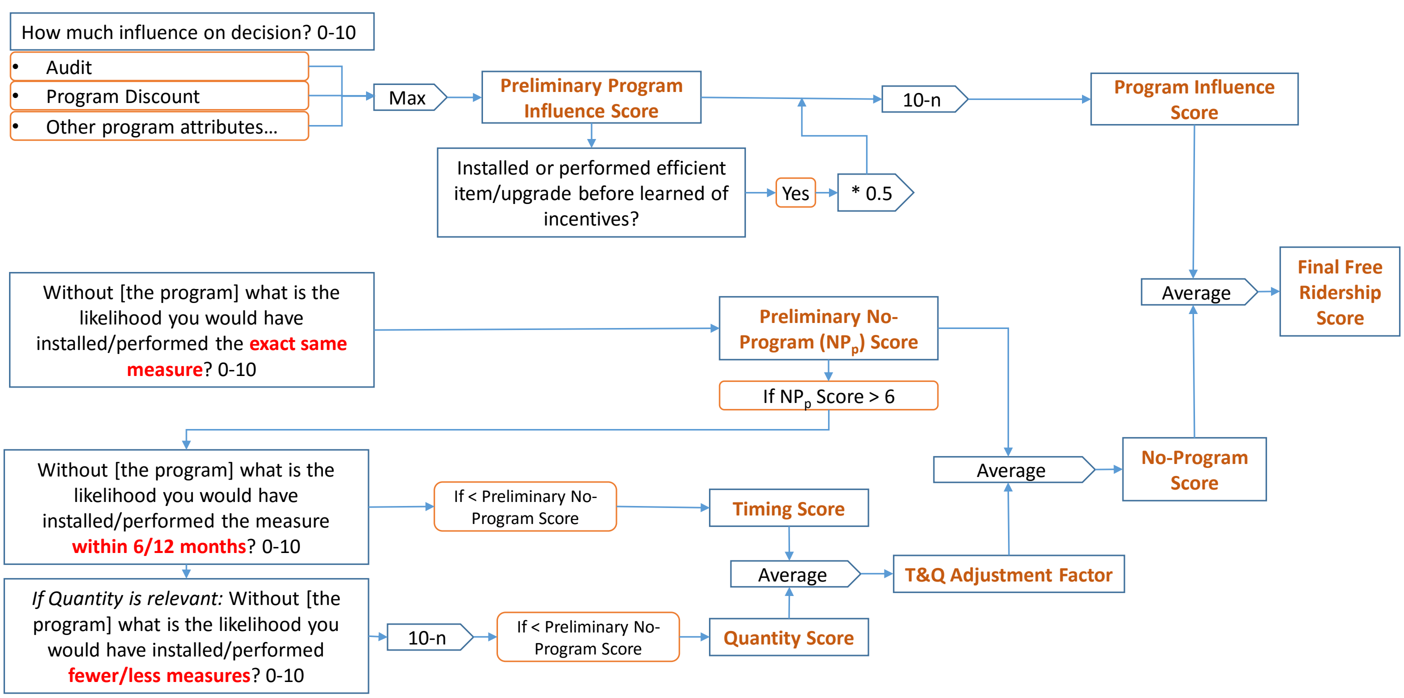
$$NP = Mean\left(NP_p, T\&Q_{ADJ}\right)$$

Averaging the PI and NP Scores produces the overall free ridership score, as shown in the following formula:

$$Free\ Ridership\ (FR) = Mean(PI, NP)$$

Figure 4-7 illustrates the algorithm for discounted measures.

Figure 4-7. Single-Family Home Energy Audit Free Ridership—Discounted Measures



In addition to reporting results based on the algorithms outlined above, evaluators should test two alternative methods of combining the program influence, no-program, timing, and quantity scores, and then should report the sensitivity of results to these changes. In particular, evaluators should test the following scenarios:

1. An average of NP_p, T, and Q scores, which is then averaged with the PI score (if applicable):

$$FR = Mean\left(Mean\left(NP_p, T, Q\right), PI\right),$$

2. Average of all four scores, PI, NP_p, T, and Q:

$$FR = Mean(PI, NP_p, T, Q)$$

Evaluated net savings results will be based on the algorithm outlined in this protocol, but sensitivity analysis results may be used to develop suggested algorithm revisions going forward.

4.5.1.3 Consistency Checks

To address the possibility of conflicting responses (e.g., the high likelihood to install the same measure in the program's absence and the high importance to program factors), the survey should include consistency checks that, at a minimum, ask participants an open-ended question to address a program's influence, such as the following:

- In your own words, please tell me the influence the program had on your decision to purchase the <insert measure name>.

For low or no-cost, direct-install measures, surveys should include two questions to assess a program's influence on the respondent. The first should be asked at the beginning of the NTG battery, and the second should be asked at its conclusion. Questions include the following:

- Prior to the audit, had you purchased any <measures>? Y/N
- IF YES AND LIKELIHOOD TO INSTALL WITHOUT THE PROGRAM IS <7: Given that you had purchased <measures> before receiving the audit, why didn't you purchase additional <measures> on your own without the program? [OPEN END]
- IF NO AND LIKELIHOOD TO INSTALL WITHOUT THE PROGRAM IS >6: Given that you have not purchased <measures> before, why were you likely to purchase <measures> on your own without the program? [OPEN END]

In both cases, the evaluation analyst will assess responses to open ended questions and their consistency with the other questions; if warranted, based on clear additional information, the evaluator will adjust the original question score will require adjustment. If inconsistency occurs and the open-ended response does not resolve it, the original question response will be removed from the calculation. Final reports should document all instances of such adjustments. Optionally, additional participant questions can be included to trigger and resolve additional consistency checks.

Missing responses to specific questions (e.g., don't know or refused) should be treated as "missing" for those particular questions, but the analysis retains the observation or case. The evaluation reports should note if this affects more than 5% of responses.

4.6 Multifamily Protocol

Multifamily energy efficiency programs typically offer direct installation of low-cost, energy-efficient measures in multifamily dwelling units, in addition to rebates for common area lighting retrofits, air sealing, insulation, and improvements to HVAC systems and controls. These programs have various target audiences from owners, managers, or developers of market rate multifamily housing to those operating lower income or assisted living housing. Across these groups, properties must generally have a minimum of between three and five units to qualify for the programs.

Most multifamily program savings are typically achieved by encouraging customers to install higher-efficiency equipment than they would have installed on their own. However, programs may also encourage early replacement of still functioning equipment that is less efficient, thus impacting the timing of the installation, so that savings is realized earlier. The incentive may also make it more affordable for customers to install a greater number of high-efficiency measures.

The basic method for estimation of free ridership and participant spillover (See Section 4.1.2) for these types of programs is based on participant self-report gathered through surveys. For common area and building shell components of the program, participants are property managers and owners responsible for building maintenance and renovation. However, depending on the program design for the in-unit component of the program and specifically the installation of efficient lighting, the decision to participate in the program (i.e., install program measures) may arise from either property managers/owners or tenants or, potentially, both. This distinction is due to the fact that in some market-rate apartments, the tenant is responsible for decisions related to the installation of program measures, including light bulbs, while this is not common practice in income-qualified or assisted-living settings. For other in-unit measures, such as faucet aerators and low-flow showerheads, evaluators interview property managers/owners regarding program influence, as these measures are typically direct installed by program staff, and there is a limited likelihood of tenants making changes to these features.

To date, most programs have included CFLs as one of their measures; so the text in this section refers to CFLs. The protocol can also be applied when the program installs LEDs.

4.6.1 Basic Method

Free ridership is calculated as the average of two distinct components: a Program Influence Score and a No-Program Score, defined as follows:

- Program Influence component: based on the participant's perception of the program's influence on their decision to carry out the energy-efficient project; and
- No-Program component: based on the participant's intention to carry out the energy-efficient project without the program.

When scored, each component assesses free ridership likelihood on a scale of 0 to 10. Averaging and dividing the components by 10 produces a combined, total free ridership score, ranging from 0 to 100%. The two main components (i.e., No-Program and Program Influence) potentially are subject to different and opposing biases. Consequently, the No-Program component typically indicates higher free ridership than the Program Influence component. Combining these decreases the biases.

