

**State of Illinois
Energy Efficiency
Technical Reference Manual**

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Acknowledgements

This document was created over the course of a six-month 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 www.ilsag.org/questions and contacting the Independent Facilitator at Annette.beitel@futureenergyenterprises.biz.

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

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

Table 1.1.1: Revision History

#	Document Title	Date	Applicable to PY Beginning

1 Purpose of the TRM

The purpose of this Technical Reference Manual (TRM) is to provide a transparent and consistent basis for calculating energy (kilowatt-hours (kWh) or therms) and capacity (kilowatts (kW)) savings generated by the State of Illinois' energy efficiency programs². To this end, the Vermont Energy Investment Corporation (VEIC) was retained by the Illinois Energy Association (IEA) on behalf of the Department of Commerce and Economic Opportunity (DCEO) and the state's electric and gas utilities³ (collectively, Program Administrators) to prepare this TRM for statewide use.

The TRM is a technical document that is filed with the Illinois Commerce Commission (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 test⁴ (TRC), as well as other cost-benefit tests in support of program design, evaluation and regulatory compliance. Actual cost-benefit calculations and the calculation of avoided costs will not be part of this TRM.
- Identify gaps in robust, primary data for Illinois, that can be addressed via evaluation efforts and/or other targeted end-use studies.
- ...[Contain] a process for periodically updating and maintaining records, and preserve a clear record of what deemed parameters are/were in effect at what times to facilitate evaluation and data accuracy reviews.
- ...[S]upport coincident peak capacity (for electric) savings estimates and calculations for electric utilities in a manner consistent with the methodologies employed by the utility's Regional Transmission Organization (“RTO”), as well as those necessary for statewide Illinois tracking of coincident peak capacity impacts.”⁵

1.1 Enabling ICC Policy

This Illinois Statewide Technical Reference Manual (TRM) was developed to comply with the Illinois Commerce Commission (ICC or Commission) Final Orders from the electric and gas Utilities⁶ Energy Efficiency Plan dockets. In the Final Orders, the ICC required the utilities to work with DCEO and the SAG to develop a statewide TRM. See, e.g., ComEd's Final Order (*Docket No. 10-0570, Final Order*⁷ at 59-60, December 21, 2010); Ameren's Final Order (*Docket No. 10-0568, Order on Rehearing*⁸ at 19, May 24, 2011); Peoples Gas/North Shore Gas' Final Order (*Docket*

(<http://www.ilga.gov/legislation/ilcs/ilcs5.asp?ActID=1277&ChapterID=23>)

³ In addition to DCEO, the utilities include; Ameren Illinois, ComEd, Peoples Gas, Peoples North Shore and NICOR GAS.

⁴ The Illinois TRC test is defined in 220 ILCS 5/8-104(b) and 20 ILCS 3855/1-10.

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

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 (Integrus), 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>

No. 10-0564, Final Order⁹ at 76, May 24, 2011), and Nicor’s Final Order (Docket No. 10-0562, Final Order¹⁰ at 30, May 24, 2011).

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

1.2 Development Process

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

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

The VEIC analytical team noticed that many of the existing measures in Illinois represent discrete cases within a range of measure possibilities across Market Sectors, End Uses, Measures & Technologies, Programs and Fuels. This document has consolidated these measures in such a way that discrete measures can be captured within a more generalized format where only individual parameters in the savings algorithm need to be changed to arrive at the savings claim for a discrete case. Finally, the measure titles used in this TRM may not match exactly the titles that the Utilities or DCEO efficiency programs use. An organizational structure, described in the next section, gives details about how measures are grouped, categorized, and described.

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>

2 Using the TRM

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

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

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

Algorithms and their parameter values are included for calculating estimated:

- Gross annual electric energy savings (kWh)
- Gross annual natural gas energy savings (therms)
- Gross electric summer coincident peak demand savings (kW)

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

- Incremental costs (\$)
- Measure life (years)
- Operation and maintenance costs (\$)
- Water (gal) and other resource savings where appropriate.

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

¹¹ As noted in the RFP, the net-to-gross ratios are provided by the evaluators and are listed in the appendices.

¹² Emphasis has been added to denote the difference between a “deemed value” and a “deemed savings estimate”. A deemed value refers to a single input value to an algorithm, while a deemed savings estimate is the result of calculating the end result of all of the values in the savings algorithm.

2.1 Organizational Structure

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

1. Market Sectors¹³

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

2. End-use Category

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

Table 2.1.1: End-Use Categories in the TRM¹⁴

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

3. Measure & Technology

- This level of organization represents individual efficient measures such as CFL lighting and LED lighting, both of which are individual technologies within the Lighting end-use category.
- Answers the question, “What technology defines the measure?”

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

¹³ 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.

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

2.2 Measure Code Specification

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

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

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

Table 2.2.1: Measure Code Specification Key

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

2.3 Components of TRM Measure Characterizations

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

DESCRIPTION

DEFINITION OF EFFICIENT EQUIPMENT

DEFINITION OF BASELINE EQUIPMENT

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

DEEMED MEASURE COST

DEEMED O&M COST ADJUSTMENTS

LOADSHAPE

COINCIDENCE FACTOR

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS

SUMMER COINCIDENT PEAK DEMAND SAVINGS

NATURAL GAS SAVINGS

WATER IMPACT DESCRIPTIONS AND CALCULATION

DEEMED O&M COST ADJUSTMENT CALCULATION

MEASURE CODE

2.4 Variable Input Tables

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

2.4.1 C&I Custom Value Use in Measure Implementation

This section defines the requirements for capturing custom variables stated in the commercial and industrial prescriptive measures defined in this statewide TRM. This approach is to be used when a variable in a measure formula can be replaced by a verifiable and documented value that is not presented in the TRM. This approach assumes that the algorithms presented in the measure are used as stated and only allows changes to certain variable values and is not a replacement algorithm for the measure.

2.4.2 Custom Variables

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

Table 2.4.1: Allowable Custom C&I Variables

Measure Number	Measure Title	Adjustable Variable	Adjustable Variable Description	Documentation	Notes
4.2.3	Commercial Steam Cooker	HOURS _{day}	Average Daily Operation (hours)	Customer input or measured value	
		F	Food cooked per day (lb)	Customer input or measured value	
		Days _{Year}	Annual Days of Operation (days)	Customer input or measured value	

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

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

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

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

Measure Number	Measure Title	Adjustable Variable	Adjustable Variable Description	Documentation	Notes
4.3.1	High Efficiency Pre-Rinse Spray Valve	Tout	Outlet Water Temperature	Customer input or measured value	
		Tin	Inlet Water Temperature	Customer input or measured value	
		EFF	Efficiency of water heater supplying hot water	Customer input or measured value or Manufacturer specification	Electric and Gas
		FLObase	Base case flow in gallons per minute	Customer input or measured value or Manufacturer specification	
		FLOeff	Efficient case flow in gallons per minute	Customer input or measured value or Manufacturer specification	
		HOURS _{day}	Hours of use per day	Customer input or measured value	
		Days _{Year}	Days of use per year	Customer input or measured value	
4.3.2	Low Flow Faucet Aerators	NOFF	Number of occupants per faucet	Customer input	
		GPM_base	Average flow rate, in gallons per minute, of the baseline faucet “as-used”	Documented value based on study or report	
		GPM_low	Average flow rate, in gallons per minute, of the low-flow faucet aerator “as-used”	Documented value based on study or report	
		L_base	Average baseline length faucet use per capita for all faucets in minutes	Documented value based on study or report	
		L_low	Average retrofit length faucet use per capita for all faucets in minutes	Documented value based on study or report	
4.3.3	Low Flow Showerheads	GPM_base	Average flow rate, in gallons per minute, of the baseline faucet “as-used”	Documented flow rate from installed equipment	
		NSPF	Number of showers per faucet	Customer input	

Measure Number	Measure Title	Adjustable Variable	Adjustable Variable Description	Documentation	Notes
4.3.4	Tankless Water Heater	Wgal	Annual Water use for equipment	Customer input or measured value	
		Tout	Outlet Water Temperature	Customer input or measured value	
		Tin	Inlet Water Temperature	Customer input or measured value	
		SL	Stand-by Loss in Base Case Btu/hr	Customer input or measured value	
		Eff_ee	Rated Efficiency of water Heater	Customer input or documented value based on study or report	
		Tank Volume	Tank Volume	Customer input or documented value based on study or report	
4.4.2	Space Boiler Tune-up	Ngi	Boiler gas input size	Customer input or measured value	
		SF	Savings Factor	Customer input or measured value	
		Effpre	Boiler Efficiency before Tune-up	Customer input or measured value	
4.4.3	Process Boiler Tune-up	Ngi	Boiler gas input size	Customer input or measured value	
		UF	Utilization Factor	Customer input or measured value	
		Effpre	Boiler Combustion Efficiency before Tune-up	Customer input or measured value	
		Eff _{measured}	Boiler Combustion Efficiency before Tune-up	Customer input or measured value	
4.4.4	Boiler Lockout/Reset Controls	Binput	Boiler Input Capacity	Customer input or measured value	
		SF	Savings Factor	Customer input or measured value	
		Effpre	Boiler Efficiency	Customer input or measured value	
4.4.11	High Efficiency Boiler	Capacity	Nominal Heating Capacity Boiler Size	Customer input or measured value	
		AFUE(base)	Efficient Furnace Annual Fuel Utilization Efficiency Rating	Customer input or measured value	
		AFUE(eff)	Efficient Furnace Annual Fuel Utilization Efficiency Rating	Customer input or measured value	

Measure Number	Measure Title	Adjustable Variable	Adjustable Variable Description	Documentation	Notes
4.4.12	High Efficiency Furnace	Capacity	Nominal Furnace input capacity	Customer input or measured value	
		AFUE(base)	Efficient Furnace Annual Fuel Utilization Efficiency Rating	Customer input or measured value	
		AFUE(eff)	Efficient Furnace Annual Fuel Utilization Efficiency Rating	Customer input or measured value	
4.4.15	Steam Trap Replacement or Repair	B	Boiler Efficiency	Customer input or measured value	
		L	Leaking and blow-thru percentage	Customer input or documented value based on study or report	
4.4.16	VSD for HVAC	HP	Motor HP	Customer input or measured value	
		Load Factor	Motor Load Factor	Customer input or measured value	
		Hours	Actual hours for equipment operations	Customer input or measured value	
		ESF	VDS Energy Savings Factors	Custom calculated values	
		CF	Coincidence factor	Custom calculated values	
4.5.3	HPT8 Lighting	Watts _{base}	Base Wattage	Customer input or measured value	This will allow for reduced wattage applications
		Watts _{EE}	Efficiency Wattage	Customer input or measured value	This will allow for reduced wattage applications
		Hours	Average use hours	Customer input or documented value based on study or report	

Measure Number	Measure Title	Adjustable Variable	Adjustable Variable Description	Documentation	Notes
4.5.4	T5 Lighting	Watts _{base}	Base Wattage	Customer input or measured value	This will allow for reduced wattage applications
		Watts _{EE}	Efficiency Wattage	Customer input or measured value	This will allow for reduced wattage applications
		Hours	Average use hours	Customer input or documented value based on study or report	
4.5.5	Lighting Controls	KW _{connected}	Total Connected kW load	Customer input or measured value	
		Hours	Hours of use	Customer input or documented value based on study or report	
		ESF	Energy Savings Factor	Customer input or documented value based on study or report	
4.5.6	Lighting Power Density Reduction	WSF _{effic}	The actual installed lighting watts per square foot or linear foot	Customer input	
		SF	Square footage of the building area applicable to the lighting design	Customer input	
		Hours	Hours of use	Customer input	

2.5 Program Delivery & Baseline Definitions

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

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

Table 2.5.1: Program Delivery Types

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

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

1. **Building Code:** As defined by the minimum specifications required under state energy code or applicable federal standards.
2. **Existing Equipment:** As determined by the most representative (or average) example of equipment that is in the existing stock. Existing equipment baselines apply over the equipment’s remaining useful life.

3. **New Equipment:** As determined by the equipment that represents standard practice in the current market environment. New equipment baselines apply over the effective useful life of the measure.
4. **Dual Baseline:** A baseline that begins as the existing equipment and shifts to new equipment after the expected life of the existing equipment is over.
5. **Zero Baseline:** A baseline that is applicable to early retirement measures where the existing equipment is no longer in service.

2.6 High Impact Measures

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

Table 2.6.1: Commercial and Industrial High Impact Measures

Section	End-use	Technology / Measure
4.2.3	Food Service	Commercial Steam Cooker
4.2.11	Food Service	High Efficiency Pre-Rinse Spray Valve
4.4.3	HVAC	Process Boiler Tune-up
4.4.4	HVAC	Boiler Lockout/Reset Controls
4.4.10	HVAC	High Efficiency Boilers
4.4.11	HVAC	High Efficiency Furnace
4.4.15	HVAC	Steam Trap Replacement or Repair
4.4.16	HVAC	Variable Speed Drives for HVAC
4.5.1	Lighting	CFL
4.5.2	Lighting	ILED
4.5.3	Lighting	High Performance T8 Fixtures and Lamps
4.5.4	Lighting	T5
4.5.5	Lighting	Lighting Controls
4.6.6	Lighting	Lighting Power Density Reduction
4.5.7	Lighting	LED Traffic and Pedestrian Signals
4.3.4	Hot Water	Tankless Water Heater

Table 2.6.2: Residential High Impact Measures

Section	End-use	Technology / Measure
5.1.2	Appliances	Clothes Washer
5.1.8	Appliances	Refrigerator & Freezer Recy.
5.4.2	Hot Water	Gas Water Heater
5.4.3	Hot Water	Heat Pump Water Heater
5.4.4	Hot Water	Low Flow Faucet Aerator
5.4.5	Hot Water	Low Flow Showerhead
5.3.1	HVAC	Air Source Heat Pump
5.3.2	HVAC	Central Air Conditioning
5.3.4	HVAC	Furnace Blower Motor
5.3.5	HVAC	Gas High Efficiency Boiler
5.3.6	HVAC	Gas High Efficiency Furnace
5.3.10	HVAC	Programmable Thermostats
5.5.5	Lighting	LED Downlights
5.5.2	Lighting	Specialty CFL
5.5.1	Lighting	Standard CFL
5.6.1	Shell	Air Sealing
5.6.2	Shell	Basement Sidewall Insulation
5.6.4	Shell	Wall and Ceiling Insulation

3 Assumptions

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

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

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

3.1 Footnotes & Documentation of Sources

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

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.

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.

3.3.1 CFL and T5/T8 Linear Fluorescents

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

Other lighting measures will also have baseline shifts (for example screw based LED and CFL fixtures) that will result in significant impacts to annual estimated savings in later years. Finally, as of July 14, 2012, Federal Standards will require that practically all linear fluorescents meet strict performance requirements essentially requiring all T12 users, when they need to purchase new bulbs, to upgrade to high performance T8 lamps and ballasts¹⁵. We have assumed that this standard will become fully effective in 2016. To account for this, we have included a methodology to address the shifting baseline in the high performance T8 measure and T5 measure which is defined specifically in each measure characterization.

¹⁵ At the time of this draft, we understand that some standard T8 lamps may meet the federal standard, and in that event, some T12 retrofits may end up being completed with standard T8s instead of high performance T8s.

3.4 Glossary

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

Building Types¹⁶:

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

¹⁶ Source: US EPA, www.energystar.gov, Space Type Definitions

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

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

Commercial & Industrial: The market sector that includes measures that apply to any of the building types defined in this TRM, which includes multifamily common areas and public housing¹⁷.

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

¹⁷ Measures that apply to the multifamily and public housing building types describe how to handle tenant versus master metered buildings.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Program: The mode of delivering a particular measure or set of measures to customers. See Table 2.5.1 for a list of program descriptions that are presently operating in Illinois.

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

Stakeholder Advisory Group (SAG): The Illinois Energy Efficiency Stakeholder Advisory Group (SAG) was first defined in the electric utilities’ first energy efficiency Plan Orders to include “... the Utility, DCEO, Staff, the Attorney General, BOMA and CUB and representation from a variety of interests, including residential consumers, business consumers, environmental and energy advocacy organizations, trades and local government... [and] a representative from the ARES (alternative retail electric supplier) community should be included.”¹⁸ A group of stakeholders who have an interest in Illinois’ energy efficiency programs and who meet regularly to share information and work toward consensus on various energy efficiency issues. The Utilities in Illinois have been directed by the ICC to work with the SAG on the development of a statewide TRM. A list of current SAG participants appears in the following table.

Table 3.4.1: SAG Stakeholder List

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

¹⁸ Docket No. 07-0540, Final Order at 32-33, February 6, 2008.
<http://www.icc.illinois.gov/downloads/public/edocket/215193.pdf>

3.5 Electrical Loadshapes (kWh)

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

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

Table 3.5.1: 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 eShapes¹⁹ data for Missouri, reconciled to Illinois loads and provided by Ameren, were used to calculate the percentage of load in to the four categories above.
2. Where the Itron eShapes data did not provide a particular end-use or specific measure load profile, loadshapes that have been developed over many years by Efficiency Vermont and that have been reviewed by the Vermont Department of Public Service, were adjusted to match Illinois period definitions. Note – no weather sensitive loadshapes were based on this method. Any of these load profiles that relate to High Impact Measures should be an area of future evaluation.

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

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

¹⁹ All loadshape information has been posted to the project’s Sharepoint site, and may be provided publically through the Stakeholder Advisory Group’s web site at their discretion. <http://www.ilsag.org/>

Table 3.5.2: Loadshapes by Season

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

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

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

Table 3.5.3: Loadshapes by Month and Day of Week

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

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

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

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

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

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 normals²⁰ 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 Laboratory²¹. Residential cooling is based on 65F in agreement with a field study in Wisconsin²². 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 55F²³. Custom degree-days with building specific base temperatures are recommended for large C&I projects.

²⁰ 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.

²¹ Belzer and Cort, Pacific Northwest National Laboratory in "Statistical Analysis of Historical State-Level Residential Energy Consumption Trends," 2004.

²² Energy Center of Wisconsin, May 2008 metering study; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research", p. 32 (amended in 2010).

²³ This value is based upon experience, and it is preferable to use building-specific base temperatures when available.

Table 3.7.1: Degree-Day Zones and Values by Market Sector

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

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

Figure 1: Cooling Degree-Day Zones by County

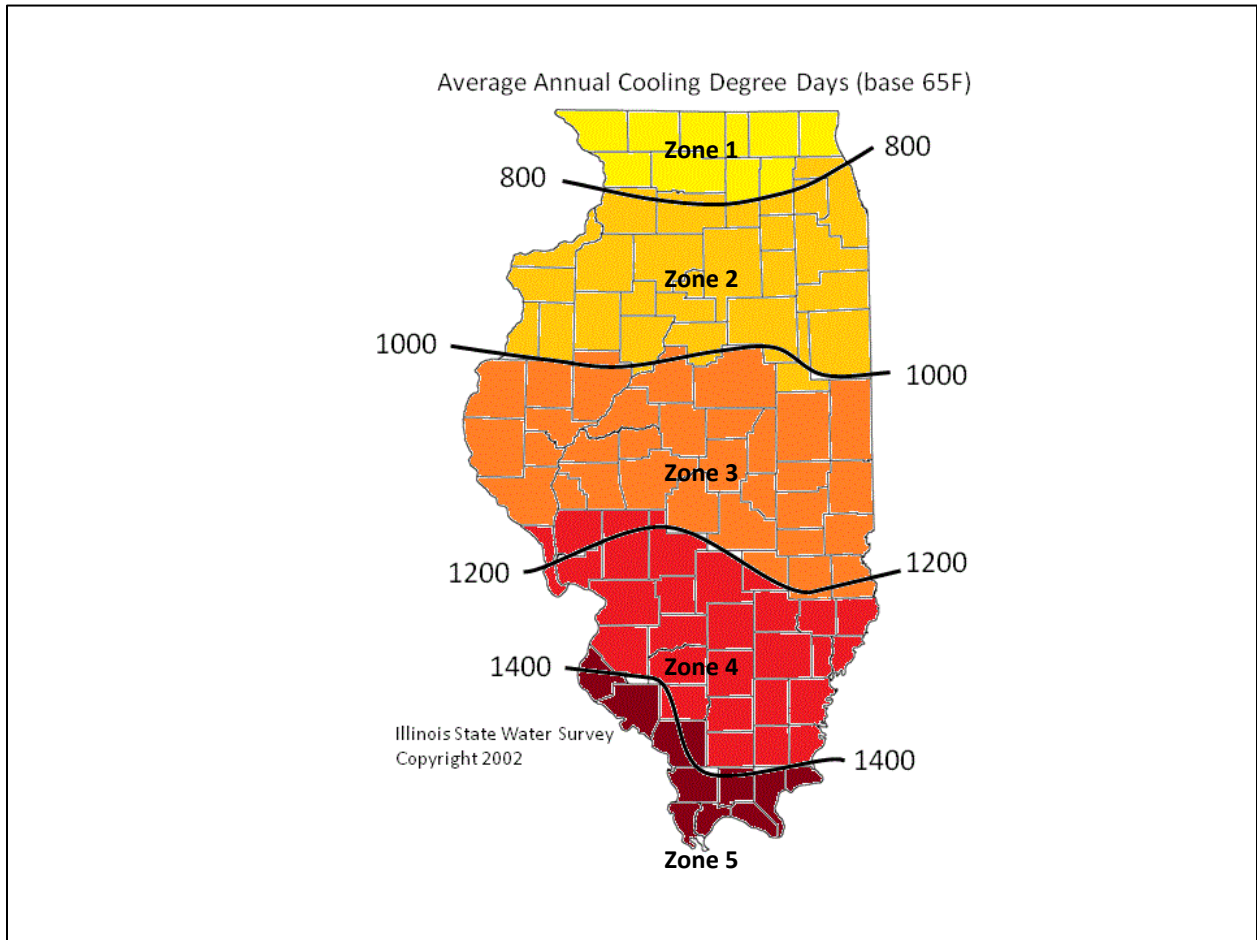


Figure 2: Heating Degree-Day Zones by County

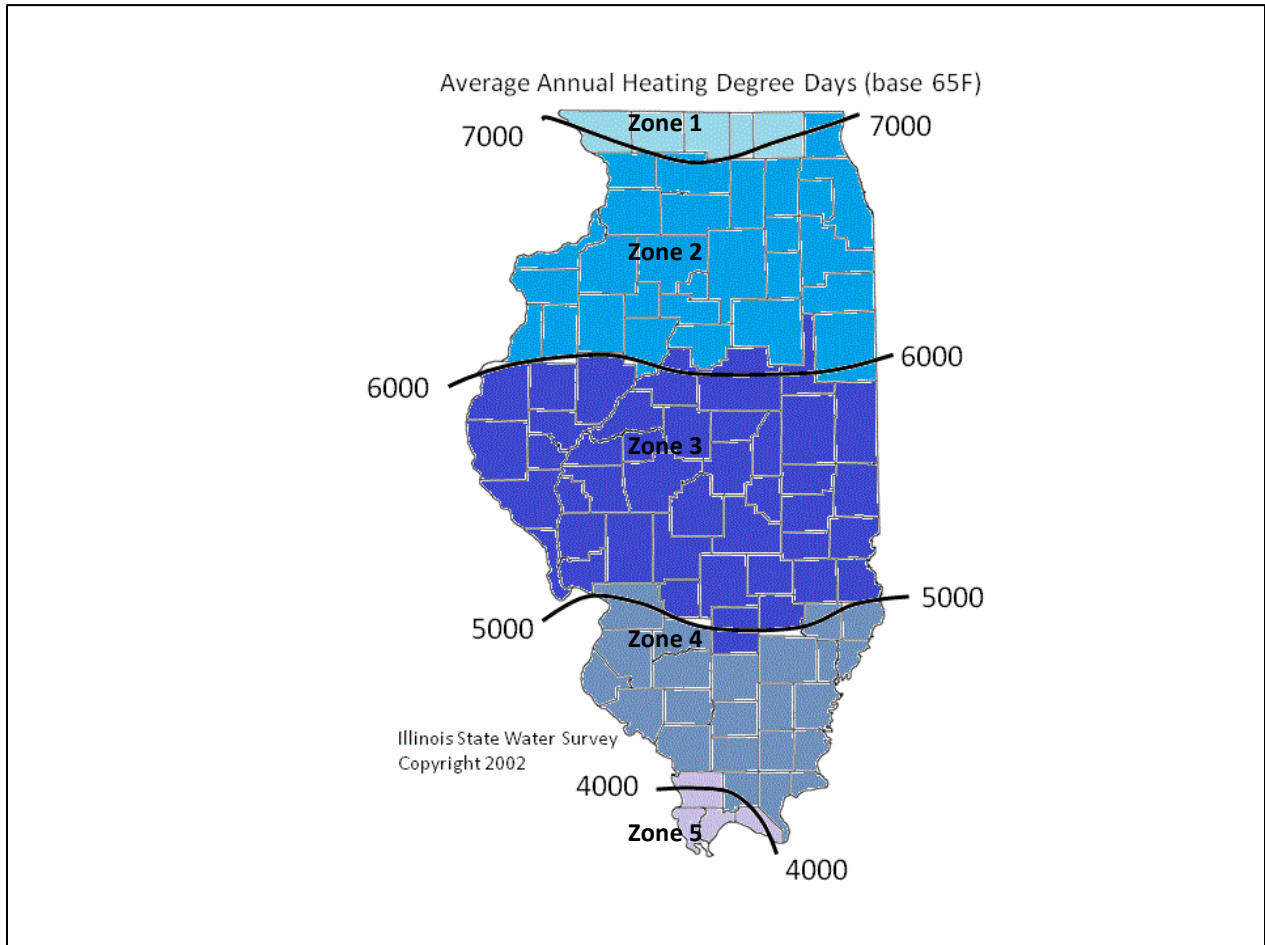


Table 3.7.2: Heating Degree-Day Zones by County

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 3.7.3: Cooling Degree-day Zones by County

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

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

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

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

EXAMPLE

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

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

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

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

3.9 Interactive Effects

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

One limitation is that some interactive effects between measures are not automatically captured. Because we cannot know what measures will be implemented at the same time with the same customer, we cannot always capture the interactions between multiple measures within individual measure characterizations. However, interactive effects with different end-uses are included in individual measure characterizations whenever possible²⁴. 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.

²⁴ For more information, please refer to the document, ‘Dealing with interactive Effects During Measure Characterization’ Memo to the Stakeholder Advisory Group dated 12/9/11.

4 Commercial and Industrial Measures

4.1 Agricultural End Use

4.1.1 Engine Block Timer for Agricultural Equipment

DESCRIPTION

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

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

DEFINITION OF EFFICIENT EQUIPMENT

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

DEFINITION OF BASELINE EQUIPMENT

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

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 3 years²⁵

DEEMED MEASURE COST

The incremental cost per installed plug-in timer is \$10.19²⁶.

DEEMED O&M COST ADJUSTMENTS

N/A

COINCIDENCE FACTOR

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

²⁵Equipment life is expected to be longer, but measure life is more conservative to account for possible attrition in use over time.

²⁶Based on bulk pricing reported by EnSave, which administers the rebate in Vermont

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\begin{aligned}\Delta\text{kWh} &= \text{ISR} * \text{Use Season} * \% \text{Days} * \text{HrSave/Day} * \text{kW}_{\text{heater}} - \text{ParaLd} \\ &= 78.39\% * 87 \text{ days} * 84.23\% * 7.765 \text{ Hr/Day} * 1.5 \text{ kW} - 5.46 \text{ kWh} \\ &= 664 \text{ kWh}\end{aligned}$$

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 VFD²⁷.

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 years²⁸.

DEEMED MEASURE COST

The incremental capital cost for the fans are as follows²⁹:

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

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape C34 - Industrial Motor

COINCIDENCE FACTOR

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

²⁷ Act on Energy Commercial Technical Reference Manual No. 2010-4

²⁸ Ibid.

²⁹ Ibid.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS³⁰

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

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

SUMMER COINCIDENT PEAK DEMAND SAVINGS³¹

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

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

NATURAL GAS ENERGY SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

³⁰ Ibid.

³¹ 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 criteria³².

Diameter of Fan (inches)	Minimum Efficiency for Exhaust & 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 years³³.

DEEMED MEASURE COST

The incremental capital cost for all fan sizes is \$150³⁴.

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape C34 - Industrial Motor

COINCIDENCE FACTOR

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

³² Act on Energy Commercial Technical Reference Manual No. 2010-4

³³ Ibid.

³⁴ Ibid.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS³⁵

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

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

SUMMER COINCIDENT PEAK DEMAND SAVINGS³⁶

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

³⁵ Ibid.

³⁶ 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 watts³⁷.

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 years³⁸.

DEEMED MEASURE COST

The incremental capital cost for the waters are \$787.50:³⁹.

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape C04 - Non-Residential Electric Heating

COINCIDENCE FACTOR

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

³⁷ Act on Energy Commercial Technical Reference Manual No. 2010-4

³⁸ Ibid.

³⁹ Ibid.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS⁴⁰

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.⁴¹

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

⁴⁰ Ibid.

⁴¹ Ibid.

4.2 Food Service Equipment End Use

4.2.1 Combination Oven

DESCRIPTION

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

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

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed equipment must be a new natural gas combination convection with steam oven cooking efficiency $\geq 38\%$ and convection mode cooking efficiency $\geq 44\%$ utilizing ASTM standard F2861 and meet idle requirements below⁴²:

Idle Rate Requirements for Commercial Combination Ovens/Steamers

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

DEFINITION OF BASELINE EQUIPMENT

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

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 12 years⁴³

DEEMED MEASURE COST

The incremental capital cost for this measure is \$4300⁴⁴

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

N/A

⁴² <http://www.fishnick.com/saveenergy/rebates/combis.pdf>

⁴³ 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.

⁴⁴ Ibid.

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

The annual natural gas energy savings from this measure is a deemed value equaling 644 therms.⁴⁵

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

⁴⁵ Nicor Gas Energy Efficiency Plan 2011-2014. Revised Plan Filed Pursuant to Order Docket 10-0562, May 27, 2011. These deemed values should be compared to PY evaluation and revised as necessary.

4.2.2 Commercial Solid and Glass Door Refrigerators & Freezers

DESCRIPTION

This measure relates to the installation of a new reach-in commercial refrigerator or freezer meeting ENERGY STAR efficiency standards. ENERGY STAR labeled commercial refrigerators and freezers are more energy efficient because they are designed with components such as ECM evaporator and condenser fan motors, hot gas anti-sweat heaters, or high-efficiency compressors, which will significantly reduce energy consumption.

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

DEFINITION OF EFFICIENT EQUIPMENT

In order for this characterization to apply, the efficient equipment is assumed to be a new vertical solid or glass door refrigerator or freezer or vertical chest freezer meeting the minimum ENERGY STAR efficiency level standards.

DEFINITION OF BASELINE EQUIPMENT

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

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 12 years⁴⁶.

⁴⁶2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Effective/Remaining Useful Life Values", California Public Utilities Commission, December 16, 2008.
<http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf>

DEEMED MEASURE COST

The incremental capital cost for this measure is provided below⁴⁷.

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

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape C23 - Commercial Refrigeration

COINCIDENCE FACTOR

The summer peak coincidence factor for this measure is assumed to be 0.937.⁴⁸

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = (kWh_{base} - kWh_{eff}) * 365.25$$

Where:

kWh_{base}= baseline maximum daily energy consumption in kWh

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

⁴⁷ 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 an 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.

⁴⁸ The CF for Commercial Refrigeration was calculated based upon the Ameren provided eShapes

Type	kWhbase ⁴⁹
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

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

V = the chilled or frozen compartment volume (ft³) (as defined in the Association of Home Appliance Manufacturers Standard HRF1–1979)

= Actual installed

365.25 = days per year

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

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

$$= 285 \text{ kWh}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

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

Where:

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

⁴⁹Energy Policy Act of 2005. Accessed on 7/7/10. <http://www.epa.gov/oust/fedlaws/publ_109-058.pdf>

⁵⁰ENERGY 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>

year.
= 8766
CF = Summer Peak Coincidence Factor for measure
= 0.937

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

$$\begin{aligned}\Delta kW &= 285 / 8766 * .937 \\ &= 0.030 \text{ kW}\end{aligned}$$

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 years⁵¹

DEEMED MEASURE COST

The incremental capital cost for this measure is \$998⁵² for a natural gas steam cooker or \$2490⁵³ for an electric steam cooker.

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape C01 - Commercial Electric Cooking

⁵¹California DEER 2008 which is also used by both the Food Service Technology Center and ENERGY STAR®.

⁵²Source for incremental cost for efficient natural gas steamer is RSG Commercial Gas Steamer Workpaper, January 2012.

⁵³Source for efficient electric steamer incremental cost is \$2,490 per 2009 PG&E Workpaper - PGECOFST104.1 - Commercial Steam Cooker - Electric and Gas as reference by KEMA in the ComeEd C & I TRM.

COINCIDENCE FACTOR

Summer Peak Coincidence Factor for measure is provided below for different building type⁵⁴:

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

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

ENERGY SAVINGS

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

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

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

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

Where:

$$\Delta\text{Idle Energy} = (((1 - \text{CSM}_{\%Baseline}) * \text{IDLE}_{BASE} + \text{CSM}_{\%Baseline} * \text{PC}_{BASE} * E_{FOOD} / \text{EFF}_{BASE}) * (\text{HOURS}_{day} - (F / \text{PC}_{BASE}) - (\text{PRE}_{number} * 0.25))) - (((1 - \text{CSM}_{\%ENERGYSTAR}) * \text{IDLE}_{ENERGYSTAR} + \text{CSM}_{\%ENERGYSTAR} * \text{PC}_{ENERGY} * E_{FOOD} / \text{EFF}_{ENERGYSTAR}) * (\text{HOURS}_{Day} - (F / \text{PC}_{ENERGY}) - (\text{PRE}_{number} * 0.25))))$$

⁵⁴Minnesota 2012 Technical Reference Manual, [Electric Food Service v03.2.xls](http://mn.gov/commerce/energy/topics/conservation/Design-Resources/Deemed-Savings.jspech), <http://mn.gov/commerce/energy/topics/conservation/Design-Resources/Deemed-Savings.jspech>

Where:

$CSM_{\%Baseline}$ = Baseline Steamer Time in Manual Steam Mode (% of time)
 = 90%⁵⁵

$IDLE_{Base}$ = Idle Energy Rate of Base Steamer⁵⁶

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 Steamer⁵⁷

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/lb⁵⁸ (gas steamers) or 0.0308⁸ (electric steamers)

EFF_{BASE} = Heavy Load Cooking Efficiency for Base Steamer
 = 15%⁵⁹ (gas steamers) or 26%⁹ (electric steamers)

⁵⁵Food Service Technology Center 2011 Savings Calculator

⁵⁶Food Service Technology Center 2011 Savings Calculator

⁵⁷Production 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.

⁵⁸Reference ENERGY STAR® savings calculator at http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COC.

⁵⁹Reference Food Service Technology Center 2011 Savings Calculator values as used by Consortium for Energy Efficiency, Inc. for baseline electric and natural gas steamer heavy cooking load energy efficiencies.

HOURS_{day} = Average Daily Operation (hours)

Type of Food Service	Hoursday60
Fast Food, limited menu	4
Fast Food, expanded menu	5
Pizza	8
Full Service, limited menu	8
Cafeteria	6
Unknown	1261
Custom	Varies

F = Food cooked per day (lbs/day)

= custom or if unknown, use 100 lbs/day⁶²

CSM_{%ENERGYSTAR} = ENERGY STAR Steamer's Time in Manual Steam Mode (% of time)⁶³

= 0%

IDLE_{ENERGYSTAR} = Idle Energy Rate of ENERGY STAR⁶⁴

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

⁶⁰Minnesota 2012 Technical Reference Manual, Electric Food Service_v03.2.xls, <http://mn.gov/commerce/energy/topics/conservation/Design-Resources/Deemed-Savings.jspech>

⁶¹ENERGY STAR[®] savings calculator which references Food Service Technology research on average use, 2009

⁶²Reference amount used by both Food Service Technology Center and ENERGY STAR[®] savings calculator

⁶³Reference information from the Food Service Technology Center siting that ENERGY STAR[®] steamers are not typically operated in constant steam mode, but rather are used in timed mode. Reference ENERGY STAR[®] savings calculator at

http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COC for efficient steamer. Both baseline & efficient steamer mode values should be considered for users in Illinois market.

⁶⁴Food Service Technology Center 2011 Savings Calculator

PC_{ENERGY} = Production Capacity of ENERGY STAR® Steamer⁶⁵

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%⁶⁶ (gas steamer) or 50%¹⁵ (electric steamer)

PRE_{number} = Number of preheats per day
 =1⁶⁷ (if unknown, use 1)

Where:

$$\Delta Preheat Energy = (PRE_{number} * \Delta Pre_{heat})$$

Where:

PRE_{number} = Number of Preheats per Day
 =1⁶⁸(if unknown, use 1)

PRE_{heat} = Preheat energy savings per preheat
 = 11,000 Btu/preheat⁶⁹ (gas steamer) or 0.5 kWh/preheat⁷⁰ (electric steamer)

Where:

⁶⁵ 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.

⁶⁶Reference 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

⁶⁷Reference ENERGY STAR® savings calculator at
http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COC and Food

⁶⁸Reference ENERGY STAR® savings calculator at
http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COC and Food

⁶⁹Ohio 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

⁷⁰Reference Food Service Technology Center 2011 Savings Calculator values for Baseline Preheat Energy.

$$\Delta\text{Cooking Energy} = ((1/\text{EFF}_{\text{BASE}}) - (1/\text{EFF}_{\text{ENERGY STAR}})) * F * E_{\text{FOOD}}$$

Where:

- EFF_{BASE} = Heavy Load Cooking Efficiency for Base Steamer
= 15%⁷¹ (gas steamer) or 26%²⁸ (electric steamer)
- $\text{EFF}_{\text{ENERGY STAR}}$ = Heavy Load Cooking Efficiency for ENERGY STAR® Steamer
= 38%⁷² (gas steamer) or 50%²³ (electric steamer)
- F = Food cooked per day (lbs/day)
= custom or if unknown, use 100 lbs/day⁷³
- E_{FOOD} = Amount of Energy Absorbed by the food during cooking known as ASTM Energy to Food⁷⁴

E_{FOOD} - gas(Btu/lb)	E_{FOOD} (kWh/lb)
105 ⁷⁵	0.0308 ⁷⁶

EXAMPLE

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

$$\begin{aligned} \Delta\text{Savings} &= \Delta\text{Idle Energy} + \Delta\text{Preheat Energy} + \Delta\text{Cooking Energy} * Z * 1/100.000 \\ \Delta\text{Idle Energy} &= (((1 - .9) * 11000 + .9 * 65 * 105 / .15) * (12 - (100 / 65) - (1 - .25))) - (((1 - 0) * 6250 + 0 * 55 * 105 / 0.38) * (12 - (100 / 55) - (1 - 0.25))) + \\ \Delta\text{Preheat Energy} &= (1 * 11,000) + \\ \Delta\text{Cooking Energy} &= (((1 / 0.15) - (1 / 0.38)) * (100 \text{ lb/day} * 105 \text{ btu/lb})) \\ &* 365.25 \text{ days}) * 1/100,000 = \\ &= 1536 \text{ therms} \end{aligned}$$

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

$$\begin{aligned} \Delta\text{Savings} &= \Delta\text{Idle Energy} + \Delta\text{Preheat Energy} + \Delta\text{Cooking Energy} * Z \\ \Delta\text{Idle Energy} &= (((1 - .9) * 1.0 + .9 * 70 * 0.0308 / .26) * (12 - (100 / 70) - (1 * .25))) - (((1 - 0) * 0.4 + 0 * 50 * .0308 / 0.50) * (12 - (100 / 50) - (1 * .25))) + \\ \Delta\text{Preheat Energy} &= (1 * 0.5) + \\ \Delta\text{Cooking Energy} &= (((1 / 0.26) - (1 / 0.5)) * (100 * 0.0308)) \\ &* 365.25 \text{ days} = \end{aligned}$$

⁷¹ 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.

⁷² Ibid.

⁷³ Amount used by both Food Service Technology Center and ENERGY STAR® savings calculator

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

⁷⁵ Ibid.

⁷⁶ Ibid.

SUMMER COINCIDENT PEAK DEMAND SAVINGS

This is only applicable to the electric steam cooker.

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

Where:

CF = Summer Peak Coincidence Factor for measure is provided below for different locations⁷⁷:

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 year⁷⁸

Other values as defined above

EXAMPLE

For 3 pan electric steam cooker located in a cafeteria:

$$\begin{aligned} \Delta kW &= (\Delta kWh / (HOURS_{Day} * Days_{Year})) * CF = \\ &= (30,533 / (12 * 365.25)) * .36 = \\ &= 2.51 kW \end{aligned}$$

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

⁷⁷ Minnesota 2012 Technical Reference Manual, Electric Food Service_v03.2.xls, <http://mn.gov/commerce/energy/topics/conservation/Design-Resources/Deemed-Savings.jspech>

W_{BASE} = Water Consumption Rate of Base Steamer (gal/hr)
 = 40⁷⁹

$W_{ENERGYSTAR}$ = Water Consumption Rate of ENERGY STAR® Steamer look up⁸⁰

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 year⁸¹

EXAMPLE

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

$$\begin{aligned} \Delta Water &= \\ \Delta Water &= [(40 - 10) * 12 * 365.25 \\ &= 131,490 \text{ gallons} \end{aligned}$$

Deemed O&M Cost Adjustment Calculation

N/A

REFERENCE TABLES

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

⁷⁹ FSTC (2002). Commercial Cooking Appliance Technology Assessment. Chapter 8: Steamers.

⁸⁰Source 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.

⁸¹Source 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/h utilizing ASTM standard F1817.

DEFINITION OF BASELINE EQUIPMENT

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

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 17 years.⁸²

DEEMED MEASURE COST

The incremental capital cost for this measure is \$1800⁸³.

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

N/A

⁸²Nicor Gas Energy Efficiency Plan 2011-2014. Revised Plan Filed Pursuant to Order Docket 10-0562, May 27, 2011

⁸³ Ibid.

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

The annual natural gas energy savings from this measure is a deemed value equaling 733 Therms⁸⁴.

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

⁸⁴Nicor Gas Energy Efficiency Plan 2011-2014. Revised Plan Filed Pursuant to Order Docket 10-0562, May 27, 2011. These deemed values should be compared to PY evaluation and revised as necessary

4.2.5 ENERGY STAR Convection Oven

DESCRIPTION

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

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

DEFINITION OF EFFICIENT EQUIPMENT

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

DEFINITION OF BASELINE EQUIPMENT

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

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 12 years⁸⁵

DEEMED MEASURE COST

The incremental capital cost for this measure is \$50⁸⁶

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

⁸⁵ 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

⁸⁶ Measure cost from ENERGY STAR which cites reference as "EPA research on available models using AutoQuotes, 2010" http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COG

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

Custom calculation below, otherwise use deemed value of 306 therms.⁸⁷

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

Where:

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

$$\Delta\text{DailyPreheatEnergy} = (\text{PreHeatNumberBase} * \text{PreheatTimeBase} / 60 * \text{PreheatRateBase}) - (\text{PreheatNumberENERGYSTAR} * \text{PreheatTimeENERGYSTAR} / 60 * \text{PreheatRateENERGYSTAR})$$

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

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

⁸⁷ 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

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 = $\text{HOURSday-LB/PCENERGYSTAR} - \text{PreHeatTimeENERGYSTAR}/60$ = $12 - 100/80 - 15/60$ =10.5 hours
IdleBaseTime	= BASE Idle Time = $\text{HOURSday-LB/PCbase} - \text{PreHeatTimeBase}/60$ =Custom or if unknown, use = $12 - 100/70 - 15/60$ =10.3 hours
EFOOD	= ASTM energy to food = 250 btu/pound

EXAMPLE

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

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

Where:

$\Delta\text{DailyIdleEnergy}$	$= (18000 * 10.3) - (13000 * 10.5)$ $= 49286 \text{ btu}$
$\Delta\text{DailyPreheatEnergy}$	$= (1 * 15 / 60 * 76000) - (1 * 15 / 60 * 44000)$ $= 8000 \text{ btu}$
$\Delta\text{DailyCookingEnergy}$	$= (100 * 250 / .30) - (100 * 250 / .44)$ $= 26515 \text{ btu}$
ΔTherms	$= (49286 + 8000 + 26515) * 365.25 / 100000$ $= 306 \text{ therms}$

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

4.2.6 ENERGY STAR Dishwasher

DESCRIPTION

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

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

DEFINITION OF EFFICIENT EQUIPMENT

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

DEFINITION OF BASELINE EQUIPMENT

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

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be⁸⁸

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

⁸⁸ Lifetime from ENERGY STAR HFHC which cites reference as "FSTC research on available models, 2009" http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COG

DEEMED MEASURE COST

The incremental capital cost for this measure is⁸⁹

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

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape C01 - Commercial Electric Cooking

SUMMER COINCIDENT PEAK DEMAND SAVINGS

Summer Peak Coincidence Factor for measure is provided below for different restaurant types⁹⁰:

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

Algorithm

ENERGY SAVINGS

ENERGY STAR dishwashers save energy in three categories, building water heating, booster water heating and idle energy. Building water heating and booster water heating could be either electric or natural gas. These deemed values are presented in a table format. Savings all water heating combinations are found in the tables below.⁹¹

⁸⁹ 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

⁹⁰Minnesota 2012 Technical Reference Manual, Electric Food Service_v03.2.xls, <http://mn.gov/commerce/energy/topics/conservation/Design-Resources/Deemed-Savings.jspech>

⁹¹Algorithms 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

Electric building and booster water heating

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

Electric building and natural gas booster water heating

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

Natural Gas building and electric booster water heating

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

Natural Gas building and booster water heating

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

WATER SAVINGS

Using standard assumptions water savings would be:

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

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = \Delta kWh / \text{AnnualHours}$$

Where:

$$\begin{aligned} \text{AnnualHours} &= \text{Hours} * \text{Days} \\ &= 365.25 * 18 \\ &= 6575 \text{ annual hours} \end{aligned}$$

Example:

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

$$\begin{aligned} \Delta kW &= \Delta kWh / \text{AnnualHours} \\ &= 1213 / 6575 \\ &= 0.184 \text{ kW} \end{aligned}$$

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

4.2.7 ENERGY STAR Fryer

DESCRIPTION

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

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

DEFINITION OF EFFICIENT EQUIPMENT

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

DEFINITION OF BASELINE EQUIPMENT

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

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 15 years.⁹²

DEEMED MEASURE COST

The incremental capital cost for this measure is \$1200.⁹³

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

⁹²Lifetime 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

⁹³Measure cost from ENERGY STAR which cites reference as “EPA research on available models using AutoQuotes, 2010” http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COG

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS⁹⁴

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

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

Where:

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

$$\Delta\text{DailyPreheatEnergy} = (\text{PreHeatNumberBase} * \text{PreheatTimeBase} / 60 * \text{PreheatRateBase}) - (\text{PreheatNumberENERGYSTAR} * \text{PreheatTimeENERGYSTAR} / 60 * \text{PreheatRateENERGYSTAR})$$

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

Where:

- HOURSday = Average Daily Operation
= custom or if unknown, use 16 hours
- Days = Annual days of operation
= custom or if unknown, use 365.25 days a year
- LB = Food cooked per day
= custom or if unknown, use 150 pounds
- EffENERGYSTAR = Cooking Efficiency ENERGY STAR
= custom or if unknown, use 50%
- EffBase = Cooking Efficiency Baseline
= custom or if unknown, use 35%
- PCENERGYSTAR = Production Capacity ENERGY STAR
= custom or if unknown, use 65 pounds/hr
- PCBase = Production Capacity base
= custom or if unknown, use 60 pounds/hr
- PreheatNumberENERGYSTAR = Number of preheats per day

⁹⁴ Algorithms and assumptions derived from ENERGY STAR fryer Commercial Kitchen Equipment Savings Calculator. http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COG

	= custom or if unknown, use 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
	= $\text{HOURSday-LB/PCENERGYSTAR} - \text{PreHeatTimeENERGYSTAR}/60$
	= Custom or if unknown, use
	= $16 - 150/65 - 15/60$
	= 13.44 hours
IdleBaseTime	= BASE Idle Time
	= $\text{HOURSday-LB/PCbase} - \text{PreHeatTimeBase}/60$
	= Custom or if unknown, use
	= $16 - 150/60 - 15/60$
	= 13.25 hours
EFOOD	= ASTM energy to food
	= 570 btu/pound

EXAMPLE

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

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

Where:

$\Delta\text{DailyIdleEnergy}$	$= (18550 * 13.25) - (120981 * 13.44)$ $= 64519 \text{ btu}$
$\Delta\text{DailyPreheatEnergy}$	$= (1 * 15 / 60 * 64000) - (1 * 15 / 60 * 62000)$ $= 500 \text{ btu}$
$\Delta\text{DailyCookingEnergy}$	$= (150 * 570 / .35) - (150 * 570 / .5)$ $= 73286 \text{ btu}$
ΔTherms	$= (64519 + 500 + 73286) * 365.25 / 100000$ $= 508 \text{ therms}$

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

4.2.8 ENERGY STAR Griddle

DESCRIPTION

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

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

DEFINITION OF EFFICIENT EQUIPMENT

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

DEFINITION OF BASELINE EQUIPMENT

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

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 12 years⁹⁵

DEEMED MEASURE COST

The incremental capital cost for this measure is \$0 for an electric griddle and \$60 for a gas griddle.⁹⁶

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape C01 - Commercial Electric Cooking

⁹⁵ 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

⁹⁶ 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 type⁹⁷:

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 SAVINGS⁹⁸

ELECTRIC ENERGY SAVINGS

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

Where:

$$\Delta Daily Idle Energy = [\text{IdleBase} * \text{Width} * \text{Length} (LB/ \text{PCBase}) - (\text{PreheatNumberBase} * \text{PreheatTimeBase}/60)] - \text{IdleENERGYSTAR} * \text{Width} * \text{Length} (LB/ \text{PCENERGYSTAR}) - (\text{PreheatNumberENERGYSTAR} * \text{PreheatTimeENERGYSTAR}/60)$$

$$\Delta Daily Preheat Energy = (\text{PreHeatNumberBase} * \text{PreheatTimeBase} / 60 * \text{PreheatRateBase} * \text{Width} * \text{Depth}) - (\text{PreheatNumberENERGYSTAR} * \text{PreheatTimeENERGYSTAR}/60 * \text{PreheatRateENERGYSTAR} * \text{Width} * \text{Depth})$$

$$\Delta Daily Cooking Energy = (LB * E_{FOOD} / \text{EffBase}) - (LB * E_{FOOD} / \text{EffENERGYSTAR})$$

Where:

- HOURS_{day} = 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

⁹⁷Minnesota 2012 Technical Reference Manual, [Electric Food Service v03.2.xls](http://mn.gov/commerce/energy/topics/conservation/Design-Resources/Deemed-Savings.jspech),

<http://mn.gov/commerce/energy/topics/conservation/Design-Resources/Deemed-Savings.jspech>

⁹⁸ 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

Width	= Griddle Width
	= custom or if unknown, use 3 feet
Depth	= Griddle Depth
	= custom or if unknown, use 2 feet
EffENERGYSTAR	= Cooking Efficiency ENERGY STAR
	= custom or if unknown, use 70%
EffBase	= Cooking Efficiency Baseline
	= custom or if unknown, use 65%
PCENERGYSTAR	= Production Capacity ENERGY STAR
	= custom or if unknown, use 6.67 pounds/hr/sq ft
PCBase	= Production Capacity base
	= custom or if unknown, use 5.83 pounds/hr/sq ft
PreheatNumberENERGYSTAR	= Number of preheats per day
	= custom or if unknown, use 1
PreheatNumberBase	= Number of preheats per day
	= custom or if unknown, use 1
PreheatTimeENERGYSTAR	= preheat length
	= custom or if unknown, use 15 minutes
PreheatTimeBase	= preheat length
	= custom or if unknown, use 15 minutes
PreheatRateENERGYSTAR	= preheat energy rate high efficiency
	= custom or if unknown, use 1333 W/sq ft
PreheatRateBase	= preheat energy rate baseline
	= custom or if unknown, use 2667 W/sq ft
IdleENERGYSTAR	= Idle energy rate
	= custom or if unknown, use 320 W/sq ft
IdleBase	= Idle energy rate

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

EFOOD = ASTM energy to food

= 139 w/pound

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

$$\begin{aligned} \Delta\text{DailyIdleEnergy} &= [400 * 3 * 2 (100/5.83) - (1 * 15/60)] - [320 * 3 * 2 (100/6.67) - (1 * 15/60)] \\ &= 3583 \text{ W} \\ \Delta\text{DailyPreheatEnergy} &= (1 * 15 / 60 * 2667 * 3 * 2) - (1 * 15/60 * 1333 * 3 * 2) \\ &= 2000 \text{ W} \\ \Delta\text{DailyCookingEnergy} &= (100 * 139 / .65) - (100 * 139 / .70) \\ &= 1527 \text{ W} \\ \Delta\text{kWh} &= (2000+1527+3583) * 365.25 / 1000 \\ &= 2597 \text{ kWh} \end{aligned}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\text{kW} = \Delta\text{kWh/Hours} * \text{CF}$$

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

$$\begin{aligned} &= 2595 \text{ kWh} / 4308 * .36 \\ &= 0.22 \text{ kW} \end{aligned}$$

NATURAL GAS ENERGY SAVINGS

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

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

Where:

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

$$\Delta\text{DailyPreheatEnergy} = (\text{PreHeatNumberBase} * \text{PreheatTimeBase} / 60 * \text{PreheatRateBase} * \text{Width} * \text{Length}) - (\text{PreHeatNumberENERGYSTAR} * \text{PreheatTimeENERGYSTAR} / 60 * \text{PreheatRateBase} * \text{Width} * \text{Length})$$

Depth) – (PreheatNumberENERGYSTAR* PreheatTimeENERGYSTAR/60 * PreheatRateENERGYSTAR * Width * Depth)

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

Where (new variables only):

EffENERGYSTAR = Cooking Efficiency ENERGY STAR

= custom or if unknown, use 38%

EffBase = Cooking Efficiency Baseline

= custom or if unknown, use 32%

PCENERGYSTAR = Production Capacity ENERGY STAR

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

PCBase = Production Capacity base

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

PreheatRateENERGYSTAR = preheat energy rate high efficiency

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

PreheatRateBase = preheat energy rate baseline

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

IdleENERGYSTAR = Idle energy rate

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

IdleBase = Idle energy rate

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

EFOOD = ASTM energy to food

= 475 btu/pound

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

$$\begin{aligned} \Delta\text{DailyIdleEnergy} &= [3500 * 3 * 2 (100/4.17) - (1 * 15/60)] - 2650 * 3 * 2 (100/7.5) - (1 * 15/60) \\ &= 11258 \text{ Btu} \\ \Delta\text{DailyPreheatEnergy} &= (1 * 15 / 60 * 14,000 * 3 * 2) - (1 * 15/60 * 10000 * 3 * 2) \\ &= 6000 \text{ btu} \\ \Delta\text{DailyCookingEnergy} &= (100 * 475 / .32) - (100 * 475 / .38) \\ &= 23438 \text{ btu} \\ \Delta\text{Therms} &= (11258 + 6000 + 23438) * 365.25 / 100000 \\ &= 149 \text{ therms} \end{aligned}$$

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

4.2.9 ENERGY STAR Hot Food Holding Cabinets

DESCRIPTION

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

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

DEFINITION OF EFFICIENT EQUIPMENT

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

DEFINITION OF BASELINE EQUIPMENT

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

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 12 years⁹⁹

DEEMED MEASURE COST

The incremental capital cost for this measure is¹⁰⁰

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

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape C01 - Commercial Electric Cooking

99 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

100 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 type¹⁰¹:

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 size¹⁰²

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

$$\Delta kWh = HFHC_{Baseline} kWh - HFHC_{ENERGYSTAR} kWh$$

Where:

$$HFHC_{Baseline} kWh = Power_{Baseline} * HOURS_{day} * Days / 1000$$

Power_{Baseline} = Custom, otherwise

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

HOURS_{day} = Average Daily Operation

= custom or if unknown, use 15 hours

¹⁰¹Minnesota 2012 Technical Reference Manual, [Electric Food Service v03.2.xls](http://mn.gov/commerce/energy/topics/conservation/Design-Resources/Deemed-Savings.jspech),

<http://mn.gov/commerce/energy/topics/conservation/Design-Resources/Deemed-Savings.jspech>

¹⁰² 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

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

HFHCENERGYSTARkWh = PowerENERGYSTAR* HOURSday * Days/1000

PowerENERGYSTAR = Custom, otherwise

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

HOURSday = Average Daily Operation
 = custom or if unknown, use 15 hours

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

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

$$\begin{aligned} \Delta kWh &= (\text{PowerBaseline} * \text{HOURSday} * \text{Days}) / 1000 - (\text{PowerENERGYSTAR} * \text{HOURSday} * \text{Days}) / 1000 \\ &= (2500 * 15 * 365.25) / 1000 - (800 * 15 * 365.25) / 1000 \\ &= 9,314 \text{ kWh} \end{aligned}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = \Delta kWh / \text{Hours} * CF$$

Where: Hours = Hoursday * Days

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

$$\begin{aligned} &= 9,314 \text{ kWh} / (15 * 365.25) * .36 \\ &= 0.61 \text{ kW} \end{aligned}$$

NATURAL GAS ENERGY SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

4.2.10 ENERGY STAR Ice Maker

DESCRIPTION

This measure relates to the installation of a new ENERGY STAR qualified commercial ice machine. The ENERGY STAR label applied to air-cooled, cube-type machines including ice-making head, self-contained, and remote-condensing units. This measure excludes flake and nugget type ice machines. This measure could relate to the replacing of an existing unit at the end of its useful life, or the installation of a new system in a new or existing building.