Descriptions of the algorithm components and their associated survey questions follow:

- **Program Influence (PI).** Evaluators assess program influence by asking respondents how important various program elements were in regard to their decisions to undertake the project as conducted (on a scale from 0 to 10, where 0 is not at all important and 10 is very important). The list is based on the program's design and theory as well as input from program staff. In addition to asking about specific program influences, surveys ask respondents whether they planned to install equipment or perform a particular upgrade before learning of the program. The Preliminary Program Influence Score is adjusted by 0.5 for those answering "yes" to that question. Evaluators should conduct a sensitivity analysis around the 0.5 adjustment factor and present it with the evaluation report.

  The Preliminary Program Influence Score equals the maximum influence rating for any program element rather than, for example, the mean influence rating. This is based on the rationale that if any given program element had a great influence on the respondent's decision, then the program itself had a great influence, even if other elements had less influence.

An inverse relationship occurs between high program influence and free ridership: the greater the program influence, the lower the free ridership. The Program Influence (PI) Score = 10 - Preliminary Program Influence Score. Should a respondent also answer that they planned to purchase a high-efficiency version of the product before learning of the program, the Preliminary Program Influence Score should be multiplied by 0.5 before subtracting from 10 to compute the Program Influence Score.

- **No-Program Score (NP).** The Preliminary No-Program (NP_p) Score reflects the likelihood that the customer would have installed the specified measures in the program's absence. Generally, this is based on a question asking respondents to rate the likelihood that they would have installed the exact same measure without receiving them through the program (on a 0 to 10 scale, where 0 is not at all likely and 10 is extremely likely). A higher likelihood value means a higher free ridership level (i.e., a lower level of attribution to the program). Survey designers are encouraged to include questions in the property owner/manager survey to determine whether they routinely replace all bulbs (in specific areas) on a schedule to reduce maintenance costs. Such a pattern might help place answers in context.

  For CFLs, the question asked of consumers differs slightly, given the specifics of program delivery. For example, program staff visit common areas, and, in some cases, tenant units, and replace working incandescent bulbs with CFLs. Thus, the CFL NP_p Score is based on a slightly different question: "If you had not received free CFLs through the program, how likely is it that you would have removed ANY of the working incandescent light bulbs in the common areas of your property and replaced them with CFLs? Please use a scale that ranges from 0 to 10, where 0 is "not at all likely" and 10 is "very likely."

  - **Timing and Quantity Adjustment Factor ($T\&Q_{ADJ}$).** This factor adjusts the Preliminary No-Program Score downwards for earlier installation of equipment and for installation of greater equipment quantities than those taking place without the program. This is based on two questions asked of respondents who say they would likely have installed the same equipment without the program (a score greater than 6, on a scale from 0-10, for the NP_p question). This will only be asked of measures where the quantity is a relevant concept (e.g., lighting).

    The first question to compute the Timing (T) Score accounts for earlier installation of a measure due to the program by asking respondents about the likelihood (0-10 scale) that they would have installed the measure within 12 months had they not received the measure through the program.

    The second question to compute the Quantity (Q) Score asks respondents the likelihood that they would have installed fewer measures or performed less weatherization in the program's absence. The response to this question is subtracted from 10 to compute the Quantity Score, as a lower score means a greater likelihood that they would have installed the same or a greater number of measures.

    Averaging the Timing and Quantity Scores provides the adjustment factor, as shown in the following equation:

$$T\&Q_{ADJ} = Mean(T, Q)$$

  The adjustment factor is then averaged with the Preliminary NP (NP_p) Score to calculate the No-Program (NP) Score:

$$NP = Mean(NP_p, T\&Q_{ADJ})$$

The overall free ridership score derives from the average of the PI and the NP Scores, as shown in the following formula:

$$Free\ Ridership\ (FR) = Mean(PI, NP)$$

Figure 4-8 and Figure 4-9 also illustrate the algorithms.

Figure 4-8. Multifamily Free Ridership for Property Managers—Non-CFL Measures

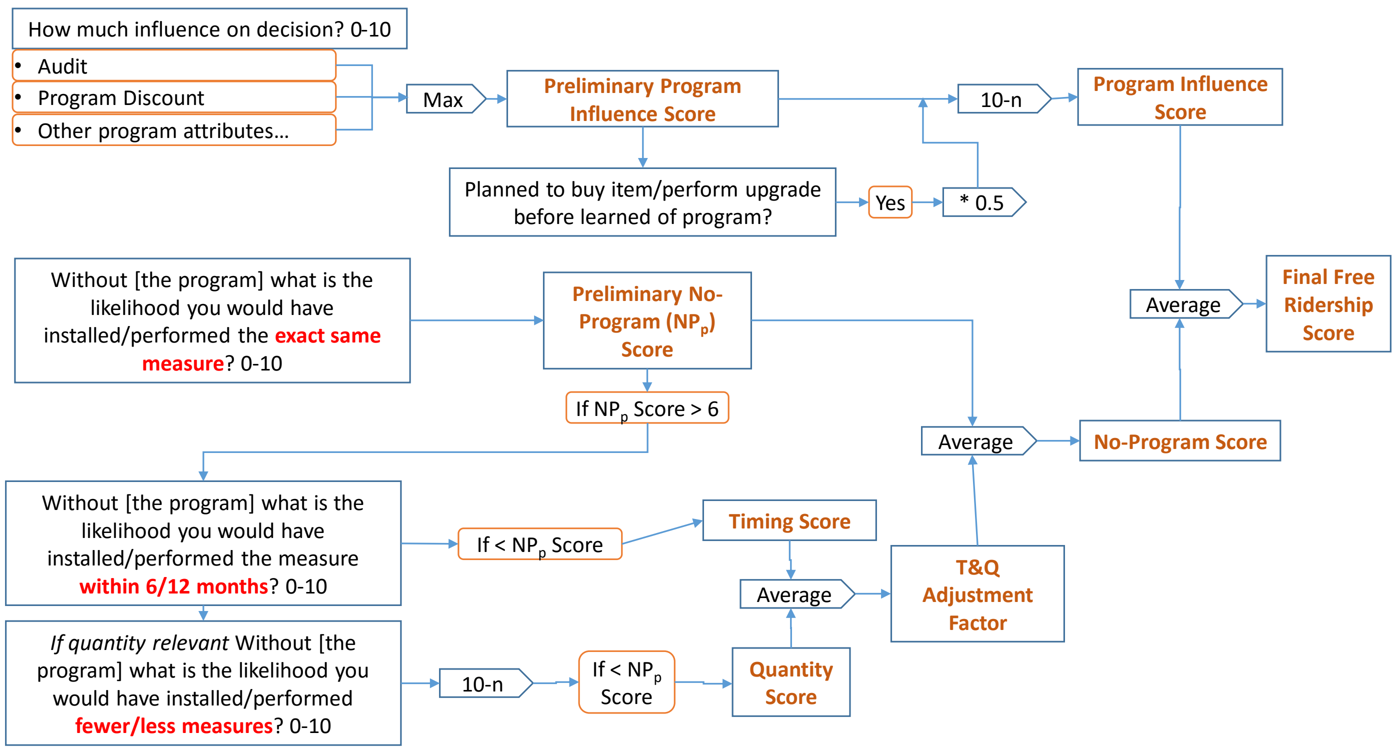
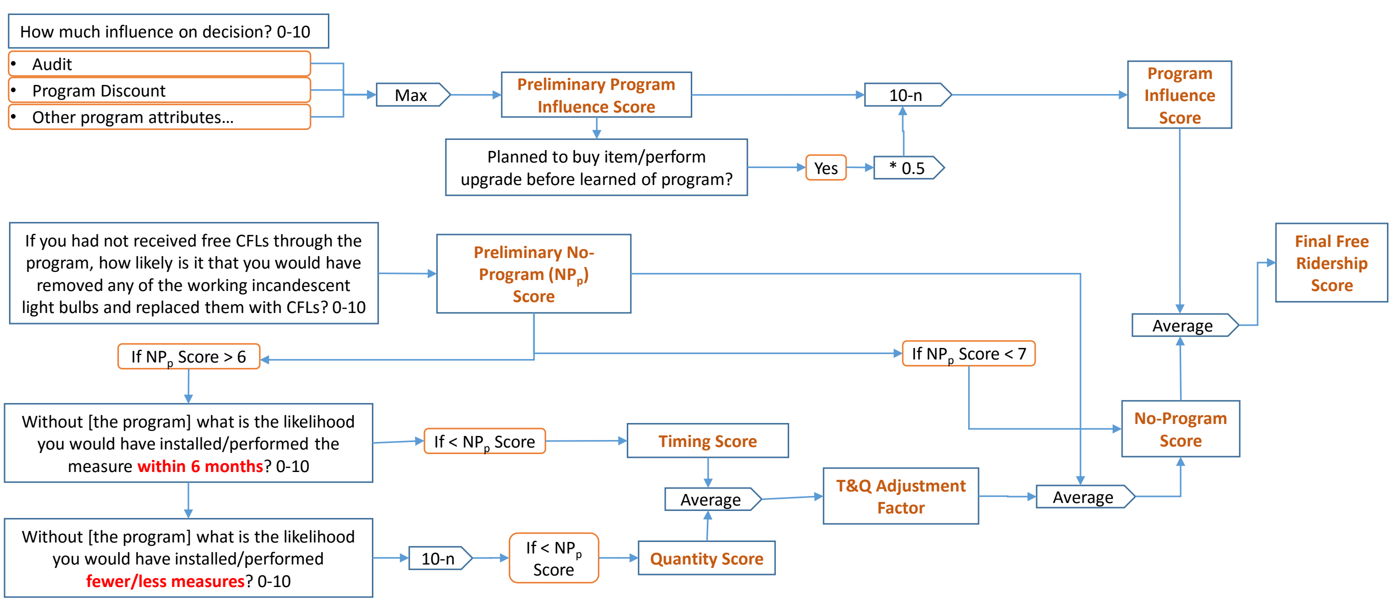