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

DEFINITION OF EFFICIENT EQUIPMENT

In order for this characterization to apply, the efficient equipment is assumed to be a new commercial ice machine meeting the minimum ENERGY STAR efficiency level standards.

DEFINITION OF BASELINE EQUIPMENT

In order for this characterization to apply, the baseline equipment is assumed to be a commercial ice machine meeting federal equipment standards established January 1, 2010.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 10 years¹⁰³.

DEEMED MEASURE COST

The incremental capital cost for this measure is provided below.¹⁰⁴

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

DEEMED O&M COST ADJUSTMENTS

N/A

¹⁰³DEER 2008

¹⁰⁴These 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%20Electric%20Measure%20Workpapers%2011-08-05.DOC>>.

LOADSHAPE

Loadshape C23 - Commercial Refrigeration

COINCIDENCE FACTOR

The Summer Peak Coincidence Factor is assumed to equal 0.937

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta \text{kWh} = [(\text{kWh}_{\text{base}} - \text{kWh}_{\text{ee}}) / 100] * (\text{DC} * \text{H}) * 365.25$$

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	kWhbase105	kWhee106
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.

¹⁰⁵ 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>>.

¹⁰⁶ 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>

DC = Duty Cycle of the ice machine

$$= 0.57^{107}$$

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

$$\begin{aligned} \Delta \text{kWh} &= [(6.4 - 5.8) / 100] * (0.57 * 450) * 365.25 \\ &= 562 \text{ kWh} \end{aligned}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta \text{kW} = \Delta \text{kWh} / (\text{HOURS} * \text{DC}) * \text{CF}$$

Where:

HOURS = annual operating hours

$$= 8766^{108}$$

CF = 0.937

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

$$\begin{aligned} \Delta \text{kW} &= 562 / (8766 * 0.57) * 0.937 \\ &= 0.105 \text{ kW} \end{aligned}$$

NATURAL GAS ENERGY SAVINGS

N/A

¹⁰⁷Duty cycle varies considerably from one installation to the next. TRM assumptions from Vermont, Wisconsin, and New York vary from 40 to 57%, whereas the ENERGY STAR Commercial Ice Machine Savings Calculator < http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_Ice_Machines.xls> assumes a value of 75%. A field study of eight ice machines in California indicated an average duty cycle of 57% ("A Field Study to Characterize Water and Energy Use of Commercial Ice-Cube Machines and Quantify Saving Potential", Food Service Technology Center, December 2007). Furthermore, a report prepared by ACEEE assumed a value of 40% (Nadel, S., Packaged Commercial Refrigeration Equipment: A Briefing Report for Program Planners and Implementers, ACEEE, December 2002). The value of 57% was utilized since it appears to represent a high quality data source.

¹⁰⁸Unit is assumed to be connected to power 24 hours per day, 365.25 days per year.

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 Directory¹⁰⁹ 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

¹⁰⁹ 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-rinse 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
<p>The baseline equipment is assumed to be 1.6 gallons per minute. The Energy Policy Act (EPAAct) 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, 2006¹¹⁰.</p>	<p>The baseline equipment is assumed to be an existing pre-rinse spray valve with a flow rate of 1.9 gallons per minute.¹¹¹ 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 (EPAAct) 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</p>

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 5 years¹¹²

¹¹¹ 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)

¹¹²Reference 2010 Ohio Technical Reference Manual, Act on Energy Business Program Technical Reference Manual Rev05, and Federal Energy Management Program (2004), "How to Buy a Low-Flow Pre-Rinse Spray Valve."

DEEMED MEASURE COST

The cost of this measure is assumed to be \$100¹¹³

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape C01 - Commercial Electric Cooking

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF ENERGY SAVINGS

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

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

Where:

- $\Delta Gallons$ = amount of water saved as calculated below
- 8.33 lbm/gal = specific mass in pounds of one gallon of water
- 1 Btu/lbm°F = Specific heat of water: 1 Btu/lbm/°F
- T_{out} = Water Heater Outlet Water Temperature
= custom, otherwise assume $T_{in} + 70^\circ \text{ F}$ temperature rise from T_{in} ¹¹⁴
- T_{in} = Inlet Water Temperature
= custom, otherwise assume 54.1 degree F¹¹⁵

¹¹³Costs range from \$60 Chicagoland (Integritys for North Shore & People's Gas) to \$150 referenced by Nicor's Resource Solutions Group Workpaper WPRSGCCODHW102 "Pre-Rinse Spray Valve." Act on Energy references \$100.

¹¹⁴If unknown, assume a 70 degree temperature rise from T_{in} per Food Service Technology Center calculator assumptions to account for variations in mixing and water heater efficiencies

¹¹⁵August 31, 2011 Memo of Savings for Hot Water Savings Measures to Nicor Gas from Navigant states that 54.1°F was calculated from the weighted average of monthly water mains temperatures reported in the 2010 Building America Benchmark Study for Chicago-Waukegan, Illinois.

EFF = Efficiency of electric water heater supplying hot water to pre-rinse spray valve
 =custom, otherwise assume 97%¹¹⁶

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 :

$$\begin{aligned} \Delta\text{kWh} &= 30,326 \times 8.33 \times 1 \times ((70+54.1) - 54.1) \times (1/.97) / 3,413 \times 1 \\ &= 5,181\text{kWh} \end{aligned}$$

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:

$$\begin{aligned} \Delta\text{kWh} &= 47,175 \times 8.33 \times 1 \times ((70+ 54.1) - 54.1) \times (1/.97) / 3,413 \times 1 \\ &= 8,060 \text{ kWh} \end{aligned}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

$$\Delta\text{Therms} = \Delta\text{Gallons} \times 8.33 \times 1 \times (\text{Tout} - \text{Tin}) \times (1/\text{EFF}) / 100,000 \text{ Btu}$$

Where (new variables only):

EFF = Efficiency of gas water heater supplying hot water to pre-rinse spray valve
 = custom, otherwise assume 75%¹¹⁷

¹¹⁶This efficiency value is based on IECC 2009 performance requirement for electric resistant water heaters rounded without the slight adjustment allowing for reduction based on size of storage tank.

¹¹⁷ IECC 2009, Table 504.2, Minimum Performance of Water-Heating Equipment

EXAMPLE

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

$$\begin{aligned} \Delta\text{Therms} &= 30,326 \times 8.33 \times 1 \times ((70+54.1) - 54.1) \times (1/.75)/100,000 \times 1.0 \\ &= 236 \text{ Therms} \end{aligned}$$

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:

$$\begin{aligned} \Delta\text{Therms} &= 47,175 \times 8.33 \times 1 \times ((70+54.1) - 54.1) \times (1/.75)/100,000 \times (1-0) \\ &= 368 \text{ Therms} \end{aligned}$$

WATER IMPACT CALCULATION¹¹⁸

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

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

Time of Sale	Retrofit, Direct Install
1.6 gal/min ¹¹⁹	1.9 gal/min ¹²⁰

FLOeff = Efficient case flow in gallons per minute or custom

Time of Sale	Retrofit, Direct Install
1.06 gal/min ¹²¹	1.06 gal/min ¹²²

¹¹⁸In order to calculate energy savings, water savings must first be calculated

¹¹⁹The baseline equipment is assumed to be 1.6 gallons per minute. The Energy Policy Act (EPA) 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.

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

¹²¹1.6 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.

¹²²1.6 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.

HOURS_{day} = Hours per day that the pre-rinse spray valve is used at the site, custom, otherwise¹²³:

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

DAYS_{year} = 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

$$= (1.6 - 1.06) * 60 * 3 * 312$$

$$= 30,326 \text{ gal/yr}$$

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 equals

$$= (1.9 - 1.06) * 60 * 3 * 312$$

$$= 47,175 \text{ gal/yr}$$

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

¹²³ 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 years¹²⁴

DEEMED MEASURE COST

The incremental capital cost for this measure is \$2200¹²⁵

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

¹²⁴Food 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

¹²⁵Ibid.

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.¹²⁶

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

¹²⁶ Nicor Gas Energy Efficiency Plan 2011-2014. Revised Plan Filed Pursuant to Order Docket 10-0562, May 27, 2011. These deemed values should be compared to PY evaluation and revised as necessary.

4.2.13 Infrared Rotisserie Oven

DESCRIPTION

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

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

DEFINITION OF EFFICIENT EQUIPMENT

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

DEFINITION OF BASELINE EQUIPMENT

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

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 12 years¹²⁷

DEEMED MEASURE COST

The incremental capital cost for this measure is \$2700¹²⁸

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

¹²⁷Food 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

¹²⁸Ibid.

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 Therms¹²⁹

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

¹²⁹Nicor Gas Energy Efficiency Plan 2011-2014. Revised Plan Filed Pursuant to Order Docket 10-0562, May 27, 2011. These deemed values should be compared to PY evaluation and revised as necessary.

4.2.14 Infrared Salamander Broiler

DESCRIPTION

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

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

DEFINITION OF EFFICIENT EQUIPMENT

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

DEFINITION OF BASELINE EQUIPMENT

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

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 12 years¹³⁰

DEEMED MEASURE COST

The incremental capital cost for this measure is \$1000¹³¹

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

¹³⁰ 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

¹³¹ Ibid.

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

The annual natural gas energy savings from this measure is a deemed value equaling 239 therms¹³²

WATER IMPACT DESCRIPTIONS AND CALCULATION

DEEMED O&M COST ADJUSTMENT CALCULATION

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

¹³² Nicor Gas Energy Efficiency Plan 2011-2014. Revised Plan Filed Pursuant to Order Docket 10-0562, May 27, 2011. These deemed values should be compared to PY evaluation and revised as necessary.

4.2.15 Infrared Upright Broiler

DESCRIPTION

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

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

DEFINITION OF EFFICIENT EQUIPMENT

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

DEFINITION OF BASELINE EQUIPMENT

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

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 10 years¹³³

DEEMED MEASURE COST

The incremental capital cost for this measure is \$5900¹³⁴

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

¹³³Food 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

¹³⁴Ibid.

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 therms¹³⁵.

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

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

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.¹³⁶

DEEMED MEASURE COST

The incremental capital cost for this measure is¹³⁷

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

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape C23 - Commercial Ventilation

COINCIDENCE FACTOR

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

¹³⁶ PG&E Workpaper: Commercial Kitchen Demand Ventilation Controls-Electric, 2004 - 2005

¹³⁷ 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 workpaper.

ELECTRIC ENERGY SAVINGS

The following table provides the kWh savings

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

SUMMER COINCIDENT PEAK DEMAND SAVINGS

The following table provides the kW savings

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

NATURAL GAS ENERGY SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

4.2.17 Pasta Cooker

DESCRIPTION

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

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

DEFINITION OF EFFICIENT EQUIPMENT

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

DEFINITION OF BASELINE EQUIPMENT

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

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 12¹³⁸.

DEEMED MEASURE COST

The incremental capital cost for this measure is \$2400¹³⁹.

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

¹³⁸Food 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

¹³⁹Ibid.

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 Therms¹⁴⁰.

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

¹⁴⁰Nicor Gas Energy Efficiency Plan 2011-2014. Revised Plan Filed Pursuant to Order Docket 10-0562, May 27, 2011. These deemed values should be compared to PY evaluation and revised as necessary.

4.2.18 Rack Oven - Double Oven

DESCRIPTION

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

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

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed equipment must be a new natural gas rack oven –double oven with a baking efficiency $\geq 50\%$ 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.¹⁴¹

DEEMED MEASURE COST

The incremental capital cost for this measure is \$8646.¹⁴²

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

¹⁴¹ 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

¹⁴² Ibid.

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

The annual natural gas energy savings from this measure is a deemed value equaling 2064 therms¹⁴³

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

¹⁴³Nicor Gas Energy Efficiency Plan 2011-2014. Revised Plan Filed Pursuant to Order Docket 10-0562, May 27, 2011. These deemed values should be compared to PY evaluation and revised as necessary

4.3 Hot Water

4.3.1 Storage Water Heater

DESCRIPTION

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

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

DEFINITION OF EFFICIENT EQUIPMENT

Gas, High Efficiency	Gas, Standard	Electric
In order for this characterization to apply, the efficient equipment is assumed to have heating capacity over 75,000 Btuh and a Thermal Efficiency (TE) greater than or equal to 88%	In order for this characterization to apply, the efficient equipment is assumed to be a gas-fired storage water heaters with 0.67 EF or better installed in a non-residential application Primary applications would include (but not limited to) hotels/motels, small commercial spaces, offices and restaurants	In order for this characterization to apply, the efficient equipment is assumed to have ¹⁴⁴ .: Energy factor greater than or equal to 0.95 Minimum Thermal Efficiency of 0.98 Less than 3% standby loss (standby loss is calculated as percentage of annual (energy usage) Equivalent storage capacity to unit being replaced Qualified units must be GAMA/AHRI efficiency rating certified

DEFINITION OF BASELINE EQUIPMENT

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

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

Gas, High Efficiency	Gas, Standard	Electric
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¹⁴⁴ Act on Energy Commercial Technical Reference Manual No. 2010-4

The expected measure life is assumed to be 15 Years ¹⁴⁵	The expected measure life is assumed to be 15 years ¹⁴⁶	The expected measure life is assumed to be 5 years ¹⁴⁷ .
--	--	---

DEEMED MEASURE COST

Gas, High Efficiency	Gas, Standard	Electric								
The incremental capital cost for this measure is \$209 ¹⁴⁸	The deemed measure cost is assumed to be \$400 ¹⁴⁹	The incremental capital cost for this measure is assumed to be ¹⁵⁰ <table border="1"> <thead> <tr> <th>Tank Size</th> <th>Incremental Cost</th> </tr> </thead> <tbody> <tr> <td>50 gallons</td> <td>\$1050</td> </tr> <tr> <td>80 gallons</td> <td>\$1050</td> </tr> <tr> <td>100 gallons</td> <td>\$1950</td> </tr> </tbody> </table>	Tank Size	Incremental Cost	50 gallons	\$1050	80 gallons	\$1050	100 gallons	\$1950
Tank Size	Incremental Cost									
50 gallons	\$1050									
80 gallons	\$1050									
100 gallons	\$1950									

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

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

COINCIDENCE FACTOR

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

¹⁴⁵ Nicor Gas Energy Efficiency Plan 2011-2014. Revised Plan Filed Pursuant to Order Docket 10-0562, May 27, 2011

¹⁴⁶ Gas Storage Water Heater 0.67. Work Paper WPRSGNGDHW106. Resource Solutions Group. December 2010

¹⁴⁷ Ibid.

¹⁵⁰ Ibid.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS¹⁵¹

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

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

SUMMER COINCIDENT PEAK DEMAND SAVINGS¹⁵²

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

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

¹⁵¹ Ibid.

¹⁵² Ibid.

NATURAL GAS ENERGY SAVINGS

Gas, High Efficiency	Gas, Standard	
The annual natural gas energy savings from this measure is a deemed value equaling 251 ¹⁵³	Gas savings depend on building type and are based on measure case energy factor of 0.67 and a heating capacity of 75 MBtuh. These values are averages of qualifying units. Savings values are derived from 2008 DEER Miser, which provides MBtuh gas savings per MBtuh capacity. Savings presented here are per water heater. ¹⁵⁴	
	Building Type	Energy Savings (therms/unit)
	Assembly	185
	Education – Primary/Secondary	124
	Education – Post Secondary	178
	Grocery	191
	Health/Medical - Hospital	297
	Lodging - Hotel	228
	Manufacturing - Light Industrial	140
	Office – > 60,000 sq-ft	164
	Office – < 60,000 sq-ft	56
	Restaurant - FastFood	109
	Restaurant – Sit Down	166
	Retail	105
	Storage	150
Multi-Family	119	
Other	148	

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

¹⁵³ 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

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

4.3.2 Low Flow Faucet Aerators

DESCRIPTION

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

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

DEFINITION OF EFFICIENT EQUIPMENT

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

DEFINITION OF BASELINE EQUIPMENT

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

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 9 years.¹⁵⁵

DEEMED MEASURE COST

The incremental cost for this measure is \$8¹⁵⁶ or program actual

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape C02 - Commercial Electric DHW

COINCIDENCE FACTOR

The coincidence factor for this measure is assumed to be 2.2%¹⁵⁷

¹⁵⁵ 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"

¹⁵⁶ 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)

¹⁵⁷ 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 $0.18 * 65 / 365.25 = 3.21\%$. The number of hours of recovery during peak

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

NOTE THESE SAVINGS ARE PER FAUCET RETROFITTED¹⁵⁸.

$$\Delta kWh = \%ElectricDHW * ((GPM_base * L_base - GPM_low * L_low) * NOPF * 365.25 * DF / GPMfactor) * EPG_electric * ISR$$

Where:

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

DHW fuel	%Electric_DHW
Electric	100%
Fossil Fuel	0%
Unknown	16% ¹⁵⁹

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

Occupant input	Number
Custom	Estimated number of people using the faucet

365.25 = Days in a year, on average.

periods is therefore assumed to be 3.21% * 180= 5.8 hours of recovery during peak period. There are 180 hours in the peak period so the probability you will see savings during the peak period is 5.8/180= 0.022

¹⁵⁸ 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.

¹⁵⁹ Default assumption for unknown fuel is based on EIA Residential Energy Consumption Survey (RECS) 2009 for Midwest Region, data for the state of IL. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area then that should be used

DF = Drain Factor

Faucet Type	Drain Factor ¹⁶⁰
Kitchen	75%
Bath	90%
Unknown	79.5%

GPM_base = Average flow rate, in gallons per minute, of the baseline faucet “as-used”
 = 1.2¹⁶¹ or custom based on metering studies¹⁶²

GPM_low = Average flow rate, in gallons per minute, of the low-flow faucet aerator “as-used”
 = 0.94¹⁶³ or custom based on metering studies¹⁶⁴

L_base = Average baseline length faucet use per capita for all faucets in minutes
 = 9.85 min/person/day¹⁶⁵ or custom based on metering studies

L_low = Average retrofit length faucet use per capita for all faucets in minutes
 = 9.85 min/person/day¹⁶⁶ or custom based on metering studies

¹⁶⁰ Because faucet usages are at times dictated by volume, it is assumed only half of the kitchen usage is of the sort that would go straight down the drain. VEIC is unaware of any metering study that has determined this specific factor and so through consensus with the Illinois Technical Advisory Group have deemed these values to be 75% for the kitchen and 90% for the bathroom. If the aerator location is unknown an average of 79.5% should be used which is based on the assumption that 70% of household water runs through the kitchen faucet and 30% through the bathroom $(0.7*0.75)+(0.3*0.9)=0.795$.

¹⁶¹ Representative baseline flow rate for kitchen and bathroom faucet aerators from sources 2, 4, 5, and 7. This accounts for all throttling and differences from rated flow rates. The most comprehensive available studies did not disaggregate kitchen use from bathroom use, but instead looked at total flow and length of use for all faucets. This makes it difficult to reliably separate kitchen water use from bathroom water use.

¹⁶² 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.

¹⁶³ 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.

¹⁶⁴ 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.

¹⁶⁵ This coincides with the middle of the range (6.74 min/per/day to 13.4 min/per/day) from sources 2, 3, 4, and 5 (See Source Table at end of measure section). A recent Midwest evaluation study included a small metering sample with measured faucet use at 4.5 min/per/day for kitchen faucets and 2.6 min/per/day for bathroom faucets. This sample was too small to extrapolate to the population as a whole, but is within the range of total faucet time per the referenced reports and confirms previous findings.

GPMfactor = Factor that normalizes flow to each faucet.¹⁶⁷

Faucet Type	GPMfactor
Kitchen	1
Bath	2.5

EPG_{electric} = Energy per gallon of water used by faucet supplied by electric water heater

$$= (8.33 * 1.0 * (\text{WaterTemp} - \text{SupplyTemp})) / (\text{RE}_{\text{electric}} * 3412)$$

$$= (8.33 * 1.0 * (90 - 54.1)) / (0.98 * 3412)$$

$$= 0.0894 \text{ kWh/gal}$$

8.33 = Specific weight of water (lbs/gallon)

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

WaterTemp = Assumed temperature of mixed water

$$= 90\text{F}^{168}$$

SupplyTemp = Assumed temperature of water entering house

$$= 54.1\text{F}^{169}$$

RE_{electric} = Recovery efficiency of electric water heater

$$= 98\%^{170}$$

3412 = Converts Btu to kWh (btu/kWh)

¹⁶⁶ Set equal to L_{base}. Studies show conflicting results with some studies showing increased time for retrofit homes and some showing decreased time. Engineering judgment leads us to conclude that using the baseline time is a reasonable assumption.

¹⁶⁷ This factor modifies the residential faucet aerator to be used in a commercial setting. This calculation assumes that the faucets in commercial facilities have similar use with respect to on/off cycle

¹⁶⁸ Temperature cited from SBW Consulting, Evaluation for the Bonneville Power Authority, 1994, http://www.bpa.gov/energy/n/reports/evaluation/residential/faucet_aerator.cfm. This is a variable that would benefit from further evaluation.

¹⁶⁹ US DOE Building America Program. Building America Analysis Spreadsheet. For Chicago, IL http://www1.eere.energy.gov/buildings/building_america/analysis_spreadsheets.html.

¹⁷⁰ Electric water heater have recovery efficiency of 98%: <http://www.ahrinet.org/ARI/util/showdoc.aspx?doc=576>

ISR = In service rate of faucet aerators dependant on install method as listed in table below¹⁷¹

Selection	ISR
Direct Install - Deemed	0.95

EXAMPLE

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

$$\Delta kWh = 1 * ((1.2 * 9.85 - 0.94 * 9.85) * (20/4) * 365.25 * .795) / (1 + 2.5) * .0894 * .95$$

$$= 90.22 \text{ kWh}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = \Delta kWh / \text{Hours} * CF$$

Where:

ΔkWh = calculated value above on a per faucet basis

Hours = Annual electric DHW recovery hours for faucet use

$$= ((GPM_base * L_base) * 365.25 * DF) * 0.545^{172} / GPH$$

$$= 14.73$$

Where :

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

$$= 27.51$$

CF = Coincidence Factor for electric load reduction

$$= 0.022^{173}$$

¹⁷¹ 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

¹⁷² 54.5% is the proportion of hot 120F water mixed with 54.1F supply water to give 90F mixed faucet water.

¹⁷³ 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 $0.18 * 65 / 365.25 = 3.21\%$. The number of hours of recovery during peak periods is therefore assumed to be $3.21\% * 180 = 5.8$ hours of recovery during peak period where 180 equals the

EXAMPLE

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

$$\begin{aligned} \Delta kW &= 90.22/14.73 * 0.032 \\ &= .196 \text{ kW} \end{aligned}$$

FOSSIL FUEL IMPACT DESCRIPTIONS AND CALCULATION

$$\Delta \text{Therms} = \% \text{FossilDHW} * ((\text{GPM}_{\text{base}} * L_{\text{base}} - \text{GPM}_{\text{low}} * L_{\text{low}}) * \text{NOPF} * 365.25 * \text{DF}) / (\text{GPMfactor} * \text{EPG}_{\text{gas}} * \text{ISR})$$

Where:

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

DHW fuel	$\% \text{Fossil_DHW}$
Electric	0%
Fossil Fuel	100%
Unknown	84% ¹⁷⁴

EPG_{gas} = Energy per gallon of Hot water supplied by gas
 = $(8.33 * 1.0 * (\text{WaterTemp} - \text{SupplyTemp})) / (\text{RE}_{\text{gas}} * 100,000)$
 = 0.0045 Therm/gal for MF homes

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 $5.8/260 = 0.022$

¹⁷⁴ Default assumption for unknown fuel is based on EIA Residential Energy Consumption Survey (RECS) 2009 for Midwest Region, data for the state of IL. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area then that should be used

Where:

RE_gas = Recovery efficiency of gas water heater

= 67%¹⁷⁵

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

Other variables as defined above.

EXAMPLE

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

$$\begin{aligned} \Delta\text{Therms} &= 1 \left((1.2 * 9.85) - (.94 * 9.85) \right) * 20 / 4 * 365.25 * 0.795 / (1 + 2.5) * 0.0045 * 0.95 \\ &= 4.54 \text{ Therms} \end{aligned}$$

WATER IMPACT DESCRIPTIONS AND CALCULATION

Δ gallons =

$$\left((\text{GPM}_{\text{base}} * L_{\text{base}} - \text{GPM}_{\text{low}} * L_{\text{low}}) * \text{NOPF} * 365.25 * \text{DF} / \text{GPMfactor} \right) * \text{ISR}$$

Variables as defined above

EXAMPLE

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

$$\begin{aligned} \Delta\text{gallons} &= \left((1.2 * 9.82) - (0.94 * 9.85) \right) * (20 / 4) * 365.25 * 0.795 / (1 + 2.5 * 0.95) \\ &= 1009.2 \text{ gallons} \end{aligned}$$

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

¹⁷⁵ Review of AHRI Directory suggests range of recovery efficiency ratings for new Gas DHW units of 70-87%. Average of existing units is estimated at 75%. Commercial properties are more similar to MF homes than SF homes. MF hot water is often provided by a larger commercial boiler. This suggests that the average recovery efficiency is somewhere between a typical central boiler efficiency of .59 and the .75 for single family home. An average is used for this analysis by default.

SOURCES

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

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

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.¹⁷⁶

DEEMED MEASURE COST

The incremental cost for this measure is \$12¹⁷⁷ or program actual.

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape CO2 - Commercial Electric DHW

COINCIDENCE FACTOR

The coincidence factor for this measure is assumed to be 2.78%¹⁷⁸.

¹⁷⁶ 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"](http://neep.org/uploads/EMV%20Forum/EMV%20Studies/measure_life_GDS%5B1%5D.pdf)

¹⁷⁷ Direct-install price per showerhead assumes cost of showerhead (Market research average of \$7 and assess and install time of \$5 (20min @ \$15/hr)

¹⁷⁸ 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 ¹⁷⁹

ELECTRIC ENERGY SAVINGS

Note these savings are per showerhead fixture

$\Delta kWh =$

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

Where:

%ElectricDHW = proportion of water heating supplied by electric resistance heating
 = 1 if electric DHW, 0 if fuel DHW, if unknown assume 16% ¹⁸⁰

GPM_base = Flow rate of the baseline showerhead
 = 2.67 for Direct-install programs ¹⁸¹

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

Rated Flow
2.0 GPM
1.75 GPM
1.5 GPM
Custom or Actual ¹⁸²

L_base = Shower length in minutes with baseline showerhead
 = 8.20 min ¹⁸³

L_low = Shower length in minutes with low-flow showerhead
 = 8.20 min ¹⁸⁴

¹⁷⁹ Based on excel spreadsheet 120911.xls ...on SharePoint

¹⁸⁰ Table HC8.9. Water Heating in U.S. Homes in Midwest Region, Divisions, and States, 2009 (RECS)

¹⁸¹ Based on measured data from Ameren IL EM&V of Direct-Install program. Program targets showers that are rated 2.5 GPM or above.

¹⁸² 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.

¹⁸³ Representative value from sources 1, 2, 3, 4, 5, and 6 (See Source Table at end of measure section)

¹⁸⁴ Set equal to L_base.

GPMFactor	= Factor that normalizes flow to each showerhead. ¹⁸⁵ =1.6
365.25	= Days per year, on average.
NSPD	= Estimated number of showers taken per day for one showerhead
EPG_electric	= Energy per gallon of hot water supplied by electric = $(8.33 * 1.0 * (\text{ShowerTemp} - \text{SupplyTemp})) / (\text{RE_electric} * 3412)$ = $(8.33 * 1.0 * (105 - 54.1)) / (0.98 * 3412)$ = 0.127 kWh/gal
8.33	= Specific weight of water (lbs/gallon)
1.0	= Heat Capacity of water (btu/lb-F)
ShowerTemp	= Assumed temperature of water = 105F ¹⁸⁶
SupplyTemp	= Assumed temperature of water entering house = 54.1F ¹⁸⁷
RE_electric	= Recovery efficiency of electric water heater = 98% ¹⁸⁸
3412	= Converts Btu to kWh (btu/kWh)

¹⁸⁶ 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

¹⁸⁷ US DOE Building America Program. Building America Analysis Spreadsheet. For Chicago, IL http://www1.eere.energy.gov/buildings/building_america/analysis_spreadsheets.html.

¹⁸⁸ Electric water heater have recovery efficiency of 98%: <http://www.ahrinet.org/ARI/util/showdoc.aspx?doc=576>

ISR = In service rate of showerhead
 = Dependant on program delivery method as listed in table below

Selection	ISR ¹⁸⁹
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:

$$\Delta kWh = (1 ((2.67*8.20) - (1.5*8.20)) * 3*365.25/1.6) * 0.127 * 0.98$$

$$= 818kWh$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

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

Where:

ΔkWh = calculated value above

Hours = Annual electric DHW recovery hours for showerhead use

$$= ((GPM_base * L_base) * NSPD * 365.25) * 0.773^{190} / GPH$$

Where:

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

$$= 27.51$$

CF = Coincidence Factor for electric load reduction

$$0.0278^{191}$$

¹⁸⁹ 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.

¹⁹⁰ 77.3% is the proportion of hot 120F water mixed with 54.1F supply water to give 105F shower water.

¹⁹¹ 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

EXAMPLE

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

$$\Delta kW = 818 / ((2.67 * 8.20) * 3 * 365.25) * .773 / 27.51 * 0.0278$$

$$= 0.033 kW$$

FOSSIL FUEL IMPACT DESCRIPTIONS AND CALCULATION

$$\Delta \text{Therms} = \% \text{FossilDHW} * ((\text{GPM}_{\text{base}} * L_{\text{base}} - \text{GPM}_{\text{low}} * L_{\text{low}}) * \text{NSPD} * 365.25 / \text{GPMfactor}) * \text{EPG}_{\text{gas}} * \text{ISR}$$

Where:

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

DHW fuel	$\% \text{Fossil_DHW}$
Electric	0%
Fossil Fuel	100%
Unknown	84% ¹⁹²

EPG_{gas} = Energy per gallon of Hot water supplied by gas

$$= (8.33 * 1.0 * (\text{ShowerTemp} - \text{SupplyTemp})) / (\text{RE}_{\text{gas}} * 100,000)$$

$$= 0.0063 \text{ Therm/gal}$$

Where:

RE_{gas} = Recovery efficiency of gas water heater

$$= 67\%^{193}$$

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

Other variables as defined above.

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 $7.23 / 260 = 0.0278$

¹⁹² 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

¹⁹³ 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:

$$\begin{aligned} \Delta\text{Therms} &= 1.0 * ((2.67 * 8.2) - (1.5 * 8.2)) * 3 * 365.25 / 1.6 * 0.0063 * 0.98 \\ &= 40.6\text{therms} \end{aligned}$$

WATER IMPACT DESCRIPTIONS AND CALCULATION

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

Variables as defined above

EXAMPLE

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

$$\begin{aligned} \Delta\text{gallons} &= ((2.67 * 8.20) - (1.5 * 8.20)) * 3 * 365.25 * .98 \\ &= 10,302 \text{ gallons} \end{aligned}$$

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

SOURCES

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

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

4.3.4 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) 2009, Table 504.2.

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) 2009, Table 504.2.

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 be¹⁹⁶

¹⁹⁴ Ibid.

¹⁹⁵ 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

¹⁹⁶ Ibid.

Output 9pgm) at delta T 70	Incremental Cost
5	\$1050
10	\$1050
15	\$1950

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

Program	Capital Cost, \$ per unit ¹⁹⁷
Retrofit	\$871.74
Time of Sale or New Construction	\$433.72

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape C02 - Commercial Electric DHW

COINCIDENCE FACTOR

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

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS¹⁹⁸

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

Output 9pgm) at delta T 70	Savings (kWh)
5.0	2,991.98
10.0	7,904.82
15.0	12,878.51

SUMMER COINCIDENT PEAK DEMAND SAVINGS¹⁹⁹

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

¹⁹⁷ 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, “Cost Values and Summary Documentation”, California Public Utilities Commission, December 16, 2008

¹⁹⁸ Ibid.

¹⁹⁹ Ibid.

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

NATURAL GAS ENERGY SAVINGS

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

Where:

- Wgal = Annual water use for equipment in gallons
= custom, otherwise assume 21,915 gallons²⁰⁰
- 8.33 lbm/gal = weight in pounds of one gallon of water
- 1 Btu/lbm°F = Specific heat of water: 1 Btu/lbm/°F
- 8,766 hr/yr = hours a year
- Tout = Unmixed Outlet Water Temperature
= custom, otherwise assume 130 degree F²⁰¹
- Tin = Inlet Water Temperature
= custom, otherwise assume 54.1 degree F²⁰²
- Eff base = Rated efficiency of baseline water heater expressed as Energy Factor (EF) or Thermal Efficiency (Et); see table below²⁰³

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

²⁰⁰ 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.

²⁰¹ Based on 2010 Ohio Technical Reference Manual and NAHB Research Center, (2002) Performance Comparison of Residential hot Water Systems. Prepared for National Renewable Energy Laboratory, Golden, Colorado.

²⁰² 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.

²⁰³ IECC 2009, Table 504.2, Minimum Performance of Water-Heating Equipment

Size: >155,000 Btu/h	80%	Thermal Efficiency
----------------------	-----	--------------------

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

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

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

= custom input, if unknown assume 0.84²⁰⁴

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

= custom input based on formula in table below, if unknown assume unit size in table below²⁰⁵

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

Where:

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

Input Value = nameplate Btu/hr rating of water heater

EXAMPLE

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

$$\Delta\text{Therms} = \frac{[(21,915 \times 8.33 \times 1 \times (130 - 54.1) \times [(1/.8) - (1/.84)])/100,000] + [(1008.3 \times 8,766)/.8]}{100,000}$$

=115 Therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

²⁰⁴ 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.

²⁰⁵ Stand-by loss is provided 2009 International Energy Conservation Code (IEYtqC 2009), Table 504.2, Minimum Performance of Water-Heating Equipment

DEEMED O&M COST ADJUSTMENT CALCULATION

The deemed O&M cost adjustment for a gas fired tankless heater is \$9.60²⁰⁶

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

REFERENCE TABLES

Minimum Performance Water Heating Equipment²⁰⁷

²⁰⁶ “Center Point Energy – Triennial CIP/DSM Plan 2010 – 2012 Report”

²⁰⁷ International Energy Conservation Code (IECC)2009

TABLE 504.2
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 - 0.00132V, 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 - 0.00132V, 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	$\frac{80\% E_t}{(Q/800 + 110\sqrt{V})}$ SL, Btu/h	ANSI Z21.10.3
	> 155,000 Btu/h	< 4,000 Btu/h/gal	$\frac{80\% E_t}{(Q/800 + 110\sqrt{V})}$ SL, Btu/h	
Instantaneous water heaters, Gas	> 50,000 Btu/h and < 200,000 Btu/h ^c	≥ 4,000 (Btu/h)/gal and < 2 gal	0.62 - 0.0019 V, EF	DOE 10 CFR Part 430
	≥ 200,000 Btu/h	≥ 4,000 Btu/h/gal and < 10 gal	80% E_t	ANSI Z21.10.3
	≥ 200,000 Btu/h	≥ 4,000 Btu/h/gal and ≥ 10 gal	$\frac{80\% E_t}{(Q/800 + 110\sqrt{V})}$ 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	$\frac{78\% E_t}{(Q/800 + 110\sqrt{V})}$ 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 - 0.0019 V, 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	$\frac{78\% E_t}{(Q/800 + 110\sqrt{V})}$ 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	$\frac{80\% E_t}{(Q/800 + 110\sqrt{V})}$ 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	$\frac{78\% E_t}{(Q/800 + 110\sqrt{V})}$ 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 · ft ² · °F)/Btu	(none)

For SL: °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, \bar{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.

4.4 HVAC End Use

4.4.1 Air Conditioner Tune-up

DESCRIPTION

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

DEFINITION OF EFFICIENT EQUIPMENT

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

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

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

DEFINITION OF BASELINE EQUIPMENT

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

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 3 years.²⁰⁸

DEEMED MEASURE COST

The incremental capital cost for this measure is \$35²⁰⁹ per ton.

DEEMED O&M COST ADJUSTMENTS

N/A

²⁰⁸ Act on Energy Commercial Technical Reference Manual No. 2010-4

²⁰⁹ Ibid.

LOADSHAPE

Loadshape C03 - Commercial Cooling

COINCIDENCE FACTOR

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

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

The measure has a deemed savings which applies to all building types and air conditioning unit size and equals an average value of 878 kWh a year.²¹⁰

SUMMER COINCIDENT PEAK DEMAND SAVINGS

The measure has a deemed savings which applies to all building types and air conditioning unit size and equals an average value 0.39 kW a year.²¹¹

NATURAL GAS ENERGY SAVINGS

WATER IMPACT DESCRIPTIONS AND CALCULATION

DEEMED O&M COST ADJUSTMENT CALCULATION

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

²¹⁰ Ibid.

²¹¹ Act on Energy Commercial Technical Reference Manual No. 2010-4. These deemed values should be compared to PY evaluation and revised as necessary.

4.4.2 Space Heating Boiler Tune-up²¹²

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 requirements²¹³ listed below, by approved technician:

- Measure combustion efficiency using an electronic flue gas analyzer
- Adjust airflow and reduce excessive stack temperatures
- Adjust burner and gas input, manual or motorized draft control
- Check for proper venting
- Complete visual inspection of system piping and insulation
- Check safety controls
- Check adequacy of combustion air intake
- Clean fireside surfaces.
- Inspect all refractory. Patch and wash coat as required.
- Inspect gaskets on front and rear doors and replace as necessary.
- Seal and close front and rear doors properly.
- Clean low and auxiliary low water cut-off controls, then re-install using new gaskets.
- Clean plugs in control piping.
- Remove all hand hole and man hole plates. Flush boiler with water to remove loose scale and sediment.
- Replace all hand hole and man hole plates with new gaskets.
- Open feedwater tank manway, inspect and clean as required. Replace manway plate with new gasket.
- Clean burner and burner pilot.
- Check pilot electrode and adjust or replace.
- Clean air damper and blower assembly.
- Clean motor starter contacts and check operation.
- Make necessary adjustments to burner for proper combustion.
- Perform all flame safeguard and safety trip checks.
- Check all hand hole plates and man hole plates for leaks at normal operating temperatures and pressures.
- Troubleshoot any boiler system problems as requested by on-site personnel

DEFINITION OF BASELINE EQUIPMENT

The baseline condition of this measure is the facility cannot have standing maintenance contract or tune-up within the past 36 months

²¹²High Impact Measure

²¹³Act on Energy Commercial Technical Reference Manual No. 2010-4, 9.2.2 Gas Boiler Tune-up

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The life of this measure is 3 years²¹⁴

DEEMED MEASURE COST

The cost of this measure is \$0.83/MBtuh²¹⁵ per tune-up

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

$$\Delta\text{therms} = N_{gi} * SF * EFLH / (\text{Eff}_{pre} * 100)$$

Where:

N_{gi} = Boiler gas input size (kBTU/hr)

= custom

SF = Savings factor

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

²¹⁴Act on Energy Commercial Technical Reference Manual No. 2010-4, 9.2.2 Gas Boiler Tune-up

²¹⁵Work Paper – Tune up for Boilers serving Space Heating and Process Load by Resource Solutions Group, January 2012

= 1.6%²¹⁶ or custom

EFLH = Equivalent Full Load Hours for heating²¹⁷

Building Type	EFLH				
	Zone 1 (Rockford)	Zone 2 (Chicago)	Zone 3 (Springfield)	Zone 4 (Belleville/)	Zone 5 (Marion)
Office - High Rise	2,746	2,768	2,656	2,155	2,420
Office - Mid Rise	996	879	824	519	544
Office - Low Rise	797	666	647	343	329
Convenience	696	550	585	272	297
Healthcare Clinic	1,118	1,036	1,029	694	737
Manufacturing Facility	1,116	1,123	904	771	857
Lodging Hotel/Motel	2,098	2,050	1,780	1,365	1,666
High School	969	807	999	569	674
Hospital	2,031	1,929	1,863	1,497	1,800
Elementary	970	840	927	524	637
Religious Facility	1,830	1,657	1,730	1,276	1,484
Restaurant	1,496	1,379	1,291	872	1,185
Retail - Strip Mall	1,266	1,147	1,151	732	863
Retail - Department Store	1,065	927	900	578	646
College/University	373	404	376	187	187
Warehouse	416	443	427	226	232
Unknown	1,249	1,163	1,130	786	910

Effpre = Boiler Combustion Efficiency Before Tune-Up

= 80%²¹⁸ or custom

EXAMPLE

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

$$\Delta \text{therms} = 1050 * .016 * 2768 / (0.80 * 100)$$

$$= 581 \text{ therms}$$

²¹⁶Work Paper WPRRSGNGRO301 Resource Solutions Group "Boiler Tune-Up" which cites Focus on Energy Evaluation Business Programs: Deemed Savings Manual V1.0, PA Consulting, KEMA, March 22, 2010

²¹⁷Equivalent full load hours for heating were developed using eQuest models for various building types averaged across each climate zones for Illinois for the following building types: office, healthcare/clinic, manufacturing, lodging, high school, hospital, elementary school, religious/assembly, restaurant, retail, college and warehouse. eQuest models werer those developed for IL lighting interactive effects.

²¹⁸Work Paper WPRRSGNGRO301 Resource Solutions Group "Boiler Tune-Up" which cites Focus on Energy Evaluation Business Programs: Deemed Savings Manual V1.0, PA Consulting, KEMA, March 22, 2010

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

4.4.3 Process Boiler Tune-up²¹⁹

DESCRIPTION

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

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the facility must, as applicable, complete the tune-up requirements²²⁰ by approved technician, as specified below:

- Measure combustion efficiency using an electronic flue gas analyzer
- Adjust airflow and reduce excessive stack temperatures
- Adjust burner and gas input, manual or motorized draft control
- Check for proper venting
- Complete visual inspection of system piping and insulation
- Check safety controls
- Check adequacy of combustion air intake
- Clean fireside surfaces
- Inspect all refractory. Patch and wash coat as required.
- Inspect gaskets on front and rear doors and replace as necessary.
- Seal and close front and rear doors properly.
- Clean low and auxiliary low water cut-off controls, then re-install using new gaskets.
- Clean plugs in control piping.
- Remove all hand hole and man hole plates. Flush boiler with water to remove loose scale and sediment.
- Replace all hand hole and man hole plates with new gaskets.
- Open feedwater tank manway, inspect and clean as required. Replace manway plate with new gasket.
- Clean burner and burner pilot.
- Check pilot electrode and adjust or replace.
- Clean air damper and blower assembly.
- Clean motor starter contacts and check operation.
- Make necessary adjustments to burner for proper combustion.
- Perform all flame safeguard and safety trip checks.
- Check all hand hole plates and man hole plates for leaks at normal operating temperatures and pressures.
- Troubleshoot any boiler system problems as requested by on-site personnel

DEFINITION OF BASELINE EQUIPMENT

The baseline condition of this measure is the facility cannot have standing maintenance contract or tune-up within the past 36 months

²¹⁹ High Impact Measure

²²⁰ Act on Energy Commercial Technical Reference Manual No. 2010-4, 9.2.2 Gas Boiler Tune-up

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The life of this measure is 3 years²²¹

DEEMED MEASURE COST

The cost of this measure is \$0.83/MBtuh²²² per tune-up

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

$$\Delta\text{therms} = ((N_{gi} * 8766 * UF) / 100) * (1 - (\text{Eff}_{pre} / \text{Eff}_{measured}))$$

Where:

N_{gi} = Boiler gas input size (kBTU/hr)

= custom

UF = Utilization Factor

= 41.9%²²³ or custom

²²¹ Act on Energy Commercial Technical Reference Manual No. 2010-4, 9.2.2 Gas Boiler Tune-up

²²² Work Paper – Tune up for Boilers serving Space Heating and Process Load by Resource Solutions Group, January 2012

²²³ Work Paper – Tune up for Boilers serving Space Heating and Process Load by Resource Solutions Group, January

Eff_{pre} = Boiler Combustion Efficiency Before Tune-Up
= 80%²²⁴ or custom

$Eff_{measured}$ = Boiler Combustion Efficiency After Tune-Up
= 81.3%²²⁵ or custom

EXAMPLE

For example, a 1050 kBtu boiler:

$$\Delta \text{therms} = (1050 * 8766 * .419) / 100 * (1 - (0.80 / .813))$$
$$= 617 \text{ therms}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

2012

²²⁴Work Paper – Tune up for Boilers serving Space Heating and Process Load by Resource Solutions Group, January 2012, which cites Focus on Energy Evaluation Business Programs: Deemed Savings Manual V1.0, PA Consulting, KEMA, March 22, 2010

²²⁵Work Paper – Tune up for Boilers serving Space Heating and Process Load by Resource Solutions Group, January 2012, which cites Focus on Energy Evaluation Business Programs: Deemed Savings Manual V1.0, PA Consulting, KEMA, March 22, 2010

4.4.4 Boiler Lockout/Reset Controls

DESCRIPTION

This measure relates to improving combustion efficiency by adding controls to non-residential building heating boilers to vary the boiler entering water temperature relative to heating load as a function of the outdoor air temperature to save energy. Energy is saved by increasing the temperature difference between the water temperature entering the boiler in the boiler's heat exchanger and the boiler's burner flame temperature. The flame temperature remains the same while the water temperature leaving the boiler decreases with the decrease in heating load due to an increase in outside air temperature. A lockout temperature is also set to prevent the boiler from turning on when it is above a certain temperature outdoors.

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

DEFINITION OF EFFICIENT EQUIPMENT

Natural gas customer adding boiler reset controls capable of resetting the boiler supply water temperature in an inverse linear fashion with outdoor air temperature. Boiler lockout temperatures should be set to 55 F at this time as well, to turn the boiler off when the temperature goes above a certain setpoint.

DEFINITION OF BASELINE EQUIPMENT

Existing boiler without boiler reset controls, any size with constant hot water flow.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

THE LIFE OF THIS MEASURE IS 20 YEARS²²⁶

DEEMED MEASURE COST

The cost of this measure is \$612²²⁷

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

²²⁶Resource Solutions Group references the Brooklyn Union Gas Company, High Efficiency Heating and Water and Controls, Gas Energy Efficiency Program Implementation Plan.

²²⁷Nexant. Questar DSM Market Characterization Report. August 9, 2006.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

$$\text{Therm Savings} = \text{Binput} * \text{SF} * \text{EFLH} / (\text{Effpre} * 100)$$

Where:

Binput = Boiler Input Capacity (kBTU)

= custom

SF = Savings factor

= 8%²²⁸ or custom

²²⁸Savings factor is the estimate of annual gas consumption that is saved due to adding boiler reset controls. The Resource Solutions Group uses a boiler tuneup savings value derived from Xcel Energy "DSM Biennial Plan- Technical Assumptions," Colorado. Focus on Energy uses 8%, citing multiple sources. Vermont Energy Investment Corporation's boiler reset savings estimates for custom projects further indicate 8% savings estimate is better reflection of actual expected savings.

EFLH = Equivalent Full Load Hours for heating²²⁹ (hr)

Building Type	EFLH				
	Zone 1 (Rockford)	Zone 2 (Chicago)	Zone 3 (Springfield)	Zone 4 (Belleville/)	Zone 5 (Marion)
Office - High Rise	2,746	2,768	2,656	2,155	2,420
Office - Mid Rise	996	879	824	519	544
Office - Low Rise	797	666	647	343	329
Convenience	696	550	585	272	297
Healthcare Clinic	1,118	1,036	1,029	694	737
Manufacturing Facility	1,116	1,123	904	771	857
Lodging Hotel/Motel	2,098	2,050	1,780	1,365	1,666
High School	969	807	999	569	674
Hospital	2,031	1,929	1,863	1,497	1,800
Elementary	970	840	927	524	637
Religious Facility	1,830	1,657	1,730	1,276	1,484
Restaurant	1,496	1,379	1,291	872	1,185
Retail - Strip Mall	1,266	1,147	1,151	732	863
Retail - Department Store	1,065	927	900	578	646
College/University	373	404	376	187	187
Warehouse	416	443	427	226	232
Unknown	1,249	1,163	1,130	786	910

Effpre = Boiler Efficiency or custom

= 80%²³⁰ or custom

EXAMPLE

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

$$\Delta\text{Therms} = 800 * 0.08 * 1,496 / (0.80 * 100)$$

$$= 1197 \text{ Therms}$$

²²⁹Equivalent full load hours for heating were developed using eQuest models for various building types averaged across each climate zones for Illinois for the following building types: office, healthcare/clinic, manufacturing, lodging, high school, hospital, elementary school, religious/assembly, restaurant, retail, college and warehouse. eQuest models were those developed for IL lighting interactive effects.

²³⁰Work Paper WPRRSGNGRO301 Resource Solutions Group "Boiler Tune-Up" which cites Focus on Energy Evaluation Business Programs: Deemed Savings Manual V1.0, PA Consulting, KEMA, March 22, 2010

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

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 years²³¹

DEEMED MEASURE COST

The incremental capital cost for a unit heater is \$676²³²

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

²³¹ DEER 2008

²³² 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

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.

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

4.4.6 Electric Chiller

DESCRIPTION

This measure relates to the installation of a new electric chiller meeting the efficiency standards presented below. This measure could relate to the replacement of an existing unit at the end of its useful life, or the installation of a new system in an existing building (i.e. time of sale). Only single-chiller applications should be assessed with this methodology. The characterization is not suited for multiple chillers projects or chillers equipped with variable speed drives (VSDs).

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

DEFINITION OF EFFICIENT EQUIPMENT

In order for this characterization to apply, the efficient equipment is assumed to exceed the efficiency requirements of the 2009 International Energy Conservation Code, Table 503.2.3(7)

DEFINITION OF BASELINE EQUIPMENT

In order for this characterization to apply, the baseline equipment is assumed to meet the efficiency requirements of the 2009 International Energy Conservation Code, Table 503.2.3(7).

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 20 years²³³.

DEEMED MEASURE COST

The incremental capital cost for this measure is provided below.

Equipment Type	Size Category	Incremental Cost (\$/ton) ²³⁴
Air cooled, electrically operated	All capacities	\$127/ton ²³⁵
Water cooled, electrically operated, positive displacement (reciprocating)	All capacities	\$22/ton
Water cooled, electrically operated, positive displacement (rotary screw and scroll)	< 150 tons	\$128/ton
	>= 150 tons and < 300 tons	\$70/ton
	>= 300 tons	\$48/ton

²³³2008 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)

²³⁴2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, “Cost Values and Summary Documentation”, California Public Utilities Commission, December 16, 2008

(http://deeresources.com/deer0911planning/downloads/DEER2008_Costs_ValuesAndDocumentation_080530Rev1.zip)

²³⁵Calculated as the simple average of screw and reciprocating air-cooled chiller incremental costs from DEER2008. This assumes that baseline shift from IECC 2006 to IECC 2009 carries the same incremental costs. Values should be verified during evaluation

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape C03 - Commercial Cooling

COINCIDENCE FACTOR

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

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

$$= 91.3\%^{236}$$

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

$$= 47.8\%^{237}$$

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = \text{TONS} * ((12/\text{IPLV}_{\text{base}}) - (12/\text{IPLV}_{\text{vee}})) * \text{EFLH}$$

Where:

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

12 = conversion factor to express Integrated Part Load Value (IPLV) EER in terms of kW per ton

IPLV_{base} = efficiency of baseline equipment expressed as Integrated Part Load Value EER. Dependent on chiller type. See Baseline Efficiency Values by Chiller Type and Capacity in the Reference Tables section.

IPLV_{vee}²³⁸ = efficiency of high efficiency equipment expressed as Integrated Part Load Value EER²³⁹

²³⁶Based 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.

²³⁷Based 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

²³⁸Integrated Part Load Value is a seasonal average efficiency rating calculated in accordance with ARI Standard

= Actual installed

EFLH = equivalent full load hours dependent on location as below:

System Type ²⁴⁰	EFLH by Zone ²⁴¹				
	1 (Rockford)	2 (Chicago)	3 (Springfield)	4 (Belleville)	5 (Marion)
CV reheat, no economizer	2,723	4,206	3,341	3,872	2,734
CV reheat, economizer	870	1,343	1,067	1,237	873
VAV reheat, economizer	803	1,241	985	1,142	806

For example, a 100 ton air cooled, with condenser, electrically operated chiller with 3 IPLV, 3 COP of in Rockford with and economizer and CV reheat would save:

$$\begin{aligned} \Delta\text{kWh} &= 100 * ((12/12.5) - (12/14)) * 870 \\ &= 8949 \text{ kWh} \end{aligned}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta\text{kW}_{\text{SSP}} = \text{TONS} * ((12/\text{PEbase}) - (12/\text{PEee})) * \text{CF}_{\text{SSP}}$$

$$\Delta\text{kW}_{\text{PJM}} = \text{TONS} * ((12/\text{PEbase}) - (12/\text{PEee})) * \text{CF}_{\text{PJM}}$$

Where:

PEbase = Peak efficiency of baseline equipment expressed as Full Load EER

PEee = Peak efficiency of high efficiency equipment expressed as Full Load EER

= Actual installed

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

= 91.3%

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

= 47.8%

550/590. It may be calculated using any measure of efficiency (EER, kW/ton, COP), but for consistency with IECC 2006, it is expressed in terms of COP here.

²³⁹ Can determine IPLV from standard testing or looking at engineering specs for design conditions. Standard data is available from AHRnetl.org. <http://www.ahrinet.org/>

²⁴⁰ CV= Constant Volume, VAV=Variable Air Volume

²⁴¹ Cooling EFLHs have been modified from the “Technical Reference Manual (TRM) for Ohio and adjusted by CDD for IL locations. These appear reasonable, but are recommended for further study.