Figure 4-9. Multifamily Free Ridership—CFL Measures



In addition to reporting results based on the above algorithms, evaluators should test two alternative methods of combining the Program Influence, No-Program, Timing, and Quantity Scores, and reporting on the sensitivity of results to these changes. In particular, evaluators should test the following scenarios:

1. An average of the NP_p, T, and Q Scores, which is then averaged with the PI Score (if applicable):

$$FR = Mean(Mean(NP_p, T, Q), PI)$$

2. Average of all four scores—PI, NP_p, T, and Q:

$$FR = Mean(PI, NP_p, T, Q)$$

Though evaluated net savings results will be based on the algorithms outlined in this protocol, results from sensitivity analysis may be used to revise the algorithm going forward.

4.6.1.1 Consistency Checks

To address the possibility of conflicting responses (e.g., high likelihood to install the same measure without the program, high importance to program factors), the survey should include consistency checks that, at a minimum, ask participants an open-ended question to address the program's influence. For example:

- In your own words, please tell me the influence the program had on your decision to purchase the <insert measure name>.

The evaluation analyst will assess the responses to the open ended questions and their consistency with the other survey questions, and, if warranted based on clear additional information, will adjust the original question score. If the open-ended response does not resolve the inconsistency, responses to the original question should be removed from the calculation. The survey may include additional consistency check triggers and resolutions through additional participant questions. The final report should document how often the consistency check rules were triggered, how often adjustments were made to scores, and how often inconsistencies could not be resolved.

Missing responses to specific questions (including don't know or refused) should be treated as missing for that particular question, but the analysis should retain that observation or case. Evaluation reports should note if this affects more than 5% of the responses.

4.6.1.2 Data Collection

A participant survey should be used as the primary source of data collected for estimating free ridership in residential multifamily programs. As discussed, evaluators may field surveys with owners, property managers, or tenants, depending on a program's design and theory. Determining the appropriate audience from which to gather information for estimating free ridership depends on the program's design, and, ultimately, the party responsible for deciding to install specific program measures.

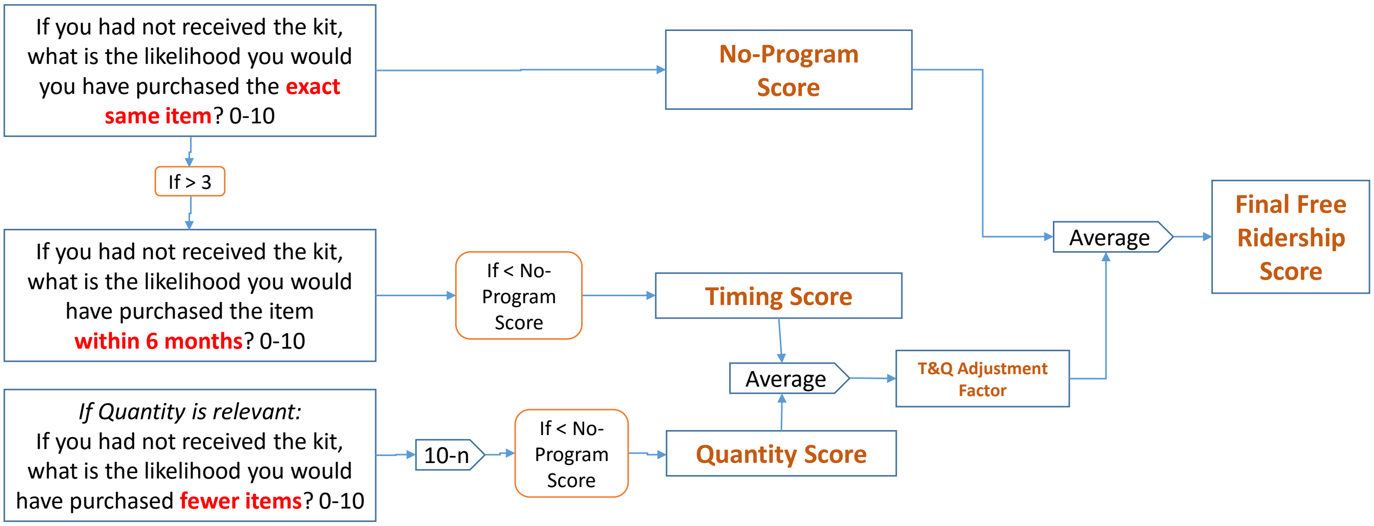
4.7 Energy Saving Kits and Elementary Education Protocol

Energy Saving Kits and Elementary Education Programs aim to secure energy savings through the distribution of kits containing various energy-saving measures, including (but not limited to): high-efficiency lighting (CFLs or LED lamps); bathroom and kitchen faucet aerators; and low-flow showerheads. Energy Saving Kits operate as an opt-in program; customers can request a kit by completing an Internet or phone application. Elementary Education Program participants do not request a kit as kits are distributed to all students in a classroom.

Free ridership and participant spillover (See Section 4.1.2) estimations for both programs rely upon participant self-report information gathered through surveys, despite the differences in distribution models. This methodology can be used for other energy-saving kit programs, including kits with alternative distribution methods (e.g., kits dropped off at a participant's home).

The following section contains a description of the basic NTG method used. Figure 4-10 illustrates the method.

Figure 4-10. Energy Saving Kits and Elementary Education Free Ridership



4.7.1 Basic Method

Free ridership calculations should include the following components: No-Program, Timing, and Quantity.

This approach provides several important benefits, such as the ability to derive a partial free ridership score based on the likelihood that similar actions would have taken place, even if the participant had not received a kit. For instance, partial scores can be assigned to customers with plans to install the measure, but the program at least influenced that decision, particularly in terms of timing (e.g., the program might have accelerated the installation) or quantity (e.g., the program might have led to the installation of additional measures).

An outline of components and their associated survey questions follows:

- **No-Program Score (NP).** This score reflects what action the customer would have taken without the existence of the program. This derives from one question that asks respondents to rate the likelihood that they would have installed the exact same measure in the absence of receiving free measures in the kit (on a 0 to 10 scale, where 0 is not at all likely and 10 is extremely likely). A higher likelihood value means a higher free ridership level (i.e., a lower level of attribution to the program).
- **Timing and Quantity Adjustment Factor ($T\&Q_{ADJ}$).** If the NP Score is greater than 3, the T&Q Adjustment Factor is computed. This factor adjusts the No-Program Score downwards for earlier installation of kit items and for installation of greater quantities than would have taken place in the program's absence. It draws upon two survey questions asked of respondents who indicate they likely would have installed the same equipment without the program (a score greater than 3, on a scale from 0-10, on the NP question).

  The first question to compute the Timing (T) Score accounts for earlier installation of a measure due to the program's influence, and it derives from one question asking respondents about the likelihood (0-10 scale) that they would have purchased the measure within six months had they not received the measure in a kit.

  The second question to compute the Quantity (Q) Score accounts for the installation of a greater number of measures than the customer would have installed independently. In particular, the question asks participants how likely they would have been to install fewer energy-efficient items had they not received them for free in the kit. The question applies only to measures with a quantity of greater than one. The response to this question is subtracted from 10 to compute the Quantity Score, as a lower score means a greater likelihood respondents would have installed the same or a greater number of measures.