For example, a 100 ton air cooled, with condenser, electrically operated chiller with 3 IPLV, 3 COP of in Rockford with and economizer and CV reheat would save:

$$\begin{aligned}\Delta kW_{SSP} &= 100 * ((12/9.562) - (12/10.0)) * .913 \\ &= 5.0 \text{ kW}\end{aligned}$$

NATURAL GAS ENERGY SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

REFERENCE TABLES

Baseline Efficiency Values by Chiller Type and Capacity²⁴²

242 International Energy Conservation Code (IECC)2009

TABLE 503.2.3(7)
WATER CHILLING PACKAGES, EFFICIENCY REQUIREMENTS*

EQUIPMENT TYPE	SIZE CATEGORY	UNITS	BEFORE 1/1/2010		AS OF 1/1/2010 ^e				TEST PROCEDURE ^b
			FULL LOAD	IPLV	PATH A		PATH B		
					FULL LOAD	IPLV	FULL LOAD	IPLV	
Air-cooled chillers	< 150 tons	EER	≥ 9.562	≥ 10.416	≥ 9.562	≥ 12.500	NA ^d	NA ^d	AHRI 550/590
	≥ 150 tons	EER			≥ 9.562	≥ 12.750	NA ^d	NA ^d	
Air cooled without condenser, electrical operated	All capacities	EER	≥ 10.586	≥ 11.782	Air-cooled chillers without condensers must be rated with matching condensers and comply with the air-cooled chiller efficiency requirements				
Water cooled, electrical operated, reciprocating	All capacities	kW/ton	≤ 0.837	≤ 0.696	Reciprocating units must comply with water cooled positive displacement efficiency requirements				
Water cooled, electrical 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, electrical operated, centrifugal	< 150 tons	kW/ton	≤ 0.703	≤ 0.669	≤ 0.634	≤ 0.596	≤ 0.639	≤ 0.450	
	≥ 150 tons and < 300 tons	kW/ton	≤ 0.634	≤ 0.596					
	≥ 300 tons and < 600 tons	kW/ton	≤ 0.576	≤ 0.549	≤ 0.576	≤ 0.549	≤ 0.600	≤ 0.400	
	≥ 600 tons	kW/ton	≤ 0.576	≤ 0.549	≤ 0.570	≤ 0.539	≤ 0.590	≤ 0.400	
Air cooled, absorption single effect	All capacities	COP	≥ 0.600	NR ^e	≥ 0.600	NR ^e	NA ^d	NA ^d	AHRI 560
Water-cooled, absorption single effect	All capacities	COP	≥ 0.700	NR ^e	≥ 0.700	NR ^e	NA ^d	NA ^d	
Absorption double effect, indirect-fired	All capacities	COP	≥ 1.000	≥ 1.050	≥ 1.000	≥ 1.050	NA ^d	NA ^d	
Absorption double effect, direct fired	All capacities	COP	≥ 1.000	≥ 1.000	≥ 1.000	≥ 1.000	NA ^d	NA ^d	

For SI: 1 ton = 3517 W, 1 British thermal unit per hour = 0.2931 W.

- a. The chiller equipment requirements do not apply for chillers used in low-temperature applications where the design leaving fluid temperature is < 40°F.
- b. Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
- c. Compliance with this standard can be obtained by meeting the minimum requirements of Path A or B. However, both the full load and IPLV must be met to fulfill the requirements of Path A or B.
- d. NA means that this requirement is not applicable and cannot be used for compliance.
- e. NR means that there are no minimum requirements for this category.

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

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:²⁴³

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.

²⁴³http://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.²⁴⁴

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.²⁴⁵

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape C03 - Commercial Cooling

COINCIDENCE FACTOR

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

$$\begin{aligned} CF_{SSP} &= \text{Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)} \\ &= 91.3\% \text{ }^{246} \end{aligned}$$

$$\begin{aligned} CF_{PJM} &= \text{PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)} \\ &= 47.8\% \text{ }^{247} \end{aligned}$$

²⁴⁴ 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

²⁴⁵ Based on field study conducted by Efficiency Vermont

²⁴⁶ 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.

²⁴⁷ 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

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:²⁴⁸

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/hour²⁴⁹

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:

$$\begin{aligned} \Delta kWh_{ENERGY STAR} &= (253 * 8500 * (1/9.8 - 1/10.8)) / 1000 \\ &= 20.3 kWh \end{aligned}$$

the year

²⁴⁸ 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.

²⁴⁹ Based on maximum capacity average from the RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = \text{Btu/H} * ((1/\text{EER}_{\text{base}} - 1/\text{EER}_{\text{ee}}))/1000 * \text{CF}$$

Where:

CF_{SSP} = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)
= 91.3%²⁵⁰

CF_{PJM} = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)
= 47.8%²⁵¹

Other variable as defined above

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

$$\begin{aligned} \Delta kW_{\text{ENERGY STAR}} &= (8500 * (1/9.8 - 1/10.8)) / 1000 * 0.913 \\ &= 0.073 \text{ kW} \end{aligned}$$

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

²⁵⁰Based 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.

²⁵¹Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year

4.4.8 Guest Room Energy Management (PTAC & PTHP)

DESCRIPTION

This measure applied to the installation of a temperature setback and lighting control system for individual guest rooms. The savings are achieved based on Guest Room Energy Management's (GREM's) ability to automatically adjust the guest room's set temperatures and control the HVAC unit for various occupancy modes.

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

DEFINITION OF EFFICIENT EQUIPMENT

Guest room temperature set point must be controlled by automatic occupancy detectors or keycard that indicates the occupancy status of the room. During unoccupied periods the default setting for controlled units differs by at least 5 degrees from the operating set point. Theoretically, the control system may also be tied into other electric loads, such as lighting and plug loads to shut them off when occupancy is not sensed. This measure bases savings on improved HVAC controls. If system is connected to lighting and plug loads, additional savings would be realized. The incentive is per guestroom controlled, rather than per sensor, for multi-room suites. Replacement or upgrades of existing occupancy-based controls are not eligible for an incentive.

DEFINITION OF BASELINE EQUIPMENT

Manual Heating/Cooling Temperature Setpoint and Fan On/Off/Auto Thermostat

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure life for GREM is 15 years²⁵².

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 GREM²⁵³.

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape C03 - Commercial Cooling

COINCIDENCE FACTOR²⁵⁴

The coincidence factor for this measure is 0.67

²⁵²DEER 2008 value for energy management systems

²⁵³This value was extracted from Smart Ideas projects in PY1 and PY2.

²⁵⁴KEMA

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. These values are from the Michigan savings database using Michigan’s 574 annual CDD and 6,676 annual HDD, which are conservative when compared to 857 CDD and 6,418 HDD in Zon2 1 (Chicago).

ELECTRIC ENERGY SAVINGS

Measure Savings for GREM

Cooling Type	Cooling kWh		Heating (kWh & Therms)		Total kWh	
	3/4 ton	1 ton	3/4 ton	1 ton	3/4 ton	1 ton
PTAC	208	287	1,234 kWh	1,645 kWh	1,441	1,932
PTHP	181	263	721 kWh	988 kWh	902	1,251
FCU with Gas Heat/Elec Cool	407	542	53 Therms	70 Therms	407	542

On average, the annual kWh saving for a 0.75 ton and 1 ton HVAC unit with electric cooling and electric heating is 1,117 kWh per room. For non-electric heating, it is assumed the savings are approximately one third at 334 kWh per room. The average between 0.75 and 1 tons is used for a conservative estimate. However, it is assumed that most PTAC units in hotel rooms are sized to 1 ton.

Measure Savings Analysis

Savings estimate shall be verified using an eQuest model. The Michigan work paper assumes a 30% savings with the GREM. The model outputs will be validated by actual monitored projects, as they become available. Once the model is calibrated, its outputs will be used to update the work paper. The inputs for simulating average occupancy and setback temperatures are as follows (90% occupancy rate is assumed):

Base case: 72°F all the time

Proposed case:

Cooling Type	Cooling, °F		Heating, °F	
	Occupied Rooms	Unoccupied Rooms	Occupied Rooms	Unoccupied Rooms
6pm-11pm	72	85	72	65
11pm- 7am	78	85	65	65
7am- 9am	72	85	72	65
9am- 6pm	78	85	65	65

SUMMER COINCIDENT PEAK DEMAND SAVINGS

The coincident kW impacts for this measure have not been sufficiently studied or modeled to provide a confident estimate. In the meantime the following kW impacts are estimated for systems that control cooling operation.

kW Savings per ton = (12/HVAC EER) x average on peak uncontrolled load factor of 50% (estimated from anecdotal observations by KEMA for NV Energy) x estimated cycling reduction of 30% (estimated by KEMA from empirical observations and logging from manufacturers for NV Energy)

$$kW = (12/8.344) \times 0.5 \times 0.3 = 1.25 \text{ kW per ton or room}$$

where,

HVAC EER = is based on a 1 ton unit at code baseline efficiency of PTAC,

$$\text{defined as } EER = 10.9 - (0.213 \times 12000 \text{ btu/hr}/1000) = 8.344$$

In addition, a coincident factor for cooling needs to be included to consider that not all room PTAC units are operating at the same. It is estimated as 0.67 (Ref: Pennsylvania Technical Resource Manual (12/23/09 version) for HVAC Measures, Table 6.17 p 55) This factor will be used pending further study.

$$\text{Coincident kW Savings} = 1.25 \times 0.67 = 0.84 \text{ kW per unit-ton or per room}$$

NATURAL GAS ENERGY SAVINGS

Heating	Heating (Therms)	
	3/4 ton	1 ton
FCU with Gas Heat/Elec Cool	53 Therms	70 Therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

4.4.9 Heat Pump Systems

DESCRIPTION

This measure applies to the installation of high-efficiency air cooled, water source, ground water source, and ground source heat pump systems. This measure could apply to replacing an existing unit at the end of its useful life, or installation of a new unit in a new or existing building

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

DEFINITION OF EFFICIENT EQUIPMENT

In order for this characterization to apply, the efficient equipment is assumed to be a high-efficiency air cooled, water source, ground water source, or ground source heat pump system that exceeds the energy efficiency requirements of the International Energy Conservation Code (IECC) 2006, Table 503.2.3(2).

DEFINITION OF BASELINE EQUIPMENT

In order for this characterization to apply, the baseline equipment is assumed to be a standard-efficiency air cooled, water source, ground water source, or ground source heat pump system that meets the energy efficiency requirements of the International Energy Conservation Code (IECC) 2006, Table 503.2.3(2). The rating conditions for the baseline and efficient equipment efficiencies must be equivalent

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 15 years.²⁵⁵

DEEMED MEASURE COST

For analysis purposes, the incremental capital cost for this measure is assumed as \$100 per ton for air-cooled units.²⁵⁶ The incremental cost for all other equipment types should be determined on a site-specific basis

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape C05 - Commercial Electric Heating and Cooling

²⁵⁵ Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, Inc., June 2007.

²⁵⁶ Based on a review of TRM incremental cost assumptions from Vermont, Wisconsin, and California.

COINCIDENCE FACTOR

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

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

$$= 91.3\%^{257}$$

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

$$= 47.8\%^{258}$$

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

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

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

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

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

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

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

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

$$\text{Annual kWh Savings}_{heat} = (kBtu/h_{heat})/3.412 * [(1/COPbase) - (1/COFee)] * EFLH_{heat}$$

Where:

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

= Actual installed

SEERbase = Seasonal Energy Efficiency Ratio of the baseline equipment; see table below for

²⁵⁷ Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility’s peak hour is divided by the maximum AC load during the year.

²⁵⁸ Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year

values.²⁵⁹

TABLE 503.2.3(2)
UNITARY AIR CONDITIONERS AND CONDENSING UNITS, ELECTRICALLY OPERATED, MINIMUM EFFICIENCY REQUIREMENTS

EQUIPMENT TYPE	SIZE CATEGORY	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY ^b	TEST PROCEDURE ^a
Air cooled, (Cooling mode)	< 65,000 Btu/h ^d	Split system	13.0 SEER	AHRI 210/240
		Single package	13.0 SEER	
	≥ 65,000 Btu/h and < 135,000 Btu/h	Split system and single package	10.1 EER ^c (before Jan 1, 2010) 11.0 EER ^c (as of Jan 1, 2010)	AHRI 340/360
	≥ 135,000 Btu/h and < 240,000 Btu/h	Split system and single package	9.3 EER ^c (before Jan 1, 2010) 10.6 EER ^c (as of Jan 1, 2010)	
	≥ 240,000 Btu/h	Split system and single package	9.0 EER ^c 9.2 IPLV ^c (before Jan 1, 2010) 9.5 EER ^c 9.2 IPLV ^c (as of Jan 1, 2010)	
Through-the-Wall (Air cooled, cooling mode)	< 30,000 Btu/h ^d	Split system	10.9 SEER (before Jan 23, 2010) 12.0 SEER (as of Jan 23, 2010)	AHRI 210/240
		Single package	10.6 SEER (before Jan 23, 2010) 12.0 SEER (as of Jan 23, 2010)	
Water Source (Cooling mode)	< 17,000 Btu/h	86°F entering water	11.2 EER	AHRI/ASHRAE 13256-1
	≥ 17,000 Btu/h and < 135,000 Btu/h	86°F entering water	12.0 EER	AHRI/ASHRAE 13256-1
Groundwater Source (Cooling mode)	< 135,000 Btu/h	59°F entering water	16.2 EER	AHRI/ASHRAE 13256-1
Ground source (Cooling mode)	< 135,000 Btu/h	77°F entering water	13.4 EER	AHRI/ASHRAE 13256-1
Air cooled (Heating mode)	< 65,000 Btu/h ^d (Cooling capacity)	Split system	7.7 HSPF	AHRI 210/240
		Single package	7.7 HSPF	
	≥ 65,000 Btu/h and < 135,000 Btu/h (Cooling capacity)	47°F db/43°F wb Outdoor air	3.2 COP (before Jan 1, 2010) 3.3 COP (as of Jan 1, 2010)	AHRI 340/360
≥ 135,000 Btu/h (Cooling capacity)	47°F db/43°F wb Outdoor air	3.1 COP (before Jan 1, 2010) 3.2 COP (as of Jan 1, 2010)		

²⁵⁹ International Energy Conservation Code (IECC) 2009

**TABLE 503.2.3(2)—continued
UNITARY AIR CONDITIONERS AND CONDENSING UNITS, ELECTRICALLY OPERATED, MINIMUM EFFICIENCY REQUIREMENTS**

EQUIPMENT TYPE	SIZE CATEGORY	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY ^b	TEST PROCEDURE ^a
Through-the-wall (Air cooled, heating mode)	< 30,000 Btu/h	Split System	7.1 HSPE (before Jan 23, 2010) 7.4 HSPF (as of Jan 23, 2010)	AHRI 210/240
		Single package	7.0 HSPF (before Jan 23, 2010) 7.4 HSPF (as of Jan 23, 2010)	
Water source (Heating mode)	< 135,000 Btu/h (Cooling capacity)	68°F entering water	4.2 COP	AHRI/ASHRAE 13256-1
Groundwater source (Heating mode)	< 135,000 Btu/h (Cooling capacity)	50°F entering water	3.6 COP	AHRI/ASHRAE 13256-1
Ground source (Heating mode)	< 135,000 Btu/h (Cooling capacity)	32°F entering water	3.1 COP	AHRI/ASHRAE 13256-1

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

db = dry-bulb temperature, °F; wb = wet-bulb temperature, °F.

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

b. IPLVs and Part load rating conditions are only applicable to equipment with capacity modulation.

c. Deduct 0.2 from the required EERs and IPLVs for units with a heating section other than electric resistance heat.

d. Single-phase air-cooled heat pumps < 65,000 Btu/h are regulated by the National Appliance Energy Conservation Act of 1987 (NAECA). SEER and HSPF values are those set by NAECA.

SEER_{ee} = Seasonal Energy Efficiency Ratio of the energy efficient equipment.

= Actual installed

EFLH_{cool} = cooling mode equivalent full load hours; see table below for default values:

Zone	Equivalent Full Load Hours Cooling (EFLH) ²⁶⁰	Equivalent Full Load heating Cooling (EFLH)
1 (Rockford)	816	1153
2 (Chicago)	819	1069
3 (Springfield)	1001	885
4 (Belleville)	1261	621
5 (Marion)	819	623

HSPF_{base} = Heating Seasonal Performance Factor of the baseline equipment; see table above for values.

HSPF_{ee} = Heating Seasonal Performance Factor of the energy efficient equipment.

= Actual installed

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

²⁶⁰ Heating and cooling EFLH data based on a series of prototypical small commercial building simulation runs for the Ohio TRM. Values shown are weighted averages across fast food restaurant, full service restaurant, assembly, big box retail, small retail, small office, light industrial and school building models. The prototypes are based on the California DEER study prototypes, modified for local construction practices. Simulations were run using TMY3 weather data for each of the cities listed. Building prototypes used in the energy modeling are described in Appendix A - Prototypical Building Energy Simulation Model Development. The Ohio values were adjusted base on CCD and HDD for IL locations. Further study recommended for IL specific building types.

- EERbase = Energy Efficiency Ratio of the baseline equipment; see the table above for values. Since IECC 2006 does not provide EER requirements for air-cooled heat pumps < 65 kBtu/h, assume the following conversion from SEER to EER: EER≈SEER/1.1.
- EERee = Energy Efficiency Ratio of the energy efficient equipment. For air-cooled air conditioners < 65 kBtu/h, if the actual EERee is unknown, assume the following conversion from SEER to EER: EER≈SEER/1.1.
- = Actual installed
- kBtu/h_{heat} = capacity of the heating equipment in kBtu per hour.
- = Actual installed
- 3.412 = Btu per Wh.
- COPbase = coefficient of performance of the baseline equipment; see table above for values.
- COPee = coefficient of performance of the energy efficient equipment.
- = Actual installed

$$\text{Annual kWh Savings}_{\text{cool}} = (\text{kBtu}/\text{h}_{\text{cool}}) * [(1/\text{SEER}_{\text{base}}) - (1/\text{SEER}_{\text{ee}})] * \text{EFLH}_{\text{cool}}$$

$$\text{Annual kWh Savings}_{\text{heat}} = (\text{kBtu}/\text{h}_{\text{heat}}) * [(1/\text{HSPF}_{\text{base}}) - (1/\text{HSPF}_{\text{ee}})] * \text{EFLH}_{\text{heat}}$$

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

$$= [(60) * [(1/13) - (1/14)] * 816] + [(60)/3.412 * [(1/7.7) - (1/9)] * 1153]$$

$$= 649 \text{ kWh}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta \text{kW} = (\text{kBtu}/\text{h}_{\text{cool}}) * [(1/\text{EER}_{\text{base}}) - (1/\text{EER}_{\text{ee}})] * \text{CF}$$

Where CF value is chosen between:

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

$$= 91.3\%^{261}$$

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

$$= 47.8\%^{262}$$

²⁶¹ Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility’s peak hour is divided by the maximum AC load during the year.

²⁶² Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average

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

$$\begin{aligned}\Delta kW &= [(60) * [(1/13) - (1/14)]] *.913 \\ &= 0.3\end{aligned}$$

NATURAL GAS ENERGY SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

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 Boiler²⁶³

DESCRIPTION

To qualify for this measure the installed equipment must be replacement of an existing boiler at the end of its service life, in a commercial space with a high efficiency, gas-fired steam or hot water boiler. High efficiency boilers achieve gas savings through the utilization of a sealed combustion chamber and multiple heat exchangers that remove a significant portion of the waste heat from flue gasses. Because multiple heat exchangers are used to remove waste heat from the escaping flue gasses, some of the flue gasses condense and must be drained.

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

DEFINITION OF EFFICIENT EQUIPMENT

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

DEFINITION OF BASELINE EQUIPMENT

dependent on when the unit is installed and whether the unit is hot water or steam. The baseline efficiency source is the Energy Independence and Security Act of 2007 with technical amendments from Federal Register, volume 73, Number 145, Monday, July 28, 2008 for boilers <300,000 Btu/h and is Final Rule, Federal Register, volume 74, Number 139, Wednesday, July 22, 2009 for boiler ≥300,000 Btu/h..

Hot water boiler baseline:

Year	AFUE or TE
Hot Water <300,000 Btu/h < Sept 1, 2012	80% AFUE
Hot Water <300,000 Btu/h ≥ Sept 1, 2012	82% AFUE
Hot Water ≥300,000 & ≤2,500,000 Btu/h	80% TE
Hot Water >2,500,000 Btu/h	82% Ec

²⁶³High Impact Measure

Steam boiler baseline:

Year	AFUE or TE
Steam <300,000 Btu/h < Sept 1, 2012	75% AFUE
Steam <300,000 Btu/h ≥Sept 1, 2012	80% AFUE
Steam - all except natural draft ≥300,000 & ≤2,500,000 Btu/h	79% TE
Steam - natural draft ≥300,000 & ≤2,500,000 Btu/h	77% TE
Steam - all except natural draft >2,500,000 Btu/h	79% TE
Steam - natural draft >2,500,000 Btu/h	77% TE

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 20 years²⁶⁴

DEEMED MEASURE COST

The incremental capital cost for this measure depends on efficiency as listed below²⁶⁵

Measure Tier	Incr. Cost, per unit
ENERGY STAR® Minimum	\$1,470
AFUE 90%	\$2,400
AFUE 95%	\$3,370
AFUE ≥ 96%	\$4,340
Boilers > 300,000 Btu/h with TE (thermal efficiency) rating	Custom

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

N/A

²⁶⁴ 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

²⁶⁵ 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.

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

$$\Delta\text{Therms} = \text{EFLH} * \text{Capacity} * (1/\text{AFUE}_{\text{base}}) - 1/\text{AFUE}_{\text{eff}}) / 100,000$$

Where:

EFH = Equivalent Full Load Hours for heating²⁶⁶ (hr)

Building Type	EFLH				
	Zone 1 (Rockford)	Zone 2 (Chicago)	Zone 3 (Springfield)	Zone 4 (Belleville/)	Zone 5 (Marion)
Office - High Rise	2,746	2,768	2,656	2,155	2,420
Office - Mid Rise	996	879	824	519	544
Office - Low Rise	797	666	647	343	329
Convenience	696	550	585	272	297
Healthcare Clinic	1,118	1,036	1,029	694	737
Manufacturing Facility	1,116	1,123	904	771	857
Lodging Hotel/Motel	2,098	2,050	1,780	1,365	1,666
High School	969	807	999	569	674
Hospital	2,031	1,929	1,863	1,497	1,800
Elementary	970	840	927	524	637
Religious Facility	1,830	1,657	1,730	1,276	1,484
Restaurant	1,496	1,379	1,291	872	1,185
Retail - Strip Mall	1,266	1,147	1,151	732	863
Retail - Department Store	1,065	927	900	578	646
College/University	373	404	376	187	187
Warehouse	416	443	427	226	232
Unknown	1,249	1,163	1,130	786	910

Capacity = Nominal Heating Capacity Boiler Size (btuh)

= custom Boiler input capacity in Btu/hr

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

Year	AFUE
Hot Water < Sept 1, 2012	80%
Hot Water ≥ Sept 1, 2012	82%
Steam < Sept 1, 2012	75%
Steam ≥ Sept 1, 2012	80%

²⁶⁶Equivalent full load hours for heating were developed using eQuest models for various building types averaged across each climate zones for Illinois for the following building types: office, healthcare/clinic, manufacturing, lodging, high school, hospital, elementary school, religious/assembly, restaurant, retail, college and warehouse. eQuest models were those developed for IL lighting interactive effects.

AFUE(eff)= Efficient Furnace Annual Fuel Utilization Efficiency Rating = dependent on tier as listed below for lookup table or custom

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

EXAMPLE

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

$$\begin{aligned} \Delta\text{Therms} &= 2,746 * 150,000 * (1/.80 - 1/.90) / 100,000 \text{ Btu/Therm} \\ &= 572 \text{ Therms} \end{aligned}$$

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

4.4.11 High Efficiency Furnace²⁶⁷

DESCRIPTION

This measure covers the installation of a high efficiency gas furnace in lieu of a standard efficiency gas furnace in a commercial or industrial space. High efficiency gas furnaces achieve savings through the utilization of a sealed, super insulated combustion chamber, more efficient burners, and multiple heat exchangers that remove a significant portion of the waste heat from the flue gasses. Because multiple heat exchangers are used to remove waste heat from the escaping flue gasses, most of the flue gasses condense and must be drained. Furnaces equipped with ECM fan motors can save additional electric energy

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

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed equipment must be a natural gas fired furnace with a minimum Annual Fuel Utilization Efficiency (AFUE) rating of 92% and input rating of less than 225,000 Btu/hr.

DEFINITION OF BASELINE EQUIPMENT

Though the current federal minimum AFUE rating is 78%, based upon market sales data, the baseline efficiency for this characterization is assumed to be 80% up until when the federal minimum efficiency standards are raised to AFUE 90% in 2013.

DEFINITION OF MEASURE LIFE

The expected measure life is assumed to be 16.5 years²⁶⁸

DEEMED MEASURE COST

The incremental capital cost for this measure depends on efficiency as listed below²⁶⁹

Measure Tier	Incr. Cost, per unit
CEE Tier 2 - 92%	\$477
CEE Tier 2 - 93%	\$567
CEE Tier 3 - 94%	\$657
CEE Tier 3 - 95%	\$754
≥ 96% AFUE	\$851

DEEMED O&M COST ADJUSTMENTS

N/A

²⁶⁷ High Impact Measure

²⁶⁸ Average of 15-18 year lifetime estimate made by the Consortium for Energy Efficiency in 2010.

²⁶⁹ Appliance Standards Technical Support Documents
(http://www1.eere.energy.gov/buildings/appliance_standards/residential/fb_tsd_0907.html)

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = \text{Heating Savings} + \text{Cooling Savings} + \text{Shoulder Season Savings}$$

Where:

$$\begin{aligned} \text{Heating Savings} &= \text{Brushless DC motor or Electronically commutated motor (ECM)} \\ &= 418 \text{ kWh}^{270} \end{aligned}$$

$$\begin{aligned} \text{Cooling Savings} &= \text{Brushless DC motor or electronically commutated motor (ECM)} \\ \text{savings during cooling season} & \end{aligned}$$

$$\text{If air conditioning} = 263 \text{ kWh}$$

$$\text{If no air conditioning} = 175 \text{ kWh}$$

$$\text{If unknown (weighted average)} = 241 \text{ kWh}^{271}$$

$$\begin{aligned} \text{Shoulder Season Savings} &= \text{Brushless DC motor or electronically commutated motor (ECM)} \\ \text{savings during shoulder seasons} & \end{aligned}$$

$$= 51 \text{ kWh}$$

EXAMPLE

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

$$\begin{aligned} \Delta kWh &= \text{Heating Savings} + \text{Cooling Savings} + \text{Shoulder Season Savings} \\ &= 418 + 251 + 51 \\ &= 721 \text{ kWh} \end{aligned}$$

²⁷⁰To 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.

²⁷¹The weighted average value is based on assumption that 75% of homes installing BPM furnace blower motors have Central AC. 66% of IL housing units have CAC and 66% have gas furnaces. It is logical these two groups overlap to a large extent (like the 95% in the FOE study above).

SUMMER COINCIDENT PEAK DEMAND SAVINGS

For units that have evaporator coils and condensing units and are cooling in the summer in addition to heating in the winter the summer coincident peak demand savings should be calculated. If the unit is not equipment with coils or condensing units, the summer peak demand savings will not apply.

$$\Delta kW = (\Delta kWh / (\text{HOURSyear} * \text{DaysYear})) * CF$$

Where:

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

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

CF =Summer Peak Coincidence Factor for measure is provided below for different building types²⁷²:

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

EXAMPLE

For example, a 150,000 btu/hr furnace for an office building:

$$\Delta kW = (721 kWh / (12 h/d * 365.25 d/yr)) * 0.68 = 0.11 kW$$

²⁷²Based on DEER 2008 values

NATURAL GAS ENERGY SAVINGS

$$\Delta\text{Therms} = \text{EFLH} * \text{Capacity} * (1/\text{AFUE}(\text{base}) - 1/\text{AFUE}(\text{eff})) / 100,000 \text{ Btu/Therm}$$

Where:

$$\text{EFLH} = \text{Equivalent Full Load Hours for heating}^{273} \text{ (hr)}$$

Building Type	EFLH				
	Zone 1 (Rockford)	Zone 2 (Chicago)	Zone 3 (Springfield)	Zone 4 (Belleville/)	Zone 5 (Marion)
Office - High Rise	2,746	2,768	2,656	2,155	2,420
Office - Mid Rise	996	879	824	519	544
Office - Low Rise	797	666	647	343	329
Convenience	696	550	585	272	297
Healthcare Clinic	1,118	1,036	1,029	694	737
Manufacturing Facility	1,116	1,123	904	771	857
Lodging Hotel/Motel	2,098	2,050	1,780	1,365	1,666
High School	969	807	999	569	674
Hospital	2,031	1,929	1,863	1,497	1,800
Elementary	970	840	927	524	637
Religious Facility	1,830	1,657	1,730	1,276	1,484
Restaurant	1,496	1,379	1,291	872	1,185
Retail - Strip Mall	1,266	1,147	1,151	732	863
Retail - Department Store	1,065	927	900	578	646
College/University	373	404	376	187	187
Warehouse	416	443	427	226	232
Unknown	1,249	1,163	1,130	786	910

Capacity = Nominal Heating Capacity Furnace Size (btuh)

= custom Furnace input capacity in Btu/hr or if unknown 150,000

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

²⁷³Equivalent full load hours for heating were developed using eQuest models for various building types averaged across each climate zones for Illinois for the following building types: office, healthcare/clinic, manufacturing, lodging, high school, hospital, elementary school, religious/assembly, restaurant, retail, college and warehouse. eQuest models were those developed for IL lighting interactive effects.

Year	AFUE
2012	80%
2013-	90%

AFUE(eff)= Efficient Furnace Annual Fuel Utilization Efficiency Rating = dependent on tier as listed below for lookup table or custom

Measure Type	Actual AFUE
AFUE 92% - 94.9%	93.5%
AFUE≥95%	96%
Custom	Value to one significant digit i.e. 95.7%

EXAMPLE

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

$$\begin{aligned} \Delta\text{Therms} &= 2,746 * 150,000 * (1/80\% - 1/92\%) / 100,000 \text{ Btu/Therm} \\ &= 672 \text{ Therms} \end{aligned}$$

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

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 years²⁷⁴

DEEMED MEASURE COST

The incremental capital cost for this measure is \$1716²⁷⁵

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

²⁷⁴ENERGY 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

²⁷⁵Ibid.

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 Therms²⁷⁶

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

²⁷⁶Nicor Gas Energy Efficiency Plan 2011-2014. Revised Plan Filed Pursuant to Order Docket 10-0562, May 27, 2011. These deemed values should be compared to PY evaluation and revised as necessary.

4.4.13 Package Terminal Air Conditioner (PTAC) and Package Terminal Heat Pump (PTHP)

DESCRIPTION

A PTAC is a packaged terminal air conditioner that cools and sometimes provides heat through an electric resistance heater (heat strip). A PTHP is a packaged terminal heat pump. A PTHP uses its compressor year round to heat or cool. In warm weather, it efficiently captures heat from inside your building and pumps it outside for cooling. In cool weather, it captures heat from outdoor air and pumps it into your home, adding heat from electric heat strips as necessary to provide heat.

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

DEFINITION OF EFFICIENT EQUIPMENT

In order for this characterization to apply, the efficient equipment is assumed to be PTACs or PTHPs that exceed baseline efficiencies replacing existing equipment at the end of its useful life.

DEFINITION OF BASELINE EQUIPMENT

In order for this characterization to apply, the baseline conditions must be met as listed in the reference table.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 15 years.²⁷⁷

DEEMED MEASURE COST

The incremental capital cost for this equipment is estimated to be \$84/ton.²⁷⁸

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape C03 - Commercial Cooling

COINCIDENCE FACTOR

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

²⁷⁷ Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, Inc., June 2007

²⁷⁸ DEER 2008 This assumes that baseline shift from IECC 2006 to IECC 2009 carries the same incremental costs. Values should be verified during evaluation

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

$$= 91.3\%^{279}$$

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

$$= 47.8\%^{280}$$

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

Electric savings for PTACs and PTHPs should be calculated using the following algorithms

ENERGY SAVINGS

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

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

$$\text{Annual kWh Savings}_{cool} = (kBtu/h_{cool}) * [(1/SEER_{base}) - (1/SEER_{ee})] * EFLH_{cool}$$

$$\text{Annual kWh Savings}_{heat} = (kBtu/h_{cool}) * [(1/HSPF_{base}) - (1/HSPF_{ee})] * EFLH_{heat}$$

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

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

$$\text{Annual kWh Savings}_{cool} = (kBtu/h_{cool}) * [(1/EER_{base}) - (1/EER_{ee})] * EFLH_{cool}$$

$$\text{Annual kWh Savings}_{heat} = (kBtu/h_{heat})/3.412 * [(1/COP_{base}) - (1/COP_{ee})] * EFLH_{heat}$$

Where:

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

= Actual installed

²⁷⁹Based 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.

²⁸⁰Based 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

SEER_{base} values²⁸¹ = Seasonal Energy Efficiency Ratio of the baseline equipment; see table below for baseline values

**TABLE 503.2.3(3)
PACKAGED TERMINAL AIR CONDITIONERS AND PACKAGED TERMINAL HEAT PUMPS**

EQUIPMENT TYPE	SIZE CATEGORY (INPUT)	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY ^b	TEST PROCEDURE ^a
PTAC (Cooling mode) New construction	All capacities	95°F db outdoor air	12.5 - (0.213 · Cap/1000) EER	AHRI 310/380
PTAC (Cooling mode) Replacements ^c	All capacities	95°F db outdoor air	10.9 - (0.213 · Cap/1000) EER	
PTHP (Cooling mode) New construction	All capacities	95°F db outdoor air	12.3 - (0.213 · Cap/1000) EER	
PTHP (Cooling mode) Replacements ^c	All capacities	95°F db outdoor air	10.8 - (0.213 · Cap/1000) EER	
PTHP (Heating mode) New construction	All capacities	—	3.2 - (0.026 · Cap/1000) COP	
PTHP (Heating mode) Replacements ^c	All capacities	—	2.9 - (0.026 · Cap/1000) COP	

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

db = dry-bulb temperature, °F.

wb = wet-bulb temperature, °F.

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

b. Cap means the rated cooling capacity of the product in Btu/h. If the unit's capacity is less than 7,000 Btu/h, use 7,000 Btu/h in the calculation. If the unit's capacity is greater than 15,000 Btu/h, use 15,000 Btu/h in the calculation.

c. Replacement units must be factory labeled as follows: "MANUFACTURED FOR REPLACEMENT APPLICATIONS ONLY: NOT TO BE INSTALLED IN NEW CONSTRUCTION PROJECTS." Replacement efficiencies apply only to units with existing sleeves less than 16 inches (406 mm) high and less than 42 inches (1067 mm) wide.

SEER_{ee} = Seasonal Energy Efficiency Ratio of the energy efficient equipment.

= Actual installed

EFLH_{cool} = cooling mode equivalent full load hours; see table below for default values:

Zone	Equivalent Full Load Hours Cooling (EFLH) ²⁸²	Equivalent Full Load heating Cooling (EFLH)
1 (Rockford)	816	1153
2 (Chicago)	819	1069
3 (Springfield)	1001	885
4 (Belleville)	1261	621
5 (Marion)	819	623

HSPF_{base} = Heating Seasonal Performance Factor of the baseline equipment; see table above for

²⁸¹ International Energy Conservation Code (IECC) 2009

²⁸² Heating and cooling EFLH data based on a series of prototypical small commercial building simulation runs for the Ohio TRM. Values shown are weighted averages across fast food restaurant, full service restaurant, assembly, big box retail, small retail, small office, light industrial and school building models. The prototypes are based on the California DEER study prototypes, modified for local construction practices. Simulations were run using TMY3 weather data for each of the cities listed. Building prototypes used in the energy modeling are described in Appendix A - Prototypical Building Energy Simulation Model Development. The Ohio values were adjusted base on CCD and HDD for IL locations. Further study recommended for IL specific building types.

values.

- HSPFee = Heating Seasonal Performance Factor of the energy efficient equipment.
= Actual installed
- EFLH_{heat} = heating mode equivalent full load hours; see table above for default values.
- EERbase = Energy Efficiency Ratio of the baseline equipment; see the table above for values. Since IECC 2009 does not provide EER requirements for air-cooled heat pumps < 65 kBtu/h, assume the following conversion from SEER to EER: EER≈SEER/1.1.
- EERee = Energy Efficiency Ratio of the energy efficient equipment. For air-cooled air conditioners < 65 kBtu/h, if the actual EERee is unknown, assume the following conversion from SEER to EER: EER≈SEER/1.1.
= Actual installed
- kBtu/h_{heat} = capacity of the heating equipment in kBtu per hour.
= Actual installed
- 3.412 = Btu per Wh.
- COPbase = coefficient of performance of the baseline equipment; see table above for values.
- COPee = coefficient of performance of the energy efficient equipment.
= Actual installed

For example a 5 ton replacement cooling unit with no heating with an efficient SEER of 20 saves

$$= [(60) * [(1/19.456) - (1/20)]] * 816$$

$$= 68 \text{ kWh}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = (\text{kBtu}/\text{h}_{\text{cool}}) * [(1/\text{EER}_{\text{base}}) - (1/\text{EER}_{\text{ee}})] * \text{CF}$$

Depending on situation:

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)

²⁸³Based 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.

$$= 47.8\%^{284}$$

For example a 5 ton replacement cooling unit with no heating with an efficient EER of 20 saves

$$\Delta kW = (60) * [(1/19.456) - (1/20)] * 0.913$$

NATURAL GAS ENERGY SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

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

4.4.14 Single-Package and Split System Unitary Air Conditioners

DESCRIPTION

This measure promotes the installation of high-efficiency unitary air-, water-, and evaporatively cooled air conditioning equipment, both single-package and split systems. Air conditioning (AC) systems are a major consumer of electricity and systems that exceed baseline efficiencies can save considerable amounts of energy. This measure could apply to the replacing of an existing unit at the end of its useful life or the installation of a new unit in a new or existing building.

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

DEFINITION OF EFFICIENT EQUIPMENT

In order for this characterization to apply, the efficient equipment is assumed to be a high-efficiency air-, water-, or evaporatively cooled air conditioner that exceeds the energy efficiency requirements of the International Energy Conservation Code (IECC) 2009, Table 503.2.3(1).

DEFINITION OF BASELINE EQUIPMENT

In order for this characterization to apply, the efficient equipment is assumed to be a standard-efficiency air-, water, or evaporatively cooled air conditioner that meets the energy efficiency requirements of the International Energy Conservation Code (IECC) 2006, Table 503.2.3(1). The rating conditions for the baseline and efficient equipment efficiencies must be equivalent.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 15 years.²⁸⁵

DEEMED MEASURE COST

The incremental capital cost for this measure is assumed to be \$100 per ton.²⁸⁶

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape C03 - Commercial Cooling

COINCIDENCE FACTOR

The summer peak coincidence factor for cooling is provided in two different ways below. The first is used to

²⁸⁵ Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, Inc., June 2007.

²⁸⁶ Based on a review of TRM incremental cost assumptions from Vermont, Wisconsin, and California. This assumes that baseline shift from IECC 2006 to IECC 2009 carries the same incremental costs. Values should be verified during evaluation

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

$$\begin{aligned} CF_{SSP} &= \text{Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)} \\ &= 91.3\%^{287} \end{aligned}$$

$$\begin{aligned} CF_{PJM} &= \text{PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)} \\ &= 47.8\%^{288} \end{aligned}$$

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

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

$$\Delta\text{kWH} = (\text{kBtu/h}) * [(1/\text{SEERbase}) - (1/\text{SEERee})] * \text{EFLH}$$

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

$$\Delta\text{kWH} = (\text{kBtu/h}) * [(1/\text{EERbase}) - (1/\text{EERee})] * \text{EFLH}$$

Where:

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

SEERbase = Seasonal Energy Efficiency Ratio of the baseline equipment; see table below for default values²⁸⁹:

²⁸⁷Based 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.

²⁸⁸Based 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

²⁸⁹International Energy Conservation Code (IECC) 2009

TABLE 503.2.3(1)
UNITARY AIR CONDITIONERS AND CONDENSING UNITS, ELECTRICALLY OPERATED, MINIMUM EFFICIENCY REQUIREMENTS

EQUIPMENT TYPE	SIZE CATEGORY	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY ^b	TEST PROCEDURE ^a
Air conditioners, Air cooled	< 65,000 Btu/h ^d	Split system	13.0 SEER	AHRI 210/240
		Single package	13.0 SEER	
	≥ 65,000 Btu/h and < 135,000 Btu/h	Split system and single package	10.3 EER ^c (before Jan 1, 2010) 11.2 EER ^c (as of Jan 1, 2010)	AHRI 340/360
			≥ 135,000 Btu/h and < 240,000 Btu/h	
	≥ 240,000 Btu/h and < 760,000 Btu/h	Split system and single package	9.5 EER ^c 9.7 IPLV ^c (before Jan 1, 2010) 10.0 EER ^c 9.7 IPLV ^s (as of Jan 1, 2010)	AHRI 340/360
≥ 760,000 Btu/h	Split system and single package	9.2 EER ^c 9.4 IPLV ^c (before Jan 1, 2010) 9.7 EER ^c 9.4 IPLV ^c (as of Jan 1, 2010)		
Through-the-wall, Air cooled	< 30,000 Btu/h ^d	Split system	10.9 SEER (before Jan 23, 2010) 12.0 SEER (as of Jan 23, 2010)	AHRI 210/240
		Single package	10.6 SEER (before Jan 23, 2010) 12.0 SEER (as of Jan 23, 2010)	
Air conditioners, Water and evaporatively cooled	< 65,000 Btu/h	Split system and single package	12.1 EER	AHRI 210/240
	≥ 65,000 Btu/h and < 135,000 Btu/h	Split system and single package	11.5 EER ^c	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Split system and single package	11.0 EER ^c	AHRI 340/360
	≥ 240,000 Btu/h	Split system and single package	11.5 EER ^c	

For SI: 1 British thermal unit per hour = 0.2931 W.

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

b. IPLVs are only applicable to equipment with capacity modulation.

c. Deduct 0.2 from the required EERs and IPLVs for units with a heating section other than electric resistance heat.

d. Single-phase air-cooled air conditioners < 65,000 Btu/h are regulated by the National Appliance Energy Conservation Act of 1987 (NAECA); SEER values are those set by NAECA.

SEER_{ee} = Seasonal Energy Efficiency Ratio of the energy efficient equipment (actually installed).

EER_{base} = Energy Efficiency Ratio of the baseline equipment; see table above for default values. Since IECC 2006 does not provide EER requirements for air-cooled air conditioners < 65 kBtu/h, assume the following conversion from SEER to EER: EER ≈ SEER/1.1

EER_{ee} = Energy Efficiency Ratio of the energy efficient equipment. For air-cooled air conditioners < 65 kBtu/h, if the actual EER_{ee} is unknown, assume the following conversion from SEER to EER: EER ≈ SEER/1.1.

= Actual installed

EFLH = cooling equivalent full load hours; see table below for default values:

Zone	Equivalent Full Load Hours Cooling (EFLH) ²⁹⁰
1 (Rockford)	816
2 (Chicago)	819
3 (Springfield)	1001
4 (Belleville)	1261
5 (Marion)	819

For example a 5 ton air cooled split system with a SEER of 15 in Rockford would save

$$\begin{aligned} \Delta \text{kWh} &= (60) * [(1/13) - (1/15)] * 816 \\ &= 502 \text{ kWh} \end{aligned}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta \text{kW}_{\text{SSP}} = (\text{kBtu/h} * (1/\text{EER}_{\text{base}} - 1/\text{EER}_{\text{ee}})) * \text{CF}_{\text{SSP}}$$

$$\Delta \text{kW}_{\text{PJM}} = (\text{kBtu/h} * (1/\text{EER}_{\text{base}} - 1/\text{EER}_{\text{ee}})) * \text{CF}_{\text{PJM}}$$

Where:

$$\begin{aligned} \text{CF}_{\text{SSP}} &= \text{Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)} \\ &= 91.3\%^{291} \end{aligned}$$

$$\begin{aligned} \text{CF}_{\text{PJM}} &= \text{PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)} \\ &= 47.8\%^{292} \end{aligned}$$

²⁹⁰ Heating and cooling EFLH data based on a series of prototypical small commercial building simulation runs for the Ohio TRM. Values shown are weighted averages across fast food restaurant, full service restaurant, assembly, big box retail, small retail, small office, light industrial and school building models. The prototypes are based on the California DEER study prototypes, modified for local construction practices. Simulations were run using TMY3 weather data for each of the cities listed. Building prototypes used in the energy modeling are described in Appendix A - Prototypical Building Energy Simulation Model Development. The Ohio values were adjusted base on CCD for IL locations. Further study recommended for IL specific building types.

²⁹¹ 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.

²⁹² 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

$$\begin{aligned}\Delta kW_{SSP} &= (60) * [(1/13) - (1/15)] * .913 \\ &= 0.562\end{aligned}$$

NATURAL GAS ENERGY SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

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

4.4.15 Steam Trap Replacement or Repair²⁹³

DESCRIPTION

The measure is for the repair or replacement of faulty steam traps that are allowing excess steam to escape and thereby increasing steam generation. The measure is applicable to commercial applications, commercial HVAC (low pressure steam), low pressure industrial applications, medium pressure industrial applications, applications and high pressure industrial applications. Maximum pressure for this measure is 300 psig.

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

DEFINITION OF EFFICIENT EQUIPMENT

Customers must have leaking traps to qualify for rebates. However, if a commercial customer opts to replace all traps without inspection, rebates and the savings are discounted to take into consideration the fact that some traps are being replaced that have not yet failed.

DEFINITION OF BASELINE EQUIPMENT

The baseline criterion is a faulty steam trap in need of replacing. No minimum leak rate is required. Any leaking or blow through trap can be repaired or replaced. If a commercial customer chooses to repair or replace all the steam traps at the facility without verification, the savings are adjusted. Savings for commercial full replacement projects 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 years²⁹⁴

²⁹³ High Impact Measure

²⁹⁴ Source paper is the Resource Solutions Group "Steam Traps Revision #1" dated August 2011. Primary studies used to prepare the source paper include Enbridge Steam Trap Survey, KW Engineering Steam Trap Survey, Enbridge Steam Saver Program 2005, Armstrong Steam Trap Survey, DOE Federal Energy Management Program Steam Trap Performance Assessment, Oak Ridge National Laboratory Steam System Survey Guide, KEMA Evaluation of PG&E's Steam Trap Program, Sept. 2007. Communication with vendors suggested a inverted bucket steam trap life typically in the range of 5 - 7 years, float and thermostatic traps 4- 6 years, float and thermodynamic disc traps of 1 - 3 years. Cost does not include installation.

DEEMED MEASURE COST

Steam System	Cost per trap ²⁹⁵ (\$)
Commercial Dry Cleaners	77
Commercial Heating , low pressure steam	77
Industrial Medium Pressure >15 psig < 30 psig	180
Steam Trap, Industrial Medium Pressure ≥30 <75 psig	223
Steam Trap, Industrial High Pressure ≥75 <125 psig	276
Steam Trap, Industrial High Pressure ≥125 <175 psig	322
Steam Trap, Industrial High Pressure ≥175 <250 psig	370
Steam Trap, Industrial High Pressure ≥250 psig	418
Steam Trap, Industrial Medium Pressure ≥30 <75 psig	223
Steam Trap, Industrial High Pressure ≥75 <125 psig	276
Steam Trap, Industrial High Pressure ≥125 <175 psig	322
Steam Trap, Industrial High Pressure ≥175 <250 psig	370
Steam Trap, Industrial High Pressure ≥250 psig	418

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

N/A

²⁹⁵ Ibid.

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ENERGY SAVINGS

$$\Delta_{\text{therm}} = S * (Hv/B) * \text{Hours} * A * L / 100,000$$

Where:

S = Maximu theoretical steam loss per trap

Steam System	Avg Steam Loss ²⁹⁶ (lb/hr/trap)
Commercial Dry Cleaners	38.1
Commercial Heating LPS	13.8
Industrial Low Pressure, <15 psig	13.8
Industrial Medium Pressure >15 psig < 30 psig	12.7
Steam Trap, Industrial Medium Pressure ≥30 <75 psig	19
Steam Trap, Industrial High Pressure ≥75 <125 psig	67.9
Steam Trap, Industrial High Pressure ≥125 <175 psig	105.8
Steam Trap, Industrial High Pressure ≥175 <250 psig	143.7
Steam Trap, Industrial High Pressure ≥250 psig	200.5

²⁹⁶Resource Solutions Group "Steam Traps Revision #1" dated August 2011.

Hv = Heat of vaporization of steam

Steam System	Heat of Vaporization ²⁹⁷ (Btu/lb)
Commercial Dry Cleaners	890
Industrial Low Pressure ≤15 psig	951
Industrial Low Pressure ≤15 psig	951
Industrial Medium Pressure >15 psig < 30 psig	945
Steam Trap, Industrial Medium Pressure ≥30 <75 psig	928
Steam Trap, Industrial High Pressure ≥75 <125 psig	894
Steam Trap, Industrial High Pressure ≥125 <175 psig	868
Steam Trap, Industrial High Pressure ≥175 <250 psig	846
Steam Trap, Industrial High Pressure ≥250 psig	820

B = Boiler efficiency

= custom, if unknown 0.8²⁹⁸

²⁹⁷ Heat of vaporization of steam at the inlet pressure to the steam trap. Implicit assumption that the average boiler nominal pressure where the vaporization occurs, is essentially that same pressure. Reference Resource Solutions Group "Steam Traps Revision #1" dated August 2011.

²⁹⁸ California Energy Commission Efficiency Data for Steam Boilers as sited in Resource Solutions Group "Steam Traps Revision #1" dated August 2011.

Hours = Annual operating hours of steam plant

Steam System	Hours/Yr ²⁹⁹	Zone
Commercial Dry Cleaners	2,425	
Industrial Low Pressure ≤15 psig	7,752	
Industrial Medium Pressure >15 psig < 30 psig	7,752	
Steam Trap, Industrial Medium Pressure ≥30 <75 psig	7,752	
Steam Trap, Industrial High Pressure ≥75 <125 psig	7,752	
Steam Trap, Industrial High Pressure ≥125 <175 psig	7,752	
Steam Trap, Industrial High Pressure ≥175 <250 psig	7,752	
Steam Trap, Industrial High Pressure ≥250 psig	7,752	
Industrial Medium Pressure >15 psig < 30 psig	7,752	
Steam Trap, Industrial Medium Pressure ≥30 <75 psig	7,752	
Commercial Heating LPS ³⁰⁰	4,272	1 (Rockford)
	4,029	2 (Chicago O'Hare)
	3,406	3 (Springfield)
	2,515	4 (Belleville)
	2,546	5 (Marion)

A = Adjustment factor

= 50%³⁰¹

This factor is to account for reducing the maximum theoretical steam flow (S) to the average steam flow (the Enbridge factor).

²⁹⁹ Resource Solutions Group "Steam Traps Revision #1" dated August 2011, which references Enbridge service territory data and kW Engineering study.

³⁰⁰ Since commercial LPS reflect heating systems, Hours/yr are equivalent to HDD55 zone table

³⁰¹ Enbridge adjustment factor used as referenced in Resource Solutions Group "Steam Traps Revision #1" dated August 2011 and DOE Federal Energy Management Program Steam Trap Performance Assessment.

L = Leaking & blow-thru

L is 1.0 when applied to the replacement of an individual leaking trap. If a number of steam traps are replaced and the system has not been audited, the leaking and blow-thru is applied to reflect the assumed percentage of steam traps that were actually leaking and needed replacing. A custom value can be utilized if supported by an evaluation.

Steam System	% ³⁰²
Custom	Custom
Commercial Dry Cleaners	27%
Industrial Low Pressure ≤15 psig	16%
Industrial Medium Pressure >15 psig	16%
Commercial Heating LPS	27%

EXAMPLE

For example, a commercial dry cleaning facility with the default hours of operation and boiler efficiency;

$$\begin{aligned} \Delta\text{Therms} &= S * (\text{Hv}/\text{B}) * \text{Hours} * A * L \\ &= 38.1 \text{ lbs/hr/trap} * (890 \text{ Btu/lb} / 80\%) / 100,000 * 2,425 * 50\% * 27\% = \\ &138.8 \text{ therms per trap} \end{aligned}$$

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

³⁰²Dry cleaners survey data as referenced in Resource Solutions Group "Steam Traps Revision #1" dated August 2011.

4.4.16 Variable Speed Drives for HVAC

DESCRIPTION

This measure is applied to variable speed drives (VSD) which are installed on the following HVAC system applications: chilled water pump, hot water pumps, supply fans, return fans. All other VSD applications require custom analysis by the program administrator. The VSD will modulate the speed of the motor when it does not need to run at full load. Since the power of the motor is proportional to the cube of the speed for these types of applications, significant energy savings will result.

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

DEFINITION OF EFFICIENT EQUIPMENT

The VSD is applied to a motor which does not have a VSD. The application must have a variable load and installation is to include the necessary controls. Savings are based on application of VSDs to a range of baseline load conditions including no control, inlet guide vanes, outlet guide vanes and throttling valves.

DEFINITION OF BASELINE EQUIPMENT

The time of sale baseline is a new motor installed without a VSD or other methods of control. Retrofit baseline is an existing motor operating as is. Retrofit baselines may or may not include guide vanes, throttling valves or other methods of control. This information shall be collected from the customer.

Installations of new equipment with VSDs which are required by IECC 2009 as adopted by the State of Illinois are not eligible for incentives.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life for HVAC application is 15 years;³⁰³ measure life for process is 10 years.³⁰⁴

³⁰³Efficiency Vermont TRM 10/26/11 for HVAC VSD motors

³⁰⁴DEER 2008

DEEMED MEASURE COST

Customer provided costs will be used when available. Default measure costs³⁰⁵ are noted below for up to 20 hp motors. Custom costs must be gathered from the customer for motor sizes not listed below.

HP	Cost
1 -5 HP	\$ 1,330
7.5 HP	\$ 1,622
10 HP	\$ 1,898
15 HP	\$ 2,518
20 HP	\$ 3,059

DEEMED O&M COST ADJUSTMENTS

There are no expected O&M savings associated with this measure

LOADSHAPE

- Loadshape C39 - VFD - Supply fans <10 HP
- Loadshape C40 - VFD - Return fans <10 HP
- Loadshape C41 - VFD - Exhaust fans <10 HP
- Loadshape C42 - VFD - Boiler feedwater pumps <10 HP
- Loadshape C43 - VFD - Chilled water pumps <10 HP
- Loadshape C44 - VFD Boiler circulation pumps <10 HP
- Loadshape C48 - VFD Boiler draft fans <10 HP
- Loadshape C49 - VFD Cooling Tower Fans <10 HP

COINCIDENCE FACTOR

The demand savings factor (DSF) is already based upon coincident savings, and thus there is no additional coincidence factor for this characterization.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = kW_{connected} * Hours * ESF$$

Where:

$kW_{connected}$ = kW of equipment is calculated using motor efficiency.

³⁰⁵Ohio TRM 8/6/2010 varies by motor/fan size based on equipment costs from Granger 2008 Catalog pp 286-289, average across available voltages and models. Labor costs from RS Means Data 2008 Ohio average cost adjustment applied.

(HP * .746 kw/hp* load factor)/motor efficiency

Motors are assumed to have a load factor of 80% for calculating KW if actual values cannot be determined³⁰⁶. Custom load factor may be applied if known. Actual motor efficiency shall be used to calculate KW. If not known a default value of 93% shall be used.³⁰⁷

HP	BHP	Load Factor	kW Connected ³⁰⁸
5 HP	5	80%	3.23
7.5 HP	7.5	80%	4.84
10 HP	10	80%	6.45
15 HP	15	80%	9.68
20 HP	20	80%	12.90

Hours = Default hours are provided for HVAC applications which vary by HVAC application and building type³⁰⁹. When available, actual hours should be used.

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

³⁰⁶ Com Ed TRM June 1, 2010

³⁰⁷ Ohio TRM 8/6/2010 pp207-209, Com Ed Trm June 1, 2010.

³⁰⁸ Field data from Illinois evaluations, Navigant, 2011.

³⁰⁹ Com Ed Trm June 1, 2010 page 139.

ESF = Energy savings factor varies by VFD application.