Averaging the Timing and Quantity Scores provides the adjustment factor, as shown in the following equation:

$$T\&Q_{ADJ} = Mean(T, Q)$$

Given the low cost of measures provided in the energy-saving kits as well as the number of measures included in each kit, efforts have been made to streamline the free ridership battery to reduce the respondent's burden. Consequently, the resulting Timing and Quantity Scores are averaged to compute the $T\&Q_{ADJ}$ Factor, with that average then averaged with the No-Program Score to derive the overall Final Free Ridership Score per measure:

$$Free\ Ridership\ (FR) = \ Mean(NP, T\&Q_{ADJ})$$

In addition to reporting results based on the above algorithms, evaluators should test alternative methods for combining the No-Program, Timing, and Quantity Scores, and to report on the sensitivity of results to these changes. In particular, evaluators should test the following scenario:

- Average of NP, T, and Q Scores:

$$FR = Mean(NP, T, Q)$$

Evaluated net savings results will be based on the algorithm outlined in this protocol, but results from the sensitivity analysis may be used to suggest revisions to the algorithm going forward.

Missing responses to specific questions (e.g., don't know or refused) should be treated as "missing" for that particular question. Despite missing responses, the case will be retained in the analysis (pairwise deletion). The evaluation reports should present the percent missing for each of the three questions.

4.7.1.1 Data Collection

Evaluators should use a participant survey as the primary data collection source for estimating free ridership in Energy Saving Kits and Elementary Education Programs. As a general rule, a free ridership rate should be calculated for each separate kit component, and then be weighted by savings to determine the program-level results.

Free ridership questions should be asked near the beginning of a participant survey, before asking satisfaction questions. This should prevent participants from confusing free ridership questions with the satisfaction questions, which would result in an artificially high free ridership score, especially for participants highly satisfied with measures included in the kit.

4.8 Residential New Construction Protocol

Residential New Construction programs typically offer builder training, technical information, marketing materials, and incentives to builders for the construction of eligible homes. Eligible homes must meet specific standards, designed to achieve energy efficiency levels above local building codes. Programs may use different tiers of standards to meet correspondingly different incentives.

The basic method for estimating free ridership and participant spillover for these programs is based on builder participant self-reporting, gathered through surveys.

The following section describes the basic method used.

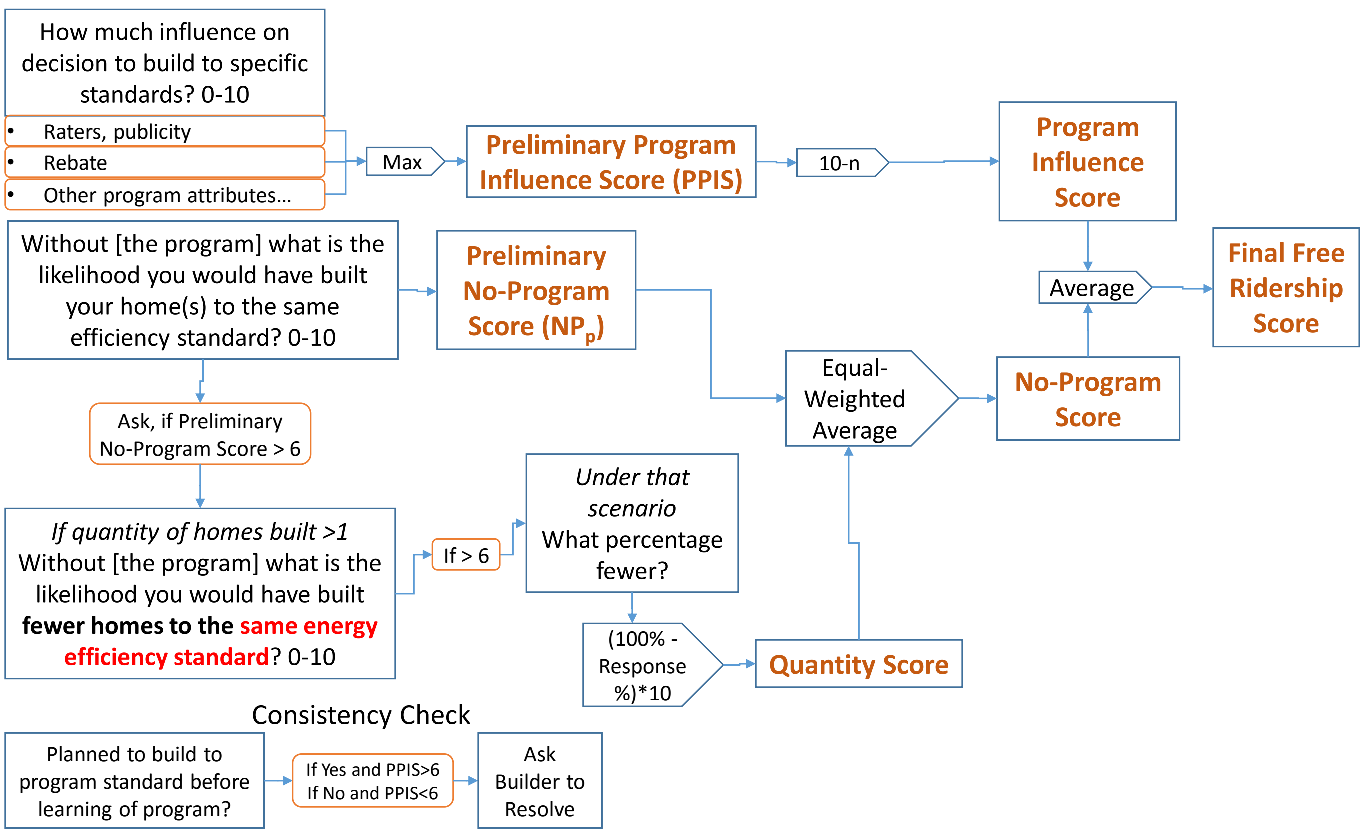
4.8.1 Basic Method

For this program, a free rider is a builder who would have constructed a home at the program's efficiency level in the program's absence. Given the multiple methods available to achieve desired home energy efficiency levels, survey questions consider the builder's likelihood of meeting the same energy efficiency standard, rather than whether or not the builder would have installed certain energy efficiency measures. Figure 4-11 (below) illustrates the method in more detail.

Evaluators assess Program Influence by asking respondents, on a scale from 0 (not at all important) to 10 (very important), how important they found various program elements in deciding to build to specific energy efficiency standards. The number of elements included vary, depending on the program's design. Logic models, program theory, and staff interviews typically inform the list of program elements included. Programs typically use the following elements to influence builder decision making: marketing materials; incentives or rebates; contacts with HERS Raters; and technical assistance.

In addition to asking about specific program influences, surveys should ask builders whether they planned to build homes to the same standard before learning of the program.

Figure 4-11. Residential New Construction Free Ridership



4.8.1.1.1 Calculation of the Program Influence Score

The Program Influence Score (PI) equals 10 minus the maximum influence rating for any program element rather than, for example, the mean influence rating. This is based on the rationale that if any given program element had a great influence on the respondent's decision, the program itself had a great influence, even if other elements had less influence.

4.8.1.1.2 Calculation of the No-Program Score

Evaluators calculate the No-Program score using a set of questions that ask respondents to gauge their likelihood of building homes to the same standards and in the same quantities had the program not existed. Three separate responses are considered in calculating the No-Program Score:

- The likelihood, on a scale of 0 to 10, that the builder would have built their homes to the same efficiency standard (Preliminary No-Program Score (NP_p))
- If that likelihood is greater than 6, the likelihood of fewer homes being built to the same efficiency standard.

- If that likelihood is greater than 6, the response to the question "for that scenario, what percentage of fewer homes would be built to the standard?" (Quantity Score = (100% - % answer) * 10, which will be a number between 0 and 10)

The resulting No-Program (NP) Score is calculated as follows:

$$NP = Mean(NP_p, Q)$$

The overall Free Ridership Score derives from the average of the PI and NP scores, as shown in the following formula:

$$FR = Mean(PI, NP)$$

4.8.1.2 Consistency Checks

To address the possibility of conflicting responses (e.g., the high likelihood to build to the same efficiency standards without the program, the high importance of program factors), the survey should include, at a minimum, consistency checks that ask participants an open-ended question to address the program's influence. For example:

- In your own words, please tell me the influence the program had on your building practices.

If a high (>6) Preliminary Program Influence Score (PPIS) results, yet the builder planned to meet the same efficiency standard prior to learning of the program; or if the Preliminary Program Influence Score is lower (<7), and the builder did not plan to build to the standards prior to learning of the program, the survey should include a question to determine why this occurred, using wording that gets at the following inconsistencies:

- IF Preliminary Program Influence Score is >6 and Builder planned to meet the same efficiency standard prior to learning OF THE PROGRAM: Given that you had plans to meet the standard prior to learning about the program, why do you think the <program elements> were influential in your decision to meet the standard? [OPEN END]
- IF Preliminary Program Influence Score is <7 and Builder had no plans to meet the same efficiency standard prior to learning of the program: Given that you had no plans to meet the standard prior to learning about the program, why do you think the <program elements> were not more influential in your decision to meet the standard? [OPEN END]

The evaluation analyst will assess the responses to the open ended questions and their consistency with the other survey questions, and, if warranted based on clear additional information, will adjust the original question score. If the open-ended response does not resolve the inconsistency, responses to the original question should be removed from the calculation. The survey may include additional consistency check triggers and resolutions through additional participant questions. The final report should document how often the consistency check rules were triggered, how often adjustments were made to scores, and how often inconsistencies could not be resolved.

Missing responses to specific questions (including don't know or refused) should be treated as missing for that particular question, but the analysis should retain that observation or case. Evaluation reports should note if this affects more than 5% of the responses.

4.8.2 Participant Spillover

Participant spillover occurs when, due to program participation, a builder increases the energy efficiency of homes built outside the program (but inside a utility's service territory) by adopting certain building practices used in participating homes. Participant spillover can be calculated based on participant builder survey questions that ask builders about homes built within the utility service territory but outside the program. Survey questions ask whether the builder increased the energy efficiency standards of non-program homes after participating in the program, and the number of homes they applied these increased standards to, within the utility's service territory. Depending on the program characteristics, spillover should be measured as changes in specific building practices or as installation of specific measures. The text below assumes the program has been targeted at modifying building practices.

Spillover may be recorded depending on responses to the following questions:

1. How important was your experience in the <PROGRAM ADMINISTRATOR'S> program in your decision to incorporate this building practice your other homes, using a scale of 0 to 10, where 0 is not at all important and 10 is extremely important?
2. If you had not participated in the <PROGRAM ADMINISTRATOR'S> program, how likely is it that you would still have incorporated this building practice using a 0 to 10, scale where 0 means you definitely WOULD NOT have implemented this practice and 10 means you definitely WOULD have implemented this practice?

Responses to the first question establish the Practice Attribution Score 1, and responses to the second question establish the Practice Attribution Score 2. Spillover may be program-attributable for building practices with self-report data meeting the following condition:

Spillover Score = (Practice Attribution Score 1 + (10 – Practice Attribution Score 2))/2 > 7.0

For responses meeting these conditions, an evaluator determines that specific building practices referenced in the question are attributable to the program; otherwise, the evaluator determines that specific building practices referenced in the question are not attributable to the program. The attribution criteria represent a threshold approach, in which energy impacts associated with building practices program participants implement outside the program are either 100% program-attributable or 0% program-attributable.

For each building practice discussed, builders will be asked how they know the building practice is more efficient than other options. If the respondent can identify the building practice as ENERGY STAR or name an efficiency level that the evaluator confirms as above the minimum federal standard, or if they identify a technology that the evaluator can confirm is above the minimum federal standard, this counts towards participant spillover.

Finally, depending on the building practice cited by the builder, follow-up questions should ask customers to provide reasonable information to allow the evaluator to estimate the amount of savings using IL-TRM protocols, such as quantity of appliances or the location and amount of insulation.

To calculate the spillover energy and demand savings for these actions, further questions should be asked to assess the gross savings of the building practice, through the appropriate version of the IL-TRM, if available, and the number of homes to which it applied. To develop the Spillover Rate, the total energy and demand impacts from the sampled participants who implemented efficient building practices in other homes due to participation in the program is summed, and then this sum is divided by the total ex post sample energy and demand impacts:

$$Participant\ Spillover\ Rate\ (PSO) = \frac{Sum\ of\ Energy\ or\ Demand\ from\ Additional\ EE\ Practices}{Sample\ Ex\ Post\ Gross\ Energy\ or\ Demand\ Impacts}$$

The equation used to adjust the Core NTGR based on participant spillover is as follows:

$$NTGR = (1 - FR + PSO)$$

4.8.2.1 Sample

The sample for a spillover survey should be a random sample of current and up to one year previous program participants. Regardless of the year of participation, spillover should be measured within the set of homes that were completed within 12 months of the survey date.

4.8.3 Builder Nonparticipant Spillover

In addition to participant free ridership and spillover, new construction programs may create NPSO through builders exposed to the program but not actually participating. Rather, they implement some or all of the efficiency measures incorporated through the program in order to compete with builders that are participating.[46] NPSO caused by builders can be determined by surveying two groups of builders:

- "Drop out" builders, who participated in the program previously but have not participated in the past 12 months.
- True nonparticipating builders that report they were aware of the program or that other builders were taking steps to improve new home efficiency, but had never participated.

Surveys ask nonparticipating builders if their knowledge of other builders' increased focus on energy efficiency influenced their building practices and in what manner, to quantify the program's impact on nonparticipating homes. The survey questions will first identify specific building practices that go beyond the implemented energy code for the specific jurisdiction in which the builder is active. Table 4-6 lists the latest building energy code in place for most areas of Illinois. Evaluators should make efforts to ensure the building code under enforcement for each jurisdiction is used as the baseline when evaluating spillover savings.

Table 4-6. IECC 2012 Building Energy Code

Component	IECC 2012
Thermostat	Heating 72F Cooling 75F Programmable Thermostat
Ceiling	U-0.026
Walls	U-0.057
Floors	U-0.033
Slab	R-10, 2ft
Windows	U-0.32
Infiltration	5ACH50
Duct Leakage	4CFM/100CFA
Duct Insulation	R-8 Attic Supply, R-6 Otherwise
Heat Pump	7.7 HSPF
Furnace	80 AFUE

[46] NPSO also can arise from nonparticipating customers as a direct result of general energy efficiency education and promotion efforts. A separate protocol addresses such NPSO. Care should be taken to ensure the different approaches do not double-count NPSO.

Component	**IECC 2012**
Boiler	82 AFUE
AC	13 SEER
Lighting	75% CFL
Appliances	RESNET Default
Gas Water Heat	0.59 EF
Electric Water Heat	0.91 EF

For each component that is more efficient than code, the following additional questions are asked:

1. How many homes did you sell in <period> that incorporated this upgrade?
2. Of these homes, how many would have incorporated this upgrade, had the <program> not existed?

Evaluators should ensure that nonparticipant builders receive sufficient time to collect specific data and not rely on "guesses" to respond. Responses should also clarify whether sales counts are specific to the utility service territory in question.

The following steps calculate the program's nonparticipant builder spillover percentage:

1. Compute the difference between the total reported number of efficiency upgrades sold and the total that would have been sold in the program's absence to obtain the total number of upgrades by type of upgrade for that builder.
2. Multiply the total net number of upgrades of each type sold by each surveyed builder by the average gross unit savings for each upgrade type.
3. Sum the result for each builder from the previous step, and weight the results by the ratio of the population of non-active builders to the sample to compute the total spillover energy over the program period.
4. Divide the spillover energy savings by program gross savings.

Should a general population survey be implemented for nonparticipant spillover, care should be taken to ensure spillover is not double-counted.

5 Cross-Sector Protocols

The following sections include protocols that may be applicable to programs in the residential as well as in the commercial, industrial, and public sectors. Table 3-1 Commercial, Industrial, and Public Sector Programs and Table 4-1 Residential and Low Income Programs present information regarding the applicability of these protocols to specific programs.

5.1 Behavioral Protocol

5.1.1 Randomized Controlled Trials

The SEE Action Network's recent monograph on evaluating residential behavioral energy efficiency programs[47] indicates most of these programs are designed as randomized controlled trials (RCTs).[48] In this design, evaluators (and sometimes implementation contractors) randomly assign sampled members of a population of interest to treatment group or a control group. Among the benefits offered by an RCT—when properly applied—is that it eliminates most selection bias, including free ridership and participant spillover effects. Hence, producing net savings estimates. For some programs, evaluators must take a second step to calculate net savings to ensure savings are not being double-counted, either counting savings being claimed by other programs or savings already credited to earlier program efforts (often called "legacy uplift").