Application	ESF ³¹⁰
Hot Water Pump	0.482
Chilled Water Pump	0.432
Constant Volume Fan	0.535
Air Foil/inlet Guide Vanes	0.227
Forward Curved Fan, with discharge dampers	0.179
Forward Curved Inlet Guide Vanes	0.092

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = kW_{\text{connected}} * DSF$$

Where:

DSF = Demand Savings Factor varies by VFD application.³¹¹ Values listed below are based on typical peak load for the listed application. When possible the actual Demand Savings Factor should be calculated.

Application	DSF
Hot Water Pump	0
Chilled Water Pump	0.299
Constant Volume Fan	0.348
Air Foil/inlet Guide Vanes	0.13
Forward Curved Fan, with discharge dampers	0.136
Forward Curved Inlet Guide Vanes	0.03
Custom Process	custom

FOSSIL FUEL IMPACT DESCRIPTIONS AND CALCULATION

There are no expected fossil fuel impacts for this measure.

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

³¹⁰CL&P and UI Program Savings Documentation for 2008 Program Year. Average of hours across all building types. <http://www.ctsavesenergy.com/files/Final%202008%20Program%20Savings%20Document.pdf>.

³¹¹Ibid

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

4.5 Lighting End Use

The commercial lighting measures use a standard set of variables for hours or use, waste heat factors, coincident factors and HVAC interaction effects. This table has been developed based on information provided by the various stakeholders. For ease of review, the table is included here and referenced in each measure.

Building Type	Fixture Annual Operating Hours ³¹²	Screw based bulb Annual Operating hours ³¹³	WHFe ³¹⁴	CF ³¹⁵	WHFd ³¹⁶	IFTherms ³¹⁷
Office	4,439	3,088	1.25	0.66	1.30	0.016
Grocery	5,802	3,650	1.43	0.69	1.52	0.012
Healthcare Clinic	5,095	4,207	1.34	0.75	1.57	0.008
Hospital	6,038	4,207	1.35	0.75	1.69	0.011
Heavy Industry	5,041	2,629	1.03	0.89	1.06	0.008
Light Industry	5,360	2,629	1.03	0.92	1.06	0.008
Hotel/Motel Common Areas	5,311	4,542	1.15	0.21	1.51	0.022
Hotel/Motel Guest Rooms	777	777	1.15	0.21	1.51	0.022
Hotel/Motel Guest Rooms with electric heat	777	777	0.69	0.21	0.09	0.00
High School/Middle School	4,311	2,327	1.23	0.22	0.74	0.017

³¹²Fixtures hours of use are primarily derived from the default PY4 values developed for ComEd based on DEER 2005, DEER 2008, FY1 and FY2 evaluation results. Lighting introwp.doc. Values for office, grocery, light industry, restaurant, retail/service and warehouse are an average of the PY4 values and AmerEn Missouri, March 2011 Final Report: Evaluation of Business Energy Efficiency Program Custom and Standard Incentives. Hotel/Motel common areas is the DEER 2008 average across all non-guest room spaces and guest rooms is the average of hotel and motel guest room values from DEER 2008. Elementary School is from Ameren Missouri evaluation results. Multi-family common area value based on Focus on Energy Evaluation, ACES Deemed Savings Desk Review, November 2010. Miscellaneous is an average of all indoor spaces.

³¹³Hours 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.

³¹⁴The Waste Heat Factor for Energy is developed using EQuest models for various building types averaged across 5 climate zones for Illinois for the following building types: office, grocery, healthcare/clinic, manufacturing, motel, high school, hospital, elementary school, restaurant, retail, college and warehouse. Exterior and garage values are 1, miscellaneous is an average of all indoor spaces.

³¹⁵Waste Heat Factor for Demand is developed using EQuest models consistent with methodology for Waste Heat Factor for Energy.

³¹⁶IF Therms value is developed using EQuest models consistent with methodology for Waste Heat Factor for Energy.

³¹⁷Hotel/Motel guest rooms are presented with either electric heat or gas heat; values chosen should match the fuel type in the space.

Building Type	Fixture Annual Operating Hours ³¹⁸	Screw based bulb Annual Operating hours ³¹⁹	WHFe ³²⁰	CF ³²¹	WHFd ³²²	IFTherms ³²³
Elementary School	2,422	2,118	1.21	0.22	1.33	0.019
Restaurant	3,673	4,784	1.34	0.80	1.65	0.023
Retail/Service	4,719	2,935	1.24	0.83	1.44	0.024
College/University	3,540	2,588	1.14	0.56	1.50	0.021
Warehouse	4,746	4,293	1.16	0.70	1.17	0.015
Garage	3,540	3,540	1.00	1.00	1.00	0.000
Garage, 24/7 lighting ³²⁴	8,766	8,766	1.00	1.00	1.00	0.000
Exterior	4,903	4,903	1.00	0.00	1.00	0.000
Multi-family Common Areas	5,950	5,950	1.34	0.75	1.57	0.015
Miscellaneous	4,576	3,198	1.24	0.66	1.46	0.000
Uncooled Building	Varies	varies	1.00	varies	varies	varies
Refrigerated Cases	5,802	n/a	1.29	0.69	1.29	0
Freezer Cases	5,802	n/a	1.5	0.69	1.5	0

³¹⁸Fixtures hours of use are primarily derived from the default PY4 values developed for ComEd based on DEER 2005, DEER 2008, FY1 and FY2 evaluation results. Lighting introwp.doc. Values for office, grocery, light industry, restaurant, retail/service and warehouse are an average of the PY4 values and AmerEn Missouri, March 2011 Final Report: Evaluation of Business Energy Efficiency Program Custom and Standard Incentives. Hotel/Motel common areas is the DEER 2008 average across all non-guest room spaces and guest rooms is the average of hotel and motel guest room values from DEER 2008. Elementary School is from Ameren Missouri evaluation results. Multi-family common area value based on Focus on Energy Evaluation, ACES Deemed Savings Desk Review, November 2010. Miscellaneous is an average of all indoor spaces.

³¹⁹Hours 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.

³²⁰The Waste Heat Factor for Energy is developed using EQuest models for various building types averaged across 5 climate zones for Illinois for the following building types: office, grocery, healthcare/clinic, manufacturing, motel, high school, hospital, elementary school, restaurant, retail, college and warehouse. Exterior and garage values are 1, miscellaneous is an average of all indoor spaces.

³²¹Waste Heat Factor for Demand is developed using EQuest models consistent with methodology for Waste Heat Factor for Energy.

³²²IF Therms value is developed using EQuest models consistent with methodology for Waste Heat Factor for Energy.

³²³Hotel/Motel guest rooms are presented with either electric heat or gas heat; values chosen should match the fuel type in the space.

³²⁴Use of this value requires documentation that the lighting is required to be on 24 hours a day, 7 days a week for 365.25 days per year.

4.5.1 Commercial Standard CFL

DESCRIPTION

A low wattage ENERGY STAR qualified compact fluorescent screw-in bulb (CFL) is installed in place of an incandescent screw-in bulb. This characterization assumes that the CFL is installed in a commercial location. If the implementation strategy means that the final installation location of the bulb is not known, deemed assumptions are provided. If however it is known, the values are dependent on the building type.

Federal legislation stemming from the Energy Independence and Security Act of 2007 will require all general-purpose light bulbs between 40 and 100W to be approximately 30% more energy efficient than current incandescent bulbs. Production of 100W, standard efficacy incandescent lamps ends in 2012 followed by restrictions on 75W in 2013 and 60W and 40W in 2014. The baseline for this measure will therefore become bulbs (improved incandescent or halogen) that meet the new standard.

To account for these new standards and the expected delay in clearing retail inventory, the first year annual savings for this measure is reduced for 100W equivalent bulbs in June 2012, for 75W equivalent bulbs in June 2013 and for 60 and 40W equivalent bulbs in June 2014.

In addition, since during the lifetime of a CFL, the baseline bulb will be replaced multiple times, the annual savings claim must also be reduced within the life of the measure. For example, for 60W equivalent bulbs installed in 2012, the full savings (as calculated below in the Algorithm) should be claimed for the first two years, but a reduced annual savings based on the EISA-compliant baseline should be claimed for the remainder of the measure life. The appropriate adjustment factors are provided in the 'Mid Life Baseline Adjustment' section below.

Finally, a provision in the EISA regulations requires that by January 1, 2020, all lamps meet efficiency criteria of at least 45 lumens per watt, in essence making the baseline equivalent to a current day CFL. Therefore the measure life (number of years that savings should be claimed) should be reduced once the assumed lifetime of the bulb exceeds 2020. Due to expected delay in clearing retail inventory and to account for the operating life of a halogen incandescent potentially spanning over 2020, this shift is assumed not to occur until mid-2020.

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

DEFINITION OF EFFICIENT EQUIPMENT

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

DEFINITION OF BASELINE EQUIPMENT

The baseline equipment is assumed to be a standard incandescent light bulb, up until when EISA regulations dictate higher efficiency baseline bulbs. A 100W baseline bulb becomes a 72W bulb in June 2012, a 75W bulb becomes 53W in June 2012 and 60W and 40W bulbs become 43W and 29W respectively in June 2014 Annual savings are reduced to account for this baseline shift within the life of a measure and the measure life is reduced to account for the baseline replacements becoming equivalent to a current day CFL by June 2020.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life (number of years that savings should be claimed) should be calculated by dividing the

rated life of the bulb (10,000 hours³²⁵) by the run hours. For example using Miscellaneous at 4,589 hours would give 2.2 years. When the number of years exceeds June 2020, the number of years to that date should be used.

DEEMED MEASURE COST

The incremental capital cost assumption for all bulbs is \$1.90, from June 2012 – May 2013, \$1.80 from June 2013 – May 2014 and \$1.50 from June 2014 – May 2015³²⁶.

DEEMED O&M COST ADJUSTMENTS

The Net Present Value of the baseline replacement costs for each CFL lumen range and installation year (2012 - 2016) are presented below³²⁷:

Lumen Range	NPV of baseline replacement costs		
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015
1490-2600	\$11.81	\$11.81	\$11.81
1050-1489	\$8.60	\$11.81	\$11.81
750-1049	\$4.68	\$8.60	\$11.81
310-749	\$4.68	\$8.60	\$11.81

The annual levelized baseline replacement costs using the statewide real discount rate of 5.23% are presented below:

CFL wattage	Levelized annual replacement cost savings		
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015
1490-2600	\$5.86	\$5.86	\$5.86
1050-1489	\$4.26	\$5.86	\$5.86
750-1049	\$2.32	\$4.26	\$5.86
310-749	\$2.32	\$4.26	\$5.86

Note incandescent bulbs in lumen range 2601 – 3300 are exempt from EISA. For these bulbs there is no baseline shift and so the assumption is a baseline replacement cost of \$0.50 every 0.2 year (1000 hr rated life/4589 run hours).

LOADSHAPE

Loadshape C06 - Commercial Indoor Lighting

³²⁵Energy 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.

³²⁶Based on Northeast Regional Residential Lighting Strategy (RLS) report, prepared by EFG, D&R International, Ecova and Optimal Energy, applying sales weighting and phase-in of EISA regulations. Assumption is \$2.50 for CFL over three years and \$0.6 for baseline in 2012, \$0.70 in 2013 and \$1.00 in 2014 as more expensive EISA qualified bulbs become baseline.

³²⁷Calculation is based on average hours of use assumption, see 'C&I Standard CFL O&M calc.xls' for more details.

- Loadshape C07 - Grocery/Conv. Store Indoor Lighting
- Loadshape C08 - Hospital Indoor Lighting
- Loadshape C09 - Office Indoor Lighting
- Loadshape C10 - Restaurant Indoor Lighting
- Loadshape C11 - Retail Indoor Lighting
- Loadshape C12 - Warehouse Indoor Lighting
- Loadshape C13 - K-12 School Indoor Lighting
- Loadshape C14 - Indust. 1-shift (8/5) (e.g., comp. air, lights)
- Loadshape C15 - Indust. 2-shift (16/5) (e.g., comp. air, lights)
- Loadshape C16 - Indust. 3-shift (24/5) (e.g., comp. air, lights)
- Loadshape C17 - Indust. 4-shift (24/7) (e.g., comp. air, lights)
- Loadshape C18 - Industrial Indoor Lighting
- Loadshape C19 - Industrial Outdoor Lighting
- Loadshape C20 - Commercial Outdoor Lighting

COINCIDENCE FACTOR

The summer peak coincidence factor for this measure is dependent on the location type. Values are provided for each building type in the reference section below.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta\text{kWh} = ((\text{WattsBase} - \text{WattsEE}) / 1000) * \text{ISR} * \text{Hours} * \text{WHFe}$$

Where:

WattsBase = Actual (if retrofit measure) or based on lumens of CFL bulb and program year purchased:

Minimum Lumens	Maximum Lumens	Incandescent Equivalent Pre-EISA 2007 (WattsBase)	Incandescent Equivalent Post-EISA 2007 (WattsBase)	Effective date from which Post – EISA 2007 assumption should be used
2601	3300	150	150	N/A 2600+ lumen bulbs are exempt from EISA.
1490	2600	100	72	June 2012
1050	1489	75	53	June 2013
750	1049	60	43	June 2014
310	749	40	29	June 2014

WattsEE = Actual wattage of CFL purchased or installed

ISR = In Service Rate or the percentage of units rebated that get installed.

=100%³²⁸ 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 1 st year In Service Rate (ISR)	2 nd year Installations	3 rd year Installations	Final Lifetime In Service Rate
69.5% ³²⁹	15.4%	13.1%	98.0% ³³⁰

Hours = Average hours of use per year are provided in Reference Table in Section 6.5,

³²⁸ 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.

³²⁹ 1st year in service rate is based upon review of PY1-3 evaluations from ComEd and Ameren (see 'IL RES Lighting ISR.xls' for more information. The average first year ISR for each utility was calculated weighted by the number of bulbs in the each year's survey. This was then weighted by annual sales to give a statewide assumption. Note these evaluations did not look at C&I specific installations but until a more appropriate C&I evaluation is performed, the Residential assumptions are applied.

³³⁰ 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.

Screw based bulb annual operating hours, for each building type³³¹. If unknown use the Miscellaneous value.

WHFe = Waste heat factor for energy to account for cooling energy savings from efficient lighting are provided below for each building type in Reference Table in Section 6.5. If unknown, use the Miscellaneous value.

Mid Life Baseline Adjustment

During the lifetime of a CFL, a baseline incandescent bulb would need to be replaced multiple times. Since the baseline bulb changes over time (except for 2600+ lumen bulbs) the annual savings claim must be reduced within the life of the measure to account for this baseline shift.

For example, for 60W equivalent bulbs installed in 2012, the full savings (as calculated above in the Algorithm) should be claimed for the first two years, but a reduced annual savings claimed for the remainder of the measure life. The appropriate adjustment factors are provided below.

Lumen Range	Pre EISA WattsBase	Post EISA WattsBase	CFL Equivalent	Delta Watts Before EISA	Delta Watts After EISA	Mid Life Adjustment	Adjustment made from date
2601-3300	150	150	42	108	108	-	-
1490-2600	100	72	25	75	47	63%	N/A (2012 is already post EISA)
1050-1489	75	53	20	55	33	60%	June, 2013
750-1049	60	43	14	46	29	63%	June, 2014
310-749	40	29	11	29	18	62%	June, 2014

For example, a 20W standard CFL, 1200 lumen is installed in an office in 2012 and sign off form provided:

$$\Delta kWh = ((75-20)/1000)*1.0*3088*1.25$$

$$= 212 kWh$$

This value should be claimed in June 2012 – May 2013, but from June 2013 on savings for that same bulb should be reduced to (212 * 0.6 =) 127 kWh for the remainder of the measure life. Note these adjustments should be applied to kW and fuel impacts.

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = ((WattsBase - WattsEE)/1000) * ISR * WHFd * CF$$

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 6.5. If unknown, use the Miscellaneous value..

³³¹Based on ComEd analysis taking DEER 2008 values and averaging with PY1 and PY2 evaluation results.

CF = Summer Peak Coincidence Factor for measure is provided in the Reference Table in Section 6.5. If unknown, use the Miscellaneous value..

Other factors as defined above

For example, a 20W standard CFL, 1200 lumen is installed in an office in 2012 and sign off form provided:

$$\begin{aligned} \Delta kW &= ((75-20)/1000)*1.0*1.3*0.66 \\ &= 0.047kW \end{aligned}$$

NATURAL GAS ENERGY SAVINGS

Heating Penalty if fossil fuel heated building (or if heating fuel is unknown):

$$\Delta Therms^{332} = (((WattsBase-WattsEE)/1000) * ISR * Hours * - IFTherms$$

Where:

IFTherms = Lighting-HVAC Interaction Factor for gas heating impacts; this factor represents the increased gas space heating requirements due to the reduction of waste heat rejected by the efficient lighting. Values are provided in the Reference Table in Section 6.5. If unknown, use the Miscellaneous value.

Other factors as defined above

For example, a 20W standard CFL, 1200 lumen is installed in an office in 2012 and sign off form provided:

$$\begin{aligned} \Delta Therms &= (((75-20)/1000)* 1.0*3088*-0.016 \\ &= - 2.7 Therms \end{aligned}$$

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

In order to account for the shift in baseline due to the Energy Independence and Security Act of 2007, an equivalent annual levelized baseline replacement cost over the lifetime of the CFL is calculated (see C&I Standard CFL O&M calc.xls). The key assumptions used in this calculation are documented below³³³:

	Standard Incandescent	Efficient Incandescent	CFL
Replacement Cost	\$0.50	\$1.50	\$2.50

³³²Negative value because this is an increase in heating consumption due to the efficient lighting.

³³³Calculation is based on average hours of use assumption.

Component Rated Life (hrs)	1000	1000 ³³⁴	10,000
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The Net Present Value of the baseline replacement costs for each CFL lumen range and installation year (2012 - 2016) are presented below³³⁵:

Lumen Range	NPV of baseline replacement costs		
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015
1490-2600	\$12.86	\$12.86	\$12.86
1050-1489	\$9.36	\$12.86	\$12.86
750-1049	\$5.10	\$9.36	\$12.86
310-749	\$5.10	\$9.36	\$12.86

The annual levelized baseline replacement costs using the statewide real discount rate of 5.23% are presented below:

CFL wattage	Levelized annual replacement cost savings		
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015
1490-2600	\$6.38	\$6.38	\$6.38
1050-1489	\$4.64	\$6.38	\$6.38
750-1049	\$2.53	\$4.64	\$6.38
310-749	\$2.53	\$4.64	\$6.38

Note incandescent bulbs in lumen range 2601 – 3300 are exempt from EISA. For these bulbs there is no baseline shift and so the assumption is a baseline replacement cost of \$0.50 every 0.2 year (1000 hr rated life/4576 run hours).

MEASURE CODE: CI-LTG-CCFL-V01-120601

³³⁴The 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.

³³⁵Calculation is based on average hours of use assumption, see 'C&I Standard CFL O&M calc.xls' for more details.

4.5.2 LED Bulbs and Fixtures

DESCRIPTION

This characterization provides savings assumptions for a variety of LED lamps including Omnidirectional (e.g. A-Type lamps), Decorative (e.g. Globes and Torpedoes) and Directional (PAR Lamps, Reflectors, MR16), and fixtures including refrigerated case , recessed and outdoor/garage fixtures.

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

DEFINITION OF EFFICIENT EQUIPMENT

In order for this characterization to apply, new lamps must be Energy Star labeled. Lamps and fixtures should be found in the reference tables below. Fixtures must be Energy Star labeled or on the Design Lights Consortium qualifying fixture list.

DEFINITION OF BASELINE EQUIPMENT

Refer to the baseline tables. In 2012, Federal legislation stemming from the Energy Independence and Security Act of 2007 (EIAS) will require all general-purpose light bulbs between 40 watts and 100 watts to have ~30% increased efficiency, essentially phasing out standard incandescent technology. In 2012, the 100 w lamp standards apply; in 2013 the 75 w lamp standards will apply, followed by restrictions on the 60 w and 40 w lamps in 2014. To account for this legislation, a mid life adjustment is calculated for Standard Omnidirectional screw based bulbs whose baseline assumes incandescent lamps.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

Lifetime is the life of the product, at the reported operating hours (lamp life in hours divided by operating hours per year – see reference table "LED component Costs and Lifetime." The analysis period is the same as the lifetime, capped at 15 years. (15 years from GDS Measure Life Report, June 2007).

DEEMED MEASURE COST

Wherever possible, actual incremental costs should be used. Refer to reference table "LED component Cost & Lifetime" for defaults.

DEEMED O&M COST ADJUSTMENTS

Refer to reference table "LED component Cost & Lifetime."

LOADSHAPE

- Loadshape C06 - Commercial Indoor Lighting
- Loadshape C07 - Grocery/Conv. Store Indoor Lighting
- Loadshape C08 - Hospital Indoor Lighting
- Loadshape C09 - Office Indoor Lighting
- Loadshape C10 - Restaurant Indoor Lighting
- Loadshape C11 - Retail Indoor Lighting

- Loadshape C12 - Warehouse Indoor Lighting
- Loadshape C13 - K-12 School Indoor Lighting
- Loadshape C14 - Indust. 1-shift (8/5) (e.g., comp. air, lights)
- Loadshape C15 - Indust. 2-shift (16/5) (e.g., comp. air, lights)
- Loadshape C16 - Indust. 3-shift (24/5) (e.g., comp. air, lights)
- Loadshape C17 - Indust. 4-shift (24/7) (e.g., comp. air, lights)
- Loadshape C18 - Industrial Indoor Lighting
- Loadshape C19 - Industrial Outdoor Lighting
- Loadshape C20 - Commercial Outdoor Lighting

COINCIDENCE FACTOR

The summer peak coincidence factor for this measure is dependent on the location type. Values are provided for each building type in the reference section below.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = ((Watts_{base} - Watts_{EE}) / 1000) * Hours * WHF_e * ISR$$

Where:

Watts_{base} = Input wattage of the existing system. Reference the “LED New and Baseline Assumptions” table for default values.

Watts_{EE} = New Input wattage of EE fixture. See the “LED New and Baseline Assumptions” table.

For ENERGY STAR rated lamps the following lumen equivalence tables should be used:

Omnidirectional Lamps - ENERGY STAR Minimum Luminous Efficacy = 50Lm/W for <10W lamps and 55Lm/W for >=10W lamps.

Nominal wattage of lamp to be replaced (Watts _{base})	Minimum initial light output of LED lamp (lumens)	Post EISA 2012-2014 Incandescent wattage	Post EISA 2020 requirement (45Lm/W)	LED Wattage (Watts _{EE})	Delta Watts (pre EISA)	Delta Watts (post EISA 2012-2014)	Effective date for post EISA 2012-2014 assumption	Delta Watts (post EISA 2020)
25	200	25	25	4.0	21.0	21.0	Exempt	21.0
35	325	29	7.2	6.5	28.5	22.5	June 2014	0.7
40	450	29	10	9.0	31.0	20.0	June 2014	1.0
60	800	43	17.8	14.5	45.5	28.5	June 2014	3.3
75	1,100	53	24.4	20.0	55.0	33.0	June 2013	4.4
100	1,600	72	35.6	29.1	70.9	42.9	June 2012	6.5
125	2,000	72	44.4	36.4	88.6	35.6	June 2012	8.0
150	2,600	150	150	47.3	102.7	102.7	Exempt	102.7

Decorative Lamps - ENERGY STAR Minimum Luminous Efficacy = 40Lm/W for all lamps

Nominal wattage of lamp to be replaced (Watts _{base})	Minimum initial light output of LED lamp (lumens)	LED Wattage (Watts _{EE})	Delta Watts
10	70	1.75	8.25
15	90	2.25	12.75
25	150	3.75	21.25
40	300	7.5	32.5
60	500	12.5	47.5

Directional lamps are exempt from EISA regulations.

Directional Lamps - ENERGY STAR Minimum Luminous Efficacy = 40Lm/W for lamp diameter <= 20/8 inch (PAR 20 and smaller) and 45 Lm/W for lamp diameter > 20/8 inch (greater than PAR20).

Nominal wattage of lamp to be replaced (Watts _{base})	Minimum initial light output of LED lamp (lumens)	LED Wattage (Watts _{EE})	Delta Watts
25	250	6.25	18.75
35	350	8.75	26.25
40	400	10.0	30.0
60	600	15.0	45.0
75	750	18.75	56.25
100	1000	25.0	75.0
125	1250	31.25	93.75
150	1500	37.5	112.5

Directional lamps are exempt from EISA regulations.

Hours = Average hours of use per year are provided in the Reference Table in Section 6.5, Screw based bulb annual operating hours, for each building type. If unknown, use the Miscellaneous value.

WHFe = Waste heat factor for energy to account for cooling energy savings from efficient lighting are provided below for each building type in the Reference Table in Section 6.5. If unknown, use the Miscellaneous value.

ISR = In service Rate -the percentage of units rebated that actually get installed. Use 100% unless an evaluation shows a lesser value.

Mid Life Baseline Adjustment

During the lifetime of a standard Omnidirectional LED, the baseline incandescent bulb would need to be replaced multiple times. Since the baseline bulb changes over time (except for 2600+ lumen bulbs) the annual savings claim must be reduced within the life of the measure to account for this baseline shift.

For example, for 60W equivalent bulbs installed in 2012, the full savings (as calculated above in the Algorithm)

should be claimed for the first two years, but a reduced annual savings (calculated energy savings above multiplied by the adjustment factor in the table below) claimed for the remainder of the measure life.

Omnidirectional Lamps

Nominal wattage of lamp to be replaced (Watts _{base})	Minimum initial light output of LED lamp (lumens)	Delta Watts (pre EISA)	Delta Watts (post EISA 2012-2014)	Mid Life adjustment 1 from first year savings	Adjustment made from date	Delta Watts (post EISA 2020)	Mid Life adjustment 2 (made from June 2020) from first year savings
25	200	21.0	21.0	Exempt	Exempt	21.0	Exempt
35	325	28.5	22.5	78.9%	June 2014	0.7	2.5%
40	450	31.0	20.0	64.5%	June 2014	1.0	3.2%
60	800	45.5	27.6	60.7%	June 2014	3.3	7.3%
75	1,100	55.0	33.0	60.0%	June 2013	4.4	8.0%
100	1,600	70.9	42.9	60.5%	June 2012	6.5	9.2%
125	2,000	88.6	35.6	40.2%	June 2012	8.0	9.0%
150	2,600	102.7	102.7	Exempt	Exempt	102.7	Exempt

For example, a 9W LED lamp, 450 lumens, is installed in an office in 2012:

$$\Delta kWh = ((40-29/1000)*1.0*3088*1.25) = 42.5 kWh$$

This value should be claimed for two years, i.e. June 2012 – May 2014, but from June 2014 on savings for that same bulb should be reduced to (42.5 * 0.645 =) 27.4 kWh for the remainder of the measure life. Note these adjustments should be applied to kW and fuel impacts.

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = ((Watts_{base} - Watts_{EE}) / 1000) * ISR * WHF_d * CF$$

Where:

WHF_d = Waste Heat Factor for Demand to account for cooling savings from efficient lighting in cooled buildings is provided in Reference Table in Section 6.5. If unknown, use the Miscellaneous value.

CF = Summer Peak Coincidence Factor for measure is provided in the Reference Table in Section 6.5. If unknown, use the Miscellaneous value.

For example, For example, a 9W LED lamp, 450 lumens, is installed in an office in 2012 and sign off form provided:

$$\begin{aligned} \Delta kW &= ((40-29/1000)* 1.0*1.3*0.66 \\ &= - 0.52 kW \end{aligned}$$

NATURAL GAS ENERGY SAVINGS

Heating Penalty if fossil fuel heated building (or if heating fuel is unknown):

$$\Delta \text{therms} = (((\text{WattsBase}-\text{WattsEE})/1000) * \text{ISR} * \text{Hours} * - \text{IFTherms}$$

Where:

IFTherms = Lighting-HVAC Integration Factor for gas heating impacts; this factor represents the increased gas space heating requirements due to the reduction of waste heat rejected by the efficient lighting. Values are provided in the Reference Table in Section 6.5. If unknown, use the Miscellaneous value.

For example, For example, a 9W LED lamp, 450 lumens, is installed in an office in 2012 and sign off form provided:

$$\begin{aligned} \Delta \text{Therms} &= ((40-29/1000)*1.0*3088* -0.016 \\ &= - 0.54 \text{ Therms} \end{aligned}$$

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 below³³⁶.

³³⁶ See "LED reference tables.xls" for breakdown of component cost assumptions.

Omnidirectional Lamps:

In order to account for the shift in baseline due to the Energy Independence and Security Act of 2007, an equivalent annual levelized baseline replacement cost over the lifetime of the LED bulb (assumed to be 25,000/4576 = 6.46 years) is calculated (see "C&I OmniDirectional LED O&M Calc.xls"). The key assumptions used in this calculation are documented below:

	Standard Incandescent	Efficient Incandescent	CFL
Replacement Cost	\$0.50	\$1.50	\$2.50
Component Rated Life (hrs)	1000	1000337	10,000

The Net Present Value of the baseline replacement costs for each lumen range and installation year (2012 -2016) are presented below:

Lumen Range	NPV of baseline replacement costs		
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015
1490-2600	\$32.23	\$32.23	\$26.78
1050-1489	\$28.66	\$32.23	\$26.78
750-1049	\$24.31	\$28.66	\$26.78
310-749	\$24.31	\$28.66	\$26.78

The annual levelized baseline replacement costs using the statewide real discount rate of 5.23% are presented below:

CFL wattage	Levelized annual replacement cost savings		
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015
1490-2600	\$6.94	\$6.94	\$5.76
1050-1489	\$6.17	\$6.94	\$5.76
750-1049	\$5.23	\$6.17	\$5.76
310-749	\$5.23	\$6.17	\$5.76

Note incandescent bulbs in lumen range <310 and >2600 are exempt from EISA. For these bulbs there is no baseline shift and so the assumption is a baseline replacement cost of \$0.50 every 0.2 year (1000 hr rated life/4576 run hours).

³³⁷The manufacturers of the new minimally compliant EISA Halogens are using regular incandescent lamps with halogen fill gas rather than halogen infrared to meet the standard and so the component rated life is equal to the standard incandescent.

LED New and Baseline Assumptions³³⁸

LED Measure Description	WattsEE	Baseline Description	WattsBASE	Basis for Watt Assumptions	LED Lamp Cost	Baseline Cost (EISA 2012-2014, EISA 2020)	Incremental Cost (EISA 2012-2014, EISA 2020)	LED Minimum Lamp Life (hrs)
LED Screw and Pin-based Bulbs, Omnidirectional, < 10W	See tables above				\$30.00	\$0.50 (\$1.50, \$2.50)	\$29.5 (\$28.50, \$27.50)	25,000
LED Screw and Pin-based Bulbs, Omnidirectional, >= 10W					\$40.00	\$0.50 (\$1.50, \$2.50)	\$29.5 (\$28.50, \$27.50)	25,000
LED Screw and Pin-based Bulbs, Decorative					\$30.00	\$1.00	\$29.00	25,000
LED Screw-based Bulbs, Directional, < 15W					\$45.00	\$5.00	\$40.00	35,000
LED Screw-based Bulbs, Directional, >= 15W					\$55.00	\$5.00	\$50.00	35,000
LED Recessed, Surface, Pendant Downlights	17.6	Baseline LED Recessed, Surface, Pendant Downlights	54.3	2008-2010 EVT Historical Data of 947 Measures	50,000		\$50.00	
LED Track Lighting	12.2	Baseline LED Track Lighting	60.4	2008-2010 EVT Historical Data of 242 Measures	50,000		\$100.00	
LED Wall-Wash Fixtures	8.3	Baseline LED Wall-Wash Fixtures	17.7	2008-2010 EVT Historical Data of 220 Measures	50,000		\$80.00	
LED Portable Desk/Task Light Fixtures	7.1	Baseline LED Portable Desk/Task Light Fixtures	36.2	2008-2010 EVT Historical Data of 21 Measures	50,000		\$50.00	
LED Undercabinet Shelf-Mounted Task Light Fixtures (per foot)	7.1	Baseline LED Undercabinet Shelf-Mounted Task Light	36.2	2008-2010 EVT Historical Data of 21	50,000		\$25.00	

³³⁸ Data is based on Efficiency Vermont derived cost and actual installed wattage information.

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		Fixtures		Measures				
LED Refrigerated Case Light, Horizontal or Vertical (per foot of light bar)	7.6	Baseline LED Refrigerated Case Light, Horizontal or Vertical (per foot of light bar)	15.2	PG&E Refrigerated Case Study ³³⁹ normalized to per foot of light bar.	50,000		\$50.00	
LED Freezer Case Light, Horizontal or Vertical (per foot)	7.7	Baseline LED Freezer Case Light, Horizontal or Vertical (per foot)	18.7	PG&E Refrigerated Case Study normalized to per foot.	50,000		\$50.00	
LED Display Case Light Fixture (per foot)	7.1	Baseline LED Display Case Light Fixture	36.2	Modeled after LED Undercabinet Shelf-Mounted Task Light Fixtures (per foot)	35,000		\$25.00	
LED 2x2 Recessed Light Fixture	44.9	T8 U-Tube 2L-FB32 w/ Elec - 2'	61.0	Based on average watts of DLC qualified products as of 11/21/11	35,000		\$75.00	
LED 2x4 Recessed Light Fixture	53.6	T8 3L-F32 w/ Elec - 4'	88.0	Based on average watts of DLC qualified products as of 11/21/11	35,000		\$125.00	
LED 1x4 Recessed Light Fixture	32.2	T8 2L-F32 w/ Elec - 4'	59.0	Based on average watts of DLC qualified products as of 11/21/11	35,000		\$100.00	
LED High- and Low-Bay Fixtures	160.2	MH 250 W CWA Pulse Start	295.0	Based on average watts of DLC qualified products as of 11/21/11	35,000		\$200.00	
LED Outdoor Pole/Arm Mounted Parking/Roadway, < 30W	18.6	Baseline LED Outdoor Pole/Arm Mounted Parking/Roadway, < 30W	124.3	2008-2010 EVT Historical Data of 2,813 Measures	50,000		\$125.00	
LED Outdoor Pole/Arm Mounted Parking/Roadway, 30W - 75W	52.5	Baseline LED Outdoor Pole/Arm Mounted Parking/Roadway, 30W - 75W	182.9	2008-2010 EVT Historical Data of 1,081 Measures	50,000		\$250.00	
LED Outdoor Pole/Arm Mounted Parking/Roadway, >= 75W	116.8	Baseline LED Outdoor Pole/Arm Mounted Parking/Roadway, >= 75W	361.4	2008-2010 EVT Historical Data of 806 Measures	50,000		\$375.00	

³³⁹ LED Refrigeration Case Ltg Workpaper 053007 rev1, May 30, 2007

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LED Outdoor Pole/Arm Mounted Decorative Parking/Roadway, < 30W	18.6	Baseline LED Outdoor Pole/Arm Mounted Decorative Parking/Roadway, < 30W	124.3	2008-2010 EVT Historical Data of 2,813 Measures	50,000		\$125.00	
LED Outdoor Pole/Arm Mounted Decorative Parking/Roadway, 30W - 75W	52.5	Baseline LED Outdoor Pole/Arm Mounted Decorative Parking/Roadway, 30W - 75W	182.9	2008-2010 EVT Historical Data of 1,081 Measures	50,000		\$250.00	
LED Outdoor Pole/Arm Mounted Decorative Parking/Roadway, >= 75W	116.8	Baseline LED Outdoor Pole/Arm Mounted Decorative Parking/Roadway, >= 75W	361.4	2008-2010 EVT Historical Data of 806 Measures	50,000		\$375.00	
LED Parking Garage/Canopy, < 30W	18.6	Baseline LED Parking Garage/Canopy, < 30W	124.3	2008-2010 EVT Historical Data of 2,813 Measures	50,000		\$125.00	
LED Parking Garage/Canopy, 30W - 75W	52.5	Baseline LED Parking Garage/Canopy, 30W - 75W	182.9	2008-2010 EVT Historical Data of 1,081 Measures	50,000		\$250.00	
LED Parking Garage/Canopy, >= 75W	116.8	Baseline LED Parking Garage/Canopy, >= 75W	361.4	2008-2010 EVT Historical Data of 806 Measures	50,000		\$375.00	
LED Wall-Mounted Area Lights, < 30W	18.6	Baseline LED Wall-Mounted Area Lights, < 30W	124.3	2008-2010 EVT Historical Data of 2,813 Measures	50,000		\$125.00	
LED Wall-Mounted Area Lights, 30W - 75W	52.5	Baseline LED Wall-Mounted Area Lights, 30W - 75W	182.9	2008-2010 EVT Historical Data of 1,081 Measures	50,000		\$250.00	
LED Wall-Mounted Area Lights, >= 75W	116.8	Baseline LED Wall-Mounted Area Lights, >= 75W	361.4	2008-2010 EVT Historical Data of 806 Measures	50,000		\$375.00	
LED Bollard, < 30W	13.9	Baseline LED Bollard, < 30W	54.3	2008-2010 EVT Historical Data of 33 Measures	50,000		\$150.00	
LED Bollard, >= 30W	41.0	Baseline LED Bollard, >= 30W	78.0	2008-2010 EVT Historical Data of 15 Measures	50,000		\$250.00	

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LED Flood Light, < 15W	8.7	Baseline LED Flood Light, < 15W	51.7	Consistent with LED Screw-base Directional	50,000		\$35.00	
LED Flood Light, >= 15W	16.2	Baseline LED Flood Light, >= 15W	64.4	Consistent with LED Screw-base Directional	50,000		\$45.00	

LED Component Costs & Lifetime³⁴⁰

LED Component Costs and Lifetimes												
LED Measure Description	LED Minimum Lamp Life (hrs)	LED Lamp Cost Total	LED Driver Life (hrs)	LED Driver Cost Total	Baseline Technology (1)	Lamp (1) Life (hrs)	Lamp (1) Total Cost	Ballast (1) Life (hrs)	Ballast (1) Total Cost	Baseline Technology (2)	Lamp (2) Life (hrs)	Lamp (2) Total Cost
LED Screw and Pin-based Bulbs, Decorative	25,000	N/A	N/A	N/A	53W EISA Halogen	2,000	\$4.67	N/A	N/A	N/A	N/A	N/A
LED Screw-based Bulbs, Directional, < 15W	35,000	N/A	N/A	N/A	15% CFL 18W Pin Base	10,000	\$11.62	40,000	\$36.00	85% Halogen PAR20	2,500	\$12.67
LED Screw-based Bulbs, Directional, >= 15W	35,000	N/A	N/A	N/A	15% CFL 26W Pin Base	10,000	\$12.62	40,000	\$36.00	85% Halogen PAR30/38	2,500	\$12.67
LED Recessed, Surface, Pendant Downlights	50,000	\$47.50	70,000	\$47.50	40% CFL 26W Pin Base	10,000	\$12.62	40,000	\$36.00	60% Halogen PAR30/38	2,500	\$12.67
LED Track Lighting	50,000	\$47.50	70,000	\$47.50	10% CMH PAR38	12,000	\$62.92	40,000	\$110.00	90% Halogen PAR38	2,500	\$12.67
LED Wall-Wash Fixtures	50,000	\$47.50	70,000	\$47.50	40% CFL 42W Pin Base	10,000	\$15.72	40,000	\$67.50	60% Halogen PAR38	2,500	\$12.67
LED Portable Desk/Task Light Fixtures	50,000	\$47.50	70,000	\$47.50	50% 13W CFL Pin Base	10,000	\$5.52	40,000	\$25.00	50% 50W Halogen	2,500	\$12.67
LED Undercabinet Shelf-Mounted Task Light Fixtures (per foot)	50,000	\$47.50	70,000	\$47.50	50% 2' T5 Linear	7,500	\$9.92	40,000	\$45.00	50% 50W Halogen	2,500	\$12.67

³⁴⁰ Note some measures have blended baselines. All values are provided to enable calculation of appropriate O&M impacts. Total costs include lamp, labor and disposal cost assumptions where applicable, see "LED reference tables.xls" for more information.

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LED Refrigerated Case Light, Horizontal or Vertical (per foot)	50,000	\$9.50	70,000	\$9.50	5' T8	15,000	\$2.77	40,000	\$9.50	N/A	N/A	N/A
LED Freezer Case Light, Horizontal or Vertical (per foot)	50,000	\$8.75	70,000	\$7.92	6' T12HO	12,000	\$11.03	40,000	\$59.58	N/A	N/A	N/A
LED Display Case Light Fixture (per foot)	35,000	\$47.50	70,000	\$28.75	50% 2' T5 Linear	7,500	\$9.92	40,000	\$45.00	50% 50W Halogen	2,500	\$12.67
LED 2x2 Recessed Light Fixture	35,000	\$47.50	70,000	\$47.50	T8 U-Tube 2L-FB32 w/ Elec - 2'	15,000	\$24.95	40,000	\$52.00	N/A	N/A	N/A
LED 2x4 Recessed Light Fixture	35,000	\$72.50	70,000	\$47.50	T8 3L-F32 w/ Elec - 4'	15,000	\$17.00	40,000	\$35.00	N/A	N/A	N/A
LED 1x4 Recessed Light Fixture	35,000	\$47.50	70,000	\$47.50	T8 2L-F32 w/ Elec - 4'	15,000	\$11.33	40,000	\$35.00	N/A	N/A	N/A
LED High- and Low-Bay Fixtures	35,000	\$112.50	70,000	\$62.50	250W MH	10,000	\$41.25	40,000	\$130.25	N/A	N/A	N/A
LED Outdoor Pole/Arm Mounted Parking/Roadway, < 30W	50,000	\$62.50	70,000	\$62.50	100W MH	10,000	\$54.25	40,000	\$166.70	N/A	N/A	N/A
LED Outdoor Pole/Arm Mounted Parking/Roadway, 30W - 75W	50,000	\$87.50	70,000	\$62.50	175W MH	10,000	\$48.25	40,000	\$110.00	N/A	N/A	N/A
LED Outdoor Pole/Arm Mounted Parking/Roadway, >= 75W	50,000	\$112.50	70,000	\$62.50	250W MH	10,000	\$41.25	40,000	\$130.25	N/A	N/A	N/A
LED Outdoor Pole/Arm Mounted Decorative Parking/Roadway, < 30W	50,000	\$62.50	70,000	\$62.50	100W MH	10,000	\$54.25	40,000	\$166.70	N/A	N/A	N/A
LED Outdoor Pole/Arm Mounted Decorative Parking/Roadway, 30W - 75W	50,000	\$87.50	70,000	\$62.50	175W MH	10,000	\$48.25	40,000	\$110.00	N/A	N/A	N/A

Illinois Statewide Technical Reference Manual - 4.5.2 LED Bulbs and Fixtures

LED Outdoor Pole/Arm Mounted Decorative Parking/Roadway, >= 75W	50,000	\$112.50	70,000	\$62.50	250W MH	10,000	\$41.25	40,000	\$130.25	N/A	N/A	N/A
LED Parking Garage/Canopy, < 30W	50,000	\$47.50	70,000	\$47.50	100W MH	10,000	\$36.92	40,000	\$151.70	N/A	N/A	N/A
LED Parking Garage/Canopy, 30W - 75W	50,000	\$72.50	70,000	\$47.50	175W MH	10,000	\$30.92	40,000	\$95.00	N/A	N/A	N/A
LED Parking Garage/Canopy, >= 75W	50,000	\$97.50	70,000	\$47.50	250W MH	10,000	\$23.92	40,000	\$115.25	N/A	N/A	N/A
LED Wall-Mounted Area Lights, < 30W	50,000	\$47.50	70,000	\$47.50	100W MH	10,000	\$36.92	40,000	\$151.70	N/A	N/A	N/A
LED Wall-Mounted Area Lights, 30W - 75W	50,000	\$72.50	70,000	\$47.50	175W MH	10,000	\$30.92	40,000	\$95.00	N/A	N/A	N/A
LED Wall-Mounted Area Lights, >= 75W	50,000	\$97.50	70,000	\$47.50	250W MH	10,000	\$23.92	40,000	\$115.25	N/A	N/A	N/A
LED Bollard, < 30W	50,000	\$47.50	70,000	\$47.50	50W MH	10,000	\$36.92	40,000	\$135.50	N/A	N/A	N/A
LED Bollard, >= 30W	50,000	\$72.50	70,000	\$47.50	70W MH	10,000	\$36.92	40,000	\$142.50	N/A	N/A	N/A
LED Flood Light, < 15W	50,000	\$47.50	70,000	\$47.50	25% 50W MH	10,000	\$36.92	40,000	\$135.50	75% Halogen PAR20	2,500	\$12.67
LED Flood Light, >= 15W	50,000	\$47.50	70,000	\$47.50	50% 50W MH	10,000	\$36.92	40,000	\$135.50	50% Halogen PAR30/38	2,500	\$12.67

MEASURE CODE: CI-LTG-LEDB-V01-120601

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.

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

The measure applies to all commercial HPT8 installations excluding new construction and major renovation or change of use measures (see lighting power density measure). Lookup tables have been provided to account for the different types of installations. Whenever possible, actual costs and hours of use should be utilized for savings calculations. Default new and baseline assumptions have been provided in the reference tables. Default component costs and lifetimes have been provided for Operating and Maintenance Calculations. Please see the Definition Table to determine applicability for each program. HPT8 configurations not included in the TRM may be included in custom program design using the provided algorithms as long as energy savings is achieved. The following table defines the applicability for different programs

Time of Sale (TOS)	Retrofit (RF)
<p>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.</p>	<p>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.</p> <p>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.</p>

DEFINITION OF EFFICIENT EQUIPMENT

The definition of efficient equipment varies based on the program and is defined below:

Time of Sale (TOS)	Retrofit (RF)
<p>In order for this characterization to apply, new lamps and ballasts must be listed on the CEE website on the qualifying High Performance T8 lamps and ballasts list (http://www.cee1.org/com/com-lt/com-lt-main.php3).</p> <p>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.</p> <p>High bay fixtures must have fixture efficiencies of 85% or greater.</p> <p>RWT8 lamps: In order for this characterization to apply, new 4' and U-tube lamps must be listed on the CEE website on the qualifying Reduced Wattage High Performance T8 lamps list. (http://www.cee1.org/com/com-lt/com-lt-main.php3). 2', 3' and 8' lamps must meet the wattage requirements specified in the RWT8 new and baseline assumptions table. This measure assumes a lamp only purchase.</p>	<p>In order for this characterization to apply, new lamps and ballasts must be listed on the CEE website on the qualifying High Performance T8 lamps and ballasts list (http://www.cee1.org/com/com-lt/com-lt-main.php3).</p> <p>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.</p> <p>High bay fixtures will have fixture efficiencies of 85% or greater.</p> <p>RWT8: in order for this characterization to apply, new 4' and U-tube lamps must be listed on the CEE website on the qualifying Reduced Wattage High Performance T8 lamps list. (http://www.cee1.org/com/com-lt/com-lt-main.php3). 2', 3' and 8' lamps must meet the wattage requirements specified in the RWT8 new and baseline assumptions table.</p>

DEFINITION OF BASELINE EQUIPMENT

The definition of baseline equipment varies based on the program and is defined below:

Time of Sale (TOS)	Retrofit (RF)
The baseline is standard efficiency T8 systems that would have been installed. The baseline for high-bay fixtures is pulse start metal halide fixtures, the baseline for a 2 lamp high efficiency troffer is a 3 lamp standard efficiency troffer.	The baseline is the existing system. For T12 systems, the baseline becomes standard T8 in 2016 regardless of the equipment on site due to the phase in of EISA standards.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The deemed lifetime of efficient equipment varies based on the program and is defined below:

Time of Sale (TOS)	Retrofit (RF)
<p>Fixture lifetime is 15 years³⁴¹.</p> <p>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.</p> <p>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.³⁴²</p>	<p>Due to new federal standards for linear fluorescent lamps, manufacturers of T12 lamps will not be permitted to manufacture most varieties of T12 lamps for sale in the United States after July 2012. All remaining stock and previously manufactured product may be sold after the July 2012 effective date. If a customer relamps an existing T12 fixture the day the standard takes effect, an assumption can be made that they would likely need to upgrade to, at a minimum, 800-series T8s in less than 5 years' time. This assumes the T12s installed have a typical rated life of 20,000 hours and are operated for 4500 hours annually (average miscellaneous hours 4576/year). Certainly, it is not realistic that everyone would wait until the final moment to relamp with T12s. Also, the exempted T12 lamps greater than 87 CRI will continue to be available to purchase, although they will be expensive. Therefore the more likely scenario would be a gradual shift to T8s over the 4 year timeframe. In other words, we can expect that for each year between 2012 and 2016, ~20% of the existing T12 lighting will change over to T8 lamps that comply with the federal standard. To simplify this assumption, we recommend assuming that standard T8s become the baseline for all T12 linear fluorescent retrofit January 1, 2016. There will be a baseline shift applied to all measures installed before 2016. See table C-1.</p>

³⁴¹ 15 years from GDS Measure Life Report, June 2007

³⁴² ibid

DEEMED MEASURE COST AND O&M COST ADJUSTMENTS

The deemed lifetime of efficient equipment varies based on the program and is defined below:

Time of Sale (TOS)	Retrofit (RF)
Refer to reference tables A-1: Time of Sale New and Baseline Assumptions and B-1 Time of Sale T8 Component Costs and Lifetime. For RTW8 refer to reference table A-3: RWT8 New and Baseline Assumptions and B-3 RWT8 T8 Component Costs and Lifetime.	Refer to reference tables A-2: Retrofit New and Baseline Assumptions and B-2 Retrofit HPT8 Component Costs and Lifetime. For RTW8 refer to reference table A-3: RWT8 New and Baseline Assumptions and B-3 RWT8 T8 Component Costs and Lifetime. For T12 Baseline Adjustment Factors, refer to Table C-1.

LOADSHAPE

- Loadshape C06 - Commercial Indoor Lighting
- Loadshape C07 - Grocery/Conv. Store Indoor Lighting
- Loadshape C08 - Hospital Indoor Lighting
- Loadshape C09 - Office Indoor Lighting
- Loadshape C10 - Restaurant Indoor Lighting
- Loadshape C11 - Retail Indoor Lighting
- Loadshape C12 - Warehouse Indoor Lighting
- Loadshape C13 - K-12 School Indoor Lighting
- Loadshape C14 - Indust. 1-shift (8/5) (e.g., comp. air, lights)
- Loadshape C15 - Indust. 2-shift (16/5) (e.g., comp. air, lights)
- Loadshape C16 - Indust. 3-shift (24/5) (e.g., comp. air, lights)
- Loadshape C17 - Indust. 4-shift (24/7) (e.g., comp. air, lights)
- Loadshape C18 - Industrial Indoor Lighting
- Loadshape C19 - Industrial Outdoor Lighting
- Loadshape C20 - Commercial Outdoor Lighting

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = ((Watts_{base} - Watts_{EE}) / 1000) * Hours * WHF_e * ISR$$

SUMMER COINCIDENT DEMAND SAVINGS

$$\Delta kW = ((Watts_{base} - Watts_{EE}) / 1000) * WHF_d * CF * ISR$$

Where:

$Watts_{base}$ = Input wattage of the existing system which depends on the baseline fixture configuration (number and type of lamp) and number of fixtures. Value can be selected from the appropriate reference table as shown below, or a custom value can be entered if the configurations in the tables is not representative of the existing 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, or a custom value can be entered if the configurations in the tables is not representative of the existing system.

Program	Reference Table
Time of Sale	A-1: HPT8 New and Baseline Assumptions
Retrofit	A-2: HPT8 New and Baseline Assumptions
Reduced Wattage T8, time of sale or retrofit	A-3: RWT8 New and Baseline Assumptions

Hours = Average hours of use per year as provided by the customer or selected from the Reference Table in Section 6.5, 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 6.5 for each building type. If building is un-cooled, the value is 1.0.

WHF_d = Waste Heat Factor for Demand to account for cooling savings from efficient lighting in cooled buildings is selected from the Reference Table in Section 6.5 for each building type. If the building is not cooled WHF_d is 1.

ISR = In Service Rate or the percentage of units rebated that get installed.

=100%³⁴³ 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	2 nd year	3 rd year	Final
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³⁴³ 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.

Average 1 st year In Service Rate (ISR)	Installations	Installations	Lifetime In Service Rate
69.5% ³⁴⁴	15.4%	13.1%	98.0% ³⁴⁵

CF= Summer Peak Coincidence Factor for measure is selected from the Reference Table in Section 6.5 for each building type. If the building type is unknown, use the Miscellaneous value of 0.66.

NATURAL GAS ENERGY SAVINGS

$$\Delta\text{Therms}^{346} = (((\text{WattsBase}-\text{WattsEE})/1000) * \text{ISR} * \text{Hours} * - \text{IFTherms}$$

Where:

IFTherms = Lighting-HVAC Integration Factor for gas heating impacts; this factor represents the increased gas space heating requirements due to the reduction of waste heat rejected by the efficient lighting. Please select from the Reference Table in Section 6.5 for each building type.

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

³⁴⁴ 1st year in service rate is based upon review of PY1-3 evaluations from ComEd and Ameren (see 'IL RES Lighting ISR.xls' for more information. The average first year ISR for each utility was calculated weighted by the number of bulbs in the each year's survey. This was then weighted by annual sales to give a statewide assumption. Note these evaluations did not look at C&I specific installations but until a more appropriate C&I evaluation is performed, the Residential assumptions are applied.

³⁴⁵ 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.

³⁴⁶ Negative value because this is an increase in heating consumption due to the efficient lighting.

DEEMED O&M COST ADJUSTMENT CALCULATION

See Reference tables for Operating and Maintenance Values

Program	Reference Table
Time of Sale	B-1: HPT8 Component Costs and Lifetime
Retrofit	B-2: HPT8 Component Costs and Lifetime
Reduced Wattage T8, time of sale or retrofit	B-3: HPT8 Component Costs and Lifetime

REFERENCE TABLES

See following page

A-1: Time of Sale: HPT8 New and Baseline Assumptions³⁴⁷

EE Measure Description	Watts _{EE}	Baseline Description	Watts _{BASE}	Measure Cost	Watts _{SAVE}
4-Lamp HPT8 w/ High-BF Ballast High-Bay	146	200 Watt Pulse Start Metal-Halide	232	\$75	86
6-Lamp HPT8 w/ High-BF Ballast High-Bay	221	320 Watt Pulse Start Metal-Halide	350	\$75	129
8-Lamp HPT8 w/ High-BF Ballast High-Bay	280	Proportionally Adjusted according to 6-Lamp HPT8 Equivalent to 320 PSMH	455	\$75	175
1-Lamp HPT8-high performance 32 w lamp	25	1-Lamp Standard F32T8 w/ Elec. Ballast	32	\$15	7
1-Lamp HPT8-high performance 28 w lamp	22	1-Lamp Standard F32T8 w/ Elec. Ballast	32	\$15	10
1-Lamp HPT8-high performance 25 w lamp	19	1-Lamp Standard F32T8 w/ Elec. Ballast	32	\$15	13
2-Lamp HPT8 -high performance 32 w lamp	49	2-Lamp Standard F32T8 w/ Elec. Ballast	59	\$18	10
2-Lamp HPT8-high performance 28 w lamp	43	2-Lamp Standard F32T8 w/ Elec. Ballast	59	\$18	16
2-Lamp HPT8-high performance 25 w lamp	35	2-Lamp Standard F32T8 w/ Elec. Ballast	59	\$18	24
3-Lamp HPT8-high performance 32 w lamp	72	3-Lamp Standard F32T8 w/ Elec. Ballast	88	\$20	16
3-Lamp HPT8-high performance 28 w lamp	65	3-Lamp Standard F32T8 w/ Elec. Ballast	88	\$20	23
3-Lamp HPT8-high performance 25 w lamp	58	3-Lamp Standard F32T8 w/ Elec. Ballast	88	\$20	30
4-Lamp HPT8 -high performance 32 w lamp	94	4-Lamp Standard F32T8 w/ Elec. Ballast	114	\$23	20
4-Lamp HPT8-high performance 28 w lamp	86	4-Lamp Standard F32T8 w/ Elec. Ballast	114	\$23	28
4-Lamp HPT8-high performance 25 w lamp	77	4-Lamp Standard F32T8 w/ Elec. Ballast	114	\$23	37
2-lamp High-Performance HPT8 Troffer	49	3-Lamp F32T8 w/ Elec. Ballast	88	\$100	39

Table developed using a constant ballast factor of .77. Input wattages are an average of manufacturer inputs that account for ballast efficacy

³⁴⁷ Adapted from Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, October 26, 2011.

A-2: Retrofit HPT8 New and Baseline Assumptions³⁴⁸ (Note see definition for validity after 2016)

EE Measure Description	Watts _{EE}	Baseline Description	Watts _{BASE}	Incremental cost	Watts _{SAVE}
4-Lamp HPT8 w/ High-BF Ballast High-Bay	146	200 Watt Pulse Start Metal-Halide	232	\$200	86
4-Lamp HPT8 w/ High-BF Ballast High-Bay	146	250 Watt Metal Halide	295	\$200	149
6-Lamp HPT8 w/ High-BF Ballast High-Bay	206	320 Watt Pulse Start Metal-Halide	350	\$225	144
6-Lamp HPT8 w/ High-BF Ballast High-Bay	206	400 Watt Metal Halide	455	\$225	249
8-Lamp HPT8 w/ High-BF Ballast High-Bay	280	Proportionally Adjusted according to 6-Lamp HPT8 Equivalent to 320 PSMH	476	\$250	196
8-Lamp HPT8 w/ High-BF Ballast High-Bay	280	Proportionally Adjusted according to 6-Lamp HPT8 Equivalent to 400 W Metal halide	618	\$250	338
1-Lamp Relamp/Reballast T12 to HPT8	25	1-Lamp F34T12 w/ EEMag Ballast	40	\$50	15
2-Lamp Relamp/Reballast T12 to HPT8	49	2-Lamp F34T12 w/ EEMag Ballast	68	\$55	19
3-Lamp Relamp/Reballast T12 to HPT8	72	3-Lamp F34T12 w/ EEMag Ballast	110	\$60	38
4-Lamp Relamp/Reballast T12 to HPT8	94	4-Lamp F34T12 w/ EEMag Ballast	139	\$65	45
1-Lamp Relamp/Reballast T12 to HPT8	25	1-Lamp F40T12 w/ EEMag Ballast	48	\$50	23
2-Lamp Relamp/Reballast T12 to HPT8	49	2-Lamp F40T12 w/ EEMag Ballast	82	\$55	33
3-Lamp Relamp/Reballast T12 to HPT8	72	3-Lamp F40T12 w/ EEMag Ballast	122	\$60	50
4-Lamp Relamp/Reballast T12 to HPT8	94	4-Lamp F40T12 w/ EEMag Ballast	164	\$65	70
1-Lamp Relamp/Reballast T12 to HPT8	25	1-Lamp F40T12 w/ Mag Ballast	57	\$50	32
2-Lamp Relamp/Reballast T12 to HPT8	49	2-Lamp F40T12 w/ Mag Ballast	94	\$55	45
3-Lamp Relamp/Reballast T12 to HPT8	72	3-Lamp F40T12 w/ Mag Ballast	147	\$60	75
4-Lamp Relamp/Reballast T12 to HPT8	94	4-Lamp F40T12 w/ Mag Ballast	182	\$65	88
1-Lamp Relamp/Reballast T8 to HPT8	25	1-Lamp F32T8 w/ Elec. Ballast	32	\$50	7
2-Lamp Relamp/Reballast T8 to HPT8	49	2-Lamp F32T8 w/ Elec. Ballast	59	\$55	10
3-Lamp Relamp/Reballast T8 to HPT8	72	3-Lamp F32T8 w/ Elec. Ballast	88	\$60	16
4-Lamp Relamp/Reballast T8 to HPT8	94	4-Lamp F32T8 w/ Elec. Ballast	114	\$65	20
2-lamp High-Performance HPT8 Troffer or high efficiency retrofit troffer	49	3-Lamp F32T8 w/ Elec. Ballast	88	\$100	39

³⁴⁸ Ibid.

A- 3: RWT8 New and Baseline Assumptions

EE Measure Description	EE Cost	System WattsEE	Baseline Description	Base Cost	System Watts Base	Measure Cost	WattsSAVE
RWT8 - F28T8 Lamp	\$4.50	25	F32T8 Standard Lamp	\$2.50	28	\$2.00	4
RWT8 - F28T8 Extra Life Lamp	\$4.50	25	F32T8 Standard Lamp	\$2.50	28	\$2.00	4
RWT8 - F32/25W T8 Lamp	\$4.50	22	F32T8 Standard Lamp	\$2.50	28	\$2.00	6
RWT8 - F32/25W T8 Lamp Extra Life	\$4.50	22	F32T8 Standard Lamp	\$2.50	28	\$2.00	6
RWT8 - F17T8 Lamp - 2 Foot	\$4.80	14	F17T8 Standard Lamp - 2 foot	\$2.80	16	\$2.00	2
RWT8 - F25T8 Lamp - 3 Foot	\$5.10	20	F25T8 Standard Lamp - 3 foot	\$3.10	23	\$2.00	3
RWT8 - F30T8 Lamp - 6" Utube	\$11.31	26	F32T8 Standard Utube Lamp	\$9.31	28	\$2.00	2
RWT8 - F29T8 Lamp - Utube	\$11.31	26	F32T8 Standard Utube Lamp	\$9.31	28	\$2.00	3
RWT8 - F96T8 Lamp - 8 Foot	\$9.00	57	F96T8 Standard Lamp - 8 foot	\$7.00	62	\$2.00	5

Notes: Wattage assumptions for Reduced-Wattage T8 based on Existing 0.88 Normal Ballast Factor.

B-1: Time of Sale T8 Component Costs and Lifetime³⁴⁹

EE Measure Description	EE Lamp Cost	EE Lamp Life (hrs)	EE Lamp Labor Cost per lamp	EE Ballast Cost	EE Ballast Life (hrs)	EE Ballast Labor Cost	Baseline Description	Base Lamp Cost	Base Lamp Life (hrs)	Base Lamp Labor Cost	Base Ballast Cost	Base Ballast Life (hrs)	Base Ballast Labor Cost
4-Lamp HPT8 w/ High-BF Ballast High-Bay	\$5.00	24000	\$6.67	\$32.50	70000	\$15.00	200 Watt Pulse Start Metal-Halide	\$21.00	10000	\$6.67	\$88	40000	\$22.50
6-Lamp HPT8 w/ High-BF Ballast High-Bay	\$5.00	24000	\$6.67	\$32.50	70000	\$15.00	320 Watt Pulse Start Metal-Halide	\$21.00	20000	\$6.67	\$109	40000	\$22.50
8-Lamp HPT8 w/ High-BF Ballast High-Bay	\$5.00	24000	\$6.67	\$32.50	70000	\$15.00	Lamp HPT8 Equivalent to 320 PSMH	\$21.00	20000	\$6.67	\$109	40000	\$22.50
1-Lamp HPT8 - all qualifying lamps	\$5.00	24000	\$2.67	\$32.50	70000	\$15.00	1-Lamp Standard F32T8 w/ Elec. Ballast	\$2.50	20000	\$2.67	\$15	70000	\$15.00
2-Lamp HPT8 - all qualifying lamps	\$5.00	24000	\$2.67	\$32.50	70000	\$15.00	2-Lamp Standard F32T8 w/ Elec. Ballast	\$2.50	20000	\$2.67	\$15	70000	\$15.00
3-Lamp HPT8 - all qualifying lamps	\$5.00	24000	\$2.67	\$32.50	70000	\$15.00	3-Lamp Standard F32T8 w/ Elec. Ballast	\$2.50	20000	\$2.67	\$15	70000	\$15.00
4-Lamp HPT8 - all qualifying lamps	\$5.00	24000	\$2.67	\$32.50	70000	\$15.00	4-Lamp Standard F32T8 w/ Elec. Ballast	\$2.50	20000	\$2.67	\$15	70000	\$15.00
2-lamp High-Performance HPT8 Troffer	\$5.00	24000	\$2.67	\$32.50	70000	\$15.00	3-Lamp F32T8 w/ Elec. Ballast	\$2.50	20000	\$2.67	\$15	70000	\$15.00

³⁴⁹ Adapted from Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, October 26, 2011.

B-2: T8 Retrofit Component Costs and Lifetime³⁵⁰

EE Measure Description	EE Lamp Cost	EE Lamp Life (hrs)	EE Lamp Rep. Labor Cost per lamp	EE Ballast Cost	EE Ballast Life (hrs)	EE Ballast Rep. Labor Cost	Baseline Description	Base Lamp Cost	Base Lamp Life (hrs)	Base Lamp Rep. Labor Cost	Base Ballast Cost	Base Ballast Life (hrs)	Base Ballast Rep. Labor Cost
4-Lamp HPT8 w/ High-BF Ballast High-Bay	\$5.00	24000	\$6.67	\$32.50	70000	\$15.00	200 Watt Pulse Start Metal-Halide	\$29.00	12000	\$6.67	\$88	40000	\$22.50
							250 Watt Metal Halide	\$21.00	10000	\$6.67	\$92	40000	\$22.50
6-Lamp HPT8 w/ High-BF Ballast High-Bay	\$5.00	24000	\$6.67	\$32.50	70000	\$15.00	320 Watt Pulse Start Metal-Halide	\$72.00	20000	\$6.67	\$109	40000	\$22.50
							400 Watt Metal Halide	\$17.00	20000	\$6.67	\$114	40000	\$22.50
8-Lamp HPT8 w/ High-BF Ballast High-Bay	\$5.00	24000	\$6.67	\$32.50	70000	\$15.00	Proportionally Adjusted according to 6-Lamp HPT8 Equivalent to 320 PSMH	\$72.00	20000	\$6.67	\$109	40000	\$22.50
							Proportionally Adjusted according to 6-Lamp HPT8 Equivalent to 400 Watt Metal Halide	\$17.00	20000	\$6.67	\$114	40000	\$22.50
1-Lamp Relamp/Reballast T12 to HPT8 (all lamp/ballast combinations)	\$5.00	24000	\$2.67	\$32.50	70000	\$15.00	1-Lamp T12 all lamp/ballast combinations	\$2.70	20000	\$2.67	\$20	40000	\$15.00
2-Lamp Relamp/Reballast T12 to HPT8 (all lamp/ballast combinations)	\$5.00	24000	\$2.67	\$32.50	70000	\$15.00	2-Lamp T12 all lamp/ballast combinations	\$2.70	20000	\$2.67	\$20	40000	\$15.00
3-Lamp Relamp/Reballast T12 to HPT8 (all lamp/ballast combinations)	\$5.00	24000	\$2.67	\$32.50	70000	\$15.00	3-Lamp T12 all lamp/ballast combinations	\$2.70	20000	\$2.67	\$20	40000	\$15.00
4-Lamp Relamp/Reballast T12 to HPT8 (all lamp/ballast combinations)	\$5.00	24000	\$2.67	\$32.50	70000	\$15.00	4-Lamp T12 all lamp/ballast combinations	\$2.70	20000	\$2.67	\$20	40000	\$15.00
1-Lamp Relamp/Reballast T8 to HPT8	\$5.00	24000	\$2.67	\$32.50	70000	\$15.00	1-Lamp F32T8 w/ Elec. Ballast	\$2.70	20000	\$2.67	\$20	70000	\$15.00
2-Lamp Relamp/Reballast T8 to HPT8	\$5.00	24000	\$2.67	\$32.50	70000	\$15.00	2-Lamp F32T8 w/ Elec. Ballast	\$2.70	20000	\$2.67	\$20	70000	\$15.00
3-Lamp Relamp/Reballast T8 to HPT8	\$5.00	24000	\$2.67	\$32.50	70000	\$15.00	3-Lamp F32T8 w/ Elec. Ballast	\$2.70	20000	\$2.67	\$20	70000	\$15.00
4-Lamp Relamp/Reballast T8 to HPT8	\$5.00	24000	\$2.67	\$32.50	70000	\$15.00	4-Lamp F32T8 w/ Elec. Ballast	\$2.70	20000	\$2.67	\$20	70000	\$15.00
2-lamp High-Performance HPT8 Troffer or high efficiency retrofit reflective troffer	\$5.00	24000	\$2.67	\$32.50	70000	\$15.00	3-Lamp F32T8 w/ Elec. Ballast	\$2.50	20000	\$2.67	\$15	70000	\$15.00

B-3: Reduced Wattage T8 Component Costs and Lifetime³⁵¹

³⁵⁰ 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/bpdeemedavingsmanuav10_evaluationreport.pdf

EE Measure Description	EE Lamp Cost	EE Lamp Life (hrs)	Baseline Description	Base Lamp Cost	Base Lamp Life (hrs)	Base Lamp Rep. Labor Cost
RWT8 - F28T8 Lamp	\$4.50	30000	F32T8 Standard Lamp	\$2.50	15000	\$2.67
RWT8 - F28T8 Extra Life Lamp	\$4.50	36000	F32T8 Standard Lamp	\$2.50	15000	\$2.67
RWT8 - F32/25W T8 Lamp	\$4.50	30000	F32T8 Standard Lamp	\$2.50	15000	\$2.67
RWT8 - F32/25W T8 Lamp Extra Life	\$4.50	36000	F32T8 Standard Lamp	\$2.50	15000	\$2.67
RWT8 - F17T8 Lamp - 2 Foot	\$4.80	18000	F17T8 Standard Lamp - 2 foot	\$2.80	15000	\$2.67
RWT8 - F25T8 Lamp - 3 Foot	\$5.10	18000	F25T8 Standard Lamp - 3 foot	\$3.10	15000	\$2.67
RWT8 - F30T8 Lamp - 6" Utube	\$11.31	24000	F32T8 Standard Utube Lamp	\$9.31	15000	\$2.67
RWT8 - F29T8 Lamp - Utube	\$11.31	24000	F32T8 Standard Utube Lamp	\$9.31	15000	\$2.67
RWT8 - F96T8 Lamp - 8 Foot	\$9.00	24000	F96T8 Standard Lamp - 8 foot	\$7.00	15000	\$2.67

³⁵¹ Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, January 2012.

C-1: T12 Baseline Adjustment:

For measures installed in 2012 through 2015, the full savings (as calculated above in the Algorithm section) will be claimed through 2015. A savings adjustment will be applied to the annual savings for the remainder of the measure life. The adjustment to be applied for each measure is listed in the reference table below.

Savings Adjustment Factors

EE Measure Description	Savings Adjustment T12 EEmag ballast and 34 w lamps to HPT8	Savings Adjustment T12 EEmag ballast and 40 w lamps to HPT8	Savings Adjustment T12 mag ballast and 40 w lamps to HPT8
1-Lamp Relamp/Reballast T12 to HPT8	47%	30%	20%
2-Lamp Relamp/Reballast T12 to HPT8	53%	30%	22%
3-Lamp Relamp/Reballast T12 to HPT8	42%	38%	21%
4-Lamp Relamp/Reballast T12 to HPT8	44%	29%	23%

Measures installed in 2012 will claim full savings for four years, 2013 for three years, 2014 two years and 2015 one year. Savings adjustment factors will be applied to the full savings for savings starting in 2016 and for the remainder of the measure life. The savings adjustment is equal to the ratio between wattage reduction from T8 baseline to HPT8 and wattage reduction from T12 EE ballast with 40 w lamp baseline from the table 'T8 New and Baseline Assumptions'.³⁵²

Example: 2 lamp T8 to 2 lamp HPT8 retrofit saves 10 watts, while the T12 EE with 40 w lamp to HPT8 saves 33 watts. Thus the ratio of wattage reduced is 30%. Thus the ratio of wattage reduced is 30%.

MEASURE CODE: CI-LTG-T8FX-V01-120601

³⁵² Adapted from EVT Technical Resource Manual, 2012-75, page 85.

4.5.4 T5 Fixtures and Lamps

DESCRIPTION

T5 Lamp/ballast systems have higher lumens per watt than a standard T8 or an existing T8 or T12 system. The smaller lamp diameter allows for better optical systems, and more precise control of lighting. These characteristics result in light fixtures that produce equal or greater light than standard T8 or T12 fixtures, while using fewer watts.

This measure applies to the installation of new equipment with efficiencies that exceed that of the equipment that would have been installed following standard market practices and is applicable to time of sale as well as retrofit measures.

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

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

The measure applies to all commercial T5 installations excluding new construction and substantial renovation or change of use measures (see lighting power density measure). Lookup tables have been provided to account for various installations. Actual existing equipment wattages should be compared to new fixture wattages whenever possible while maintaining lumen equivalent designs. Default new and baseline assumptions are provided if existing equipment cannot be determined. Actual costs and hours of use should be utilized when available. Default component costs and lifetimes have been provided for Operating and Maintenance Calculations. Please see the Definition Table to determine applicability for each program. Configurations not included in the TRM may be included in custom program design using the provided algorithms as long as energy savings is achieved. The following table defines the applicability for different programs:

Time of Sale (TOS)	Retrofit (RF)
This program applies to installations where customer and location of equipment is not known, or at time of burnout of existing equipment. T5 Lamp/ballast systems have higher lumens per watt than a standard T8 system. The smaller lamp diameter allows for better optical systems, and more precise control of lighting. These characteristics result in light fixtures that produce equal or greater light than standard T8 fixtures, while using fewer watts.	For installations that upgrade installations before the end of their useful life. T5 Lamp/ballast systems have higher lumens per watt than a standard T8 or T12 system. The smaller lamp diameter allows for better optical systems, and more precise control of lighting. These characteristics result in light fixtures that produce equal or greater light than standard T8 or T12 fixtures, while using fewer watts and having longer life.

DEFINITION OF EFFICIENT EQUIPMENT

The definition of efficient equipment varies based on the program and is defined below:

Time of Sale (TOS)	Retrofit (RF)
4' fixtures must use a T5 lamp and ballast configuration. 1' and 3' lamps are not eligible. High Performance Troffers must be 85% efficient or greater. T5 HO high bay fixtures must be 3, 4 or 6 lamps and 90% efficient or better.	4' fixtures must use a T5 lamp and ballast configuration. 1' and 3' lamps are not eligible. High Performance Troffers must be 85% efficient or greater. T5 HO high bay fixtures must be 3, 4 or 6 lamps and 90% efficient or better.

DEFINITION OF BASELINE EQUIPMENT

The definition of baseline equipment varies based on the program and is defined below:

Time of Sale (TOS)	Retrofit (RF)
<p>The baseline is T8 with equivalent lumen output. In high-bay applications, the baseline is pulse start metal halide systems.</p>	<p>The baseline is the existing system. For T12 systems, the baseline becomes standard T8 in 2016.</p> <p>Retrofits to T12 systems installed before 2016 have a baseline adjustment applied in 2016 for the remainder of the measure life.</p> <p>Due to new federal standards for linear fluorescent lamps, manufacturers of T12 lamps will not be permitted to manufacture most varieties of T12 lamps for sale in the United States after July 2012. All remaining stock and previously manufactured product may be sold after the July 2012 effective date. If a customer relamps an existing T12 fixture the day the standard takes effect, an assumption can be made that they would likely need to upgrade to, at a minimum, 800-series T8s in less than 5 years' time. This assumes the T12s installed have a typical rated life of 20,000 hours and are operated for 4500 hours annually (average miscellaneous hours 4576/year). Certainly, it is not realistic that everyone would wait until the final moment to relamp with T12s. Also, the exempted T12 lamps greater than 87 CRI will continue to be available to purchase, although they will be expensive. Therefore the more likely scenario would be a gradual shift to T8s over the 4 year timeframe. In other words, we can expect that for each year between 2012 and 2016, ~20% of the existing T12 lighting will change over to T8 lamps that comply with the federal standard. To simplify this assumption, we recommend assuming that standard T8s become the baseline for all T12 linear fluorescent retrofit January 1, 2016. There will be a baseline shift applied to all measures installed before 2016 in 2016 in years remaining in the measure life.. See table C-1.</p>

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The deemed lifetime of the efficient equipment fixture, regardless of program type is Fixture lifetime is 15 years³⁵³.

DEEMED MEASURE COST AND O&M COST ADJUSTMENTS

The deemed lifetime of efficient equipment varies based on the program and is defined below:

Time of Sale (TOS)	Retrofit (RF)
Refer to reference tables A-1: Time of Sale New and Baseline Assumptions and B-1: Time of Sale T5 Component Costs and Lifetime.	Refer to reference tables A-2: Retrofit New and Baseline Assumptions and B-2 Retrofit T5 Component Costs and Life.

LOADSHAPE

- Loadshape C06 - Commercial Indoor Lighting
- Loadshape C07 - Grocery/Conv. Store Indoor Lighting
- Loadshape C08 - Hospital Indoor Lighting
- Loadshape C09 - Office Indoor Lighting
- Loadshape C10 - Restaurant Indoor Lighting
- Loadshape C11 - Retail Indoor Lighting
- Loadshape C12 - Warehouse Indoor Lighting
- Loadshape C13 - K-12 School Indoor Lighting
- Loadshape C14 - Indust. 1-shift (8/5) (e.g., comp. air, lights)
- Loadshape C15 - Indust. 2-shift (16/5) (e.g., comp. air, lights)
- Loadshape C16 - Indust. 3-shift (24/5) (e.g., comp. air, lights)
- Loadshape C17 - Indust. 4-shift (24/7) (e.g., comp. air, lights)
- Loadshape C18 - Industrial Indoor Lighting
- Loadshape C19 - Industrial Outdoor Lighting
- Loadshape C20 - Commercial Outdoor Lighting

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = ((Watts_{base} - Watts_{EE}) / 1000) * Hours * WHF_e * ISR$$

SUMMER COINCIDENT DEMAND SAVINGS

$$\Delta kW = ((Watts_{base} - Watts_{EE}) / 1000) * WHF_d * CF * ISR$$

³⁵³ 15 years from GDS Measure Life Report, June 2007

Where:

Program	Reference Table
Time of Sale	A-1: T5 New and Baseline Assumptions
Retrofit	A-2: T5 New and Baseline Assumptions

Watts_{base} = Input wattage of the existing system which depends on the baseline fixture configuration (number and type of lamp) and number of fixtures. Value can be selected from the appropriate reference table as shown below, or a custom value can be entered if the configurations in the tables is not representative of the existing system.

Watts_{EE} = New Input wattage of EE fixture which depends on new fixture configuration (number of lamps) and ballast factor and number of fixtures. Value can be selected from the appropriate reference table as shown below, or a custom value can be entered if the configurations in the tables is not representative of the existing system.

Program	Reference Table
Time of Sale	A-1: T5 New and Baseline Assumptions
Retrofit	A-2: T5 New and Baseline Assumptions

Hours = Average hours of use per year as provided by the customer or selected from the Reference Table in Section 6.5, 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 6.5 for each building type. If building is un-cooled, the value is 1.0.

WHFd = Waste Heat Factor for Demand to account for cooling savings from efficient lighting in cooled buildings is selected from the Reference Table in Section 6.5 for each building type. If the building is not cooled WHFd is 1.

ISR = In Service Rate or the percentage of units rebated that get installed.

=100%³⁵⁴ if application form completed with sign off that equipment is not placed into storage

If sign off form not completed assume the following 3 year ISR assumptions:

Weighted	2 nd year	3 rd year	Final
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³⁵⁴ Illinois evaluation of PY1 through PY3 has not found that fixtures or lamps placed into storage to be a significant enough issue to warrant including an "In-Service Rate" when commercial customers complete an application form.

Average 1 st year In Service Rate (ISR)	Installations	Installations	Lifetime In Service Rate
69.5% ³⁵⁵	15.4%	13.1%	98.0% ³⁵⁶

CF= Summer Peak Coincidence Factor for measure is selected from the Reference Table in Section 6.5 for each building type. If the building type is unknown, use the Miscellaneous value of 0.66.

NATURAL GAS ENERGY SAVINGS

$$\Delta\text{Therms}^{357} = (((\text{WattsBase}-\text{WattsEE})/1000) * \text{ISR} * \text{Hours} * - \text{IFTherms}$$

Where:

IFTherms = Lighting-HVAC Integration Factor for gas heating impacts; this factor represents the increased gas space heating requirements due to the reduction of waste heat rejected by the efficient lighting. This value is selected from the Reference Table in Section 6.5 for each building type.

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

³⁵⁵ 1st year in service rate is based upon review of PY1-3 evaluations from ComEd and Ameren (see 'IL RES Lighting ISR.xls' for more information. The average first year ISR for each utility was calculated weighted by the number of bulbs in the each year's survey. This was then weighted by annual sales to give a statewide assumption. Note these evaluations did not look at C&I specific installations but until a more appropriate C&I evaluation is performed, the Residential assumptions are applied.

³⁵⁶ The 98% Lifetime ISR assumption is based upon review of two evaluations: 'Nexus Market Research, RLW Analytics and GDS Associates study; "New England Residential Lighting Markdown Impact Evaluation, January 20, 2009' and 'KEMA Inc, Feb 2010, Final Evaluation Report:, Upstream Lighting Program, Volume 1.' This implies that only 2% of bulbs purchased are never installed. The second and third year installations are based upon Ameren analysis of the Californian KEMA study showing that 54% of future installs occur in year 2 and 46% in year 3. The 2nd and 3rd year installations should be counted as part of those future program year savings.

³⁵⁷ Negative value because this is an increase in heating consumption due to the efficient lighting.

DEEMED O&M COST ADJUSTMENT CALCULATION

See Reference tables for Operating and Maintenance Values

Program	Reference Table
Time of Sale	B-1: T5 Component Costs and Lifetime
Retrofit	B-2: T5 Component Costs and Lifetime

REFERENCE TABLES

See following page

A-1: Time of Sale: T5 New and Baseline Assumptions³⁵⁸

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

³⁵⁸ 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 Assumptions³⁵⁹

EE Measure Description	EE Cost	Watts _{EE}	Baseline Description	Watts _{BASE}
3-Lamp T5 High-Bay	\$ 200	180	200 Watt Pulse Start Metal-Halide	232
4-Lamp T5 High-Bay	\$ 225	240	250 Watt Metal-Halide	295
6-Lamp T5 High-Bay	\$ 250	360	320 Watt Pulse Start Metal-Halide	350
			400 Watt Metal halide	455
1-Lamp T5 Troffer/Wrap	\$ 100	32	400 Watt Pulse Start Metal-halide	476
2-Lamp T5 Troffer/Wrap	\$ 100	64		
			1-Lamp F34T12 w/ EEMag Ballast	40
1-Lamp T5 Industrial/Strip	\$ 70	32	2-Lamp F34T12 w/ EEMag Ballast	68
2-Lamp T5 Industrial/Strip	\$ 70	64	3-Lamp F34T12 w/ EEMag Ballast	110
3-Lamp T5 Industrial/Strip	\$ 70	96	4-Lamp F34T12 w/ EEMag Ballast	139
4-Lamp T5 Industrial/Strip	\$ 70	128		
			1-Lamp F40T12 w/ EEMag Ballast	48
1-Lamp T5 Indirect	\$ 175	32	2-Lamp F40T12 w/ EEMag Ballast	82
2-Lamp T5 Indirect	\$ 175	64	3-Lamp F40T12 w/ EEMag Ballast	122
			4-Lamp F40T12 w/ EEMag Ballast	164
			1-Lamp F40T12 w/ Mag Ballast	57
			2-Lamp F40T12 w/ Mag Ballast	94
			3-Lamp F40T12 w/ Mag Ballast	147
			4-Lamp F40T12 w/ Mag Ballast	182
			1-Lamp F32 T8	32
			2-Lamp F32 T8	59
			3-Lamp F32 T18	88
			4-Lamp F32 T8	114

³⁵⁹ Ibid.

B-1: Time of Sale T5 Component Costs and Lifetime³⁶⁰

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

³⁶⁰ 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 Lifetime³⁶¹

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	\$ 32	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

³⁶¹ Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, October 26, 2011 EPE Program Downloads. Web accessed <http://www.epelectricityefficiency.com/downloads.asp?section=ci> download Copy of LSF_2012_v4.04_250rows.xls. Kuiken et al, Focus on Energy Evaluation. Business Programs: Deemed Savings Manual v1.0, Kema, march 22, 2010 available at http://www.focusonenergy.com/files/Document_Management_System/Evaluation/bpdeemedsavingsmanuav10_evaluationreport.pdf

C-1: T12 Baseline Adjustment:

Savings Adjustment Factors

	watts	Equivalent T12 watts adjusted for lumen equivalency-34 w and 40 w with EEMag ballast	Equivalent T12 watts adjusted for lumen equivalency-40 w with EEMag ballast	Equivalent T12 watts adjusted for lumen equivalency-40 w with Mag ballast	Prportionally Adjusted for Lumens wattage for T8 equivalent
1-Lamp T5 Industrial/Strip	32	61	73	82	44
2-Lamp T5 Industrial/Strip	64	103	125	135	88
3-Lamp T5 Industrial/Strip	96	167	185	211	132
4-Lamp T5 Industrial/Strip	128	211	249	226	178
		Savings Factor Adjustment to the T8 baseline	Savings Factor Adjustment to the T8 baseline	Savings Factor Adjustment to the T8 baseline	
1-Lamp T5 Industrial/Strip		42%	29%	24%	
2-Lamp T5 Industrial/Strip		61%	40%	34%	
3-Lamp T5 Industrial/Strip		51%	40%	31%	
4-Lamp T5 Industrial/Strip		60%	41%	51%	

Measures installed in 2012 will claim full savings for four years, 2013 for three years, 2014 two years and 2015 one year. Savings adjustment factors based on a T8 baseline will be applied to the full savings for savings starting in 2016 and for the remainder of the measure life. The adjustment to be applied for each measure is listed in the reference table above and is based on equivalent lumens.

MEASURE CODE: CI-LTG-T5FX-V01-120601

4.5.5 Occupancy Sensor Lighting Controls

DESCRIPTION

This measure relates to the installation of new occupancy sensors on a new or existing lighting system. Lighting control types covered by this measure include wall, ceiling or fixture mounted occupancy sensors. Passive infrared, ultrasonic detectors and fixture-mounted sensors or sensors with a combination thereof are eligible. Lighting controls required by state energy codes are not eligible. This must be a new installation and may not replace an existing lighting occupancy sensor control.

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

DEFINITION OF EFFICIENT EQUIPMENT

In order for this characterization to apply, the existing system is assumed to be manually controlled or an uncontrolled lighting system which is being controlled by one of the lighting controls systems listed above. All sensors must be hard wired and control interior lighting.

DEFINITION OF BASELINE EQUIPMENT

The baseline is assumed to be a lighting system uncontrolled by occupancy.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life for all lighting controls is assumed to be 8 years³⁶².

DEEMED MEASURE COST

When available, the actual cost of the measure shall be used. When not available, the following default values are provided:

Lighting control type	Cost
Full cost of wall mounted occupancy sensor	\$42 ³⁶³
Full cost mounted occupancy sensor	\$66 ³⁶⁴
Full cost of fixture-mounted occupancy sensor	\$125 ³⁶⁵

DEEMED O&M COST ADJUSTMENTS

N/A

³⁶² DEER 2008

³⁶³ Goldberg et al, State of Wisconsin, Public Service Commission of Wisconsin, Focus on Energy Evaluation Business programs Incremental Cost Study, KEMA, October 28, 2009

³⁶⁴ Ibid

³⁶⁵ Efficiency Vermont TRM, October 26, 2011.

LOADSHAPE

- Loadshape C06 - Commercial Indoor Lighting
- Loadshape C07 - Grocery/Conv. Store Indoor Lighting
- Loadshape C08 - Hospital Indoor Lighting
- Loadshape C09 - Office Indoor Lighting
- Loadshape C10 - Restaurant Indoor Lighting
- Loadshape C11 - Retail Indoor Lighting
- Loadshape C12 - Warehouse Indoor Lighting
- Loadshape C13 - K-12 School Indoor Lighting
- Loadshape C14 - Indust. 1-shift (8/5) (e.g., comp. air, lights)
- Loadshape C15 - Indust. 2-shift (16/5) (e.g., comp. air, lights)
- Loadshape C16 - Indust. 3-shift (24/5) (e.g., comp. air, lights)
- Loadshape C17 - Indust. 4-shift (24/7) (e.g., comp. air, lights)
- Loadshape C18 - Industrial Indoor Lighting
- Loadshape C19 - Industrial Outdoor Lighting
- Loadshape C20 - Commercial Outdoor Lighting

COINCIDENCE FACTOR

The summer peak coincidence factor for this measure is dependent on location.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = KW_{\text{Controlled}} * \text{Hours} * \text{ESF} * \text{WHF}_e$$

Summer Coincident Peak Demand Savings

$$\Delta kW = KW_{\text{controlled}} * \text{WHF}_d * (\text{CF}_{\text{baseline}} - \text{CF}_{\text{os}})$$

Where:

$KW_{\text{Controlled}}$ = Total lighting load connected to the control in kilowatts. Savings is per control. The total connected load per control should be collected from the customer or the default values presented below used;

Lighting Control Type	Default kw controlled
Wall mounted occupancy sensor	0.350 ³⁶⁶
Remote mounted occupancy sensor	0.587 ³⁶⁷
Fixture mounted sensor	0.073 ³⁶⁸

³⁶⁶ Goldberg et al, State of Wisconsin Public Service Commission of Wisconsin, Focus on Energy Evaluation, Business Programs, Incremental Cost Study, KEMA, October 28, 2009

³⁶⁷ Ibid

Hours = total operating hours of the controlled lighting circuit before the lighting controls are installed. This number should be collected from the customer. Average hours of use per year are provided in the Reference Table in Section 6.5, Fixture annual operating hours, for each building type if customer specific information is not collected. If unknown building type, use the Miscellaneous value.

ESF = Energy Savings factor (represents the percentage reduction to the operating Hours from the non-controlled baseline lighting system).

Lighting Control Type	Energy Savings Factor ³⁶⁹
Wall or Ceiling-Mounted Occupancy Sensors	41% or custom
Fixture Mounted Occupancy Sensors	30% or custom

WHF_e = Waste heat factor for energy to account for cooling energy savings from efficient lighting is provided in the Reference Table in Section 6.5 for each building type. If building is un-cooled, the value is 1.0.

WHF_d = Waste Heat Factor for Demand to account for cooling savings from efficient lighting in cooled buildings is provided in the Reference Table in Section 6.5. If the building is un-cooled WHF_d is 1.

CF_{baseline} = Baseline Summer Peak Coincidence Factor for the lighting system without Occupancy Sensors installed selected from the Reference Table in Section 6.5 for each building type. If the building type is unknown, use the Miscellaneous value of 0.66

CF_{os} = Retrofit Summer Peak Coincidence Factor the lighting system with Occupancy Sensors installed is 0.15 regardless of building type.³⁷⁰

NATURAL GAS ENERGY SAVINGS

$$\Delta\text{therms} = \Delta\text{KWH}^* - \text{IFTherms}$$

Where:

IFTherms = Lighting-HVAC Integration Factor for gas heating impacts; this factor represents the increased gas space heating requirements due to the reduction of waste heat rejected by the efficient lighting and provided in the Reference Table in Section 6.5 by building type.

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

³⁶⁸ Efficiency Vermont TRM 2/19/2010

³⁶⁹ Kuiken, Tammy et al, State of Wisconsin/Public Service Commission of Wisconsin, Focus on Energy Evaluation, Business Programs, Deemed Savings Manual V1.0, PA Consulting Group and KEMA, March 22, 2010 pp 4-192-194.

³⁷⁰ 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.

MEASURE CODE: CI-LTG-OSLC-V01-120601

4.5.6 Lighting Power Density

DESCRIPTION

This measure relates to installation of efficient lighting systems in new construction or substantial renovation of commercial buildings excluding low rise (three stories or less) residential buildings. Substantial renovation is when two or more building systems are renovated, such as shell and heating, heating and lighting, etc. State Energy Code specifies a lighting power density level by building type for both the interior and the exterior. Either the Building Area Method as defined in IECC 2009 or the Space-by-Space Method defined in ASHAE 90.1 2007 can be used for calculating the Interior Lighting Power Density³⁷¹. The measure consists of a design that is more efficient (has a lower lighting power density in watts/square foot) than code requires. The IECC 2009, which is adopted in Illinois, applies to both new construction and renovation.

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

DEFINITION OF EFFICIENT EQUIPMENT

In order for this characterization to apply, the lighting system must be more efficient than the baseline Energy Code lighting power density in watts/square foot for either the interior space or exterior space.

DEFINITION OF BASELINE EQUIPMENT

The baseline is assumed to be a lighting power density that meets IECC 2009, the State of Illinois Energy Code by building type or ASHRAE 90.1 2007 Space – by- Space requirements.

DEEMED CALCULATION FOR THIS MEASURE

$$\text{Annual kWh Savings} = \Delta\text{kWh} = (\text{WSFbase} - \text{WSFeffic}) / 1000 * \text{SF} * \text{Hours} * \text{WHF}_e$$

$$\text{Summer Coincident Peak kW Savings} = \Delta\text{kW} = (\text{WSFbase} - \text{WSFeffic}) / 1000 * \text{SF} * \text{CF} * \text{WHF}_d$$

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 15 years³⁷²

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.

DEEMED O&M COST ADJUSTMENTS

N/A

³⁷¹ 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).

³⁷² Measure Life Report, Residential and Commercial/Industrial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007.

LOADSHAPE

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- Loadshape C07 - Grocery/Conv. Store Indoor Lighting
- Loadshape C08 - Hospital Indoor Lighting
- Loadshape C09 - Office Indoor Lighting
- Loadshape C10 - Restaurant Indoor Lighting
- Loadshape C11 - Retail Indoor Lighting
- Loadshape C12 - Warehouse Indoor Lighting
- Loadshape C13 - K-12 School Indoor Lighting
- Loadshape C14 - Indust. 1-shift (8/5) (e.g., comp. air, lights)
- Loadshape C15 - Indust. 2-shift (16/5) (e.g., comp. air, lights)
- Loadshape C16 - Indust. 3-shift (24/5) (e.g., comp. air, lights)
- Loadshape C17 - Indust. 4-shift (24/7) (e.g., comp. air, lights)
- Loadshape C18 - Industrial Indoor Lighting
- Loadshape C19 - Industrial Outdoor Lighting
- Loadshape C20 - Commercial Outdoor Lighting

COINCIDENCE FACTOR

The summer peak coincidence factor for this measure is dependent on the building type.

Algorithm

CALCULATION OF SAVINGS

ENERGY SAVINGS

$$\Delta kWh = (WSF_{base} - WSF_{effic}) / 1000 * SF * Hours * WHF_e$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = (WSF_{base} - WSF_{effic}) / 1000 * SF * CF * WHF_d$$

Where:

WSF_{base} = Baseline lighting watts per square foot or linear foot as determined by building or space type. Whole building analysis values are presented in the Reference Tables below.³⁷³

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 6.5, Fixture annual

³⁷³ IECC 2009 - Reference Code documentation for additional information.

operating hours.

WHF_e = Waste Heat Factor for Energy to account for cooling savings from efficient lighting is as provided in the Reference Table in Section 6.5 by building type. If building is not cooled WHF_e is 1.

WHF_d = Waste Heat Factor for Demand to account for cooling savings from efficient lighting in cooled buildings is as provided in the Reference Table in Section 6.5 by building type. If building is not cooled WHF_d is 1.

CF = Summer Peak Coincidence Factor for measure is as provided in the Reference Table in Section 5.4 by building type. If the building type is unknown, use the Miscellaneous value of 0.66.

NATURAL GAS ENERGY SAVINGS

$$\Delta \text{therms} = \Delta \text{KWH}^* - \text{IFTherms}$$

Where:

IFTherms = Lighting-HVAC Integration Factor for gas heating impacts; this factor represents the increased gas space heating requirements due to the reduction of waste heat rejected by the efficient lighting. This value is provided in the Reference Table in Section 6.5 by building type.

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

REFERENCE TABLES

Lighting Power Density Values from IECC 2009 for Interior Commercial New Construction and Substantial Renovation

Building Area Type ³⁷⁴	Lighting Power Density (w/ft ²)
Automotive Facility	0.9
Convention Center	1.2
Court House	1.2
Dining: Bar Lounge/Leisure	1.3
Dining: Cafeteria/Fast Food	1.4
Dining: Family	1.6
Dormitory	1.0
Exercise Center	1.0
Gymnasium	1.1
Healthcare – clinic	1.0

³⁷⁴ IECC 2009 in cases where both a general building area type and a more specific building area type are listed, the more specific building area type shall apply.

Building Area Type ³⁷⁴	Lighting Power Density (w/ft ²)
Hospital	1.2
Hotel	1.0
Library	1.3
Manufacturing Facility	1.3
Motel	1.0
Motion Picture Theater	1.2
Multifamily	0.7
Museum	1.1
Office	1.0
Parking Garage	0.3
Penitentiary	1.0
Performing Arts Theater	1.6
Police/Fire Station	1.0
Post Office	1.1
Religious Building	1.3
Retail ³⁷⁵	1.5
School/University	1.2
Sports Arena	1.1
Town Hall	1.1
Transportation	1.0
Warehouse	0.8
Workshop	1.4

REFERENCE TABLES

The exterior lighting design will be based on the building location and the applicable “Lighting Zone” as defined in IECC 2009 Table 505.6.2(1) which follows.

³⁷⁵ Where lighting equipment is specified to be installed to highlight specific merchandise in addition to lighting equipment specified for general lighting and is switched or dimmed on circuits different from the circuits for general lighting, the small of the actual wattage of the lighting equipment installed specifically for merchandise, or additional lighting power as determined below shall be added to the interior lighting power determined in accordance with this line item.

**TABLE 505.6.2(1)
EXTERIOR LIGHTING ZONES**

LIGHTING ZONE	DESCRIPTION
1	Developed areas of national parks, state parks, forest land, and rural areas
2	Areas predominantly consisting of residential zoning, neighborhood business districts, light industrial with limited nighttime use and residential mixed use areas
3	All other areas
4	High-activity commercial districts in major metropolitan areas as designated by the local land use planning authority

The lighting power density savings will be based on reductions below the allowable design levels as specified in IECC 2009 Table 505.6.2(2) which follows.

**TABLE 505.6.2(2)
INDIVIDUAL LIGHTING POWER ALLOWANCES FOR BUILDING EXTERIORS**

	Zone 1	Zone 2	Zone 3	Zone 4	
Base Site Allowance (Base allowance may be used in tradable or nontradable surfaces.)	500 W	600 W	750 W	1300 W	
Tradable Surfaces (Lighting power densities for uncovered parking areas, building grounds, building entrances and exits, canopies and overhangs and outdoor sales areas may be traded.)	Uncovered Parking Areas				
	Parking areas and drives	0.04 W/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

MEASURE CODE: CI-LTG-LPDE-V01-120601

4.5.7 LED Traffic and Pedestrian Signals

DESCRIPTION

Traffic and pedestrian signals are retrofitted to be illuminated with light emitting diodes (LED) instead of incandescent lamps. Incentive applies for the replacement or retrofit of existing incandescent traffic signals with new LED traffic and pedestrian signal lamps. Each lamp can have no more than a maximum LED module wattage of 25. Incentives are not available for spare lights. Lights must be hardwired and single lamp replacements are not eligible, with the exception of pedestrian hand signals. Eligible lamps must meet the Energy Star Traffic Signal Specification and the Institute for Transportation Engineers specification for traffic signals.

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

DEFINITION OF EFFICIENT EQUIPMENT

Refer to the Table titled 'Traffic Signals Technology Equivalencies' for efficient technology wattage and savings assumptions.

DEFINITION OF BASELINE EQUIPMENT

Refer to the Table titled 'Traffic Signals Technology Equivalencies' for baseline efficiencies and savings assumptions.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The assumed lifetime of an LED traffic signal is 100,000 hours (manufacturer's estimate), capped at 10 years.³⁷⁶ The life in years is calculated by dividing 100,000 hrs by the annual operating hours for the particular signal type.

DEEMED MEASURE COST

The actual measure installation cost should be used (including material and labor).

DEEMED O&M COST ADJUSTMENTS³⁷⁷

Because LEDs last much longer than incandescent bulbs, LEDs offer operation and maintenance (O&M) savings over the life of the lamps for avoided replacement lamps and the labor to install them. The following assumptions are used to calculate the O&M savings:

Incandescent bulb cost: \$3 per bulb

Labor cost to replace incandescent lamp: \$60 per signal

Life of incandescent bulb: 8000 hours

³⁷⁶ ACEEE, (1998) A Market Transformation Opportunity Assessment for LED Traffic Signals, <http://www.cee1.org/gov/led/led-ace3/ace3led.pdf>

³⁷⁷ Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010

LOADSHAPE

- Loadshape C24 - Traffic Signal - Red Balls, always changing or flashing
- Loadshape C25 - Traffic Signal - Red Balls, changing day, off night
- Loadshape C26 - Traffic Signal - Green Balls, always changing
- Loadshape C27 - Traffic Signal - Green Balls, changing day, off night
- Loadshape C28 - Traffic Signal - Red Arrows
- Loadshape C29 - Traffic Signal - Green Arrows
- Loadshape C30 - Traffic Signal - Flashing Yellows
- Loadshape C31 - Traffic Signal - “Hand” Don’t Walk Signal
- Loadshape C32 - Traffic Signal - “Man” Walk Signal
- Loadshape C33 - Traffic Signal - Bi-Modal Walk/Don’t Walk

COINCIDENCE FACTOR³⁷⁸

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

³⁷⁸ Ibid

- = 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:

$$\begin{aligned} \Delta kWh &= ((69 - 7) \times 4818) / 1000 \\ &= 299 \text{ kWh} \end{aligned}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = (W_{base} - W_{eff}) \times CF / 1000$$

Where:

- W_{base} = The connected load of the baseline equipment
- = see Table 'Traffic Signals Technology Equivalencies'
- W_{eff} = The connected load of the efficient equipment
- = see Table 'Traffic Signals Technology Equivalencies'
- CF = Summer Peak Coincidence Factor for measure

EXAMPLE

For example, an 8 inch red, round signal:

$$\begin{aligned} \Delta kW &= ((69 - 7) \times 0.55) / 1000 \\ &= 0.0341 \text{ kW} \end{aligned}$$

NATURAL GAS ENERGY SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

REFERENCE TABLES

Traffic Signals Technology Equivalencies³⁷⁹

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 ³⁸⁰	8" Red	LED	Incandescent	4380	7	69	272
Flashing Signal	12" Red	LED	Incandescent	4380	6	150	631
Flashing Signal	8" Yellow	LED	Incandescent	4380	10	69	258
Flashing Signal	12" Yellow	LED	Incandescent	4380	13	150	600
Round Signals	8" Yellow	LED	Incandescent	175	10	69	10
Round Signals	12" Yellow	LED	Incandescent	175	13	150	24
Round Signals	8" Green	LED	Incandescent	3767	9	69	266
Round Signals	12" Green	LED	Incandescent	3767	12	150	520
Turn Arrows	8" Yellow	LED	Incandescent	701	7	116	76
Turn Arrows	12" Yellow	LED	Incandescent	701	9	116	75
Turn Arrows	8" Green	LED	Incandescent	701	7	116	76
Turn Arrows	12" Green	LED	Incandescent	701	7	116	76
Pedestrian Sign	12" Hand/Man	LED	Incandescent	8760	8	116	946

Reference specifications for above traffic signal wattages are from the following manufacturers:

1. 8" Incandescent traffic signal bulb: General Electric Traffic Signal Model 17325-69A21/TS
2. 12" Incandescent traffic signal bulb: General Electric Signal Model 35327-150PAR46/TS
3. Incandescent Arrows & Hand/Man Pedestrian Signs: General Electric Traffic Signal Model 19010-116A21/TS
4. 8" and 12" LED traffic signals: Leotek Models TSL-ES08 and TSL-ES12
5. 8" LED Yellow Arrow: General Electric Model DR4-YTA2-01A
6. 8" LED Green Arrow: General Electric Model DR4-GCA2-01A

³⁷⁹ 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

³⁸⁰ Technical Reference Manual for Ohio, August 6, 2010

7. 12" LED Yellow Arrow: Dialight Model 431-3334-001X
8. 12: LED Green Arrow: Dialight Model 432-2324-001X
9. LED Hand/Man Pedestrian Sign: Dialight 430-6450-001X

MEASURE CODE: CI-LTG-LEDT-V01-120601

4.6 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.³⁸¹

DEEMED MEASURE COST

The deem measure cost is \$156.82 for a walk-in cooler or freezer.³⁸²

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape C22 - Commercial Refrigeration

COINCIDENCE FACTOR

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

³⁸¹ Source: DEER 2008

³⁸² Ibid.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

Savings calculations are based on values from through PG&E's Workpaper PGECOREF110.1 – Auto-Closers for Main Cooler or Freezer Doors. Savings are averaged across all California climate zones and vintages³⁸³.

Annual Savings	kWh
Walk in Cooler	943 kWh
Walk in Freezer	2307 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

Annual Savings	kW
Walk in Cooler	0.137 kW
Walk in Freezer	0.309 kW

NATURAL GAS ENERGY SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-RFG-ATDC-V01-120601

³⁸³ Measure savings from ComEd TRM developed by KEMA. June 1, 2010

4.6.2 Beverage and Snack Machine Controls

DESCRIPTION

This measure relates to the installation of new controls on refrigerated beverage vending machines, non-refrigerated snack vending machines, and glass front refrigerated coolers. Controls can significantly reduce the energy consumption of vending machine and refrigeration systems. Qualifying controls must power down these systems during periods of inactivity but, in the case of refrigerated machines, must always maintain a cool product that meets customer expectations. This measure relates to the installation of a new control on a new or existing unit. This measure should **not** be applied to ENERGY STAR qualified vending machines, as they already have built-in controls.

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

DEFINITION OF EFFICIENT EQUIPMENT

In order for this characterization to apply, the efficient equipment is assumed to be a standard efficiency refrigerated beverage vending machine, non-refrigerated snack vending machine, or glass front refrigerated cooler with a control system capable of powering down lighting and refrigeration systems during periods of inactivity.

DEFINITION OF BASELINE EQUIPMENT

In order for this characterization to apply, the baseline equipment is assumed to be a standard efficiency refrigerated beverage vending machine, non-refrigerated snack vending machine, or glass front refrigerated cooler without a control system capable of powering down lighting and refrigeration systems during periods of inactivity.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 5 years³⁸⁴.

DEEMED MEASURE COST

The actual measure installation cost should be used (including material and labor), but the following can be assumed for analysis purposes³⁸⁵:

Refrigerated Vending Machine and Glass Front Cooler: \$180.00

Non-Refrigerated Vending Machine: \$80.00

DEEMED O&M COST ADJUSTMENTS

N/A

³⁸⁴ Measure Life Study, prepared for the Massachusetts Joint Utilities, Energy & Resource Solutions, November 2005.

³⁸⁵ ComEd workpapers, 8—15-11.pdf

LOADSHAPE

Loadshape C52 - Beverage and Snack Machine Controls

COINCIDENCE FACTOR

The summer peak coincidence factor for this measure is assumed to be 0³⁸⁶.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = WATTSbase / 1000 * HOURS * ESF$$

Where:

WATTSbase = connected W of the controlled equipment; see table below for default values by connected equipment type:

Equipment Type	WATTSbase ³⁸⁷
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) ³⁸⁸
Refrigerated Beverage Vending Machines	46%
Non-Refrigerated Snack Vending Machines	46%
Glass Front Refrigerated Coolers	30%

³⁸⁶ Assumed that the peak period is coincident with periods of high traffic diminishing the demand reduction potential of occupancy based controls.

³⁸⁷ USA Technologies Energy Management Product Sheets, July 2006; cited September 2009. <http://www.usatech.com/energy_management/energy_productsheets.php>

³⁸⁸ Ibid.

EXAMPLE

For example, adding controls to a refrigerated beverage vending machine:

$$\begin{aligned}\Delta\text{kWh} &= \text{WATTS}_{\text{base}} / 1000 * \text{HOURS} * \text{ESF} \\ &= 400/1000 * 8766 * .46 = 1.6 \text{ kWh}\end{aligned}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-RFG-BEVM-V01-120601

4.6.3 Door Heater Controls for Cooler or Freezer

DESCRIPTION

By installing a control device to turn off door heaters when there is little or no risk of condensation, one can realize significant energy savings. There are two commercially available control strategies that achieve “on-off” control of door heaters based on either (1) the relative humidity of the air in the store or (2) the “conductivity” of the door (which drops when condensation appears). In the first strategy, the system activates your door heaters when the relative humidity in your store rises above a specific setpoint, and turns them off when the relative humidity falls below that setpoint. In the second strategy, the sensor activates the door heaters when the door conductivity falls below a certain setpoint, and turns them off when the conductivity rises above that setpoint.

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

DEFINITION OF EFFICIENT EQUIPMENT

In order for this characterization to apply, the efficient equipment is assumed to be a door heater control on a commercial glass door cooler or refrigerator utilizing humidity or conductivity control.

DEFINITION OF BASELINE EQUIPMENT

In order for this characterization to apply, the baseline condition is assumed to be a commercial glass door cooler or refrigerator with a standard heated door with no controls installed.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 12 years³⁸⁹.

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 \$200³⁹⁰.

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape C51 - Door Heater Control

³⁸⁹ 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, “Effective/Remaining Useful Life Values”, California Public Utilities Commission, December 16, 2008.

³⁹⁰ Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010

COINCIDENCE FACTOR³⁹¹

The summer peak coincidence factor for this measure is assumed to be 0%³⁹².

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta \text{kWH} = \text{kWbase} * \text{NUMdoors} * \text{ESF} * \text{BF} * 8760$$

Where:

kWbase^{393} = 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^{394} = 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^{395} = Bonus Factor; represents the increased savings due to reduction in cooling load inside the cases, and the increase in cooling load in the building space to cool the additional heat generated by the door heaters.

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³⁹¹ Source partial list from DEER 2008

³⁹² 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.

³⁹³ 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.

³⁹⁴ 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.

³⁹⁵ Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010

³⁹⁶ Energy Efficiency Supermarket Refrigeration, Wisconsin Electric Power Company, July 23, 1993

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 preparation rooms	1.15

8760 = annual hours of operation

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

Deemed O&M Cost Adjustment Calculation

N/A

MEASURE CODE: CI-RFG-DHCT-V01-120601

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 years³⁹⁷

DEEMED MEASURE COST

The measure cost is assumed to be \$50 for a walk in cooler and walk in freezer.³⁹⁸

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape C22 - Commercial Refrigeration

COINCIDENCE FACTOR

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

Algorithm

CALCULATION OF SAVINGS³⁹⁹

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

³⁹⁷ DEER

³⁹⁸ Act on Energy Commercial Technical Reference Manual No. 2010-4

³⁹⁹ "Efficient Evaporator Fan Motors (Shaded Pole to ECM)," Workpaper WPCNRRN0011. Southern California Edison Company. 2007.

Illinois Statewide Technical Reference Manual - 4.6.4 Electronically Commutated Motors (ECM) for Walk-in and Reach-in Coolers / Freezers

and grocery stores. We have used only PG&E climate zones in calculating our averages and have taken out the drier, warmer climates of southern California. SCE’s savings approach calculates refrigeration demand, by taking into consideration temperature, compressor efficiency, and various loads involved for both walk-in and reach-in refrigerators. Details on cooling load calculations, including refrigeration conditions, can be found in the SCE workpaper. The baseline for this measure assumes that the refrigeration unit has a shaded-pole motor. The following tables are values calculated within the SCE workpaper.