Free ridership refers to participants in an energy efficiency program that would have saved energy even without the program's stimulus. As these program participants would have engaged in energy-saving actions in the program's absence, counting their savings exaggerates the program's impact. RCTs eliminate free ridership bias because the random assignment of customers to treatment and control groups equally distributes such participants between the two.[49] Upon comparing the two groups' energy consumption, free ridership energy savings in the control group cancel out those in the treatment group, eliminating free ridership bias.

Participant spillover refers to the tendency of participants in an energy efficiency program to engage in additional energy-saving actions. Though these actions occur outside of the program's scope, they also occur as a direct or indirect result of the program. The extent that these additional savings are not measured and attributed to the program by the evaluator understates the program's impact.

Consideration of participant spillover effects begins by considering what participant spillover means in the context of behavior-based energy efficiency programs. As behavioral programs prescribe neither the installation of any specific measures or sets of measures nor the adoption of any particular behaviors, they likely would not cause participant spillover effects: energy savings resulting from a behavioral program's influence would, by definition,

---

[47] State and Local Energy Efficiency Action Network. *Evaluation, Measurement and Verification (EM&V) of Residential Behavior-Based Energy Efficiency Programs: Issues and Recommendations.* Prepared by A. Todd, E. Stuart, S. Schiller, and C. Goldman. Lawrence Berkeley National Laboratory, 2012. (http://emp.lbl.gov/publications/evaluation-measurement-and-verification-emv-residential-behavior-based-energy-efficiency)

[48] For example, most residential, behavior-based energy efficiency programs administered by Opower on behalf of energy utilities are designed as RCTs, as are some commercial and industrial behavioral programs: for example, the EnergyCheck program that Pulse Energy implements for Commonwealth Edison.

[49] Small differences may occur between the distributions of free ridership's propensity in the two groups for any given sample. Their expected values, however, will be identical, and in any case the size of any such discrepancies shrinks as sample size increases. Thus, this is only a potential concern for programs with unusually small numbers of participants.

be "in scope," eliminating nearly all possibilities for participant spillover.

The only exceptions would be participant spillover effects not reflected on customers' bills or meter data. These can arise if spillover savings occur in another venue—outside of the home (e.g., a workplace) for a residential behavioral program—or if the program's design reduces energy consumption in one form (e.g., electricity) but results in spillover savings in another form (e.g., natural gas). To the extent that either situation occurs, an evaluation relying on an RCT would understate program savings.

In general, RCTs do not address nonparticipant spillover, which reflects a program's influence on nonparticipants. Such spillover may arise from a behavioral energy efficiency program if, for example, the program indirectly influences customers in the control group or affects the availability of energy efficiency products and services to those served by the relevant market, regardless of whether they participate in the program or belong to the control group. Where significant nonparticipant spillover occurs, an evaluation relying on RCT would understate program savings.

In an RCT, energy consumption of the treatment and control groups can be appropriately compared through a regression analysis, using time-series observations on the usage of individual customers in the treatment and control groups during the pre- and post-treatment periods. Such data most commonly derive from customers' monthly bill records, hence the frequent use of "billing analysis" to describe this approach (although higher-frequency usage data from customer AMI meters also can be used and provide some additional benefits).[50] Due to the combined time-series/cross-section structure of such data sets, the NTG Working group recommends that panel regression techniques be used.[51]

5.1.2 Non-Randomized Designs

Where randomized assignments prove infeasible, quasi-experimental evaluation methods can be substituted. These methods select a control group using nonrandom methods and are less reliable than RCTs, but, with appropriate care, they can produce valid results. Non-randomized designs can still produce net savings as their primary output, just as RCTs do.

Three quasi-experimental approaches are commonly used to evaluate behavior-based energy efficiency programs that cannot be construed as RCTs:

- Regression discontinuity (RD)
- Variation-in-adoption (VIA)
- Matched controls (MC).

All three create a nonrandom control group to replace a random control group used in the RCT approach.

Regression Discontinuity. RD requires basing a program's eligibility on a continuous variable (e.g., customers' adjusted gross income falling below a cutoff value for them to qualify for the program). When this is true, the RD

[50] These benefits include: having more observations per customer, which improves model precision; obviating concerns over billing periods with differing numbers of days; and providing the ability to observe intraday load shifting in addition to energy savings.

[51] "Panel" refers to the data set consisting of time-series observations on energy consumption of a cross-section of treatment and control customers. Panel estimation techniques refer to the model's inclusion of terms that control for individual customer heterogeneity (e.g., customer fixed effects or a lagged dependent variable), and cluster-robust standard errors, which can accommodate differing error variances across customers and an intracustomer correlation of errors.

method assumes customers just beyond the cutoff likely will be very similar, on average, to those just inside of it. The method compares changes in energy usage for a group just outside of the eligible range to that of a group of participants just on the other side of the eligibility cutoff. The RD approach, however, is susceptible to an important weakness: misspecification of the regression functional form.[52]

Variation-in-Adoption. The VIA model applies only to program participants.[53] For this method, customers must sign up for the program on a rolling basis. VIA takes advantage of its enrollment's differential timing to compare energy usage of customers opting in to that of customers not yet opting in (but doing so later). The method relies on an assumption that, in any given month, customers have already opted in; those that soon opt in have similar characteristics to those who have enrolled, both in observable and unobservable characteristics. For this assumption to prove valid, customers must decide to opt into the program at different times for essentially random reasons (e.g., influenced only by marketing exposure and program awareness).[54] In particular, the decision to opt in should not relate to observable or unobservable household characteristics.[55]

Matched Controls. MC creates a control group by matching each treatment customer to the most similar nonparticipant customer available on the basis of exogenous covariates from the pre-enrollment period known to highly correlate with post-enrollment usage.[56] The covariate most likely to correlate with post-enrollment energy usage in a given time period is customer energy usage during the same period of the preceding year, but other observable factors may be used when available. Implementing MC requires customer usage data for the year preceding all opt-in customers' decisions to participate in the program, along with a large group of nonparticipants who can be assumed to be similar to opt-in customers, aside from their program participation status. The pool of potential matches should be drawn from the same customer class and rate category.

The MC method involves identifying a nonparticipant customer whose energy usage closely matches that of a program participant in the months preceding the participant's enrollment in the program. The logic inherent in this approach is: if the analyst finds a set of nonparticipants who, on average, are the same as participants regarding energy consumption before program enrollment, these matches will provide a good counterfactual estimate of how much energy participants would have used in the program's absence.

The MC approach does present a main weakness: it can only identify matches based on observable customer characteristics, which leaves open the exclusion of the possible influence of relevant unobservables. While factors

[52] The most common misspecifications are: mistaking a nonlinear relationship for a discontinuity; and failing to recognize potential interactions between assignments and the treatment studied. See W.R. Shadish, T.D. Cook and D.T. Campbell, *Experimental and Quasi-Experimental Designs for Generalized Causal Inference*, adsworth 2002, pp. 229-238.

[53] M. Harding and A. Hsiaw, "Goal Setting and Energy Conservation," July 2013. Available at: http://people.duke.edu/~mch55/resources/Harding_Goals.pdf.

[54] This differs from an RCT with a recruit-and-delay design, in which customers do not choose when to opt in, but instead are randomly assigned different times to opt in, or from an RCT with a recruit-and-deny design, where customers are randomly denied access to the program.

[55] As the validity of the VIA method depends on this assumption, it should be empirically tested to the extent possible. If program marketing is punctuated and dates of marketing exposure are known, it is possible to test whether household enrollment in any particular month is driven by marketing activity, as opposed to observed household characteristics or unobserved heterogeneity. A test of whether the energy usage of households before they opt in differs from households that opt in during any particular month as opposed to another month is built into the VIA regression model's functional form. See Harding and Hsiaw, op. cit., for details.

[56] See Daniel E. Ho, Kosuke Imai, Gary King, and Elizabeth Stuart, 2007, "Matching as Nonparametric Preprocessing for Reducing Model Dependence in Parametric Causal Inference." *Political Analysis* 15(3): 199-236.

other than pre-enrollment energy usage plausibly could be used (e.g., household income, demographics, geographic location) in the matching process to address relevant unobservable characteristics (e.g., attitudes toward energy conservation and environmental concerns), this assumption cannot be directly tested.[57]

There is a special case of MC called propensity-score matching. This develops a binary choice model to predict the probability that a customer will opt into the program, and then, for a control group, chooses customers with a high propensity for opting in but choosing not to do so. This functions well if observable variables used to calculate the propensity score sufficiently correlate with relevant unobservables to explain differences between treatment and control customers that cannot be explained by matching observables. With most evaluations of energy efficiency programs, however, little (if any) data are available on customers other than their energy usage; so the distinction usually becomes irrelevant.