Table 156 SCE Restaurant Savings Walk-In

SCE Workpaper Values	Restaurant			
	Cooler		Freezer	
	Northern California Climate Zones	kWh Savings Per Motor	Peak kW Savings Per Motor	kWh Savings Per Motor
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

Illinois Statewide Technical Reference Manual - 4.6.4 Electronically Commutated Motors (ECM) for Walk-in and Reach-in Coolers / Freezers

Table 157: SCE Grocery Savings Walk-In

SCE Workpaper Values Northern California Climate Zones	Grocery			
	Cooler		Freezer	
	kWh Savings Per Motor	Peak kW Savings Per Motor	kWh Savings Per Motor	Peak kW Savings Per Motor
1	318	0.0284	438	0.03
2	252	0.0534	263	0.064
3	364	0.0486	552	0.056
4	365	0.048	553	0.055
5	349	0.0452	516	0.051
11	410	0.0601	656	0.074
12	398	0.0566	631	0.069
13	406	0.0574	649	0.07
16	354	0.0486	528	0.056
Average	357	0.0496	532	0.058

Table 158: SCE Grocery Savings Reach-In

SCE Workpaper Values Northern California Climate Zones	Grocery			
	Cooler		Freezer	
	kWh Savings Per Motor	Peak kW Savings Per Motor	kWh Savings Per Motor	Peak kW Savings Per Motor
1	306	0.031	362	0.031
2	269	0.033	273	0.035
3	331	0.032	421	0.034
4	332	0.032	422	0.034
5	323	0.032	402	0.033
11	357	0.034	476	0.037
12	350	0.034	462	0.036
13	355	0.034	472	0.037
16	325	0.032	409	0.034
Average	328	0.033	411	0.035

Savings values in the following table are an average of walk-in cooler (80 percent) and freezer (20 percent) applications. The workpapers for the 2006-2008 program years include this distribution of coolers and freezers in their refrigeration measure savings analyses.

ELECTRIC ENERGY SAVINGS

The following table provides the kWh savings.

Building type	kWh Savings/ft
Restaurant	411
Grocery	392
Average	401

SUMMER COINCIDENT PEAK DEMAND SAVINGS

The following table provides the kW savings

Building Type	Peak kW Savings/motor
Restaurant	0.033
Grocery	0.051
Average	0.042

NATURAL GAS ENERGY SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-RFG-ECMF-V01-120601

4.6.5 ENERGY STAR Refrigerated Beverage Vending Machine

DESCRIPTION

ENERGY STAR qualified new and rebuilt vending machines incorporate more efficient compressors, fan motors, and lighting systems as well as low power mode option that allows the machine to be placed in low-energy lighting and/or low-energy refrigeration states during times of inactivity.

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

DEFINITION OF EFFICIENT EQUIPMENT

The refrigerated vending machine can be new or rebuilt but must meet the ENERGY STAR specifications which include low power mode.

DEFINITION OF BASELINE EQUIPMENT

The baseline vending machine is a standard unit

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The deemed lifetime of this measure is 14 years⁴⁰⁰

DEEMED MEASURE COST

The incremental cost of this measure is \$500⁴⁰¹

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape C22 - Commercial Refrigeration

COINCIDENCE FACTOR

It is assumed that controls are only effective during off-peak hours and so have no peak-kW savings.

Algorithm

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.

⁴⁰⁰ ENERGY STAR

⁴⁰¹ ENERGY STAR

ELECTRIC ENERGY SAVINGS

ENERGY STAR Vending Machine Savings⁴⁰²

Vending Machine Capacity (cans)	kWh Savings Per Machine w/o software	kWh Savings Per Machine w/ software
<500	1,099	1,659
500	1,754	2,231
699	1,242	1,751
799	1,741	2,283
800+	713	1,288
Average	1,310	1,842

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-RFG-ESVE-V01-120601

⁴⁰² Savings from Vending Machine Calculator:
http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=VMC

4.6.6 Evaporator Fan Control

DESCRIPTION

This measure is for the installation of controls in existing medium temperature walk-in coolers. The controller reduces airflow of the evaporator fans when there is no refrigerant flow.

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

DEFINITION OF EFFICIENT EQUIPMENT

The measure must control a minimum of 1/20 HP where fans operate continuously at full speed. The measure also must reduce fan motor power by at least 75% during the off cycle. This measure is not applicable if any of the following conditions apply:

- The compressor runs all the time with high duty cycle
- The evaporator fan does not run at full speed all the time
- The evaporator fan motor runs on poly-phase power
- Evaporator does not use off-cycle or time-off defrost.

DEFINITION OF BASELINE EQUIPMENT

In order for this characterization to apply, the baseline measure is assumed to be a cooler with continuously running evaporator fan. An ECM can also be updated with controls.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 16 years⁴⁰³

DEEMED MEASURE COST

The measure cost is assumed to be \$291⁴⁰⁴

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape C46 - Evaporator Fan Control

COINCIDENCE FACTOR

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

⁴⁰³ Source: DEER

⁴⁰⁴ Source: DEER

Algorithm

CALCULATION OF SAVINGS

Savings for this measure were obtained from the DEER database and are summarized in the following table. The baseline is assumed to be evaporator fans that run continuously with either a permanent split capacitor or shaded-pole motors. In the energy-efficient case the fan is still assumed to operate even with the evaporator inactive⁴⁰⁵.

ELECTRIC ENERGY SAVINGS

DEER provides savings numbers for building vintages and grocery only. The numbers above are averages of these vintages. We are assuming that this measure will be applicable for all building types

The following table provides the kWh savings

Northern California Climate Zones	kWh Savings Per Motor
1	480
2	476
3	479
4	475
5	477
11	476
12	476
13	476
16	483
Average	478

SUMMER COINCIDENT PEAK DEMAND SAVINGS

The following table provides the kW savings

Northern California Climate Zones	Peak kW Savings Per Motor
1	0.057
2	0.064
3	0.062
4	0.061
5	0.056
11	0.058
12	0.065
13	0.061
16	0.061
Average	0.06

NATURAL GAS ENERGY SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-RFG-EVPF-V01-120601

4.6.7 Strip Curtain for Walk-in Coolers and Freezers

DESCRIPTION

This commercial measure pertains to the installation of infiltration barriers (strip curtains) on walk-in coolers or freezers. Strip curtains impede heat transfer from adjacent warm and humid spaces into walk-ins when the main door is opened, thereby reducing the cooling load. As a result, compressor run time and energy consumption are reduced. The engineering assumption is that the walk-in door is open 72 minutes per day every day, and the strip curtain covers the entire door frame.

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

DEFINITION OF EFFICIENT EQUIPMENT

The efficient equipment is a polyethylene strip curtain added to a walk-in cooler or freezer

DEFINITION OF BASELINE EQUIPMENT

The baseline assumption is a walk-in cooler or freezer that previously had either no strip curtain installed or an old, ineffective strip curtain installed

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 6 years⁴⁰⁶.

DEEMED MEASURE COST

The incremental capital cost for this measure is \$10.22 per square foot of door opening (includes material and labor)⁴⁰⁷.

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape C22 - Commercial Refrigeration

COINCIDENCE FACTOR

The summer peak coincidence factor for this measure is 100%⁴⁰⁸.

⁴⁰⁶ 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.

⁴⁰⁷ 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Cost Values and Summary Documentation", California Public Utilities Commission, December 16, 2008

⁴⁰⁸ The summer coincident peak demand reduction is assumed as the total annual savings divided by the total number of hours per year, effectively assuming the average demand reduction is realized during the peak period. This is a reasonable assumption for refrigeration savings.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS⁴⁰⁹

$$\begin{aligned}\Delta\text{kWh} &= 2,974 \text{ per freezer with curtains installed} \\ &= 422 \text{ per cooler with curtains installed}\end{aligned}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\begin{aligned}\Delta\text{kW} &= \Delta\text{kWh} / 8760 * \text{CF} \\ &= 0.35 \text{ for freezers} \\ &= 0.05 \text{ for coolers}\end{aligned}$$

Where:

$$\begin{aligned}8766 &= \text{hours per year} \\ \text{CF} &= \text{Summer Peak Coincidence Factor for the measure} \\ &= 1.0\end{aligned}$$

NATURAL GAS ENERGY SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-RFG-CRTN-V01-120601

⁴⁰⁹ Values based on analysis prepared by ADM for FirstEnergy utilities in Pennsylvania, provided via personal communication with Diane Rapp of FirstEnergy on June 4, 2010. Based on a review of deemed savings assumptions and methodologies from Oregon and California, the values from Pennsylvania appear reasonable and are the most applicable.

4.7 Miscellaneous End Use

4.7.1 VSD Air Compressor

DESCRIPTION

This measure relates to the installation of an air compressor with a variable frequency drive, load/no load controls or variable displacement control. The baseline compressors defined choke off the inlet air to modulate the compressor output, which is not efficient. Efficient compressors use a variable speed drive on the motor to match output to the load. Savings are calculated using representative baseline and efficient demand numbers for compressor capacities according to the facility's load shape, and the number of hours the compressor runs at that capacity. Demand curves are as per DOE data for a Variable Speed compressor versus a Modulating compressor. This measure applies only to an individual compressor ≤ 40 hp

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

DEFINITION OF EFFICIENT EQUIPMENT

The high efficiency equipment is a compressor ≤ 40 hp with variable speed control.

DEFINITION OF BASELINE EQUIPMENT

The baseline equipment is a modulating compressor with blow down ≤ 40 hp

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

10 years.

DEEMED MEASURE COST

$$\text{IncrementalCost (\$)} = (127 \times \text{hp}_{\text{compressor}}) + 1446$$

Where:

127 and 1446⁴¹⁰ = compressor motor nominal hp to incremental cost conversion factor and offset

$\text{hp}_{\text{compressor}}$ = compressor motor nominal

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape C35 - Industrial Process

⁴¹⁰ 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.

COINCIDENCE FACTOR

The coincidence factor equals 0.95

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = 0.9 \times hp_{\text{compressor}} \times \text{HOURS} \times (CF_b - CF_e)$$

Where:

ΔkWh = gross customer annual kWh savings for the measure

$hp_{\text{compressor}}$ = compressor motor nominal hp

0.9^{411} = 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 factor⁴¹²

=0.890

CF_e = efficient compressor⁴¹³

⁴¹¹ 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".

⁴¹² 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).

=0.705

EXAMPLE

For example a VFD compressor with 10 HP operating in a 1 shift facility would save

$$\begin{aligned}\Delta\text{kWh} &= 0.9 \times 10 \times 1976 \times (0.890 - 0.705) \\ &= 3290 \text{ kWh}\end{aligned}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

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

EXAMPLE

For example a VFD compressor with 10 HP operating in a 1 shift facility would save

$$\begin{aligned}\Delta\text{kW} &= 3290/1976 * .95 \\ &= 1.58 \text{ kW}\end{aligned}$$

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

⁴¹³ Ibid.

5 Residential Measures

5.1 Appliances End Use

5.1.1 ENERGY STAR Air Purifier/Cleaner

DESCRIPTION

An air purifier (cleaner) meeting the efficiency specifications of ENERGY STAR is purchased and installed in place of a model meeting the current federal standard.

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

DEFINITION OF EFFICIENT EQUIPMENT

The efficient equipment is defined as an air purifier meeting the efficiency specifications of ENERGY STAR as provided below.

- Must produce a minimum 50 Clean Air Delivery Rate (CADR) for Dust⁴¹⁴ 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 unit⁴¹⁵.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure life is assumed to be 9 years⁴¹⁶.

DEEMED MEASURE COST

The incremental cost for this measure is \$70.⁴¹⁷

⁴¹⁴ Measured according to the latest ANSI/AHAM AC-1 (AC-1) Standard

⁴¹⁵ As defined as the average of non-ENERGY STAR products found in EPA research, 2008, ENERGY STAR Qualified Room Air Cleaner Calculator, http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorRoomAirCleaner.xls?8ed7-275b.

⁴¹⁶ ENERGY STAR Qualified Room Air Cleaner Calculator, http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorRoomAirCleaner.xls?8ed7-275b.

⁴¹⁷ Ibid

DEEMED O&M COST ADJUSTMENTS

There are no operation and maintenance cost adjustments for this measure.⁴¹⁸

LOADSHAPE

Loadshape C53 - Flat

COINCIDENCE FACTOR

The summer peak coincidence factor for this measure is assumed to be 100 % (the unit is assumed to be always on).

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = kWh_{BASE} - kWh_{ESTAR}$$

Where:

kWh_{BASE} = Baseline kWh consumption per year⁴¹⁹

= see table below

kWh_{ESTAR} = ENERGY STAR kWh consumption per year⁴²⁰

= see table below

Clean Air Delivery Rate	Baseline Unit Energy Consumption (kWh/year)	ENERGY STAR Unit Energy Consumption (kWh/year)	ΔkWh
CADR 51-100	596	329	268
CADR 101-150	1,072	548	525
CADR 151-200	1,480	767	714
CADR 201-250	1,887	986	902
CADR Over 250	1,641	1205	437

⁴¹⁸ 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.

⁴¹⁹ ENERGY STAR Qualified Room Air Cleaner Calculator, http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorRoomAirCleaner.xls?8ed7-275b

⁴²⁰ Ibid.

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = \Delta kWh / \text{Hours} * CF$$

Where:

ΔkWh = Gross customer annual kWh savings for the measure

Hours = Average hours of use per year

= 8766 hours⁴²¹

CF = Summer Peak Coincidence Factor for measure

= 1.0

Clean Air Delivery Rate	ΔkW
CADR 51-100	0.031
CADR 101-150	0.060
CADR 151-200	0.081
CADR 201-250	0.103
CADR Over 250	0.050

NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

⁴²¹ Consistent with ENERGY STAR Qualified Room Air Cleaner Calculator.

5.1.2 ENERGY STAR and CEE Tier 2 and 3 Clothes Washers

DESCRIPTION

This measure relates to the installation of a clothes washer meeting the Energy Star, or CEE Tier 2 or Tier 3 minimum qualifications. Note if the DHW and dryer fuels of the installations are unknown (for example through a retail program) savings should be based on a weighted blend using RECS data (the resultant values (kWh, therms and gallons of water) are provided). The algorithms can also be used to calculate site specific savings where DHW and dryer fuels are known.

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

DEFINITION OF EFFICIENT EQUIPMENT

Clothes washer must meet the ENERGY STAR or CEE Tier 2 or 3 minimum qualifications, as required by the program.

DEFINITION OF BASELINE EQUIPMENT

The baseline condition is a clothes washer meeting the minimum federal baseline.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 14 years⁴²².

DEEMED MEASURE COST

The incremental cost for an Energy Star unit is assumed to be \$210, for a CEE Tier 2 unit is \$360 and for a CEE Tier 3 unit it is \$458⁴²³.

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape R01 - Residential Clothes Washer

COINCIDENCE FACTOR

The coincidence factor for this measure is 3.8%⁴²⁴.

⁴²² 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

⁴²³ Cost estimates are based on Navigant analysis for the Department of Energy (see CW Analysis.xls). This analysis looked at incremental cost and shipment data from manufacturers and the Association of Home Appliance Manufacturers and attempts to find the costs associated only with the efficiency improvements.

⁴²⁴ Calculated from Itron eShapes, 8760 hourly data by end use for Missouri, as provided by Ameren.

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"*⁴²⁵.

The hot water and dryer savings calculated here assumes electric DHW and Dryer (this will be separated in Step 2).

$$\text{MEFsavings}^{426} = \text{Capacity} * (1/\text{MEFbase} - 1/\text{MEFeff}) * \text{Ncycles}$$

Where

- Capacity = Clothes Washer capacity (cubic feet)
 = Actual. If capacity is unknown assume 3.5 cubic feet⁴²⁷
- MEFbase = Modified Energy Factor of baseline unit
 = 1.64⁴²⁸
- MEFeff = Modified Energy Factor of efficient unit
 = Actual. If unknown assume average values provided below.
- Ncycles = Number of Cycles per year
 = 295⁴²⁹

MEFsavings is provided below based on deemed values⁴³⁰:

⁴²⁵ Definition provided on the Energy star website.

⁴²⁶ Tsavings represents total kWh only when water heating and drying are 100% electric.

⁴²⁷ Based on the average clothes washer volume of all post-1/1/2007 units from the California Energy Commission (CEC) database of Clothes Washer products. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area then that should be used.

⁴²⁸ Average MEF of non-ENERGY STAR units from the California Energy Commission (CEC) database of Clothes Washer products.

⁴²⁹ 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.

Efficiency Level	MEF	MEFSavings (kWh)
Federal Standard	1.64	0.0
Energy Star	2.07	130
CEE Tier 2	2.28	177
CEE Tier 3	2.71	248

2. Break out savings calculated in Step 1 for electric DHW and electric dryer

$$\Delta kWh = [(Capacity * 1/MEF_{base} * Ncycles) * (\%CW_{base} + (\%DHW_{base} * \%Electric_DHW) + (\%Dryer_{base} * \%Electric_Dryer))] - [(Capacity * 1/MEF_{eff} * Ncycles) * (\%CW_{eff} + (\%DHW_{eff} * \%Electric_DHW) + (\%Dryer_{eff} * \%Electric_Dryer))]$$

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 ⁴³¹		
	%CW	%DHW	%Dryer
Baseline	7%	33%	59%
Non-CEE Energy Star Units	6%	31%	62%
CEE 2	8%	24%	68%
CEE 3	10%	16%	74%

%Electric_DHW = Percentage of DHW savings assumed to be electric

DHW fuel	%Electric_DHW
Electric	100%
Natural Gas	0%
Unknown	16% ⁴³²

⁴³⁰ MEF values are the average of the from the California Energy Commission (CEC) database of Clothes Washer products. See “CW Analysis.xls” for the calculation.

⁴³¹ The percentage of total energy consumption that is used for the machine, heating the hot water or by the dryer is different depending on the efficiency of the unit. Values are based on a sales weighted average of top loading and front loading units based on data from Life-Cycle Cost and Payback Period Excel-based analytical tool, available online at:

http://www1.eere.energy.gov/buildings/appliance_standards/residential/clothes_washers_support_stakeholder_negotiations.html. See “CW Analysis.xls” for the calculation.

⁴³² 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

%Electric_Dryer = Percentage of dryer savings assumed to be electric

Dryer fuel	%Electric_DHW
Electric	100%
Natural Gas	0%
Unknown	27% ⁴³³

In summation, the complete algorithm is as follows:

$$\Delta\text{kWh} = [(\text{Capacity} * 1/\text{MEFbase} * \text{Ncycles}) * (\%CW\text{base} + (\%DHW\text{base} * \%Electric_DHW) + (\%Dryer\text{base} * \%Electric_Dryer))] - [(\text{Capacity} * 1/\text{MEFeff} * \text{Ncycles}) * (\%CW\text{eff} + (\%DHW\text{eff} * \%Electric_DHW) + (\%Dryereff * \%Electric_Dryer))]$$

Using the default assumptions provided above, the prescriptive savings for each configuration are presented below:

	ΔkWh			
	Electric DHW Electric Dryer	Gas DHW Electric Dryer	Electric DHW Gas Dryer	Gas DHW Gas Dryer
Non-CEE Energy Star Units	129.6	75.7	69.8	15.9
CEE 2	177.2	76.4	112.8	12.0
CEE 3	248.0	99.0	157.3	8.3

If the DHW and dryer fuel is unknown the prescriptive kWh savings based on defaults provided above should be:

	ΔkWh
Non-CEE Energy Star Units	40.69
CEE 2	45.52
CEE 3	56.63

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta\text{kW} = \Delta\text{kWh}/\text{Hours} * \text{CF}$$

Where:

ΔkWh = Energy Savings as calculated above

Hours = Assumed Run hours of Clothes Washer

= 295 hours⁴³⁴

⁴³³ 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.

CF = Summer Peak Coincidence Factor for measure.
 = 0.038⁴³⁵

Using the default assumptions provided above, the prescriptive savings for each configuration are presented below:

	ΔkW			
	Electric DHW Electric Dryer	Gas DHW Electric Dryer	Electric DHW Gas Dryer	Gas DHW Gas Dryer
Non-CEE Energy Star Units	0.017	0.010	0.009	0.002
CEE 2	0.023	0.010	0.015	0.002
CEE 3	0.032	0.013	0.020	0.001

If the DHW and dryer fuel is unknown the prescriptive kW savings should be:

	ΔkW
Non-CEE Energy Star Units	0.005
CEE 2	0.006
CEE 3	0.007

NATURAL GAS SAVINGS

Break out savings calculated in Step 1 of electric energy savings (MEF savings) and extract Natural Gas DHW and Natural Gas dryer savings from total savings:

$$\Delta\text{Therm} = [(\text{Capacity} * 1/\text{MEFbase} * \text{Ncycles}) * ((\% \text{DHWbase} * \% \text{Natural Gas_DHW} * \text{R_eff}) + (\% \text{Dryerbase} * \% \text{Gas_Dryer}))] - [(\text{Capacity} * 1/\text{MEFeff} * \text{Ncycles}) * ((\% \text{DHWeff} * \% \text{Natural Gas_DHW} * \text{R_eff}) + (\% \text{Dryereff} * \% \text{Gas_Dryer}))] * \text{Therm_convert}$$

Where:

Therm_convert = Conversion factor from kWh to Therm
 = 0.03413

R_eff = Recovery efficiency factor
 = 1.26⁴³⁶

⁴³⁴ 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/>)

⁴³⁵ Calculated from Itron eShapes, 8760 hourly data by end use for Missouri, as provided by Ameren.

⁴³⁶ To account for the different efficiency of electric and Natural Gas hot water heaters (gas water heater: recovery

%Natural Gas_DHW = Percentage of DHW savings assumed to be Natural Gas

DHW fuel	%Natural Gas_DHW
Electric	0%
Natural Gas	100%
Unknown	84% ⁴³⁷

%Gas_Dryer = Percentage of dryer savings assumed to be Natural Gas

Dryer fuel	%Gas_Dryer
Electric	100%
Natural Gas	0%
Unknown	44% ⁴³⁸

Other factors as defined above

Using the default assumptions provided above, the prescriptive savings for each configuration are presented below:

	ΔTherms			
	Electric DHW Electric Dryer	Gas DHW Electric Dryer	Electric DHW Gas Dryer	Gas DHW Gas Dryer
Non-CEE Energy Star Units	0.00	2.32	2.04	4.36
CEE 2	0.00	4.34	2.20	6.53
CEE 3	0.00	6.41	3.10	9.50

If the DHW and dryer fuel is unknown the prescriptive Therm savings should be:

	ΔTherms
Non-CEE Energy Star Units	2.84
CEE 2	4.61
CEE 3	6.74

WATER IMPACT DESCRIPTIONS AND CALCULATION

$$\Delta\text{Water (gallons)} = (\text{Capacity} * (\text{WFbase} - \text{WFeff})) * \text{Ncycles}$$

Where

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.

⁴³⁷ 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

⁴³⁸ Ibid.

WFbase = Water Factor of baseline clothes washer
 = 7.59⁴³⁹

WFeff = Water Factor of efficient clothes washer
 = Actual. If unknown assume average values provided below.

Using the default assumptions provided above, the prescriptive water savings for each efficiency level are presented below:

Efficiency Level	WF ⁴⁴⁰	ΔWater (gallons per year)
Federal Standard	7.59	0.0
Energy Star	4.75	2,934
CEE Tier 2	4.15	3,557
CEE Tier 3	3.46	4,264

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

⁴³⁹ Average MEF of non-ENERGY STAR units.

⁴⁴⁰ Water Factor is the number of gallons required for each cubic foot of laundry. WF values are the average of the CEC data set. See "CW Analysis.xls" for the calculation.

5.1.3 ENERGY STAR Dehumidifier

DESCRIPTION

A dehumidifier meeting the minimum qualifying efficiency standard established by the current ENERGY STAR (Version 2.1 or 3.0)⁴⁴¹ is purchased and installed in a residential setting in place of a unit that meets the minimum federal standard efficiency.

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

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure, the new dehumidifier must meet the ENERGY STAR standards as defined below:

Until 9/30/2012:

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

After 10/1/2012⁴⁴²:

Capacity (pints/day)	ENERGY STAR Criteria (L/kWh)
<75	≥1.85
75 to ≤185	≥2.80

Qualifying units shall be equipped with an adjustable humidistat control or shall require a remote humidistat control to operate.

DEFINITION OF BASELINE EQUIPMENT

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

⁴⁴¹ Energy Star Version 3.0 will become effective 10/1/12

⁴⁴² http://www.energystar.gov/ia/partners/prod_development/revisions/downloads/dehumid/ES_Dehumidifiers_Final_V3.0_Eligibility_Criteria.pdf?d70c-99b0

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

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The assumed lifetime of the measure is 12 years⁴⁴³.

DEEMED MEASURE COST

The assumed incremental capital cost for this measure is \$45⁴⁴⁴.

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape R12 - Residential - Dehumidifier

COINCIDENCE FACTOR

The coincidence factor is assumed to be 37%⁴⁴⁵.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = (((Avg Capacity * 0.473) / 24) * Hours) * (1 / (L/kWh_Base) - 1 / (L/kWh_Eff))$$

Where:

⁴⁴³ ENERGY STAR Dehumidifier Calculator

http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDehumidifier.xls

⁴⁴⁴ Based on available data from the Department of Energy's Life Cycle Cost analysis spreadsheet:

http://www1.eere.energy.gov/buildings/appliance_standards/residential/docs/lcc_dehumidifier.xls

⁴⁴⁵ Assume usage is evenly distributed day vs. night, weekend vs. weekday and is used between April through the end of September (4392 possible hours). 1620 operating hours from ENERGY STAR Dehumidifier Calculator. Coincidence peak during summer peak is therefore 1620/4392 = 36.9%

- Avg Capacity = Average capacity of the unit (pints/day)
- 0.473 = Constant to convert Pints to Liters
- 24 = Constant to convert Liters/day to Liters/hour
- Hours = Run hours per year
= 1620⁴⁴⁶
- L/kWh = Liters of water per kWh consumed, as provided in tables above

Annual kWh results for each capacity class are presented below:

Until 9/30/2012 (V 2.1):

Capacity (pints/day) Range	Avg Capacity	Annual kWh		
		ENERGY STAR	Federal Standard	Savings
≤25	22.4	596	650	54
> 25 to ≤35	30	684	802	117
> 35 to ≤45	40	851	1064	213
> 45 to ≤ 54	49.5	988	1285	297
> 54 to ≤ 75	64.5	1144	1329	185
> 75 to ≤ 185	92.8	1185	1559	374

After 10/1/2012 (V 3.0):

Capacity (pints/day) Range	Avg Capacity ⁴⁴⁷	Annual kWh		
		ENERGY STAR	Federal Standard ⁴⁴⁸	Savings
<75	68	1174	1401	227
75 to ≤185	127	1448	2134	686

Summer Coincident Peak Demand Savings

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

⁴⁴⁶ ENERGY STAR Dehumidifier Calculator

http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDehumidifier.xls

⁴⁴⁷ Average capacity of current Energy Star qualified products (2/8/2012) that will qualify under V 3.0

⁴⁴⁸ Assuming 1.55 kWh/L for units of capacity <75, and 1.90 kWh/L for units of capacity 75 to ≤185

Where:

Hours = Annual operating hours⁴⁴⁹
 = 1620 hours

CF = Summer Peak Coincidence Factor for measure
 = 0.37⁴⁵⁰

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

Until 9/30/2012 (V 2.1):

Capacity Range	Annual Summer peak kW Savings
≤25	0.012
> 25 to ≤35	0.027
> 35 to ≤45	0.048
> 45 to ≤ 54	0.068
> 54 to ≤ 75	0.042
> 75 to ≤ 185	0.085

After 10/1/2012 (V 3.0):

Capacity (pints/day) Range	Annual Summer peak kW Savings
<75	0.052
75 to ≤185	0.157

NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

⁴⁴⁹ 1620 operating hours from ENERGY STAR Dehumidifier Calculator

⁴⁵⁰ Assume usage is evenly distributed day vs. night, weekend vs. weekday and is used between April through the end of September (4392 possible hours). 1620 operating hours from ENERGY STAR Dehumidifier Calculator. Coincidence peak during summer peak is therefore 1620/4392 = 36.9%

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

DEFINITION OF EFFICIENT EQUIPMENT

The efficient equipment is defined as a dishwasher meeting the efficiency specifications of ENERGY STAR (for standard and compact dishwashers). The Energy Star standard is presented in the table below:

Dishwasher Type	Maximum kWh/year	Maximum gallons/cycle
Standard	295	4.25
Compact	222	3.5

DEFINITION OF BASELINE EQUIPMENT

The Baseline reflects the minimum federal efficiency standards for dishwashers effective January 1, 2010, as presented in the table below.

Dishwasher Type	Maximum kWh/year	Maximum gallons/cycle
Standard	355	6.5
Compact	260	4.5

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The assumed lifetime of the measure is 13 years⁴⁵¹.

DEEMED MEASURE COST

The incremental cost for this measure is \$50⁴⁵².

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape R02 - Residential Dish Washer

⁴⁵¹ Koomey, Jonathan et al. (Lawrence Berkeley National Lab), Projected Regional Impacts of Appliance Efficiency Standards for the U.S. Residential Sector, February 1998.

⁴⁵² Estimate based on review of Energy Star stakeholder documents

COINCIDENCE FACTOR

The coincidence factor is assumed to be 2.6%⁴⁵³.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh^{454} = ((kWh_{BASE} - kWh_{ESTAR}) * (\%kWh_{op} + (\%kWh_{heat} * \%Electric_DHW)))$$

Where:

- kWh_{BASE} = Baseline kWh consumption per year
 - = 355 kWh for standard
 - = 260 kWh for Compact
- kWh_{ESTAR} = ENERGY STAR kWh annual consumption
 - = 295 kWh for standard
 - = 222 kWh for compact
- %kWh_{op} = Percentage of dishwasher energy consumption used for unit operation
 - = 1 - 56%⁴⁵⁵
 - = 44%
- %kWh_{heat} = Percentage of dishwasher energy consumption used for water heating
 - = 56%⁴⁵⁶
- %Electric_{DHW} = Percentage of DHW savings assumed to be electric

DHW fuel	%Electric_DHW
Electric	100%
Natural Gas	0%
Unknown	16% ⁴⁵⁷

⁴⁵³ Calculated from Itron eShapes, 8760 hourly data by end use for Missouri, as provided by Ameren.

⁴⁵⁴ 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.

⁴⁵⁵ ENERGY STAR Dishwasher Calculator

(http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDishwasher.xls)

⁴⁵⁶ Ibid.

⁴⁵⁷ Default assumption for unknown fuel is based on EIA Residential Energy Consumption Survey (RECS) 2009 for Midwest Region, data for the state of IL. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area then that should be used.

An Energy Star standard dishwasher installed in place of a baseline unit with unknown DHW fuel:

$$\begin{aligned} \Delta\text{kWh} &= ((355 - 295) * (0.44 + (0.56*0.16))) \\ &= 31.8 \text{ kWh} \end{aligned}$$

An Energy Star compact dishwasher installed in place of a baseline unit with unknown DHW fuel:

$$\begin{aligned} \Delta\text{kWh} &= ((260 - 222) * (0.44 + (0.56*0.16))) \\ &= 20.1 \text{ kWh} \end{aligned}$$

An Energy Star standard dishwasher installed in place of a baseline unit with electric DHW:

$$\begin{aligned} \Delta\text{kWh} &= ((355 - 295) * (0.44 + (0.56*1.0))) \\ &= 60.0 \text{ kWh} \end{aligned}$$

An Energy Star compact dishwasher installed in place of a baseline unit with electric DHW:

$$\begin{aligned} \Delta\text{kWh} &= ((260 - 222) * (0.44 + (0.56*1.0))) \\ &= 38.0 \text{ kWh} \end{aligned}$$

Summer Coincident Peak Demand Savings

$$\Delta\text{kW} = \Delta\text{kWh}/\text{Hours} * \text{CF}$$

Where:

$$\begin{aligned} \text{Hours} &= \text{Annual operating hours}^{458} \\ &= 252 \text{ hours} \end{aligned}$$

$$\begin{aligned} \text{CF} &= \text{Summer Peak Coincidence Factor} \\ &= 2.6\%^{459} \end{aligned}$$

An Energy Star standard dishwasher installed in place of a baseline unit with unknown DHW fuel:

$$\begin{aligned} \Delta\text{kWh} &= 31.8/252 * 0.026 \\ &= 0.003 \text{ kW} \end{aligned}$$

An Energy Star compact dishwasher installed in place of a baseline unit with unknown DHW fuel:

⁴⁵⁸ 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/>

⁴⁵⁹ End use data from Ameren representing the average DW load during peak hours/peak load.

$$\begin{aligned} \Delta \text{kWh} &= 20.1/252 * 0.026 \\ &= 0.002 \text{ kWh} \end{aligned}$$

An Energy Star standard dishwasher installed in place of a baseline unit with electric DHW:

$$\begin{aligned} \Delta \text{kWh} &= 60.0/252 * 0.026 \\ &= 0.006 \text{ kWh} \end{aligned}$$

An Energy Star compact dishwasher installed in place of a baseline unit with electric DHW:

$$\begin{aligned} \Delta \text{kWh} &= 38.0/252 * 0.026 \\ &= 0.004 \text{ kWh} \end{aligned}$$

NATURAL GAS SAVINGS

$$\Delta \text{Therm} = (\text{kWh}_{\text{Base}} - \text{kWh}_{\text{ESTAR}}) * \% \text{kWh}_{\text{heat}} * \% \text{Natural Gas}_{\text{DHW}} * R_{\text{eff}} * 0.03413$$

Where

$$\begin{aligned} \% \text{kWh}_{\text{heat}} &= \% \text{ of dishwasher energy used for water heating} \\ &= 56\% \end{aligned}$$

$$\% \text{Natural Gas}_{\text{DHW}} = \text{Percentage of DHW savings assumed to be Natural Gas}$$

DHW fuel	%Natural Gas_DHW
Electric	0%
Natural Gas	100%
Unknown	84% ⁴⁶⁰

R_eff = Recovery efficiency factor

$$= 1.26^{461}$$

0.03413 = factor to convert from kWh to Therm

An Energy Star standard dishwasher installed in place of a baseline unit with unknown DHW fuel:

$$\Delta \text{Therm} = (355 - 295) * 0.56 * 0.84 * 1.26 * 0.03413$$

⁴⁶⁰ 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.

⁴⁶¹ 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.

$$= 1.26 \text{ Therm}$$

An Energy Star compact dishwasher installed in place of a baseline unit with unknown DHW fuel:

$$\Delta \text{ Therm} = (260 - 222) * 0.56 * 0.84 * 1.26 * 0.03413$$

$$= 0.77 \text{ Therm}$$

An Energy Star standard dishwasher installed in place of a baseline unit with gas DHW:

$$\Delta \text{ Therm} = (355 - 295) * 0.56 * 1.0 * 1.26 * 0.03413$$

$$= 1.44 \text{ Therm}$$

An Energy Star compact dishwasher installed in place of a baseline unit with gas DHW:

$$\Delta \text{ Therm} = (260 - 222) * 0.56 * 1.0 * 1.26 * 0.03413$$

$$= 0.92 \text{ Therm}$$

WATER IMPACT DESCRIPTIONS AND CALCULATION

$$\Delta \text{Water} = \text{Water}_{\text{Base}} - \text{Water}_{\text{EFF}}$$

Where

$\text{Water}_{\text{Base}}$ = water consumption of conventional unit

= 1008 gallons⁴⁶² for standard unit

= 672 gallons⁴⁶³ for compact

$\text{Water}_{\text{EFF}}$ = annual water consumption of efficient unit:

= 672 gallons⁴⁶⁴ for standard unit

= 504 gallons⁴⁶⁵ for compact

$$\Delta \text{ Water (Standard)} = 1008 - 672$$

⁴⁶² Assuming 6 gallons/cycle based on ENERGY STAR Dishwasher Calculator (http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDishwasher.xls) and 168 cycles per year based on a weighted average of dishwasher usage in Illinois derived from the 2009 RECs data; <http://205.254.135.7/consumption/residential/data/2009/>

⁴⁶³ Assuming 4 gallons/cycle for baseline unit

⁴⁶⁴ Assuming 4gallons/cycle based on ENERGY STAR Dishwasher Calculator (http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDishwasher.xls) and 168 cycles per year based on a weighted average of dishwasher usage in Illinois derived from the 2009 RECs data; <http://205.254.135.7/consumption/residential/data/2009/>

⁴⁶⁵ Assuming 3 gallons/cycle for efficient unit

= 336 gallons
 Δ Water (Compact) = 672 – 504
= 168 gallons

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

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 $1.73 \times \text{Total Volume}$):⁴⁶⁶

Product Category	NAECA Maximum Energy Usage in kWh/year ⁴⁶⁷	ENERGY STAR Maximum Energy Usage in kWh/year ⁴⁶⁸	Volume (cubic feet)
Upright Freezers with Manual Defrost	$7.55 \times \text{AV} + 258.3$	$6.795 \times \text{AV} + 232.47$	7.75 or greater
Upright Freezers with Automatic Defrost	$12.43 \times \text{AV} + 326.1$	$11.187 \times \text{AV} + 293.49$	7.75 or greater
Chest Freezers and all other Freezers except Compact Freezers	$9.88 \times \text{AV} + 143.7$	$8.892 \times \text{AV} + 129.33$	7.75 or greater
Compact Upright Freezers with Manual Defrost	$9.78 \times \text{AV} + 250.8$	$7.824 \times \text{AV} + 200.64$	< 7.75 and 36 inches or less in height
Compact Upright Freezers with Automatic Defrost	$11.40 \times \text{AV} + 391$	$9.12 \times \text{AV} + 312.8$	< 7.75 and 36 inches or less in height
Compact Chest Freezers	$10.45 \times \text{AV} + 152$	$8.36 \times \text{AV} + 121.6$	< 7.75 and 36 inches or less in height

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

DEFINITION OF EFFICIENT EQUIPMENT

The efficient equipment is defined as a freezer meeting the efficiency specifications of ENERGY STAR, as defined below and calculated above:

Equipment	Volume	Criteria
Full Size Freezer	7.75 cubic feet or greater	At least 10% more energy efficient than the minimum federal government standard (NAECA).
Compact Freezer	Less than 7.75 cubic feet and 36 inches or less in height	At least 20% more energy efficient than the minimum federal government standard (NAECA).

DEFINITION OF BASELINE EQUIPMENT

The baseline equipment is assumed to be a model that meets the federal minimum standard for energy efficiency. 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.

⁴⁶⁶ http://www.energystar.gov/ia/products/appliances/refrig/NAECA_calculation.xls?c827-f746

⁴⁶⁷ as of July 1, 2001

⁴⁶⁸ as of April 28, 2008

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure life is assumed to be 11 years⁴⁶⁹.

DEEMED MEASURE COST

The incremental cost for this measure is \$35⁴⁷⁰.

DEEMED O&M COST ADJUSTMENTS

There are no operation and maintenance cost adjustments for this measure.

LOADSHAPE

Loadshape R04 - Residential Freezer

COINCIDENCE FACTOR

The summer peak coincidence factor for this measure is assumed to be 95%⁴⁷¹.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS:

$$\Delta\text{kWh} = \text{kWh}_{\text{BASE}} - \text{kWh}_{\text{ESTAR}}$$

Where:

kWh_{BASE} = Baseline kWh consumption per year as calculated in algorithm provided in table above.

$\text{kWh}_{\text{ESTAR}}$ = ENERGY STAR kWh consumption per year as calculated in algorithm provided in table above.

⁴⁶⁹ Energy Star Freezer Calculator;

http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Consumer_Residential_Freezer_Sav_Calc.xls?570a-f000

⁴⁷⁰ 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.

⁴⁷¹ Based on eShapes Residential Freezer load data as provided by Ameren.

For example for a 7.75 cubic foot Upright Freezers with Manual Defrost:

$$\begin{aligned} \Delta\text{kWh} &= (7.55 * (7.75 * 1.73) + 258.3) - (6.795 * (7.75 * 1.73) + 232.47) \\ &= 359.5 - 323.6 \\ &= 35.9 \text{ kWh} \end{aligned}$$

If volume is unknown, use the following default values:

Product Category	Volume Used ⁴⁷²	kWh _{BASE}	kWh _{ESTAR}	kWh Savings
Upright Freezers with Manual Defrost	27.9	469.1	422.2	46.9
Upright Freezers with Automatic Defrost	27.9	673.2	605.9	67.3
Chest Freezers and all other Freezers except Compact Freezers	27.9	419.6	377.6	42.0
Compact Upright Freezers with Manual Defrost	10.4	352.3	281.9	70.5
Compact Upright Freezers with Automatic Defrost	10.4	509.3	407.5	101.9
Compact Chest Freezers	10.4	260.5	208.4	52.1

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta\text{kW} = \Delta\text{kWh} / \text{Hours} * \text{CF}$$

Where:

$$\Delta\text{kWh} = \text{Gross customer annual kWh savings for the measure}$$

$$\begin{aligned} \text{Hours} &= \text{Full Load hours per year} \\ &= 5890^{473} \end{aligned}$$

$$\begin{aligned} \text{CF} &= \text{Summer Peak Coincident Factor} \\ &= 0.95^{474} \end{aligned}$$

⁴⁷² Volume is based on ENERGY STAR Calculator assumption of 16.14 ft³ average volume, converted to Adjusted volume by multiplying by 1.73.

⁴⁷³ Calculated from eShapes Residential Freezer load data as provided by Ameren by dividing total annual load by the maximum kW in any one hour.

⁴⁷⁴ Based on eShapes Residential Freezer load data as provided by Ameren.

For example for a 7.75 cubic foot Upright Freezers with Manual Defrost:

$$\begin{aligned} \Delta kW &= 35.9/5890 * 0.95 \\ &= 0.0058 \text{ kW} \end{aligned}$$

If volume is unknown, use the following default values:

Product Category	kW Savings
Upright Freezers with Manual Defrost	0.0076
Upright Freezers with Automatic Defrost	0.0109
Chest Freezers and all other Freezers except Compact Freezers	0.0068
Compact Upright Freezers with Manual Defrost	0.0114
Compact Upright Freezers with Automatic Defrost	0.0164
Compact Chest Freezers	0.0084

NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

5.1.6 ENERGY STAR and CEE Tier 2 Refrigerator

DESCRIPTION

This measure relates to the purchase and installation of a new refrigerator meeting either ENERGY STAR or CEE TIER 2 specifications. Energy usage specifications are defined in the table below (note, Adjusted Volume is calculated as the fresh volume + (1.63 * Freezer Volume):⁴⁷⁵

Product Category	NAECA as of July 1, 2001 Maximum Energy Usage in kWh/year	Current ENERGY STAR level Maximum Energy Usage in kWh/year
1. Refrigerators and Refrigerator-freezers with manual defrost	8.82*AV+248.4	7.056*AV+198.72
2. Refrigerator-Freezer--partial automatic defrost	8.82*AV+248.4	7.056*AV+198.72
3. Refrigerator-Freezers--automatic defrost with top-mounted freezer without through-the-door ice service and all-refrigerators--automatic defrost	9.80*AV+276	7.84*AV+220.8
4. Refrigerator-Freezers--automatic defrost with side-mounted freezer without through-the-door ice service	4.91*AV+507.5	3.928*AV+406
5. Refrigerator-Freezers--automatic defrost with bottom-mounted freezer without through-the-door ice service	4.60*AV+459	3.68*AV+367.2
6. Refrigerator-Freezers--automatic defrost with top-mounted freezer with through-the-door ice service	10.20*AV+356	8.16*AV+284.8
7. Refrigerator-Freezers--automatic defrost with side-mounted freezer with through-the-door ice service	10.10*AV+406	8.08*AV+324.8

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

DEFINITION OF EFFICIENT EQUIPMENT

The efficient equipment is defined as a refrigerator meeting the efficiency specifications of ENERGY STAR or CEE Tier 2 (defined as requiring $\geq 20\%$ or $\geq 25\%$ less energy consumption than an equivalent unit meeting federal standard requirements respectively). The ENERGY STAR standard varies according to the size and configuration of the unit, as shown in table above.

DEFINITION OF BASELINE EQUIPMENT

The baseline condition is a new refrigerator meeting the minimum federal efficiency standard for refrigerator efficiency. The current federal minimum standard varies according to the size and configuration of the unit, as shown in table above. Note also that this federal standard will be increased for units manufactured after January 1, 2014.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure life is assumed to be 12 years.⁴⁷⁶

⁴⁷⁵ http://www.energystar.gov/ia/products/appliances/refrig/NAECA_calculation.xls?c827-f746

⁴⁷⁶ From ENERGY STAR calculator:

DEEMED MEASURE COST

The incremental cost for this measure is assumed to be \$30⁴⁷⁷ for an ENERGY STAR unit and \$140⁴⁷⁸ for a CEE Tier 2 unit.

DEEMED O&M COST ADJUSTMENTS

There are no operation and maintenance cost adjustments for this measure.

LOADSHAPE

Loadshape R05 - Residential Refrigerator

COINCIDENCE FACTOR

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

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS:

$$\Delta kWh = UEC_{BASE} - UEC_{EE}$$

Where:

UEC_{BASE} = Annual Unit Energy Consumption of baseline unit as calculated in algorithm provided in table above.

UEC_{EE} = Annual Unit Energy Consumption of ENERGY STAR unit as calculated in algorithm provided in table above.

For CEE Tier 2, unit consumption is calculated as 25% lower than baseline.

If volume is unknown, use the following defaults:

Product Category	Volume Used ⁴⁷⁹	UEC_{base}	ENERGY STAR	CEE T2 UEC_{EE}	ENERGY STAR	CEE T2 kWh
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http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Consumer_Residential_Refrig_Sav_Calc.xls

⁴⁷⁷ Ibid.

⁴⁷⁸ 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

⁴⁷⁹ Volume is based on the ENERGY STAR calculator average assumption of 14.75 ft³ fresh volume and 6.76 ft³

			UEC _{EE}		kWh Savings	Savings
1. Refrigerators and Refrigerator-freezers with manual defrost	25.8	475.7	380.5	356.8	95.1	118.9
2. Refrigerator-Freezer--partial automatic defrost	25.8	475.7	380.5	356.8	95.1	118.9
3. Refrigerator-Freezers--automatic defrost with top-mounted freezer without through-the-door ice service and all-refrigerators--automatic defrost	25.8	528.5	422.8	396.4	105.7	132.1
4. Refrigerator-Freezers--automatic defrost with side-mounted freezer without through-the-door ice service	25.8	634.0	507.2	475.5	126.8	158.5
5. Refrigerator-Freezers--automatic defrost with bottom-mounted freezer without through-the-door ice service	25.8	577.5	462.0	433.2	115.5	144.4
6. Refrigerator-Freezers--automatic defrost with top-mounted freezer with through-the-door ice service	25.8	618.8	495.1	464.1	123.8	154.7
7. Refrigerator-Freezers--automatic defrost with side-mounted freezer with through-the-door ice service	25.8	666.3	533.0	499.7	133.3	166.6

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = (\Delta kWh/8766) * TAF * LSAF$$

Where:

TAF = Temperature Adjustment Factor

$$= 1.25^{480}$$

LSAF = Load Shape Adjustment Factor

freezer volume.

⁴⁸⁰ Average temperature adjustment factor (to account for temperature conditions during peak period as compared to year as a whole) based on Blasnik, Michael, "Measurement and Verification of Residential Refrigerator Energy Use, Final Report, 2003-2004 Metering Study", July 29, 2004 (p. 47). It assumes 90 °F average outside temperature during peak period, 71°F average temperature in kitchens and 65°F average temperature in basement, and uses assumption that 66% of homes in Illinois having central cooling (CAC saturation: "Table HC7.9 Air Conditioning in Homes in Midwest Region, Divisions, and States, 2009 from Energy Information Administration", 2009 Residential Energy Consumption Survey; <http://www.eia.gov/consumption/residential/data/2009/xls/HC7.9%20Air%20Conditioning%20in%20Midwest%20Region.xls>)

$$= 1.057^{481}$$

If volume is unknown, use the following defaults:

Product Category	ENERGY STAR kW Savings	CEE T2 kW Savings
1. Refrigerators and Refrigerator-freezers with manual defrost	0.0143	0.0179
2. Refrigerator-Freezer--partial automatic defrost	0.0143	0.0179
3. Refrigerator-Freezers--automatic defrost with top-mounted freezer without through-the-door ice service and all-refrigerators--automatic defrost	0.0159	0.0199
4. Refrigerator-Freezers--automatic defrost with side-mounted freezer without through-the-door ice service	0.0191	0.0239
5. Refrigerator-Freezers--automatic defrost with bottom-mounted freezer without through-the-door ice service	0.0174	0.0218
6. Refrigerator-Freezers--automatic defrost with top-mounted freezer with through-the-door ice service	0.0187	0.0233
7. Refrigerator-Freezers--automatic defrost with side-mounted freezer with through-the-door ice service	0.0201	0.0251

NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

⁴⁸¹ 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)

5.1.7 ENERGY STAR and CEE Tier 1 Room Air Conditioner

DESCRIPTION

This measure relates to the purchase and installation of a room air conditioning unit that meets either the ENERGY STAR or CEE TIER 1 minimum qualifying efficiency specifications, in place of a baseline unit meeting minimum Federal Standard efficiency ratings presented below⁴⁸²:

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

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

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

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

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the new room air conditioning unit must meet the ENERGY STAR efficiency standards

⁴⁸² 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

presented above.

DEFINITION OF BASELINE EQUIPMENT

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

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure life is assumed to be 12 years⁴⁸³.

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 unit⁴⁸⁴.

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape R08 - Residential Cooling

COINCIDENCE FACTOR

The coincidence factor for this measure is assumed to be 0.3⁴⁸⁵.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC 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 location⁴⁸⁶:

⁴⁸³ 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

⁴⁸⁴ Based on field study conducted by Efficiency Vermont

⁴⁸⁵ 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

Climate Zone (City based upon)	FLH _{RoomAC}
1 (Rockford)	220
2 (Chicago)	210
3 (Springfield)	319
4 (Belleville)	428
5 (Marion)	374
Weighted Average ⁴⁸⁷	248

- Btu/H = Size of rebated unit
 = Actual. If unknown assume 8500 BTU/hour⁴⁸⁸
- EERbase = Efficiency of baseline unit
 = As provided in tables above
- EERee = Efficiency of ENERGY STAR or CEE Tier 1 unit
 = Actual. If unknown assume minimum qualifying standard as provided in tables above

For example for an 8,500 BTU/H capacity unit, with louvered sides, in an unknown location:

$$\begin{aligned} \Delta kWh_{ENERGY STAR} &= (248 * 8500 * (1/9.8 - 1/10.8)) / 1000 \\ &= 19.9 kWh \\ \Delta kWh_{CEE TIER 1} &= (248 * 8500 * (1/9.8 - 1/11.3)) / 1000 \\ &= 28.6 kWh \end{aligned}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = Btu/H * ((1/EERbase - 1/EERee)/1000) * CF$$

⁴⁸⁶ Full load hours for room AC is significantly lower than for central AC. The average ratio of FLH for Room AC (provided in RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008: http://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/117_RLW_CF%20Res%20RAC.pdf) to FLH for Central Cooling for the same location (provided by AHRI: http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_CAC.xls) is 31%. This ratio is applied to those IL cities that have FLH for Central Cooling provided in the Energy Star calculator. For other cities this is extrapolated using the FLH assumptions VEIC have developed for Central AC. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

⁴⁸⁷ Weighted based on number of residential occupied housing units in each zone.

⁴⁸⁸ Based on maximum capacity average from the RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008

Where:

CF = Summer Peak Coincidence Factor for measure

$$= 0.3^{489}$$

Other variable as defined above

For example for an 8,500 BTU/H capacity unit, with louvered sides, for an unknown location:

$$\Delta kW_{\text{ENERGY STAR}} = (8500 * (1/9.8 - 1/10.8)) / 1000 * 0.3$$

$$= 0.024 \text{ kW}$$

$$\Delta kW_{\text{CEE TIER 1}} = (8500 * (1/9.8 - 1/11.3)) / 1000 * 0.3$$

$$= 0.035 \text{ kW}$$

NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

⁴⁸⁹ 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)

5.1.8 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 2012 metering study that provides a regression equation that uses key inputs describing the retired unit. The savings are equivalent to the Unit Energy Consumption of the retired unit and should be claimed for the assumed remaining useful life of that unit. A part use factor is applied to account for those secondary units that are not in use throughout the entire year. The reader should note that the regression algorithm is designed to provide an accurate portrayal of savings for the population as a whole and includes those parameters that have a significant effect on the consumption. The precision of savings for individual units will vary.

The Net to Gross factor applied to these units should incorporate adjustments that account for:

- Those participants who would have removed the unit from the grid anyway (e.g. customers replacing their refrigerator via a big box store and using the pick-up option, customers taking their unit to the landfill or recycling station);
- Those participants who decided, based on the incentive provided by the Appliance Recycling program alone, to replace their existing inefficient unit with a new unit. This segment of participants is expected to be very small and documentation of their intentions will be gathered via telephone surveys (i.e., primary data sources). For such customers, the consumption of the new unit should be subtracted from the retired unit consumption and savings claimed for the remaining life of the existing unit. Note that participants who were already planning to replace their unit, and the incentive just ensured that the retired unit was recycled and not placed on the secondary market, should not be included in this adjustment.

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

DEFINITION OF EFFICIENT EQUIPMENT

n/a

DEFINITION OF BASELINE EQUIPMENT

The existing inefficient unit must be operational and have a capacity of between 10 and 30 cubic feet.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The estimated remaining useful life of the recycling units is 8 years⁴⁹⁰.

DEEMED MEASURE COST

Measure cost includes the cost of pickup and recycling of the refrigerator and should be based on actual costs of running the program. If unknown assume \$120⁴⁹¹ per unit.

DEEMED O&M COST ADJUSTMENTS

n/a

⁴⁹⁰ KEMA "Residential refrigerator recycling ninth year retention study", 2004

⁴⁹¹ Based on similar Efficiency Vermont program.

LOADSHAPE

Loadshape R05 - Residential Refrigerator

COINCIDENCE FACTOR

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

Algorithm

CALCULATION OF SAVINGS

ENERGY SAVINGS

Energy savings are based upon a linear regression model using the following coefficients⁴⁹²:

Variable Description	Coefficient
Intercept	-103.39
Freezer dummy (=1 if freezer)	433.40
Side-by-side dummy (= 1 if side-by-side)	614.91
Chest dummy (=1 if chest freezer)	-490.78
Single door dummy (=1 if single door) ⁴⁹³	-797.90
Age	23.93
Pre-1993 dummy (=1 if manufactured pre-1993)	289.82
Capacity (Cubic Feet)	13.52
Manual defrost dummy (= 1 if manual defrost)	-381.23

$$\Delta kWh = [-103.39 + (Freezer * 433.40) + (Side * 614.91) + (Chest * -490.78) + (SingleDoor * -797.90) + (Age * 23.93) + (Pre1993 * 289.82) + (Capacity * 13.52) + (ManualDefrost * -381.23)] * Part Use Factor$$

Where:

- Freezer = Freezer dummy (=1 if freezer, else 0)
- Side = Side-by-side dummy (= 1 if side-by-side, else 0)
- Chest = Chest dummy (= 1 if chest freezer, else 0)
- Age = Age of retired unit
- Pre1993 = Pre-1993 dummy (=1 if manufactured pre-1993, else 0)

⁴⁹² Energy savings are based on an average 30-year TMY temperature of 51.1 degrees. Coefficients provided in May 31, 2012 memo from Opinion Dynamics; "Fridge & Freezer Recycle Rewards Program PY4 Metering Study: DRAFT Savings Results".

⁴⁹³ This variable is only applicable to refrigerators.

- Capacity = Capacity (cubic feet) of retired unit
- ManualDefrost = Manual defrost dummy (= 1 if manual defrost, else 0)
- Part Use Factor = To account for those units that are not running throughout the entire year.
= 0.877⁴⁹⁴

For example, a 24 year old, 22 cubic feet, 2 door side by side unit with automatic defrost that was located in the kitchen is retired.

$$\begin{aligned} \Delta kWh &= [-103.39 + (0 * 433.40) + (1 * 614.91) + (0 * -490.78) + (0 * -797.90) + (24 * 23.93) + (1 * 289.82) + (22 * 13.52) + (0 * -381.23)] * 0.877 \\ &= 1673 * 0.877 \\ &= 1467 \text{ kWh} \end{aligned}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

Summer Coincident Peak Demand Savings are based upon a linear regression model using the following coefficients⁴⁹⁵:

Variable	Coefficient
Side-by-Side (dummy)	0.04920
Freezer (dummy)	0.01988
Age	0.01199
Age-squared	-0.0001443
Capacity (Cubic Feet)	0.001156
Manual Defrost	-0.04503
Garage, Porch or Patio (dummy)	0.04681
Constant	-0.09662

$$\Delta kW = [(Side * 0.04920) + (Freezer * 0.01988) + (Age * 0.01199) + (Age^2 * -0.0001443) + (Capacity * 0.001156) + (ManualDefrost * -0.04503) + (GaragePorchPatio * 0.04681) - 0.09662] * Part Use Factor$$

Where:

- GaragePorchPatio = Variable based on unit location (=1 if unit in Garage, Porch or Patio, else 0)

⁴⁹⁴ Weighted average PY2 and PY3 part use factor from Opinion Dynamics, May 31 2012 memo; "Fridge & Freezer Recycle Rewards Program PY4 Metering Study: Preliminary Savings Results".

⁴⁹⁵ Coefficients provided in May 30, 2012 version of Opinion Dynamics; "PY4 Appliance Recycling Program PJM Post Install M&V Demand Analysis Report Draft".

Other variables as above

For example, a 24 year old, 22 cubic feet, Side by Side unit with automatic defrost that was located in the kitchen is retired.

$$\begin{aligned}\Delta kW &= [(1 * 0.04920) + (0 * 0.01988) + (24 * 0.01199) + (24^2 * -0.0001443) + (22 * \\ &0.001156) + (0 * -0.04503) + (0 * 0.04681) - 0.09662] * 0.877 \\ &= 0.183 * 0.877 \\ &= 0.16 \text{ kW}\end{aligned}$$

NATURAL GAS SAVINGS

n/a

WATER IMPACT DESCRIPTIONS AND CALCULATION

n/a

DEEMED O&M COST ADJUSTMENT CALCULATION

n/a

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

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 years⁴⁹⁶.

DEEMED MEASURE COST

The actual implementation cost for recycling the existing unit should be used.

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape R08 - Residential Cooling

COINCIDENCE FACTOR

The coincidence factor for this measure is assumed to be 30%⁴⁹⁷.

⁴⁹⁶ A third of assumed measure life for Room AC.

⁴⁹⁷ Consistent with coincidence factors found in: RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008

(http://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/117_RLW_CF%20Res%20RAC.pdf)

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = ((FLH_{RoomAC} * BtuH * (1/EE_{Exist}))/1000)$$

Where:

FLH_{RoomAC} = Full Load Hours of room air conditioning unit
 = dependent on location⁴⁹⁸:

Climate Zone (City based upon)	FLH_{RoomAC}
1 (Rockford)	220
2 (Chicago)	210
3 (Springfield)	319
4 (Belleville)	428
5 (Marion)	374
Weighted Average ⁴⁹⁹	248

Btu/H = Size of retired unit
 = Actual. If unknown assume 8500 BTU/hour⁵⁰⁰

EE_{Exist} = Efficiency of existing unit
 = 7.7⁵⁰¹

⁴⁹⁸ The average ratio of FLH for Room AC (provided in RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008: http://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/117_RLW_CF%20Res%20RAC.pdf) to FLH for Central Cooling for the same location (provided by AHRI: http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_CAC.xls) is 31%. This ratio is applied to those IL cities that have FLH for Central Cooling provided in the Energy Star calculator. For other cities this is extrapolated using the FLH assumptions VEIC have developed for Central AC. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

⁴⁹⁹ Weighted based on number of residential occupied housing units in each zone.

⁵⁰⁰ Based on maximum capacity average from the RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008

⁵⁰¹ 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:

$$\begin{aligned}\Delta\text{kWh} &= ((319 * 8500 * (1/7.7)) / 1000) \\ &= 352 \text{ kWh}\end{aligned}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta\text{kW} = (\text{BtuH} * (1/\text{EER}_{\text{exist}}))/1000 * \text{CF}$$

Where:

$$\begin{aligned}\text{CF} &= \text{Summer Peak Coincidence Factor for measure} \\ &= 0.3^{502}\end{aligned}$$

For example an 8500 BTU/h unit:

$$\begin{aligned}\Delta\text{kW} &= (8500 * (1/7.7)) / 1000 * 0.3 \\ &= 0.33 \text{ kW}\end{aligned}$$

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

⁵⁰² Consistent with coincidence factors found in:

RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008

(http://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/117_RLW_CF%20Res%20RAC.pdf)

5.2 Consumer Electronics End Use

5.2.1 Smart Strip

DESCRIPTION

This measure relates to Controlled Power Strips (or Smart Strips) which are multi-plug power strips with the ability to automatically disconnect specific connected loads depending upon the power draw of a control load, also plugged into the strip. Power is disconnected from the switched (controlled) outlets when the control load power draw is reduced below a certain adjustable threshold, thus turning off the appliances plugged into the switched outlets. By disconnecting, the standby load of the controlled devices, the overall load of a centralized group of equipment (i.e. entertainment centers and home office) can be reduced. Uncontrolled outlets are also provided that are not affected by the control device and so are always providing power to any device plugged into it. This measure characterization provides savings for a 5-plug strip and a 7-plug strip.

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

DEFINITION OF EFFICIENT EQUIPMENT

The efficient case is the use of a 5 or 7-plug smart strip.

DEFINITION OF BASELINE EQUIPMENT

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

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The assumed lifetime of the smart strip is 4 years⁵⁰³.

DEEMED MEASURE COST

The incremental cost of a smart strip over a standard power strip with surge protection is assumed to be \$16 for a 5-plug and \$26 for a 7-plug⁵⁰⁴.

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape R13 - Residential Standby Losses – Entertainment
Loadshape R14 - Residential Standby Losses - Home Office

⁵⁰³ David Rogers, Power Smart Engineering, October 2008; “Smart Strip electrical savings and usability”, p22.

⁵⁰⁴ Price survey performed in NYSERDA Measure Characterization for Advanced Power Strips, p4

COINCIDENCE FACTOR

The summer peak coincidence factor for this measure is assumed to be 80%⁵⁰⁵.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh_{5-plug} = 56.5 \text{ kWh}^{506}$$

$$\Delta kWh_{7-plug} = 103 \text{ kWh}^{507}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = \Delta kWh / \text{Hours} * CF$$

Where:

Hours = Annual number of hours during which the controlled standby loads are turned off by the Smart Strip.

$$= 7,129^{508}$$

CF = Summer Peak Coincidence Factor for measure

$$= 0.8^{509}$$

$$\Delta kW_{5-plug} = 56.5 / 7129 * 0.8$$

$$= 0.00634 \text{ kW}$$

⁵⁰⁵ Efficiency Vermont coincidence factor for smart strip measure –in the absence of empirical evaluation data, this was based on assumptions of the typical run pattern for televisions and computers in homes.

⁵⁰⁶ NYSERDA Measure Characterization for Advanced Power Strips. Study based on review of:

- I. Smart Strip Electrical Savings and Usability, Power Smart Engineering, October 27, 2008.
- II. Final Field Research Report, Ecos Consulting, October 31, 2006. Prepared for California Energy Commission’s PIER Program.
- III. Developing and Testing Low Power Mode Measurement Methods, Lawrence Berkeley National Laboratory (LBNL), September 2004. Prepared for California Energy Commission’s Public Interest Energy Research (PIER) Program.
- IV. 2005 Intrusive Residential Standby Survey Report, Energy Efficient Strategies, March, 2006.
- V. Smart Strip Portfolio of the Future, Navigant Consulting for San Diego G&E, March 31, 2009.

⁵⁰⁷ Ibid.

⁵⁰⁸ Average of hours for controlled TV and computer from; NYSERDA Measure Characterization for Advanced Power Strips

⁵⁰⁹ Efficiency Vermont coincidence factor for smart strip measure –in the absence of empirical evaluation data, this was based on assumptions of the typical run pattern for televisions and computers in homes.

$$\begin{aligned}\Delta kW_{7-Plug} &= 102.8 / 7129 * 0.8 \\ &= 0.0115 \text{ kW}\end{aligned}$$

NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-CEL-SSTR-V01-120601

5.3 HVAC End Use

5.3.1 Air Source Heat Pump

DESCRIPTION

A heat pump provides heating or cooling by moving heat between indoor and outdoor air. This measure involves the installation of a new residential sized ($\leq 65,000$ BTU/hr) air source heat pump that is more efficient than required by federal standards.

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

DEFINITION OF EFFICIENT EQUIPMENT

A new residential sized ($\leq 65,000$ BTU/hr) air source heat pump with specifications to be determined by program.

DEFINITION OF BASELINE EQUIPMENT

A new residential sized ($\leq 65,000$ BTU/hr) air source heat pump meeting federal standards.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 18 years⁵¹⁰.

DEEMED MEASURE COST

The incremental capital cost for this measure is dependent on the efficiency and capacity of the new unit⁵¹¹. Note these costs are per ton of unit capacity:

Efficiency (SEER)	Incremental Cost per Ton of Capacity (\$/ton)
14	137
15	274
16	411
17	548
18	685

DEEMED O&M COST ADJUSTMENTS

N/A

⁵¹⁰ 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>

⁵¹¹ Based on costs derived from DEER 2008 Database Technology and Measure Cost Data (www.deeresources.com).

LOADSHAPE

Loadshape R10 - Residential Electric Heating and Cooling

COINCIDENCE FACTOR

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

$$CF_{SSP} = \text{Summer System Peak Coincidence Factor for Central A/C (during utility peak hour)}$$

$$= 91.5\%^{512}$$

$$CF_{PJM} = \text{PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)}$$

$$= 46.6\%^{513}$$

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = ((FLH_{cooling} * Capacity_{cooling} * (1/SEER_{base} - 1/SEER_{ee})) / 1000) + ((FLH_{heat} * Capacity_{heating} * (1/HSPF_{base} - 1/HSFP_{ee})) / 1000)$$

Where:

FLH_{cooling} = Full load hours of air conditioning
 = dependent on location⁵¹⁴:

Climate Zone (City based upon)	FLH _{cooling} (single family)	FLH _{cooling} (multi family)
1 (Rockford)	512	467
2 (Chicago)	570	506
3 (Springfield)	730	663
4 (Belleveille)	1,035	940

⁵¹² 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.

⁵¹³ 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.

⁵¹⁴ Full load hours for Chicago, Moline and Rockford are provided in “Final Evaluation Report: Central Air Conditioning Efficiency Services (CACES), 2010, Navigant Consulting”, http://ilsag.org/yahoo_site_admin/assets/docs/ComEd_PY2_CACES_Evaluation_Report_2010-10-18.299122020.pdf, p.33. An average FLH/Cooling Degree Day (from NCDC) ratio was calculated for these locations and applied to the CDD of the other locations in order to estimate FLH. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

5 (Marion)	903	820
Weighted Average ⁵¹⁵	629	564

Capacity_cooling = Cooling Capacity of Air Source Heat Pump (Btu/h)

= Actual (1 ton = 12,000Btu/h)

SEER_base = Seasonal Energy Efficiency Ratio of baseline Air Source Heat Pump (kBtu/kWh)

= 13⁵¹⁶

SEER_ee = Seasonal Energy Efficiency Ratio of efficient Air Source Heat Pump (kBtu/kWh)

= Actual

FLH_heat = Full load hours of heating

= Dependent on location⁵¹⁷:

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 ⁵¹⁸	1,821

Capacity_heating = Heating Capacity of Air Source Heat Pump (Btu/h)

= Actual (1 ton = 12,000Btu/h)

HSPF_base = Heating System Performance Factor of baseline Air Source Heat Pump (kBtu/kWh)

⁵¹⁵ Weighted based on number of occupied residential housing units in each zone.

⁵¹⁶ Based on Minimum Federal Standard;

http://www1.eere.energy.gov/buildings/appliance_standards/residential/residential_cac_hp.html.

⁵¹⁷ Full load heating hours for heat pumps are provided for Rockford, Chicago and Springfield in the Energy Star Calculator. Estimates for the other locations were calculated based on the FLH to Heating Degree Day (from NCDC) ratio. VEIC consider Energy Star estimates to be high due to oversizing not being adequately addressed. Using average Illinois billing data (from <http://www.icc.illinois.gov/ags/consumereducation.aspx>) VEIC estimated the average gas heating load and used this to estimate the average home heating output (using 83% average gas heat efficiency). Dividing this by a typical 36,000 Btu/h ASHP gives an estimate of average ASHP FLH_heat of 1821 hours. We used the ratio of this value to the average of the locations using the Energy Star data (1994 hours) to scale down the Energy Star estimates. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

⁵¹⁸ Weighted based on number of occupied residential housing units in each zone.

$$= 7.7^{519}$$

HSFP_ee = Heating System Performance Factor of efficient Air Source Heat Pump (kBtu/kWh)

= Actual

For example, a three ton, 15 SEER, 12EER, 9 HSPF Air Source Heat Pump installed in Marion:

$$\begin{aligned} \Delta kWh &= ((903 * 36,000 * (1/13 - 1/15)) / 1000) + ((1,288 * 36,000 * (1/7.7 - 1/9)) / 1000) \\ &= 1,203 \text{ kWh} \end{aligned}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = (\text{Capacity}_{\text{cooling}} * (1/\text{EER}_{\text{base}} - 1/\text{EER}_{\text{ee}})) / 1000 * \text{CF}$$

Where:

EER_base = Energy Efficiency Ratio of baseline Air Source Heat Pump (kBtu/h / kW)
= 11.2⁵²⁰

EER_ee = Energy Efficiency Ratio of efficient Air Source Heat Pump (kBtu/h / kW)
= Actual, If not provided convert SEER to EER using this formula:⁵²¹
= (-0.02 * SEER²) + (1.12 * SEER)

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)
= 91.5%⁵²²

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)
= 46.6%⁵²³

⁵¹⁹ Based on Minimum Federal Standard;

http://www1.eere.energy.gov/buildings/appliance_standards/residential/residential_cac_hp.html.

⁵²⁰ 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.

⁵²¹ 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.

⁵²² 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.

⁵²³ Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The

For example, a three ton, 15 SEER, 12EER, 9 HSPF Air Source Heat Pump installed in Marion:

$$\Delta kW_{SSP} = ((36,000 * (1/11.2 - 1/12)) / 1000) * 0.915$$

$$= 0.196 \text{ kW}$$

$$\Delta kW_{PJM} = ((36,000 * (1/11.2 - 1/12)) / 1000) * 0.466$$

$$= 0.100 \text{ kW}$$

NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HVC-ASHP-V01-120601

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.

5.3.2 Central Air Conditioning > 14.5 SEER

DESCRIPTION

This measure relates to:

- a) Time of sale: the installation of a new residential sized ($\leq 65,000$ BTU/hr) Central Air Conditioning ducted split system meeting ENERGY STAR efficiency standards presented below. This could relate to the replacement of an existing unit at the end of its useful life, or the installation of a new system in a new home.
- b) Early replacement: the early removal of an existing residential sized ($\leq 65,000$ BTU/hr) inefficient Central Air Conditioning unit from service, prior to its natural end of life, and replacement with a new ENERGY STAR qualifying unit. Savings are calculated between existing unit and efficient unit consumption during the remaining life of the existing unit, and between new baseline unit and efficient unit consumption for the remainder of the measure life.

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

DEFINITION OF EFFICIENT EQUIPMENT

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

DEFINITION OF BASELINE EQUIPMENT

The baseline for the Time of Sale measure is based on the current Federal Standard efficiency level; 13 SEER and 11 EER.

The baseline for the early replacement measure is the efficiency of the existing equipment for the assumed remaining useful life of the unit and the new baseline as defined above⁵²⁴ for the remainder of the measure life.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 18 years⁵²⁵.

Remaining life of existing equipment is assumed to be 6 years⁵²⁶.

DEEMED MEASURE COST

Time of sale: The incremental capital cost for this measure is dependent on equipment size and efficiency.

⁵²⁴ Baseline SEER and EER should be updated when new minimum federal standards become effective.

⁵²⁵ 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).

⁵²⁶ Assumed to be one third of effective useful life

Assumed costs per ton of cooling capacity are provided below⁵²⁷:

Efficiency Level	Cost per Ton
SEER 14	\$119
SEER 15	\$238
SEER 16	\$357
SEER 17	\$476
SEER 18	\$596
SEER 19	\$715
SEER 20	\$834
SEER 21	\$908
Average	\$530

Early replacement: The incremental capital cost for this measure is the actual cost of removing the existing unit and installing the new one. If this is unknown, assume \$3,413⁵²⁸.

Assumed deferred cost (after 6 years) of replacing existing equipment with new baseline unit is assumed to be \$2,857⁵²⁹. This cost should be discounted to present value using the utilities discount rate.

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape R08 - Residential Cooling

COINCIDENCE FACTOR

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

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)

⁵²⁷ DEER 2008 Database Technology and Measure Cost Data (www.deeresources.com)

⁵²⁸ 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).

⁵²⁹ 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.

$$CF_{PJM} = 91.5\%^{530}$$

= PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)

$$CF_{PJM} = 46.6\%^{531}$$

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

Time of sale:

$$\Delta kWh = (FLH_{cool} * BtuH * (1/SEER_{base} - 1/SEER_{ee}))/1000$$

Early replacement⁵³²:

ΔkWh for remaining life of existing unit (1st 6 years):

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

ΔkWh for remaining measure life (next 12 years):

$$= ((FLH_{cool} * Capacity * (1/SEER_{base} - 1/SEER_{ee}))/1000)$$

Where:

FLH_{cool} = Full load cooling hours
 = dependent on location and building type⁵³³:

Climate Zone	FLH _{cool}	FLH _{cool}
--------------	---------------------	---------------------

⁵³⁰ 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.

⁵³¹ 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.

⁵³² 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).

⁵³³ Full load hours for Chicago, Moline and Rockford are provided in “Final Evaluation Report: Central Air Conditioning Efficiency Services (CACES), 2010, Navigant Consulting”, http://ilsag.org/yahoo_site_admin/assets/docs/ComEd_PY2_CACES_Evaluation_Report_2010-10-18.299122020.pdf, p.33. An average FLH/Cooling Degree Day (from NCDC) ratio was calculated for these locations and applied to the CDD of the other locations in order to estimate FLH. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

(City based upon)	(single family)	(multi family)
1 (Rockford)	512	467
2 (Chicago)	570	506
3 (Springfield)	730	663
4 (Belleville)	1035	940
5 (Marion)	903	820
Weighted Average ⁵³⁴	629	564

Capacity = Size of new equipment in Btuh (note 1 ton = 12,000Btuh)

= Actual installed, or if actual size unknown 33,600Btuh for single-family buildings⁵³⁵

SEERbase = Seasonal Energy Efficiency Ratio of baseline unit (kBtu/kWh)

= 13⁵³⁶

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 10.0⁵³⁷.

SEERee = Seasonal Energy Efficiency Ratio of ENERGY STAR unit (kBtu/kWh)

= Actual installed or 14.5 if unknown

Time of sale example: a 3 ton unit with SEER rating of 14.5, in unknown location:

$$\Delta \text{kWh} = (629 * 36,000 * (1/13 - 1/14.5)) / 1000$$

$$= 180 \text{ kWh}$$

⁵³⁴ Weighted based on number of residential occupied housing units in each zone.

⁵³⁵ 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.

⁵³⁶ Based on Minimum Federal Standard;

http://www1.eere.energy.gov/buildings/appliance_standards/residential/residential_cac_hp.html.

⁵³⁷ VEIC estimate based on Department of Energy Federal Standard between 1992 and 2006. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area then that should be used.

Early replacement example: a 3 ton unit, with SEER rating of 14.5 replaces an existing unit in unknown location:

$$\begin{aligned} \Delta\text{kWh}(\text{for first 6 years}) &= (629 * 36,000 * (1/10 - 1/14.5)) / 1000 \\ &= 702 \text{ kWh} \end{aligned}$$

$$\begin{aligned} \Delta\text{kWh}(\text{for next 12 years}) &= (629 * 36,000 * (1/13 - 1/14.5)) / 1000 \\ &= 180 \text{ kWh} \end{aligned}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

Time of sale:

$$\Delta\text{kW} = (\text{Capacity} * (1/\text{EER}_{\text{base}} - 1/\text{EER}_{\text{ee}}))/1000 * \text{CF}$$

Early replacement⁵³⁸:

ΔkW for remaining life of existing unit (1st 6 years):

$$= ((\text{Capacity} * (1/\text{EER}_{\text{exist}} - 1/\text{EER}_{\text{ee}}))/1000 * \text{CF});$$

ΔkW for remaining measure life (next 12 years):

$$= ((\text{Capacity} * (1/\text{EER}_{\text{base}} - 1/\text{EER}_{\text{ee}}))/1000 * \text{CF})$$

Where:

EER_{base} = EER Efficiency of baseline unit
= 11.2⁵³⁹

EER_{exist} = EER Efficiency of existing unit
= Actual EER of unit should be used, if EER is unknown, use 9.2⁵⁴⁰

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)

⁵³⁸ 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).

⁵³⁹ 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: $(-0.02 * \text{SEER}^2) + (1.12 * \text{SEER})$ (from Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder).

⁵⁴⁰ Based on SEER of 10,0, using formula above to give 9.2 EER.

$$\begin{aligned}
 & \text{hour)} \\
 & = 91.5\%^{541} \\
 CF_{PJM} & = \text{PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)} \\
 & = 46.6\%^{542}
 \end{aligned}$$

Time of sale example: a 3 ton unit with EER rating of 12:

$$\begin{aligned}
 \Delta kW_{SSP} & = (36,000 * (1/11.2 - 1/12)) / 1000 * 0.915 \\
 & = 0.196 \text{ kW}
 \end{aligned}$$

$$\begin{aligned}
 \Delta kW_{PJM} & = (36,000 * (1/11.2 - 1/12)) / 1000 * 0.466 \\
 & = 0.100 \text{ kW}
 \end{aligned}$$

Early replacement example: a 3 ton unit with EER rating of 12 replaces an existing unit:

$$\begin{aligned}
 \Delta kW_{SSP} \text{ (for first 6 years)} & = (36,000 * (1/9.2 - 1/12)) / 1000 * 0.915 \\
 & = 0.835 \text{ kW}
 \end{aligned}$$

$$\begin{aligned}
 \Delta kW_{SSP} \text{ (for next 12 years)} & = (36,000 * (1/11.2 - 1/12)) / 1000 * 0.915 \\
 & = 0.196 \text{ kW}
 \end{aligned}$$

$$\begin{aligned}
 \Delta kW_{PJM} \text{ (for first 6 years)} & = (36,000 * (1/9.2 - 1/12)) / 1000 * 0.466 \\
 & = 0.425 \text{ kW}
 \end{aligned}$$

$$\begin{aligned}
 \Delta kW_{PJM} \text{ (for next 12 years)} & = (36,000 * (1/11.2 - 1/12)) / 1000 * 0.466 \\
 & = 0.100 \text{ kW}
 \end{aligned}$$

NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

⁵⁴¹ 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.

⁵⁴² Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HVC-CAC1-V01-120601

5.3.3 Duct Insulation and Sealing

DESCRIPTION

This measure describes evaluating the savings associated with performing duct sealing using mastic sealant or metal tape to the distribution system of homes with either central air conditioning or a ducted heating system.

Two methodologies for estimating the savings associate from sealing the ducts are provided. The first preferred method requires the use of a blower door and the second requires careful inspection of the duct work.

1. **Modified Blower Door Subtraction** – this technique is described in detail on p.44 of the Energy Conservatory Blower Door Manual; <http://www.energyconservatory.com/download/bdmanual.pdf>
2. **Evaluation of Distribution Efficiency** – this methodology requires the evaluation of three duct characteristics below, and use of the Building Performance Institutes ‘Distribution Efficiency Look-Up Table’;
<http://www.bpi.org/files/pdf/DistributionEfficiencyTable-BlueSheet.pdf>
 - a. Percentage of duct work found within the conditioned space
 - b. Duct leakage evaluation
 - c. Duct insulation evaluation

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

DEFINITION OF EFFICIENT EQUIPMENT

The efficient condition is sealed duct work throughout the unconditioned space in the home.

DEFINITION OF BASELINE EQUIPMENT

The existing baseline condition is leaky duct work within the unconditioned space in the home.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The assumed lifetime of this measure is 20 years⁵⁴³.

DEEMED MEASURE COST

The actual duct sealing measure cost should be used.

⁵⁴³ 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 Error! Hyperlink reference not valid.

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape R08 - Residential Cooling

Loadshape R09 - Residential Electric Space Heat

Loadshape R10 - Residential Electric Heating and Cooling (Shell Measures)

COINCIDENCE FACTOR

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

$$CF_{SSP} = \text{Summer System Peak Coincidence Factor for Central A/C (during utility peak hour)}$$

$$= 91.5\%^{544}$$

$$CF_{PJM} = \text{PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)}$$

$$= 46.6\%^{545}$$

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

Methodology 1: Modified Blower Door Subtraction

- a) Determine Duct Leakage rate before and after performing duct sealing:

$$\text{Duct Leakage (CFM50}_{DL}) = (\text{CFM50}_{\text{Whole House}} - \text{CFM50}_{\text{Envelope Only}}) * SCF$$

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.

⁵⁴⁴ 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.

⁵⁴⁵ 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.

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

$$\text{Duct Leakage Reduction } (\Delta\text{CFM25}_{\text{DL}}) = (\text{Pre CFM50}_{\text{DL}} - \text{Post CFM50}_{\text{DL}}) * 0.64 * (\text{SLF} + \text{RLF})$$

Where:

0.64 = Converts CFM50 to CFM25⁵⁴⁶

SLF = Supply Loss Factor
 = % leaks sealed located in Supply ducts * 1⁵⁴⁷
 Default = 0.5⁵⁴⁸

RLF = Return Loss Factor
 = % leaks sealed located in Return ducts * 0.5⁵⁴⁹
 Default = 0.25⁵⁵⁰

c) Calculate Energy Savings:

$$\Delta\text{kWh}_{\text{cooling}} = ((\Delta\text{CFM25}_{\text{DL}}) / ((\text{Capacity}/12,000) * 400)) * \text{FLH}_{\text{cool}} * \text{Capacity} / 1000 / \eta_{\text{Cool}}$$

Where:

$\Delta\text{CFM25}_{\text{DL}}$ = Duct leakage reduction in CFM25
 = calculated above

⁵⁴⁶ 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).

⁵⁴⁷ 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>

⁵⁴⁸ Assumes 50% of leaks are in supply ducts.

⁵⁴⁹ 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>

⁵⁵⁰ Assumes 50% of leaks are in return ducts.

Capacity = Capacity of Air Cooling system (Btu/H)

=Actual

12,000 = Converts Btu/H capacity to tons

400 = Converts capacity in tons to CFM (400CFM / ton)

FLHcool = Full load cooling hours

= Dependent on location as below⁵⁵¹:

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 ⁵⁵²	629	564

1000 = Converts Btu to kBtu

η Cool = Efficiency (SEER) of Air Conditioning equipment (kBtu/kWh)

= Actual. If unknown assume the following⁵⁵³:

Age of Equipment	SEER Estimate
Before 2006	10
After 2006	13

⁵⁵¹ Based on Full Load Hours from ENERGY Star with adjustments made in a Navigant Evaluation, other cities were scaled using those results and CDD. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

⁵⁵² Weighted based on number of occupied residential housing units in each zone.

⁵⁵³ These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Central AC was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate.

For example, duct sealing in a single family house in Springfield with a 36,000 Btu/H, SEER 11 central air conditioning and the following blower door test results:

Before: $CFM50_{Whole\ House} = 4800\ CFM50$

$CFM50_{Envelope\ Only} = 4500\ CFM50$

House to duct pressure of 45 Pascals. = 1.29 SCF (Energy Conservatory look up table)

After: $CFM50_{Whole\ House} = 4600\ CFM50$

$CFM50_{Envelope\ Only} = 4500\ CFM50$

House to duct pressure of 43 Pascals = 1.39 SCF (Energy Conservatory look up table)

Duct Leakage:

$$CFM50_{DL\ before} = (4800 - 4500) * 1.29$$

$$= 387\ CFM$$

$$CFM50_{DL\ after} = (4600 - 4500) * 1.39$$

$$= 139\ CFM$$

Duct Leakage reduction at CFM25:

$$\Delta CFM25_{DL} = (387 - 139) * 0.64 * (0.5 + 0.25)$$

$$= 119\ CFM25$$

Energy Savings:

$$\Delta kWh_{cooling} = ((119 / ((36,000/12,000) * 400)) * 730 * 36,000) / 1000 / 11$$

$$= 237\ kWh$$

Heating savings for homes with electric heat (Heat Pump):

$$\Delta kWh_{heating} = (((\Delta CFM25_{DL} / ((Capacity/12,000) * 400)) * FLH_{heat} * Capacity) / \eta_{Heat} / 3412$$

Where:

FLH_{heat} = Full load heating hours

= Dependent on location as below⁵⁵⁴:

⁵⁵⁴ Heating EFLH based on ENERGY Star EFLH for Rockford, Chicago, and Springfield and on NCDC/NOAA HDD for

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 ⁵⁵⁵	1,821

η_{Heat} = Efficiency in COP of Heating equipment

= Actual. If not available use⁵⁵⁶:

System Type	Age of Equipment	HSPF Estimate	COP Estimate
Heat Pump	Before 2006	6.8	2.00
	After 2006	7.7	2.26
Resistance	N/A	N/A	1.00

3412 = Converts Btu to kWh

For example, duct sealing in a 36,000 Btu/H 2.5 COP heat pump heated single family house in Springfield with the blower door results described above:

$$\Delta kWh_{heating} = (((119 / ((36,000/12,000) * 400)) * 1,754 * 36,000) / 2.5 / 3412)$$

$$= 734 \text{ kWh}$$

Methodology 2: Evaluation of Distribution Efficiency

Determine Distribution Efficiency by evaluating duct system before and after duct sealing using Building Performance Institute “Distribution Efficiency Look-Up Table”

$$\Delta kWh_{cooling} = ((DE_{after} - DE_{before}) / DE_{after}) * FLH_{cool} * Capacity / 1000 / \eta_{Cool}$$

Where:

DE_{after} = Distribution Efficiency after duct sealing

the other two cities. In all cases, the hours were adjusted based on average natural gas heating consumption in IL.
⁵⁵⁵ Weighted based on number of occupied residential housing units in each zone.

⁵⁵⁶ 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.

DE_{before} = Distribution Efficiency before duct sealing

FLH_{cool} = Full load cooling hours

= Dependent on location as below⁵⁵⁷:

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 ⁵⁵⁸	629	564

Capacity = Capacity of Air Cooling system (Btu/H)

=Actual

1000 = Converts Btu to kBtu

η_{Cool} = Efficiency (SEER) of Air Conditioning equipment (kBtu/kWh)

= Actual. If unknown assume⁵⁵⁹:

Age of Equipment	SEER Estimate
Before 2006	10
After 2006	13

⁵⁵⁷ Based on Full Load Hours from ENERGY Star with adjustments made in a Navigant Evaluation, other cities were scaled using those results and CDD. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

⁵⁵⁸ Weighted based on number of occupied residential housing units in each zone.

⁵⁵⁹ These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Central AC was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate.

For example, duct sealing in a single family house in Springfield, with 36,000 Btu/H SEER 11 central air conditioning and the following duct evaluation results:

$$DE_{\text{before}} = 0.85$$

$$DE_{\text{after}} = 0.92$$

Energy Savings:

$$\begin{aligned} \Delta kWh_{\text{cooling}} &= ((0.92 - 0.85)/0.92) * 730 * 36,000 / 1000 / 11 \\ &= 182 \text{ kWh} \end{aligned}$$

Heating savings for homes with electric heat (Heat Pump or resistance):

$$\Delta kWh_{\text{heating}} = ((DE_{\text{after}} - DE_{\text{before}}) / DE_{\text{after}}) * FLH_{\text{heat}} * Capacity / \eta_{\text{Heat}} / 3412$$

Where:

FLH_{heat} = Full load heating hours

= Dependent on location as below⁵⁶⁰:

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 ⁵⁶¹	1,821

⁵⁶⁰ 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.

⁵⁶¹ Weighted based on number of occupied residential housing units in each zone.

COP = Coefficient of Performance of electric heating system⁵⁶²

= Actual. If not available use⁵⁶³:

System Type	Age of Equipment	HSPF Estimate	COP Estimate
Heat Pump	Before 2006	6.8	2.00
	After 2006	7.7	2.26
Resistance	N/A	N/A	1.00

For example, duct sealing in a 36,000 Btu/H, 2.5 COP heat pump heated single family house in Springfield with the following duct evaluation results:

$$DE_{\text{after}} = 0.92$$

$$DE_{\text{before}} = 0.85$$

Energy Savings:

$$\begin{aligned} \Delta kWh_{\text{heating}} &= ((0.92 - 0.85)/0.92) * 1,967 * 36,000 / 2.5 / 3412 \\ &= 632 \text{ kWh} \end{aligned}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = \Delta kWh_{\text{cooling}} / FLH_{\text{cool}} * CF$$

Where:

⁵⁶² Note that the HSPF of a heat pump is equal to the COP * 3.413.

⁵⁶³ These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Heat Pumps was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate.

FLHcool = Full load cooling hours:
 = Dependent on location as below⁵⁶⁴:

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 ⁵⁶⁵	629	564

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)
 = 91.5%⁵⁶⁶

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)
 = 46.6%⁵⁶⁷

NATURAL GAS SAVINGS

For homes with Natural Gas Heating:

Methodology 1: Modified Blower Door Subtraction

$$\Delta\text{Therm} = ((\Delta\text{CFM}_{25\text{DL}} / (\text{Capacity} * 0.0123)) * \text{FLHheat} * \text{Capacity}) / 100,000 / \eta\text{Heat}$$

Where:

$\Delta\text{CFM}_{25\text{DL}}$ = Duct leakage reduction in CFM25

Capacity = Capacity of Air Cooling system (Btu/H)
 =Actual

0.0123 = Conversion of Capacity to CFM (0.0123CFM / Btu/h)⁵⁶⁸

⁵⁶⁴ Based on Full Load Hours from ENERGY Star with adjustments made in a Navigant Evaluation, other cities were scaled using those results and CDD. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

⁵⁶⁵ Weighted based on number of occupied residential housing units in each zone.

⁵⁶⁶ 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.

⁵⁶⁷ 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.

⁵⁶⁸ 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-

FLHeat = Full load heating hours

=Dependent on location as below⁵⁶⁹:

Climate Zone (City based upon)	FLH_heat
1 (Rockford)	1,969
2 (Chicago)	1,840
3 (Springfield)	1,754
4 (Belleville)	1,266
5 (Marion)	1,288
Weighted Average ⁵⁷⁰	1,821

100,000 = Converts Btu to therms

η Heat = Average Net Heating System Efficiency (Equipment Efficiency * Distribution Efficiency)⁵⁷¹

= Actual. If not available use 70%⁵⁷².

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.

⁵⁶⁹ Heating EFLH based on ENERGY Star EFLH for Rockford, Chicago, and Springfield and on NCDC/NOAA HDD for the other two cities. In all cases, the hours were adjusted based on average natural gas heating consumption in IL.

⁵⁷⁰ Weighted based on number of occupied residential housing units in each zone.

⁵⁷¹ The System Efficiency can be obtained either by recording the AFUE of the unit, or performing a steady state efficiency test. The Distribution Efficiency can be estimated via a visual inspection and by referring to a look up table such as that provided by the Building Performance Institute:

(<http://www.bpi.org/files/pdf/DistributionEfficiencyTable-BlueSheet.pdf>) or by performing duct blaster testing.

If there are more than one heating systems, the weighted (by consumption) average efficiency should be used.

If the heating system or distribution is being upgraded within a package of measures together with the insulation upgrade, the new average heating system efficiency should be used.

⁵⁷² This has been estimated assuming that natural gas central furnace heating is typical for Illinois residences (66% of Illinois homes have a Natural Gas Furnace (based on Energy Information Administration, 2009 Residential Energy Consumption Survey:

<http://www.eia.gov/consumption/residential/data/2009/xls/HC6.9%20Space%20Heating%20in%20Midwest%20Region.xls>))

In 2000, 24% of furnaces purchased in Illinois were condensing (based on data from GAMA, provided to Department of Energy during the federal standard setting process for residential heating equipment - see Furnace Penetration.xls). Furnaces tend to last up to 20 years and so units purchased 10 years ago provide a reasonable proxy for the current mix of furnaces in the State. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows:

$$(0.24*0.92) + (0.76*0.8) * (1-0.15) = 0.70$$

For example, duct sealing in a house in Springfield with an 80% AFUE, 105,000 Btu/H natural gas furnace and the following blower door test results:

Before: $CFM50_{Whole\ House} = 4800\ CFM50$

$CFM50_{Envelope\ Only} = 4500\ CFM50$

House to duct pressure of 45 Pascals = 1.29 SCF (Energy Conservatory look up table)

After: $CFM50_{Whole\ House} = 4600\ CFM50$

$CFM50_{Envelope\ Only} = 4500\ CFM50$

House to duct pressure of 43 Pascals = 1.39 SCF (Energy Conservatory look up table)

Duct Leakage:

$CFM50_{DL\ before} = (4800 - 4500) * 1.29$

$= 387\ CFM$

$CFM50_{DL\ after} = (4600 - 4500) * 1.39$

$= 119\ CFM$

Duct Leakage reduction at CFM25:

$\Delta CFM25_{DL} = (387 - 119) * 0.64 * (0.5 + 0.25)$

$= 119\ CFM25$

Energy Savings:

$\Delta Therm = ((119 / (105,000 * 0.0123)) * 1,754 * 105,000) / 100,000 / 0.80$

$= 212\ therms$

Methodology 2: Evaluation of Distribution Efficiency

$\Delta Therm = ((DE_{after} - DE_{before}) / DE_{after}) * FLH_{heat} * Capacity / 100,000 / \eta_{Heat}$

Where:

DE_{after} = Distribution Efficiency after duct sealing

DE_{before} = Distribution Efficiency before duct sealing

Other variables as defined above

For example, duct sealing in a house in Springfield an 80% AFUE, 105,000 Btu/H natural gas furnace and the following duct evaluation results:

$$DE_{\text{after}} = 0.92$$

$$DE_{\text{before}} = 0.85$$

Energy Savings:

$$\Delta\text{Therm} = ((0.92 - 0.85)/0.92) * 1,754 * 105,000 / 100,000 / 0.80$$

$$= 175 \text{ therm}$$

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HVC-DINS-V01-120601

5.3.4 Furnace Blower Motor

DESCRIPTION

A new furnace with a brushless permanent magnet (BPM) blower motor is installed instead of a new furnace with a lower efficiency motor. This measure characterizes only the electric savings associated with the fan and could be coupled with gas savings associated with a more efficient furnace. Savings decrease sharply with static pressure so duct improvements, and clean, low pressure drop filters can maximize savings. Savings improve when the blower is used for cooling as well and when it is used for continuous ventilation, but only if the non-BPM motor would have been used for continuous ventilation too. If the resident runs the BPM blower continuously because it is a more efficient motor and would not run a non-BPM motor that way, savings are near zero and possibly negative. This characterization uses a 2009 Focus on Energy study of BPM blower motor savings in Wisconsin, which accounted for the effects of this behavioral impact.

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

DEFINITION OF EFFICIENT EQUIPMENT

A furnace with a brushless permanent magnet (BPM) blower motor, also known by the trademark ECM, BLDC, and other names.

DEFINITION OF BASELINE EQUIPMENT

A furnace with a non-BPM blower motor.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 20 years⁵⁷³.

DEEMED MEASURE COST

The capital cost for this measure is assumed to be \$97⁵⁷⁴.

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

⁵⁷³ 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

⁵⁷⁴ Adapted from Tables 8.2.3 and 8.2.13 in

http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/hvac_ch_08_lcc_2011-06-24.pdf

COINCIDENCE FACTOR

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

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during utility peak hour)
 = 91.5%⁵⁷⁵

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)
 = 46.6%⁵⁷⁶

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$\Delta kWh = \text{Heating Savings} + \text{Cooling Savings} + \text{Shoulder Season Savings}$

Where:

Heating Savings = Blower motor savings during heating season
 = 418 kWh⁵⁷⁷

Cooling Savings = Blower motor savings during cooling season
 If Central AC = 263 kWh
 If No Central AC = 175 kWh
 If unknown (weighted average)
 = 241 kWh⁵⁷⁸

⁵⁷⁵ Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility’s peak hour is divided by the maximum AC load during the year.

⁵⁷⁶ Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.

⁵⁷⁷ 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.

⁵⁷⁸ 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).

$$\begin{aligned} \text{Shoulder Season Savings} &= \text{Blower motor savings during shoulder seasons} \\ &= 51 \text{ kWh} \end{aligned}$$

For example, a blower motor in a home where Central AC presence is unknown:

$$\begin{aligned} \Delta\text{kWh} &= \text{Heating Savings} + \text{Cooling Savings} + \text{Shoulder Season Savings} \\ &= 418 + 251 + 51 \\ &= 721 \text{ kWh} \end{aligned}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta\text{kW} = \text{Cooling Savings} / \text{FLH}_{\text{cooling}} * \text{CF}$$

Where:

$$\begin{aligned} \text{FLH}_{\text{cooling}} &= \text{Full load hours of air conditioning} \\ &= \text{Dependent on location}^{579}: \end{aligned}$$

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 ⁵⁸⁰	629

$$\text{CF}_{\text{SSP}} = \text{Summer System Peak Coincidence Factor for Central A/C (during system peak hour)}$$

$$= 91.5\%^{581}$$

$$\text{CF}_{\text{PJM}} = \text{PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)}$$

$$= 46.6\%^{582}$$

⁵⁷⁹ Full load hours for Chicago, Moline and Rockford are provided in “Final Evaluation Report: Central Air Conditioning Efficiency Services (CACES), 2010, Navigant Consulting”, http://ilsag.org/yahoo_site_admin/assets/docs/ComEd_PY2_CACES_Evaluation_Report_2010-10-18.299122020.pdf, p.33. An average FLH/Cooling Degree Day (from NCDC) ratio was calculated for these locations and applied to the CDD of the other locations in order to estimate FLH. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

⁵⁸⁰ Weighted based on number of occupied residential housing units in each zone.

⁵⁸¹ 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.

For example, a blower motor in a home of unknown location where Central AC prevalence is unknown:

$$\Delta kW_{SSP} = 251 / 629 * 0.915$$

$$= 0.365 \text{ kW}$$

$$\Delta kW_{SSP} = 251 / 629 * 0.466$$

$$= 0.186 \text{ kW}$$

NATURAL GAS SAVINGS

$$\Delta \text{therms}^{583} = - \text{Heating Savings} * 0.03412 \text{ therms/kWh}$$

$$= - (418 * 0.03412)$$

$$= - 14.3 \text{ therms}^{584}$$

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HVC-FBMT-V01-120601

⁵⁸² 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.

⁵⁸³ The blower fan is in the heating duct so all, or very nearly all, of its waste heat is delivered to the conditioned space.

⁵⁸⁴ Negative value since this measure will increase the heating load due to reduced waste heat.

5.3.5 Gas High Efficiency Boiler

DESCRIPTION

This measure describes the purchase and installation of a new high efficiency, gas-fired hot water boiler in a residential location. High efficiency boilers achieve most gas savings through the utilization of a sealed combustion chamber and multiple heat exchangers that remove a significant portion of the waste heat from flue gasses. Because multiple heat exchangers are used to remove waste heat from the escaping flue gasses, some of the flue gasses condense and must be drained.

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

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed Boiler must be ENERGY STAR qualified (AFUE rated at or greater than 85% and input capacity less than 300,000 BTUh).

DEFINITION OF BASELINE EQUIPMENT

The baseline equipment for this measure is a new, gas-fired, standard-efficiency water boiler. The current Federal Standard minimum AFUE rating is 80%. For boilers manufactured after September 2012 the Federal Standards is raised to 82% AFUE. Baseline assumptions are therefore provided below:

Program Year	AFUE
June 2012 – May 2013 ⁵⁸⁵	80%
June 2013 on	82%

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 25 years⁵⁸⁶.

DEEMED MEASURE COST

The incremental cost for this measure is dependent on tier⁵⁸⁷:

Measure Type	Incr. Cost
AFUE 85% (Energy Star Minimum)	\$216
AFUE 90%	\$422
AFUE 95%	\$628

DEEMED O&M COST ADJUSTMENTS

N/A

⁵⁸⁵ There will be some delay to the baseline shift while existing stocks of lower efficiency equipment is sold.

⁵⁸⁶ 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

⁵⁸⁷ Appliance Standards Technical Support Documents (http://www1.eere.energy.gov/buildings/appliance_standards/residential/fb_tsd_0907.html). Note this assumes the baseline of 80% and should be reevaluated when new information is available for the new baseline.

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS SAVINGS

$$\Delta\text{Therms} = \text{Gas_Boiler_Load} * (1/\text{AFUE}(\text{base}) - 1/\text{AFUE}(\text{eff}))$$

Where:

$$\text{Gas_Boiler_Load}^{588}$$

= Estimate of annual household Load for gas boiler heated single-family homes. If location is unknown, assume the average below⁵⁸⁹.

= or Actual if informed by site-specific load calculations, ACCA Manual J or equivalent⁵⁹⁰.

Climate Zone (City based upon)	Gas_Boiler Load (therms)
1 (Rockford)	1275
2 (Chicago)	1218

⁵⁸⁸ 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)

⁵⁸⁹ 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.

⁵⁹⁰ 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.

3 (Springfield)	1043
4 (Belleville)	805
5 (Marion)	819
Average	1158

AFUE(base) = Baseline Boiler Annual Fuel Utilization Efficiency Rating

= Dependent on year as listed below:

Program Year	AFUE(base)
June 2012 – May 2013	80%
June 2013 on	82%

AFUE(eff) = Efficient Boiler Annual Fuel Utilization Efficiency Rating

= Actual. If unknown, use defaults dependent⁵⁹¹ on tier as listed below:

Measure Type	AFUE(eff)
ENERGY STAR®	87.5%
AFUE 90%	92.5%
AFUE 95%	95%

For example, a default sized ENERGY STAR boiler purchased and installed near Springfield in the year 2012

$$\Delta\text{Therms} = (1043) * (1/0.8) - 1/0.875$$

$$= 112 \text{ Therms}$$

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HVC-GHEB-V01-120601

⁵⁹¹ 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.

5.3.6 Gas High Efficiency Furnace

DESCRIPTION

This measure covers the purchase of a new ENERGY STAR-qualified high efficiency gas-fired condensing furnace for residential space heating in place of a new Federal Standard furnace. High efficiency features may include improved heat exchangers and modulating multi-stage burners.

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

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed equipment must be a residential sized (input energy less than 225,000 BTU/h) ENERGY STAR rated natural gas fired furnace with an Annual Fuel Utilization Efficiency (AFUE) rating and fan electrical efficiency in accordance with ENERGY STAR criteria⁵⁹², as defined below:

ENERGY STAR Furnaces Specification	Min. AFUE	Min. Fan Efficiency ⁵⁹³	Max. Air Leakage
Version 2.0 – Effective until 2.1.12	90%	N/A	N/A
Version 3.0 – Effective 2.1.12	95%	2.0%	N/A
Version 4.0 – Effective 2.1.13	95%	2.0%	2.0%

DEFINITION OF BASELINE EQUIPMENT

Although the current Federal Standard for gas furnaces is an AFUE rating of 78%, based upon review of available product in the AHRI database, the baseline efficiency for this characterization is assumed to be 80% for program year June 2012 – May 2013.

For furnaces manufactured after September 2012 the Federal minimum efficiency Standards are raised to 90% AFUE. Baseline assumptions are therefore provided below:

Program Year	AFUE
June 2012 – May 2013	80%
June 2013 on	90%

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 20 years⁵⁹⁴.

DEEMED MEASURE COST

The incremental capital cost for this measure depends on efficiency as listed below⁵⁹⁵:

⁵⁹² Source: Final Furnace Version3.0/4.0 Specification schedules available here:

http://www.energystar.gov/index.cfm?c=revisions.furnace_spec

⁵⁹³ Fan efficiency, as determined by the “Interim Approach for Determining Furnace Fan Energy Use Rev. June-2011” is a performance-based metric that was designed to function in a manner that resembles past program criteria requiring an ECM or BPM fan motor.

⁵⁹⁴ 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

AFUE	Incremental Cost (June 2012 – May 2013)	Incremental Cost (June 2013 on)
90%	\$304	\$0
91%	\$394	\$90
92%	\$477	\$173
93%	\$567	\$263
94%	\$657	\$353
95%	\$754	\$450
96%	\$851	\$547

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

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

$$\Delta\text{Therms} = \text{Gas_Furnace_Heating_Load} * (1/\text{AFUE}(\text{base}) - 1/\text{AFUE}(\text{eff}))$$

Where:

Gas_Furnace_Heating_Load

= Estimate of annual household heating load⁵⁹⁶ for gas furnace heated single-family homes. If location is unknown, assume the average below⁵⁹⁷.

⁵⁹⁵ Appliance Standards Technical Support Documents

(http://www1.eere.energy.gov/buildings/appliance_standards/residential/fb_tsd_0907.html)

⁵⁹⁶ Heating load is used to describe the household heating need, which is equal to (gas consumption * AFUE)

⁵⁹⁷ Values are based on household heating consumption values and inferred average AFUE results from Table 3-4,

= Actual if informed by site-specific load calculations, ACCA Manual J or equivalent⁵⁹⁸.

Climate Zone (City based upon)	Gas_Furnace_Heating_Load (therms)
1 (Rockford)	843
2 (Chicago)	806
3 (Springfield)	690
4 (Belleville)	532
5 (Marion)	542
Average	766

AFUE(base) = Baseline Furnace Annual Fuel Utilization Efficiency Rating

= Dependent on year as listed below⁵⁹⁹:

Program Year	AFUE(base)
June 2012 – May 2013	80%
June 2013 on	90%

AFUE(eff) = Efficient Furnace Annual Fuel Utilization Efficiency Rating

= Actual. If unknown, assume 95%⁶⁰⁰

For example, a 95% AFUE furnace near Rockford and purchased in the year 2012

$$\Delta\text{Therms} = 843 * (1/0.8 - 1/0.95)$$

$$=166 \text{ therms}$$

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

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.

⁵⁹⁸ 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.

⁵⁹⁹ 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.

⁶⁰⁰ Minimum ENERGY STAR efficiency after 2.1.2012.

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HVC-GHEF-V01-120601

5.3.7 Ground Source Heat Pump

DESCRIPTION

This measure relates to the installation of a new Ground Source Heat Pump system meeting ENERGY STAR efficiency standards presented below.

ENERGY STAR Requirements (Effective January 1, 2012)

Product Type	EER	COP
Water-to-air		
Closed Loop	17.1	3.6
Open Loop	21.1	4.1
Water-to-Water		
Closed Loop	16.1	3.1
Open Loop	20.1	3.5
DGX	16	3.6

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

DEFINITION OF EFFICIENT EQUIPMENT

In order for this characterization to apply, the efficient equipment must be a Ground Source Heat Pump unit meeting the minimum ENERGY STAR efficiency level standards effective at the time of installation as detailed above.

DEFINITION OF BASELINE EQUIPMENT

The baseline equipment is assumed to be an Air Source Heat Pump meeting the Federal Standard efficiency level; 13 SEER and 11 EER.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 18 years⁶⁰¹.

DEEMED MEASURE COST

The actual installed cost of the Ground Source Heat Pump should be used, minus the assumed installation cost of a 3 ton standard baseline Air Source Heat Pump of \$3,609⁶⁰².

⁶⁰¹ Lifetime for an air source heat pump. The ground loop has a much longer life, but the compressor and other mechanical components are the same as an ASHP. The more moderate operating conditions for a GSHP may extend the life of these components beyond the life of an ASHP. Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007.

http://neep.org/uploads/EMV%20Forum/EMV%20Studies/measure_life_GDS%5B1%5D.pdf

⁶⁰² Based on DEER 2008 Database Technology and Measure Cost Data (www.deeresources.com). Material cost of 13 SEER AC is \$796 per ton, and labor cost of \$407 per ton. For a 3 ton unit this would be (796+407) *3 = \$3609.

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape R10 - Residential Electric Heating and Cooling

COINCIDENCE FACTOR

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

$$CF_{SSP} = \text{Summer System Peak Coincidence Factor for Central A/C (during utility peak hour)} \\ = 91.5\%^{603}$$

$$CF_{PJM} = \text{PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)} \\ = 46.6\%^{604}$$

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = (FLH_{cool} * Btu/H * (1/SEER_{base} - (1/(EER_{ee} * 1.02)))/1000 + (FLH_{heat} * Btu/H * (1/HSPF_{base} - (1/COPE_{ee} * 3.412))/1000$$

Where:

FLH_{cool} = Full load cooling hours

⁶⁰³ 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.

⁶⁰⁴ Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.

Dependent on location as below⁶⁰⁵:

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 ⁶⁰⁶	629	564

Btu/H = Size of equipment in Btu/h (note 1 ton = 12,000Btu/h)

= Actual installed

SEERbase = SEER Efficiency of baseline ASHP unit

= 13⁶⁰⁷

EERee = EER Efficiency of efficient GSHP unit

= Actual installed

1.02 = Constant used to estimate the equivalent air conditioning SEER based on the GSHP unit's EER⁶⁰⁸.

⁶⁰⁵ Based on Full Load Hours from ENERGY Star with adjustments made in a Navigant Evaluation, other cities were scaled using those results and CDD. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

⁶⁰⁶ Weighted based on number of occupied residential housing units in each zone.

⁶⁰⁷ Minimum Federal Standard; Federal Register, Vol. 66, No. 14, Monday, January 22, 2001/ Rules and Regulations, p. 7170-7200.

⁶⁰⁸ Note that EERs of GSHPs are measured differently than EERs of air source heat pumps (focusing on entering water temperatures rather than ambient air temperatures). The equivalent SEER of a GSHP can be estimated by multiplying EER by 1.02, based on VEIC extrapolation of manufacture data.

FLHheat = Full load heating hours

Dependent on location as below⁶⁰⁹:

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 ⁶¹⁰	1,821

HSPFbase = Heating Season Performance Factor for baseline unit

= 7.7⁶¹¹

COPee = Coefficient of Performance of efficient unit

= Actual Installed

3.412 = Constant to convert the COP of the unit to the Heating Season Performance Factor (HSPF).

For example, a 3 ton unit with EER rating of 16 and COP of 3.5 in single family house in Springfield:

$$\Delta kWh = (FLH_{cool} * Btu/H * (1/SEER_{base} - 1/(EER_{ee} * 1.02)))/1000 + (FLH_{heat} * Btu/H * (1/HSPF_{base} - 1/COP_{ee} * 3.412))/1000$$

$$\Delta kWh = (730 * 36,000 * (1/13 - 1/(16 * 1.02))) / 1000 + (1967 * 36,000 * (1/7.7 - 1/(3.5 * 3.412))) / 1000$$

$$= 3680 kWh$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = (Btu/H * (1/EER_{base} - 1/EER_{ee, AC equivalent}))/1000 * CF$$

Where:

EERbase = EER Efficiency of baseline ASHP unit

= 11⁶¹²

⁶⁰⁹ Heating EFLH based on ENERGY Star EFLH for Rockford, Chicago, and Springfield and on NCDC/NOAA HDD for the other two cities. In all cases, the hours were adjusted based on average natural gas heating consumption in IL. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

⁶¹⁰ Weighted based on number of occupied residential housing units in each zone.

⁶¹¹ Minimum Federal Standard; Federal Register, Vol. 66, No. 14, Monday, January 22, 2001/Rules and Regulations, p. 7170-7200.