5.2 Code Compliance Protocol

The protocol represents a basic framework for estimating the NTGR that may be refined based on impact evaluation results. The NTGR is used to convert an estimate of gross savings into an estimate of net savings. Two general methods can be used to estimate gross energy impacts: (1) utility billing data analysis; and (2) building energy modeling.[58] The specific method used depends on the availability of necessary data.

5.2.1 Data Collection

5.2.1.1 Program Documentation

To inform the NTGR estimate, the evaluator documents program delivery. Information collected includes the following: the number, location, and dates of training workshops; the topics covered; materials disseminated; the number of trainees in each workshop and the type of trainee; and the hours of instruction.

5.2.1.2 Stakeholder Interviews

To inform the NTGR estimate, the evaluator conducts interviews with key stakeholders involved in the program. Interviews should include training program managers, instructors, and trainees. Trainees typically include contractors, builders, consultants, code officials, and others involved in building design and construction. The interviews seek to gather information on how training affected building design, construction, new code compliance, and enforcement.

5.2.2 Attribution Assessment

The NTGR estimation method stays the same, regardless of the method used to estimate gross energy savings.

A Delphi panel[59] produces an NTGR estimate that reflects the share of gross energy savings resulting from increased code compliance attributable to the program. Formed by selecting four to six knowledgeable

---

[57] Such secondary, observable characteristics are rarely available to evaluators of energy efficiency programs, except for geographic location (e.g., postal zone of customer premise).

[58] The modeled energy savings approach is similar to the approach described by Department of Commerce in Exhibits 6.1 and 6.2 from excerpts of Docket 13-0499 through estimation of potential energy savings.

[59] The Delphi panel should be conducted according to best practices. For example, see: Day J and Bobeva M (2005) "A Generic Toolkit for the Successful Management of Delphi Studies" *The Electronic Journal of Business Research Methodology* Volume 3 Issue 2, pp. 103-116, available online at www.ejbrm.com.

professionals not associated with the program in any way,[60] the panel receives estimates of gross energy savings, building construction data, and evidence of attribution—including the results of stakeholder interviews and program documentation. Panel members individually review the information and provide feedback regarding their NTGR estimates and rationales. Responses are compiled, with combined, anonymous responses circulated to all panel members. Panelists review this information, revise their initial estimates and rationales, as they deem appropriate, and provide new estimates and rationales. Evaluators review the second set of estimates and rationales to develop a final attribution estimate, accompanied with a summary of supporting rationales. This NTGR estimate, used in combination with the gross energy savings estimate and building construction data, produces a final estimate of net energy savings attributable to the program.

[60] Delphi panelists should have no biases that would affect their assessment of the program's effectiveness. Selected individuals should be knowledgeable about building codes and all factors that could conceivably affect code compliance.

6 Appendix A: Overview of NTG Methods

The evaluation teams present information in this appendix to provide a relatively quick overview of NTG methods for readers unaccustomed to the possible methods that evaluators may deploy. It is not meant to be a complete or deep discussion about each of the methods presented. However, the evaluators in Illinois considered the inclusion of this appendix to be very important in acknowledging the current suite of methods deployed by evaluators throughout the U.S. and giving a framework for work within Illinois.

Much of the information shown below is taken directly from a single source—the national Uniform Methods Project, Chapter 23: Estimating Net Savings: Common Practices. (Violette and Rathbun, 2014) This document has done a nice job of summarizing the eight most common attribution methods currently in use across the U.S. The evaluation teams recommend that readers go first to this reference for further information. Additionally, while there are slightly over 100 references within the Violette and Rathbun document, other non-duplicative references are included where reasonable as additional resources for those interested in further research into any specific method.

6.1 Survey-Based Approaches

Virtually all Illinois based evaluations use a survey-based approach for programs where primary data is used to determine net savings. (The main exception is for behavioral programs which use statistical analysis based on a randomized control trial program design.) Survey-based approaches obtain data from program participants and nonparticipants using a structured data collection instrument implemented via phone, in person, or online. At times, evaluators create and use an unstructured depth-interview guide to collect information about attribution, and this provides both contextual data and quantitative data about a given project.

6.1.1 Self-Report Approach

The self-report approach relies on the abilities of customers to discuss the program influence as well as the somewhat abstract ideas of the counterfactual (i.e., what would have occurred absent the program) after making a choice to purchase an energy efficient item or take an energy efficient action unrelated to a purchase. For program participants, this could include doing nothing (i.e., leaving the existing equipment as-is), installing the same energy efficient equipment as they did through the program, or an intermediate step of installing equipment that is more efficient than what they had in place previously, but less efficient than what they installed through the program . Evaluators also use this approach when collecting information from trade allies or distributors. This self-report approach is not new, nor is it exclusively used by the energy efficiency industry. An important attribute of this approach is its reliance on well-designed and fielded survey questions; so that the data underlying subsequent analyses are accurate and complete.

The output of this approach is a NTG ratio which can be considered an index of the program's influence on the decision to install energy-efficient equipment. The NTG ratio is applied to gross savings in order to obtain an estimate of net savings. The NTG ratio may include free ridership, spillover, or market effects, depending on the survey and analytical design. NTG ratios may be calculated at the measure, suite of measures, or program level and are typically average values weighted by savings. If sufficient information is available, analysis of NTG ratios among certain customer segments may be done to further inform changes to program design.

References

- Sudman, 1996
- Stone, et al., 2000
- Bradburn, et al., 2004

6.1.2 Econometric/Revealed Preference Approach

The econometric/revealed preference approach, while still considered a survey approach due to how data is collected, moves beyond asking people about the counterfactual and instead uses the observations of the evaluator to collect information for analysis of a NTG ratio. Within this approach, evaluators typically deploy similar sampling designs as for the self-report approach to collect data, but actively gather what a person is doing (i.e., what is being purchased in a store) to determine attribution.

6.2 Randomized Control Trials and Quasi-Experimental Designs

As mentioned earlier, evaluators deploy randomized control trials (RCT) for estimating savings from the behavioral programs within Illinois. Additionally, quasi-experimental designs (QED) have been used in the past in Illinois to estimate net savings from the upstream CFL program, and CFL, insulation, and air-sealing measures within the Home Performance with ENERGY STAR program.

RCT and QED use statistical analysis to determine regularities within the data that reveal net savings due to a program intervention.[61] The analytical design attempts to control for factors that can confound net analysis.[62] When estimating net savings within both an RCT and QED, two groups are included within the analysis: 1) a group that has been exposed to (i.e., treated by) a program; and 2) a group that has not been exposed to the program. Evaluators must carefully consider the choice of the non-exposed group (called a control group for RCTs or comparison group for QEDs).

RCT: This design must be integral to a program's implementation. Without the ability to randomly assign customers to one group or another (or at least randomly encourage customers to participate in a program), the ability of the design to yield unambiguous estimates of net impacts is compromised. Evaluators often help design how a program is implemented and, if not involved at the outset, carefully review choices made by the implementation team.

QED: A QED may be designed after a program has been implemented. It relies on determination of an equivalent comparison group, which is often chosen based on energy use. QED is difficult to perform well within the commercial sector due to the heterogeneity of end uses within the sector.

The output of an RCT or QED equals the average net savings for the population within the statistical model. Evaluators may also analyze the data to help understand the savings within specific known segments if sufficient information and data points are available.

References

- Mohr, 1995
- Shadish, Cook, Campbell, 2002
- Scriven, 2008
- Donaldson, 2009

[61] Net savings are calculated when a comparison or control group of non-treated customers are part of the design. Statistical analyses can also obtain gross savings.

[62] Economists strongly support this approach, but among program evaluators, the idea that an RCT is a "gold standard" for attribution research has been hotly debated for decades.

6.3 Deemed or Stipulated NTG Ratios

A deemed (or stipulated) NTG ratio is a value known prior to implementing a program and applied to estimate net savings for that program in a certain year.

Deemed or stipulated NTG ratios may be based on previous primary data collection, a review of secondary data, or agreed to among stakeholders. In Illinois, deemed or stipulated NTG ratios should reflect best estimates of likely future actual NTG ratios for the relevant program year, taking into consideration stakeholder input, the evaluator's expertise, and the best and most up-to-date information.

6.4 Common Practice Baseline Approaches

For this method, the evaluation team estimates what a typical consumer would have done at the time of the project implementation. Essentially, what is "commonly done" becomes the basis for baseline energy consumption and calculation of net savings. No gross impacts are calculated in this approach. This baseline is defined as the counterfactual "i.e., what would have occurred absent the program" and has been referred to as current practice, common practice, or industry standard practice. Evaluators determine these practices through multiple methods, but often can be from self-report or on-site audits. The difference between the energy use of measures installed in the program and the energy use associated with current practice is considered by some to be sufficiently close to the net savings.

This approach is not in use in Illinois, but it is used elsewhere in the country, such as the Pacific Northwest and Delaware.

6.5 Market Analyses

Market analyses can be done in several ways. Market analyses are often used in theory-driven evaluations of market transformation programs.

Other non-sales data market analyses can be postulated on changes specified in program logic such as: 1) changes in the number of energy-efficient units manufactured; 2) changes in market actor behavior around promotion or stocking of energy-efficient items; or 3) reductions in prices. The analyses involving non-sales data must make a clear link between the program intervention and the changes found in the market. Additionally, outside of Illinois, while evaluators have extrapolated the market changes to specific energy or demand reductions, this activity may be viewed as tenuous due to assumptions that evaluators must make within the analysis.

Illinois is in a position to begin to discuss market analyses and how specific research may be able to interpret changes that have occurred (or may occur in the future) because of the program interventions over the past eight years. Market analyses can be backward looking through historical tracing, but it is best used when the logic of an intervention is described and specific market metrics are tracked over time.

6.6 Structured Expert Judgment Approaches

Closely tied to market analysis, this approach is a way for evaluators to gather credible evidence of changes that arise due to the intervention of a program. When deployed, it is often used as a cost-effective approach to estimate market effects or reach agreement on a NTG value when several different types of evidence are available. The key premise of this approach is the use of a select group of known experts that all stakeholders agree can provide unbiased information as well as having sufficient knowledge to judge what may have occurred absent a program intervention.

A Delphi Panel is an example of this approach where data are collected from two or more rounds of data collection (which can occur via e-mail, Internet, or in person). A round is when experts make their thoughts known about a specific subject; the evaluation team synthesizes the data and provides this collated data back to the group to discuss again. Allowing the full experts to see how their peers think about a topic helps to move the group towards consensus.

References

- Mosenthal, et al., 2000
- Powell, 2002

6.7 Program Theory-Driven Approach

This approach is not included in the Violette and Rathbun (2014) document as a high-level method, but it is discussed by the authors under the historical tracing method. The Illinois evaluators believe that it deserves at least a short discussion within this framework.

A program theory is the written narrative about why the activities of a program are expected to bring about change. Typically associated with this approach is the direct graphical explication of the linkages between activities, outputs, and outcomes through an impact logic model.[63]

A theory-driven evaluation denotes "[A]ny evaluation strategy or approach that explicitly integrates and uses stakeholder, social science, some combination of, or other types of theories in conceptualizing, designing, conducting, interpreting, and applying an evaluation." (Coryn 2011) Within this approach, the ultimate conclusions regarding the efficacy of a program are based on the preponderance of the evidence and not on the results of any single analysis. Coryn and colleagues systematically examined 45 cases of theory-driven evaluations published over a 20-year period to ascertain how closely theory-driven evaluation practices comport with the key tenants of theory-driven evaluation as described and prescribed by prominent theoretical writers. One output from this analysis was the identification of the core principles and sub-principles of theory-driven evaluation. If interested, please review the reference under Coryn 2011.

As an approach, it is best used for complex programs and/or causal mechanisms that extend far into the future. Evaluators collect evidence that supports or rejects hypotheses that are explicit in the logic model. The case for program attribution is strengthened based on the extent to which an evaluation shows that the expected changes occur. Additionally, the evaluation team may be able to collect data that will answer questions about the longer-term outcomes of a program. This type of data collection may be very similar to market tracking activities described briefly above under Market Analyses.

This approach does not specifically estimate a NTG value, but Program Administrators can choose to keep, drop, or change a program based on intermediary data. Regulators must be convinced that the logic of a program is sound and that the intermediary outcomes are causally linked to expected savings.

References

- Weiss, 1997
- Chen, 2000
- Coryn, 2011

6.8 Case Studies Design

Case studies are used extensively in social sciences as well as many other disciplines or practice-oriented areas, such as political science, economics, education, and public policy. Case studies help to understand the how and

[63] Evaluators may use logic models to show program processes as well, but this is a program flow chart, not an impact model.

why of a situation and typically retain a holistic aspect of real-life events. As such, they may be a useful approach to determine attribution. As with program theory design, though, the data collected and analyzed within a case study approach will not typically yield a specific NTG value, but can provide credible evidence and insight that supports or refutes the changes brought about by program intervention.

To be used to assess attribution, evaluators must carefully design case studies to assure they account for the threats to causality (i.e., internal validity) that arise in any design. While not typically thought of in this manner, case study design can address multiple types of validity such as construct, internal, and external validity as well as assuring reliability. When establishing construct validity and reliability, evaluators must use multiple sources of evidence, create and maintain a study database, and maintain a “chain of evidence” within the analysis. Internal validity is shown through analytic tactics such as pattern matching, explanation building, addressing rival explanations, or using logic models. External validity centers on the ability to generalize the analytical findings to other similar situations. External validity may be shown through the replication of findings.

References

- Yin, 2003
- Stake, 2006

7 Appendix B: References

Bradburn, Norman, Sudman, Seymore, and Wansink, Brian. 2004. *Asking Questions. The Definitive Guide to Questionnaire Design – For Market Research, Political Polls, and Social and Health Questionnaires*. San Francisco, CA: Jossey-Bass.

Chen, Huey-Tsyh. 1990. *Theory-Driven Evaluations*. Sage Publications.

Coryn, Chris L.S., Norakes, Linday A., Westine, Carl D., Schröter, Daniela C. 2011. "A Systematic Review of Theory-Driven Evaluation Practice from 1990 to 2009." American Journal of Evaluation, 32(2): 199-226.

Donaldson, Steward I., Christie, Christina A., Mark, Melvin M. 2009. *What Counts as Credible Evidence in Applied Research and Evaluation Practice?* Los Angeles, CA: Sage Publications, Inc.

Mohr, Lawrence B. 1995. *Impact Analysis for Program Evaluation, Second Edition*. Thousand Oaks, CA: Sage Publications, Inc.

Mosenthal, Philip, Prahl, Ralph, Neme, Chris, and Cuomo, Robert. 2000. *A Modified Delphi Approach to Predict Market Transformation Program Effects*. Proceedings from the 2000 ACEEE Conference.

Powell, Catherine. 2002. "The Delphi Technique: Myths and Realities." Journal of Advanced Nursing. 41(4), 376-382.

Scriven, Michael. "A Summative Evaluation of RCT Methodology and an Alternative Approach to Causal Research." March 2008. Journal of MultiDisciplinary Evaluation, Volume 5, Number 9. ISSN 1556-8180.

Shadish, William R., Cook, Thomas D., and Campbell, Donald T. 2002. *Experimental and Quasi-Experimental Designs for Generalized Causal Inference.* Boston: Houghton Mifflin Company.

Stake, Robert E. 2006. *Multiple Case Study Analysis*. The Guilford Press.

Stone, Arthur A., Turkkan, Jaylan S., Bachrach, Christine A., Jobe, Jared B., Kurtzman, Howard S., Cain, Virginia S. editors. 2000. *The Science of Self-Report. Implications for Research and Practice*. Lawrence Erlbaum Associates, Inc.

Sudman, Seymour, Bradburn, Norman, Schwarz, Norbert. 1996. *Thinking about Answers. The Application of Cognitive Processes to Survey Methodology*. Jossey-Bass.

Violette, Daniel M., Rathbun, Pamela. 2014. "Chapter 23: Estimating Net Savings: Common Practices. The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures." Available electronically at http://www.nrel.gov/docs/fy14osti/62678.pdf .

Weiss, Carol H. 1998. *Evaluation Methods for Studying Programs and Policies, 2nd Edition*. Upper Saddle River, New Jersey: Prentice Hall.

Yin, Robert K. 2003. *Case Study Research. Design and Methods*. Thousand Oaks, CA: Sage Publications, Inc.