$EER_{AC\ equivalent}$ = Equivalent Air Conditioning EER Efficiency of ENERGY STAR GSHP unit⁶¹³

To calculate this, the actual EER of the GSHP is converted to an air conditioning SEER equivalent by multiplying by 1.02⁶¹⁴

This is then converted to the air conditioning EER equivalent resulting in the following algorithm:

$$EER_{AC\ equivalent} = (-0.02 * (EER * 1.02)^2 + (1.12 * (EER * 1.02)))^{615}$$

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)

$$= 91.5\%^{616}$$

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)

$$= 46.6\%^{617}$$

For example, a 3 ton unit with EER rating of 16:

$$\begin{aligned} \Delta kW_{SSP} &= ((36,000 * (1/11 - 1/(-0.02 * (16 * 1.02)^2 + (1.12 * (16 * 1.02)))))/1000) * 0.915 \\ &= 0.451 \text{ kW} \end{aligned}$$

$$\begin{aligned} \Delta kW_{SSP} &= ((36,000 * (1/11 - 1/(-0.02 * (16 * 1.02)^2 + (1.12 * (16 * 1.02)))))/1000) * 0.466 \\ &= 0.230 \text{ kW} \end{aligned}$$

NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

⁶¹² Minimum Federal Standard; as above.

⁶¹³ EERs of GSHPs are measured differently than EERs of air source heat pumps (focusing on entering water temperatures rather than ambient air temperatures).

⁶¹⁴ Based on VEIC extrapolation of manufacturer data.

⁶¹⁵ Air conditioning SEER to EER algorithm based on Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder. Note this is appropriate for single speed units only.

⁶¹⁶ 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.

⁶¹⁷ Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HVC-GSHP-V01-120601

5.3.8 High Efficiency Bathroom Exhaust Fan

DESCRIPTION

This market opportunity is defined by the need for continuous mechanical ventilation due to reduced air-infiltration from a tighter building shell. In retrofit projects, existing fans may be too loud, or insufficient in other ways, to be operated as required for proper ventilation. This measure assumes a fan capacity of 50 CFM rated at a sound level of less than 2.0 sones at 0.1 inches of water column static pressure. This measure may be applied to larger capacity, up to 130 CFM, efficient fans with bi-level controls because the savings and incremental costs are very similar. All eligible installations shall be sized to provide the mechanical ventilation rate indicated by ASHRAE 62.2.

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

DEFINITION OF EFFICIENT EQUIPMENT

New efficient (average CFM/watt of 8.3⁶¹⁸) exhaust-only ventilation fan, quiet (< 2.0 sones) Continuous operation in accordance with recommended ventilation rate indicated by ASHRAE 62.2⁶¹⁹

DEFINITION OF BASELINE EQUIPMENT

New standard efficiency (average CFM/Watt of 3.1⁶²⁰) exhaust-only ventilation fan, quiet (< 2.0 sones) operating in accordance with recommended ventilation rate indicated by ASHRAE 62.2⁶²¹

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 19 years⁶²².

DEEMED MEASURE COST

Incremental cost per installed fan is \$43.50 for quiet, efficient fans⁶²³.

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape R11 - Residential Ventilation

⁶¹⁸ 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.

⁶¹⁹ Bi-level controls may be used by efficient fans larger than 50 CFM

⁶²⁰ 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.

⁶²¹ On/off cycling controls may be required of baseline fans larger than 50CFM.

⁶²² 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.

⁶²³ VEIC analysis using cost data collected from wholesale vendor; <http://www.westsidewholesale.com/>.

COINCIDENCE FACTOR

The summer Peak Coincidence Factor is assumed to be 100% because the fan runs continuously.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = (CFM * (1/\eta_{BASELINE} - 1/\eta_{EFFICIENT})/1000) * Hours$$

Where:

- CFM = Nominal Capacity of the exhaust fan
= 50 CFM⁶²⁴
- $\eta_{BASELINE}$ = Average efficacy for baseline fan
= 3.1 CFM/Watt⁶²⁵
- $\eta_{EFFICIENT}$ = Average efficacy for efficient fan
= 8.3 CFM/Watt⁶²⁶
- Hours = assumed annual run hours,
= 8766 for continuous ventilation.

$$\begin{aligned} \Delta kWh &= (50 * (1/3.1 - 1/8.3)/1000) * 8766 \\ &= 88.6 kWh \end{aligned}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = (CFM * (1/\eta_{BASELINE} - 1/\eta_{EFFICIENT})/1000) * CF$$

Where:

⁶²⁴ 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.

⁶²⁵ 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.

⁶²⁶ VEIC analysis looking at average efficient fan (i.e. Brushless Permanent Magnet) efficacies at static pressures of 0.1 and 0.25 inches of water column for quiet fans rated for 50 CFM.

CF = Summer Peak Coincidence Factor
= 1.0 (continuous operation)
Other variables as defined above

$$\Delta kW = (50 * (1/3.1 - 1/8.3)/1000) * 1.0$$
$$= 0.0101 \text{ kW}$$

NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HVC-BAFA-V01-120601

5.3.9 HVAC Tune Up (Central Air Conditioning or Air Source Heat Pump)

DESCRIPTION

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

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

This measure was developed to be applicable to the following program types: RF.

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

DEFINITION OF EFFICIENT EQUIPMENT

N/A

DEFINITION OF BASELINE EQUIPMENT

This measure assumes that the existing unit being maintained is either a residential central air conditioning unit or an air source heat pump that has not been serviced for at least 3 years.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

THE MEASURE LIFE IS ASSUMED TO BE 2 YEARS⁶²⁷.

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 \$175⁶²⁸.

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape R08 - Residential Cooling

COINCIDENCE FACTOR

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

⁶²⁷ Based on VEIC professional judgment.

⁶²⁸ 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.

calibrated to Illinois loads, supplied by Ameren.

$$CF_{SSP} = \text{Summer System Peak Coincidence Factor for Central A/C (during utility peak hour)}$$

$$= 91.5\%^{629}$$

$$CF_{PJM} = \text{PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)}$$

$$= 46.6\%^{630}$$

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh_{\text{Central AC}} = (\text{FLHcool} * \text{Capacity_cooling} * (1/\text{SEER}_{\text{CAC}}))/1000 * \text{MFe}$$

$$\Delta kWh_{\text{Air Source Heat Pump}} = ((\text{FLHcool} * \text{Capacity_cooling} * (1/\text{SEER}_{\text{ASHP}}))/1000 * \text{MFe}) + (\text{FLHheat} * \text{Capacity_heating} * (1/\text{HSPF}_{\text{ASHP}}))/1000 * \text{MFe}$$

Where:

FLHcool = Full load cooling hours

Dependent on location as below:⁶³¹

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 ⁶³²	629	564

Capacity_cooling = Cooling capacity of equipment in Btu/h (note 1 ton = 12,000 Btu/h)

= Actual

⁶²⁹ 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.

⁶³⁰ 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.

⁶³¹ Based on Full Load Hours from ENERGY Star with adjustments made in a Navigant Evaluation, other cities were scaled using those results and CDD. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

⁶³² Weighted based on number of occupied residential housing units in each zone.

SEER_{CAC} = SEER Efficiency of existing central air conditioning unit receiving maintenance
 = Actual. If unknown assume 10 SEER ⁶³³

MFe = Maintenance energy savings factor
 = 0.05 ⁶³⁴

SEER_{ASHP} = SEER Efficiency of existing air source heat pump unit receiving maintenance
 = Actual. If unknown assume 10 SEER ⁶³⁵

FLH_{heat} = Full load heating hours
 Dependent on location: ⁶³⁶

Climate Zone (City based upon)	FLH _{heat}
1 (Rockford)	2208
2 (Chicago)	2064
3 (Springfield)	1967
4 (Belleville)	1420
5 (Marion)	1445
Weighted Average ⁶³⁷	1821

Capacity_{heating} = Heating capacity of equipment in Btu/h (note 1 ton = 12,000 Btu/h)
 = Actual

HSPF_{base} = Heating Season Performance Factor of existing air source heat pump unit receiving maintenance
 = Actual. If unknown assume 6.8 HSPF ⁶³⁸

⁶³³ 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.

⁶³⁴ Energy Center of Wisconsin, May 2008; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research."

⁶³⁵ 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.

⁶³⁶ Full load heating hours for heat pumps are provided for Rockford, Chicago and Springfield in the Energy Star Calculator. Estimates for the other locations were calculated based on the FLH to Heating Degree Day (from NCDC) ratio. VEIC consider Energy Star estimates to be high due to oversizing not being adequately addressed. Using average Illinois billing data (from <http://www.icc.illinois.gov/ags/consumereducation.aspx>) VEIC estimated the average gas heating load and used this to estimate the average home heating output (using 83% average gas heat efficiency). Dividing this by a typical 36,000 Btu/h ASHP gives an estimate of average ASHP FLH_{heat} of 1821 hours. We used the ratio of this value to the average of the locations using the Energy Star data (1994 hours) to scale down the Energy Star estimates. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

⁶³⁷ Weighted based on number of occupied residential housing units in each zone.

For example, maintenance of a 3-ton, SEER 10 air conditioning unit in a single family house in Springfield:

$$\begin{aligned}\Delta\text{kWh}_{\text{CAC}} &= (730 * 36,000 * (1/10))/1000 * 0.05 \\ &= 131 \text{ kWh}\end{aligned}$$

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

$$\begin{aligned}\Delta\text{kWh}_{\text{ASHP}} &= ((730 * 36,000 * (1/10))/1000 * 0.05) + (1967 * 36,000 * (1/6.8))/1000 * 0.05 \\ &= 652 \text{ kWh}\end{aligned}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta\text{kW} = \text{Capacity}_{\text{cooling}} * (1/\text{EER})/1000 * \text{MFd} * \text{CF}$$

Where:

$$\begin{aligned}\text{EER} &= \text{EER Efficiency of existing unit receiving maintenance in Btu/H/Watts} \\ &= \text{Calculate using Actual SEER} \\ &= -0.02 * \text{SEER}^2 + 1.12 * \text{SEER}^{639}\end{aligned}$$

$$\begin{aligned}\text{MFd} &= \text{Maintenance demand savings factor} \\ &= 0.02^{640}\end{aligned}$$

$$\begin{aligned}\text{CF}_{\text{SSP}} &= \text{Summer System Peak Coincidence Factor for Central A/C (during system peak hour)} \\ &= 91.5\%^{641}\end{aligned}$$

$$\begin{aligned}\text{CF}_{\text{PJM}} &= \text{PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)} \\ &= 46.6\%^{642}\end{aligned}$$

⁶³⁸ 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.

⁶³⁹ 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.

⁶⁴⁰ 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.

⁶⁴¹ 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.

⁶⁴² Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load

For example, maintenance of 3-ton, SEER 10 (equals EER 9.2) unit:

$$\Delta kW_{SSP} = 36,000 * 1/(9.2)/1000 * 0.02 * 0.915$$

$$= 0.0716 \text{ kW}$$

$$\Delta kW_{PJM} = 36,000 * 1/(9.2)/1000 * 0.02 * 0.466$$

$$= 0.0365 \text{ kW}$$

NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

Conservatively not included

MEASURE CODE: RS-HVC-TUNE-V01-120601

during the year.

5.3.10 Programmable Thermostats

DESCRIPTION

This measure characterizes the household energy savings from the installation of a Programmable Thermostat for reduced heating energy consumption through temperature set-back during unoccupied or reduced demand times. Because a literature review was not conclusive in providing a defensible source of prescriptive cooling savings from programmable thermostats, cooling savings from programmable thermostats are assumed to be zero for this version of the measure. It is not appropriate to assume a similar pattern of savings from setting a thermostat down during the heating season and up during the cooling season. Note that the EPA's EnergyStar program is developing a new specification for this project category, and if/when evaluation results demonstrate consistent cooling savings, subsequent versions of this measure will revisit this assumption⁶⁴³.

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

DEFINITION OF EFFICIENT EQUIPMENT

The criteria for this measure are established by replacement of a manual-only temperature control, with one that has the capability to adjust temperature setpoints according to a schedule without manual intervention. This category of equipment is broad and rapidly advancing in regards to the capability, and usability of the controls and their sophistication in setpoint adjustment and information display, but for the purposes of this characterization, eligibility is perhaps most simply defined by what it isn't: a manual only temperature control.

DEFINITION OF BASELINE EQUIPMENT

Non-Programmable Thermostat requiring manual intervention to change temperature setpoint.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 10 years⁶⁴⁴ based upon equipment life only⁶⁴⁵. This is reduced by a 50% persistence factor to give final measures life of 5 years.

DEEMED MEASURE COST

Actual material and labor costs should be used if the implementation method allows. If unknown (e.g. through a retail program) the capital cost for this measure is assumed to be \$30⁶⁴⁶.

⁶⁴³ 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'.

⁶⁴⁴ Table 1, HVAC Controls, Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007

⁶⁴⁵ 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.

⁶⁴⁶ Market prices vary significantly in this category, generally increasing with thermostat capability and sophistication. The basic functions required by this measure's eligibility criteria are available on units readily available in the market for the listed price.

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape R09 - Residential Electric Space Heat

COINCIDENCE FACTOR

N/A due to no savings attributable to cooling during the summer peak period.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh^{647} = \%ElectricHeat * Elec_Heating_Consumption * Heating_Reduction * HF * Eff_ISR + (\Delta Therms * F_e * 29.3)$$

Where:

$\%ElectricHeat$ = Percentage of heating savings assumed to be electric

Heating fuel	$\%ElectricHeat$
Electric	100%
Natural Gas	0%
Unknown	13% ⁶⁴⁸

$Elec_Heating_Consumption$

= Estimate of annual household heating consumption for electrically heated single-family homes⁶⁴⁹. If location and heating type is unknown, assume 17,734 kWh⁶⁵⁰

⁶⁴⁷ Note the second part of the algorithm relates to furnace fan savings if the heating system is Natural Gas.

⁶⁴⁸ 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.

⁶⁴⁹ Values in table are based on converting an average household heating consumption (849 therms) for Chicago based on 'Table 3-4, Program Sample Analysis, Nicor R29 Res Rebate Evaluation Report 092611_REV FINAL to Nicor', to an electric heat consumption (divide by 0.03413 and assuming efficiencies of 100% for resistance and 200% for HP) and then adjusting to a statewide average using relative HDD assumptions to adjust for the evaluation results focus on northern region. Values for individual cities are then calculated by comparing average HDD to the individual city's HDD.

⁶⁵⁰ 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.

Climate Zone (City based upon)	Electric Resistance Elec_Heating_ Consumption (kWh)	Electric Heat Pump Elec_Heating_ Consumption (kWh)
1 (Rockford)	26,038	13,019
2 (Chicago)	24,875	12,438
3 (Springfield)	21,304	10,652
4 (Belleville)	16,434	8,217
5 (Marion)	16,726	8,363
Average	23,645	11,822

Heating_Reduction = Assumed percentage reduction in heating energy consumption due to programmable thermostat

= 6.2%⁶⁵¹

HF = Household factor, to adjust heating consumption for non-single-family households.

Household Type	HF
Single-Family	100%
Multi-Family	65% ⁶⁵²
Actual	Custom ⁶⁵³

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% ⁶⁵⁴

ΔTherms = Therm savings if Natural Gas heating system

= See calculation in Natural Gas section below

⁶⁵¹ 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.

⁶⁵² 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

⁶⁵³ Program-specific household factors may be utilized on the basis of sufficiently validated program evaluations.

⁶⁵⁴ "Programmable Thermostats. Report to KeySpan Energy Delivery on Energy Savings and Cost Effectiveness," GDS Associates, Marietta, GA. 2002GDS

F_e = Furnace Fan energy consumption as a percentage of annual fuel consumption
 = 3.14%⁶⁵⁵
 29.3 = kWh per therm

For example, a programmable thermostat directly installed in an electric resistance heated, single-family home in Springfield:

$$\Delta\text{kWh} = 1 * 20,214 * 0.062 * 100\% * 100\% + (0 * 0.0314 * 29.3)$$

$$= 1253 \text{ kWh}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A due to no savings from cooling during the summer peak period.

NATURAL GAS ENERGY SAVINGS

$$\Delta\text{Therms} = \%FossilHeat * Gas_Heating_Consumption * Heating_Reduction * HF * Eff_ISR$$

Where:

$\%FossilHeat$ = Percentage of heating savings assumed to be Natural Gas

Heating fuel	$\%FossilHeat$
Electric	0%
Natural Gas	100%
Unknown	87% ⁶⁵⁶

Gas_Heating_Consumption

= Estimate of annual household heating consumption for gas heated single-family homes. If location is unknown, assume the average below⁶⁵⁷.

Climate Zone	Gas_Heating_
--------------	--------------

⁶⁵⁵ 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.

⁶⁵⁶ 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.

⁶⁵⁷ 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' adjusting to a statewide average using relative HDD assumptions to adjust for the evaluation results focus on northern region. Values for individual cities are then calculated by comparing average HDD to the individual city's HDD.

(City based upon)	Consumption (therms)
1 (Rockford)	889
2 (Chicago)	849
3 (Springfield)	727
4 (Belleville)	561
5 (Marion)	571
Average	807

For example, a programmable thermostat directly-installed in a gas heated single-family home in Chicago:

$$\begin{aligned} \Delta\text{Therms} &= 1.0 * 849 * 0.062 * 100\% * 100\% \\ &= 52.6 \text{ therms} \end{aligned}$$

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HVC-PROG-V01-120601

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 years⁶⁵⁸.

DEEMED MEASURE COST

The measure cost including material and installation is assumed to be \$3 per linear foot⁶⁵⁹.

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape C53 - Flat

COINCIDENCE FACTOR

This measure assumes a flat loadshape since savings relate to reducing standby losses and as such the coincidence factor is 1.

Algorithm

⁶⁵⁸ 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>

⁶⁵⁹ Consistent with DEER 2008 Database Technology and Measure Cost Data (www.deeresources.com).

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

For electric DHW systems:

$$\Delta kWh = ((1/R_{exist} - 1/R_{new}) * (L * C) * \Delta T * 8,766) / \eta_{DHW} / 3412$$

Where:

R_{exist} = Pipe heat loss coefficient of uninsulated pipe (existing) [(hr-°F-ft)/Btu]
 = 1.0⁶⁶⁰

R_{new} = Pipe heat loss coefficient of insulated pipe (new) [(hr-°F-ft)/Btu]
 = Actual (1.0 + R value of insulation)

L = Length of pipe from water heating source covered by pipe wrap (ft)
 = Actual

C = Circumference of pipe (ft) (Diameter (in) * 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°F⁶⁶¹

8,766 = Hours per year

η_{DHW} = Recovery efficiency of electric hot water heater
 = 0.98⁶⁶²

3412 = Conversion from Btu to kWh

For example, insulating 5 feet of 0.75" pipe with R-5 wrap:

$$\begin{aligned} \Delta kWh &= ((1/R_{exist} - 1/R_{new}) * (L * C) * \Delta T * 8,766) / \eta_{DHW} / 3412 \\ &= ((1/1 - 1/5) * (5 * 0.196) * 60 * 8766) / 0.98 / 3412 \\ &= 123 \text{ kWh} \end{aligned}$$

⁶⁶⁰ Navigant Consulting Inc., April 2009; "Measures and Assumptions for Demand Side Management (DSM) Planning; Appendix C Substantiation Sheets", p77.

⁶⁶¹ Assumes 125°F water leaving the hot water tank and average temperature of basement of 65°F.

⁶⁶² Electric water heater have recovery efficiency of 98%: <http://www.ahrinet.org/ARI/util/showdoc.aspx?doc=576>

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.

$$\begin{aligned} \Delta kWh &= ((1/R_{exist} - 1/R_{new}) * (L * C) * \Delta T * 8,766) / \eta_{DHW} / 3412 \\ &= ((1/1 - 1/5) * (3 * 0.196) * 60 * 8766) / 0.98 / 3412 \\ &= 74.0 \text{ kWh per 3ft length} \end{aligned}$$

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:

$$\begin{aligned} \Delta kW &= 123/8766 \\ &= 0.014kW \end{aligned}$$

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.

$$\begin{aligned} \Delta kW &= 73.9/8766 \\ &= 0.0084 \text{ kW} \end{aligned}$$

NATURAL GAS SAVINGS

For Natural Gas DHW systems:

$$\Delta Therm = ((1/R_{exist} - 1/R_{new}) * (L * C) * \Delta T * 8,766) / \eta_{DHW} / 100,000$$

Where:

η_{DHW} = Recovery efficiency of gas hot water heater

= 0.78⁶⁶³

Other variables as defined above

⁶⁶³ 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%

For example, insulating 5 feet of 0.75" pipe with R-5 wrap:

$$\begin{aligned}\Delta\text{Therm} &= ((1/1 - 1/5) * (5 * 0.196) * 60 * 8766) / 0.78 / 100,000 \\ &= 5.29 \text{ therms}\end{aligned}$$

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.

$$\begin{aligned}\Delta\text{Therm} &= ((1/R_{\text{exist}} - 1/R_{\text{new}}) * (L * C) * \Delta T * 8,766) / \eta_{\text{DHW}} / 100,000 \\ &= ((1/1 - 1/5) * (3 * 0.196) * 60 * 8766) / 0.78 / 100,000 \\ &= 3.17 \text{ therms per 3ft length}\end{aligned}$$

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HWE-PINS-V01-120601

5.4.2 Gas Water Heater

DESCRIPTION

This measure characterizes the purchase and installation of a new efficient gas-fired water heater, in place of a Federal Standard unit in a residential setting. Savings are provided for power-vented, condensing storage, and whole-house tankless units meeting specific EF criteria.

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

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the efficient equipment must be a water heater rated with the following minimum efficiency ratings:

Water heater Type	Minimum Energy Factor
Gas Storage	0.67
Condensing gas storage	0.80
Tankless whole-house unit	0.82

DEFINITION OF BASELINE EQUIPMENT

The baseline condition is assumed to be a standard gas storage water heater of the same capacity as the efficient unit, rated at the federal minimum ($0.67 - 0.0019 * \text{storage size in gallons}$)⁶⁶⁴. For a 40-gallon storage water heater this would be 0.594 EF.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 13 years⁶⁶⁵.

⁶⁶⁴ Federal Standard as of January 2004,

http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/water_heater_fr.pdf

⁶⁶⁵ DOE, 2010 Residential Heating Products Final Rule Technical Support Document, Table 8.2.14

http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/htgp_finalrule_ch8.pdf Note: This source is used to support this category in aggregate. For all water heaters, life expectancy will depend on local variables such as water chemistry and homeowner maintenance. Some categories, including condensing storage and tankless water heaters do not yet have sufficient field data to support separate values. Preliminary data show lifetimes may exceed 20 years, though this has yet to be sufficiently demonstrated.

DEEMED MEASURE COST

The incremental capital cost for this measure is dependent on the type of water heater as listed below⁶⁶⁶:

Water heater Type	Incremental Cost
Gas Storage	\$400
Condensing gas storage	\$685
Tankless whole-house unit	\$605

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

$$\Delta\text{Therms} = (1/EF_{\text{BASE}} - 1/EF_{\text{EFFICIENT}}) * (\text{GPD} * 365.25 * \gamma_{\text{Water}} * (T_{\text{OUT}} - T_{\text{IN}}) * 1.0) / 100,000$$

Where:

⁶⁶⁶ Source for cost info; DOE, 2010 Residential Heating Products Final Rule Technical Support Document, Table 8.2.14 (http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/htgp_finalrule_ch8.pdf)

EF_Baseline = Energy Factor rating for baseline equipment
 = $(0.67 - 0.0019 * \text{tank_size})^{667}$

Tank_size (gallons)	EF_Baseline
40	0.594
50	0.575
60	0.556

= If tank size unknown assume 40 gallons and EF_Baseline of 0.594

EF_Efficient = Energy Factor Rating for efficient equipment

= Actual. If Tankless whole-house multiply rated efficiency by 0.91⁶⁶⁸.
 If unknown assume values in look up in table below

Water Heater Type	EF_Efficient
Condensing Gas Storage	0.80
Gas Storage	0.67
Tankless whole-house	$0.82 * 0.91 = 0.75$

GPD = Gallons Per Day of hot water use per household

= 50⁶⁶⁹

365.25 = Days per year, on average

yWater = Specific Weight of water

= 8.33 pounds per gallon

T_{OUT} = Tank temperature

= 125°F

⁶⁶⁷ Algorithm based on current Federal Standard;

http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/water_heater_fr.pdf

Note that changes to the Federal Standard will be applied from April 16, 2015, see link below for more details:

http://www1.eere.energy.gov/buildings/appliance_standards/residential/heating_products_fr.html.

⁶⁶⁸ 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.

⁶⁶⁹ Federal Register, Test Procedures for Water Heaters, Comments on "Test Conditions,"

http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/wtrhtr.pdf

T_{IN} = Incoming water temperature from well or municipal system
= 54°F⁶⁷⁰

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:

$$\Delta\text{Therms} = (1/0.594) - 1/0.8) * (50 * 365.25 * 8.33 * (125 - 54) * 1) / 100,000$$
$$= 46.8 \text{ therms}$$

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HWE-GWHT-V01-120601

⁶⁷⁰ US DOE Building America Program. Building America Analysis Spreadsheet. For Chicago, IL
http://www1.eere.energy.gov/buildings/building_america/analysis_spreadsheets.html

5.4.3 Heat Pump Water Heaters

DESCRIPTION

The installation of a heat pump domestic hot water heater in place of a standard electric water heater in a home. Savings are presented dependent on the heating system installed in the home due to the impact of the heat pump water heater on the heating loads.

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

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed equipment must be a Heat Pump domestic water heater.

DEFINITION OF BASELINE EQUIPMENT

The baseline condition is assumed to be a new electric water heater meeting federal minimum efficiency standards.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 13 years⁶⁷¹.

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 respectively⁶⁷².

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape R03 - Residential Electric DHW

COINCIDENCE FACTOR

The summer Peak Coincidence Factor is assumed to be 12%⁶⁷³.

⁶⁷¹ 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

⁶⁷² 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

⁶⁷³ Calculated from Figure 8 "Combined six-unit summer weekday average electrical demand" in FEMP study; Field Testing of Pre-Production Prototype Residential Heat Pump Water Heaters
http://www1.eere.energy.gov/femp/pdfs/tir_heatpump.pdf as (average kW usage during peak period * hours in peak period) / [(annual kWh savings / FLH) * hours in peak period] = (0.1 kW * 5 hours) / [(2100 kWh (default assumptions) / 2533 hours) * 5 hours] = 0.12

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta \text{kWh} = (((1/\text{EF}_{\text{BASE}} - 1/\text{EF}_{\text{EFFICIENT}}) * \text{GPD} * 365.25 * \gamma_{\text{Water}} * (T_{\text{OUT}} - T_{\text{IN}}) * 1.0) / 3412) + \text{kWh}_{\text{cooling}} - \text{kWh}_{\text{heating}}$$

Where:

- EF_{BASE} = Energy Factor (efficiency) of standard electric water heater according to federal standards:
 = $0.93 - (0.00132 * \text{rated volume in gallons})^{674}$
 = 0.904 for a 50 gallon tank, the most common size for HPWH
- $\text{EF}_{\text{EFFICIENT}}$ = Energy Factor (efficiency) of Heat Pump water heater
 = Actual
- GPD = Gallons Per Day of hot water use per household
 = 50⁶⁷⁵
- 365.25 = Days per year
- γ_{Water} = Specific weight of water
 = 8.33 pounds per gallon
- T_{OUT} = Tank temperature
 = 125°F
- T_{IN} = Incoming water temperature from well or munipcle system
 = 54°F⁶⁷⁶
- 1.0 = Heat Capacity of water (1 Btu/lb*°F)
- 3412 = Conversion from BTU to kWh

⁶⁷⁴ Current Federal Standard EF, since 2004, for a 50-gal electric storage WH, Federal Register Vol. 66, No. 11/1/17/2001, page 4497,

http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/water_heater_fr.pdf

⁶⁷⁵ Federal Register, Test Procedures for Water Heaters, Comments on "Test Conditions,"

http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/wtrhtr.pdf

⁶⁷⁶ US DOE Building America Program. Building America Analysis Spreadsheet. For Chicago, IL

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

$$\begin{aligned} \text{kWh_cooling}^{677} &= \text{Cooling savings from conversion of heat in home to water heat} \\ &= \left(\left[\left(\text{GPD} * 365.25 * \gamma_{\text{Water}} * (T_{\text{OUT}} - T_{\text{IN}}) * 1.0 \right) / 3412 \right] - \right. \\ &\quad \left. \left(\text{GPD} * 365.25 * \gamma_{\text{Water}} * (T_{\text{OUT}} - T_{\text{IN}}) * 1.0 \right) / \text{EF}_{\text{NEW}} \right] * \text{LF} * 27\% \right) / \\ &\quad \text{COP}_{\text{COOL}} * \text{LM} \end{aligned}$$

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 savings⁶⁷⁸
- 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
 = 1.33⁶⁷⁹:

kWh_heating = Heating cost from conversion of heat in home to water heat (dependent on heating fuel)

For Natural Gas heating, kWh_heating = 0

For electric heating:

$$\begin{aligned} &= \left(\left[\left(\text{GPD} * 365.25 * \rho * (T_{\text{OUT}} - T_{\text{IN}}) * 1.0 \right) / 3412 \right] - \right. \\ &\quad \left. \left(\text{GPD} * 365.25 * \rho * (T_{\text{OUT}} - T_{\text{IN}}) * 1.0 \right) / \text{EF}_{\text{NEW}} \right] * \text{LF} * 49\% \right) / \\ &\quad \text{COP}_{\text{HEAT}} \end{aligned}$$

Where:

- 49% = Portion of reduced waste heat that results in increased

⁶⁷⁷ 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.

⁶⁷⁸ 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).

⁶⁷⁹ 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

heating load⁶⁸⁰

COP_{HEAT} = COP of electric heating system

= actual. If not available use⁶⁸¹:

System Type	Age of Equipment	HSPF Estimate	COP_{HEAT} (COP Estimate)
Heat Pump	Before 2006	6.8	2.00
	After 2006	7.7	2.26
Resistance	N/A	N/A	1.00

For example, a 2.0 EF heat pump water heater, in a conditioned space in a home with gas space heat and central air conditioning (SEER 10.5) in Belleville:

$$\Delta kWh = [(1 / 0.904 - 1 / 2.0) * 50 * 365.25 * 8.33 * (125 - 54)] / 3412 + 185 - 0$$

$$= 2100 \text{ kWh}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = \Delta kWh / \text{Hours} * CF$$

Where:

Hours = Full load hours of water heater

$$= 2533^{682}$$

CF = Summer Peak Coincidence Factor for measure

$$= 0.12^{683}$$

⁶⁸⁰ 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).

⁶⁸¹ 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.

⁶⁸² Full load hours assumption based on Efficiency Vermont analysis of Itron eShapes.

⁶⁸³ 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

For example, a 2.0 COP heat pump water heater, in a conditioned space in a home with gas space heat and central air conditioning in Belleville:

$$\begin{aligned} \text{kW} &= 2100 / 2533 * 0.12 \\ &= 0.099 \text{ kW} \end{aligned}$$

NATURAL GAS SAVINGS

$$\Delta\text{Therms} = - \left(\left(\left(\text{GPD} * 365.25 * \gamma_{\text{Water}} * (T_{\text{OUT}} - T_{\text{IN}}) * 1.0 \right) / 3412 \right) - \left(\left(\text{GPD} * 365.25 * \gamma_{\text{Water}} * (T_{\text{OUT}} - T_{\text{IN}}) * 1.0 \right) / 3412 \right) / \text{EF}_{\text{EFFICIENT}} \right) * \text{LF} * 49\% * 0.03412 / (\eta_{\text{Heat}} * \% \text{ Natural Gas})$$

Where:

- ΔTherms = Heating cost from conversion of heat in home to water heat for homes with Natural Gas heat.⁶⁸⁴
- 0.03412 = conversion factor (therms per kWh)
- η_{Heat} = Efficiency of heating system
= Actual.⁶⁸⁵ If not available use 70%.⁶⁸⁶

⁶⁸⁴ 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.

⁶⁸⁵ 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.

⁶⁸⁶ This has been estimated assuming that natural gas central furnace heating is typical for Illinois residences (66% of Illinois homes have a Natural Gas Furnace (based on Energy Information Administration, 2009 Residential Energy Consumption Survey:

<http://www.eia.gov/consumption/residential/data/2009/xls/HC6.9%20Space%20Heating%20in%20Midwest%20Region.xls>)

In 2000, 24% of furnaces purchased in Illinois were condensing (based on data from GAMA, provided to Department of Energy during the federal standard setting process for residential heating equipment - see Furnace Penetration.xls). Furnaces tend to last up to 20 years and so units purchased 10 years ago provide a reasonable proxy for the current mix of furnaces in the State. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows:

$(0.24 * 0.92) + (0.76 * 0.8) * (1 - 0.15) = 0.70$

% Natural Gas = Factor dependent on heating fuel:

Heating System	%Natural Gas
Electric resistance or heat pump	0%
Natural Gas	100%
Unknown heating fuel ⁶⁸⁷	87%

Other factors as defined above

For example, a 2.0 COP heat pump water heater in conditioned space, in a home with gas space heat (70% system efficiency):

$$\Delta\text{Therms} = - (1582.9 * 1 * 0.49 * 0.03412) / 0.7 * 1$$

$$= - 35.1 \text{ therms}$$

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HWE-HPWH-V01-120601

⁶⁸⁷ 2010 American Community Survey.

5.4.4 Low Flow Faucet Aerators

DESCRIPTION

This measure relates to the installation of a low flow faucet aerator in a household kitchen or bath faucet fixture.

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

DEFINITION OF EFFICIENT EQUIPMENT

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

DEFINITION OF BASELINE EQUIPMENT

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

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 9 years⁶⁸⁸.

DEEMED MEASURE COST

The incremental cost for this measure is \$8⁶⁸⁹ or program actual.

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape R03 - Residential Electric DHW

COINCIDENCE FACTOR

The coincidence factor for this measure is assumed to be 2.2%⁶⁹⁰.

⁶⁸⁸ 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"](http://neep.org/uploads/EMV%20Forum/EMV%20Studies/measure_life_GDS%5B1%5D.pdf)

⁶⁸⁹ 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)

⁶⁹⁰ 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

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

NOTE THESE SAVINGS ARE PER FAUCET RETROFITTED⁶⁹¹.

$$\Delta kWh = \%ElectricDHW * ((GPM_base * L_base - GPM_low * L_low) * Household * 365.25 * DF / FPH) * EPG_electric * ISR$$

Where:

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

DHW fuel	%ElectricDHW
Electric	100%
Natural Gas	0%
Unknown	16% ⁶⁹²

GPM_base = Average flow rate, in gallons per minute, of the baseline faucet “as-used”
 = 1.2⁶⁹³ or custom based on metering studies⁶⁹⁴

GPM_low = Average flow rate, in gallons per minute, of the low-flow faucet aerator “as-used”
 = 0.94⁶⁹⁵ or custom based on metering studies⁶⁹⁶

peak period so the probability you will see savings during the peak period is 5.8/260 = 0.022

⁶⁹¹ This algorithm calculates the amount of energy saved per aerator by determining the fraction of water consumption savings for the upgraded fixture.

⁶⁹² 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

⁶⁹³ Representative baseline flow rate for kitchen and bathroom faucet aerators from sources 2, 4, 5, and 7 (see source table at end of characterization). This accounts for all throttling and differences from rated flow rates. The most comprehensive available studies did not disaggregate kitchen use from bathroom use, but instead looked at total flow and length of use for all faucets. This makes it difficult to reliably separate kitchen water use from bathroom water use.

⁶⁹⁴ 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.

⁶⁹⁵ 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.

⁶⁹⁶ Measurement should be based on actual average flow consumed over a period of time rather than a onetime

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

= 9.85 min/person/day⁶⁹⁷ or custom based on metering studies

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

= 9.85 min/person/day⁶⁹⁸ or custom based on metering studies

Household = Average number of people per household

Household Unit Type	Household
Single-Family - Deemed	2.56 ⁶⁹⁹
Multi-Family - Deemed	2.1 ⁷⁰⁰
Custom	Actual Occupancy or Number of Bedrooms ⁷⁰¹

365.25 = Days in a year, on average.

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.

⁶⁹⁷ This coincides with the middle of the range (6.74 min/person/day to 13.4 min/person/day) from sources 2, 3, 4, and 5 (See Source Table at end of measure section). A recent Midwest evaluation study included a small metering sample with measured faucet use at 4.5 min/person/day for kitchen faucets and 2.6 min/person/day for bathroom faucets. This sample was too small to extrapolate to the population as a whole, but is within the range of total faucet time per the referenced reports and confirms previous findings.

⁶⁹⁸ Set equal to L_base. Studies show conflicting results with some studies showing increased time for retrofit homes and some showing decreased time. Engineering judgment leads us to conclude that using the baseline time is a reasonable assumption.

⁶⁹⁹ 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

⁷⁰⁰ ComEd PY3 Multi-Family Evaluation Report REVISED DRAFT v5 2011-12-08.docx

⁷⁰¹ Bedrooms are suitable proxies for household occupancy, and may be preferable to actual occupancy due to turnover rates in residency and non-adult population impacts.

DF = Drain Factor

Faucet Type	Drain Factor ⁷⁰²
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	2.83 ⁷⁰³
Bathroom Faucets Per Home (BFPH): Multi-Family	1.5 ⁷⁰⁴

EPG_{electric} = Energy per gallon of water used by faucet supplied by electric water heater

$$= (8.33 * 1.0 * (\text{WaterTemp} - \text{SupplyTemp})) / (\text{RE}_{\text{electric}} * 3412)$$

$$= (8.33 * 1.0 * (90 - 54.1)) / (0.98 * 3412)$$

$$= 0.0894 \text{ kWh/gal}$$

8.33 = Specific weight of water (lbs/gallon)

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

WaterTemp = Assumed temperature of mixed water

$$= 90\text{F}^{705}$$

SupplyTemp = Assumed temperature of water entering house

$$= 54.1\text{F}^{706}$$

⁷⁰² 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 $(0.7 * 0.75) + (0.3 * 0.9) = 0.795$.

⁷⁰³ Based on findings from a 2009 ComEd residential survey of 140 sites, provided by Cadmus.

⁷⁰⁴ Ibid.

⁷⁰⁵ Temperature cited from SBW Consulting, Evaluation for the Bonneville Power Authority, 1994, http://www.bpa.gov/energy/n/reports/evaluation/residential/faucet_aerator.cfm. This is a variable that would benefit from further evaluation.

⁷⁰⁶ US DOE Building America Program. Building America Analysis Spreadsheet. For Chicago, IL http://www1.eere.energy.gov/buildings/building_america/analysis_spreadsheets.html.

RE_electric = Recovery efficiency of electric water heater
 = 98%⁷⁰⁷

3412 = Converts Btu to kWh (btu/kWh)

ISR = In service rate of faucet aerators dependant on install method as listed in table below⁷⁰⁸

Selection	ISR
Direct Install - Deemed	0.95
Self-Install - Deemed	0.48

For example, a direct installed faucet in a single-family electric DHW home:

$$\Delta kWh = 1.0 * ((1.2 * 9.85 - 0.94 * 9.85) * 2.56 * 365.25 * 0.795 / (1+2.83)) * 0.0894 * 0.95$$

$$= 42.2 \text{ kWh}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = \Delta kWh / \text{Hours} * CF$$

Where:

ΔkWh = calculated value above

Hours = Annual electric DHW recovery hours for faucet use

$$= ((GPM_base * L_base) * Household * 365.25 * DF) * 0.545^{709} / GPH$$

$$= 197 \text{ for SF; } 162 \text{ for MF}$$

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

$$= 27.51$$

CF = Coincidence Factor for electric load reduction

$$= 0.022^{710}$$

⁷⁰⁷ Electric water heater have recovery efficiency of 98%: <http://www.ahrinet.org/ARI/util/showdoc.aspx?doc=576>

⁷⁰⁸ ComEd Energy Efficiency/ Demand Response Plan: Plan Year 2 (6/1/2009-5/31/2010) Evaluation Report: All Electric Single Family Home Energy Performance Tune-Up Program Table 3-8

⁷⁰⁹ 54.5% is the proportion of hot 120F water mixed with 54.1F supply water to give 90F mixed faucet water.

⁷¹⁰ 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->

For example, a direct installed faucet in a single family electric DHW home:

$$\begin{aligned} \Delta kW &= 48/197 * 0.022 \\ &= 0.005kW \end{aligned}$$

NATURAL GAS SAVINGS

$$\Delta \text{Therms} = \% \text{FossilDHW} * ((\text{GPM}_{\text{base}} * L_{\text{base}} - \text{GPM}_{\text{low}} * L_{\text{low}}) * \text{Household} * 365.25 * \text{DF} / \text{FPH}) * \text{EPG}_{\text{gas}} * \text{ISR}$$

Where:

$\% \text{FossilDHW}$ = proportion of water heating supplied by Natural Gas heating

DHW fuel	$\% \text{Fossil}_{\text{DHW}}$
Electric	0%
Natural Gas	100%
Unknown	84% ⁷¹¹

EPG_{gas} = Energy per gallon of Hot water supplied by gas
 $= (8.33 * 1.0 * (\text{WaterTemp} - \text{SupplyTemp})) / (\text{RE}_{\text{gas}} * 100,000)$

= 0.0040 Therm/gal for SF homes

= 0.0045 Therm/gal for MF homes

RE_{gas} = Recovery efficiency of gas water heater

= 75% For SF homes⁷¹²

= 67% For MF homes⁷¹³

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

[Family-Homes-Using-Flow-Trace-Analysis.pdf](#) There are 65 days in the summer peak period, so the percentage of total annual aerator use in peak period is $0.18 * 65 / 365 = 3.21\%$. 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 $5.8 / 260 = 0.022$

⁷¹¹ 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

⁷¹² DOE Final Rule discusses Recovery Efficiency with an average around 0.76 for Gas Fired Storage Water heaters and 0.78 for standard efficiency gas fired tankless water heaters up to 0.95 for the highest efficiency gas fired condensing tankless water heaters. These numbers represent the range of new units however, not the range of existing units in stock. Review of AHRI Directory suggests range of recovery efficiency ratings for new Gas DHW units of 70-87%. Average of existing units is estimated at 75%.

⁷¹³ MF hot water is often provided by a larger central boiler. This suggests that the average recovery efficiency is somewhere between a typical central boiler efficiency of 0.59 and the 0.75 for single family homes. An average is used for this analysis as a default.

Other variables as defined above.

For example, a direct-installed faucet aerator in a fuel DHW single-family home:

$$\begin{aligned} \Delta\text{Therms} &= 1.0 * ((1.2 * 9.85 - 0.94 * 9.85) * 2.56 * 365.25 * 0.795 / (1+2.83)) * 0.0040 * 0.95 \\ &= 1.89 \text{ Therms} \end{aligned}$$

WATER IMPACT DESCRIPTIONS AND CALCULATION

$$\Delta\text{gallons} = ((\text{GPM}_{\text{base}} * L_{\text{base}} - \text{GPM}_{\text{low}} * L_{\text{low}}) * \text{Household} * 365.25 * \text{DF} / \text{FPH}) * \text{ISR}$$

Variables as defined above

For example, a direct-installed aerator in a single family home

$$\begin{aligned} \Delta\text{gallons} &= ((1.2 * 9.85 - 0.94 * 9.85) * 2.56 * 365.25 * 0.795 / (1+2.83)) * 0.95 \\ &= 472 \text{ gallons} \end{aligned}$$

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-V01-120601

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

DEFINITION OF EFFICIENT EQUIPMENT

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

DEFINITION OF BASELINE EQUIPMENT

For Direct-install programs, the baseline condition is assumed to be a standard showerhead rated at 2.5 GPM or greater.

For retrofit and time-of-sale programs, the baseline condition is assumed to be a representative average of existing showerhead flow rates of participating customers including a range of low flow showerheads, standard-flow showerheads, and high-flow showerheads.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 10 years⁷¹⁴.

DEEMED MEASURE COST

The incremental cost for this measure is \$12⁷¹⁵ or program actual.

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape R03 - Residential Electric DHW

COINCIDENCE FACTOR

The coincidence factor for this measure is assumed to be 2.78%⁷¹⁶.

⁷¹⁴ 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"](http://neep.org/uploads/EMV%20Forum/EMV%20Studies/measure_life_GDS%5B1%5D.pdf)

⁷¹⁵ Direct-install price per showerhead assumes cost of showerhead (Market research average of \$7 and assess and install time of \$5 (20min @ \$15/hr)

⁷¹⁶ 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->

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

Note these savings are per showerhead fixture

$$\Delta kWh = \%ElectricDHW * ((GPM_base * L_base - GPM_low * L_low) * Household * SPCD * 365.25 / SPH) * EPG_electric * ISR$$

Where:

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

DHW fuel	%ElectricDHW
Electric	100%
Natural Gas	0%
Unknown	16% ⁷¹⁷

GPM_base = Flow rate of the baseline showerhead

Program	GPM_base
Direct-install	2.67 ⁷¹⁸
Retrofit or TOS	2.35 ⁷¹⁹

[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 $7.23 / 260 = 0.0278$

⁷¹⁷ 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

⁷¹⁸ Based on measured data from Ameren IL EM&V of Direct-Install program. Program targets showers that are rated 2.5 GPM or above.

⁷¹⁹ Representative value from sources 1, 2, 4, 5, 6 and 7 (See Source Table at end of measure section) adjusted slightly upward to account for program participation which is expected to target customers with existing higher flow devices rather than those with existing low flow devices.

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

Rated Flow
2.0 GPM
1.75 GPM
1.5 GPM
Custom or Actual ⁷²⁰

L_base = Shower length in minutes with baseline showerhead
 = 8.20 min⁷²¹

L_low = Shower length in minutes with low-flow showerhead
 = 8.20 min⁷²²

Household = Average number of people per household

Household Unit Type ⁷²³	Household
Single-Family - Deemed	2.56 ⁷²⁴
Multi-Family - Deemed	2.1 ⁷²⁵
Custom	Actual Occupancy or Number of Bedrooms ⁷²⁶

SPCD = Showers Per Capita Per Day
 = 0.75⁷²⁷

365.25 = Days per year, on average.

⁷²⁰ 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.

⁷²¹ Representative value from sources 1, 2, 3, 4, 5, and 6 (See Source Table at end of measure section)

⁷²² Set equal to L_base.

⁷²³ If household type is unknown, as may be the case for time of sale measures, then single family deemed value shall be used.

⁷²⁴ 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

⁷²⁵ ComEd PY3 Multi-Family Evaluation Report REVISED DRAFT v5 2011-12-08.docx

⁷²⁶ 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.

⁷²⁷ Source ID 3

SPH = Showerheads Per Household so that per-showerhead savings fractions can be determined

Household Type	SPH
Single-Family	1.79 ⁷²⁸
Multi-Family	1.3 ⁷²⁹
Custom	Actual

EPG_{electric} = Energy per gallon of hot water supplied by electric
 = $(8.33 * 1.0 * (\text{ShowerTemp} - \text{SupplyTemp})) / (\text{RE}_{\text{electric}} * 3412)$
 = $(8.33 * 1.0 * (105 - 54.1)) / (0.98 * 3412)$
 = 0.127 kWh/gal

8.33 = Specific weight of water (lbs/gallon)

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

ShowerTemp = Assumed temperature of water
 = 105F⁷³⁰

SupplyTemp = Assumed temperature of water entering house
 = 54.1F⁷³¹

RE_{electric} = Recovery efficiency of electric water heater
 = 98%⁷³²

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 ⁷³³
Direct Install - Deemed	0.98

⁷²⁸ Based on findings from a 2009 ComEd residential survey of 140 sites, provided by Cadmus.

⁷²⁹ Ibid.

⁷³⁰ 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

⁷³¹ US DOE Building America Program. Building America Analysis Spreadsheet. For Chicago, IL http://www1.eere.energy.gov/buildings/building_america/analysis_spreadsheets.html.

⁷³² Electric water heater have recovery efficiency of 98%: <http://www.ahrinet.org/ARI/util/showdoc.aspx?doc=576>

⁷³³ 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.

Self-Install - Deemed	0.81
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For example, a direct-installed 1.5 GPM showerhead in a single family home with electric DHW where the number of showers is not known:

$$\begin{aligned} \Delta kWh &= 1.0 * ((2.67 * 8.2 - 1.5 * 8.2) * 2.56 * 0.75 * 365.25 / 1.79) * 0.127 * 0.98 \\ &= 468 kWh \end{aligned}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = \Delta kWh / \text{Hours} * CF$$

Where:

ΔkWh = calculated value above

Hours = Annual electric DHW recovery hours for showerhead use

$$= ((\text{GPM}_{\text{base}} * L_{\text{base}}) * \text{Household} * \text{SPCD} * 365.25) * 0.773^{734} / \text{GPH}$$

= 431 for SF Direct Install; 354 for MF Direct Install

= 380 for SF Retrofit and TOS; 311 for MF Retrofit and TOS

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

= 27.51

CF = Coincidence Factor for electric load reduction

= 0.0278⁷³⁵

⁷³⁴ 77.3% is the proportion of hot 120F water mixed with 54.1F supply water to give 105F shower water.

⁷³⁵ 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

For example, a direct installed 1.5 GPM showerhead in a single family home with electric DHW where the number of showers is not known:

$$\begin{aligned} \Delta kW &= 468/431 * 0.0278 \\ &= 0.030 \text{ kW} \end{aligned}$$

NATURAL GAS SAVINGS

$$\Delta \text{Therms} = \% \text{FossilDHW} * ((\text{GPM_base} * \text{L_base} - \text{GPM_low} * \text{L_low}) * \text{Household} * \text{SPCD} * 365.25 / \text{SPH}) * \text{EPG_gas} * \text{ISR}$$

Where:

$\% \text{FossilDHW}$ = proportion of water heating supplied by Natural Gas heating

DHW fuel	$\% \text{Fossil_DHW}$
Electric	0%
Natural Gas	100%
Unknown	84% ⁷³⁶

EPG_gas = Energy per gallon of Hot water supplied by gas
 $= (8.33 * 1.0 * (\text{ShowerTemp} - \text{SupplyTemp})) / (\text{RE_gas} * 100,000)$
 = 0.0054 Therm/gal for SF homes
 = 0.0063 Therm/gal for MF homes

RE_gas = Recovery efficiency of gas water heater
 = 78% For SF homes⁷³⁷
 = 67% For MF homes⁷³⁸

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

Other variables as defined above.

⁷³⁶ 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

⁷³⁷ 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%.

⁷³⁸ MF hot water is often provided by a larger central boiler. This suggests that the average recovery efficiency is somewhere between a typical central boiler efficiency of 0.59 and the 0.75 for single family homes. An average is used for this analysis as a default.

For example, a direct installed 1.5 GPM showerhead in a gas fired DHW single family home where the number of showers is not known:

$$\begin{aligned} \Delta\text{Therms} &= 1.0 * ((2.67 * 8.2 - 1.5 * 8.2) * 2.56 * 0.75 * 365.25 / 1.79) * 0.0054 * 0.98 \\ &= 19.9 \text{ therms} \end{aligned}$$

WATER IMPACT DESCRIPTIONS AND CALCULATION

$$\Delta\text{gallons} = ((\text{GPM_base} * \text{L_base} - \text{GPM_low} * \text{L_low}) * \text{Household} * \text{SPCD} * 365.25 / \text{SPH}) * \text{ISR}$$

Variables as defined above

For example, a direct installed 1.5 GPM showerhead where the number of showers is not known:

$$\begin{aligned} \Delta\text{gallons} &= ((2.67 * 8.2 - 1.5 * 8.2) * 2.56 * 0.75 * 365.25 / 1.79) * 0.98 \\ &= 3438 \text{ gallons} \end{aligned}$$

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

SOURCES

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

MEASURE CODE: RS-HWE-LFSH-V01-120601

5.4.6 Water Heater Temperature Setback

DESCRIPTION

The thermostat setting of a hot water tank is lowered to 120 degrees. The savings are from the Connecticut TRM which considers that for some draws, the hot water flow will be increased to make up for the lower temperature, and that additional dishwasher's supplemental heating will be required.

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

DEFINITION OF EFFICIENT EQUIPMENT

High efficiency is a hot water tank with the thermostat set at 120 degrees.

DEFINITION OF BASELINE EQUIPMENT

The baseline condition is a hot water tank with a thermostat setting that is higher than 120 degrees, typically systems with settings of 130 degrees or higher, this analysis assumes a 15 degree setback.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The assumed lifetime of the measure is 2 years.

DEEMED MEASURE COST

The incremental cost of a setback is assumed to be \$5 for contractor time.

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape R03 - Residential Electric DHW

COINCIDENCE FACTOR

The summer peak coincidence factor for this measure is assumed to be 1.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

For homes with electric DHW tanks:

$$\Delta\text{kWh} = 86.4 \text{ kWh}^{739}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta\text{kW} = \Delta\text{kWh} / \text{Hours} * \text{CF}$$

Where:

$$\text{Hours} = 8766$$

$$\begin{aligned} \text{CF} &= \text{Summer Peak Coincidence Factor for measure} \\ &= 1 \end{aligned}$$

$$\begin{aligned} \Delta\text{kW} &= 86.4 / 8766 * 1 \\ &= 0.00986 \text{ kW} \end{aligned}$$

NATURAL GAS SAVINGS

For homes with gas water heaters:

$$\Delta\text{Therms} = 6.4 \text{ therms}^{740}$$

$$\Delta\text{kWh} = -34.2 \text{ kWh}^{741}$$

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HWE-TMPS-V01-120601

⁷³⁹ All savings estimates are based on UL and CLP Program Savings Documentation, 2010. This is the net savings after taking into account increased use of dishwasher's supplemental heating.

http://neep.org/uploads/EMV%20Forum/EMV%20Studies/CT-UI_CLP_2010_PSD.pdf

⁷⁴⁰ All savings estimates are based on UL and CLP Program Savings Documentation, 2010. The Δ therms are the gross savings for a gas heater. http://neep.org/uploads/EMV%20Forum/EMV%20Studies/CT-UI_CLP_2010_PSD.pdf

⁷⁴¹ The Δ kWh accounts for the increased use of dishwasher's supplemental heating.

5.4.7 Water Heater Wrap

DESCRIPTION

This measure relates to a Tank Wrap or insulation “blanket” that is wrapped around the outside of a hot water tank to reduce stand-by losses. This measure applies only for homes that have an electric water heater that is not already well insulated. Generally this can be determined based upon the appearance of the tank.⁷⁴²

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 years⁷⁴³.

DEEMED MEASURE COST

The incremental cost for this measure will be the actual material cost of procuring and labor cost of installing the tank wrap.

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape R03 - Residential Electric DHW

COINCIDENCE FACTOR

This measure assumes a flat loadshape and as such the coincidence factor is 1.

Algorithm

⁷⁴² Visually determine whether it is insulated by foam (newer, rigid, and more effective) or fiberglass (older, gives to gently pressure, and not as effective)

⁷⁴³ This estimate assumes the tank wrap is installed on an existing unit with 5 years remaining life.

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

For electric DHW systems:

$$\Delta \text{kWh} = ((U_{\text{base}}A_{\text{base}} - U_{\text{insul}}A_{\text{insul}}) * \Delta T * \text{Hours}) / (3.412 * \eta_{\text{DHW}})$$

Where:

- U_{base} = Overall heat transfer coefficient prior to adding tank wrap (Btu/Hr-F-ft²).
- U_{insul} = Overall heat transfer coefficient after addition of tank wrap (Btu/Hr-F-ft²).
- A_{base} = Surface area of storage tank prior to adding tank wrap (square feet)⁷⁴⁴
- A_{insul} = Surface area of storage tank after addition of tank wrap (square feet)⁷⁴⁵
- ΔT = Average temperature difference between tank water and outside air temperature (°F)
= 60°F⁷⁴⁶
- Hours = Number of hours in a year (since savings are assumed to be constant over year).
= 8766
- 3412 = Conversion from BTU to kWh
- η_{DHW} = Recovery efficiency of electric hot water heater
= 0.98⁷⁴⁷

⁷⁴⁴ Area includes tank sides and top to account for typical wrap coverage.

⁷⁴⁵ Ibid.

⁷⁴⁶ Assumes 125°F water leaving the hot water tank and average temperature of basement of 65°F.

⁷⁴⁷ Electric water heater have recovery efficiency of 98%: <http://www.ahrinet.org/ARI/util/showdoc.aspx?doc=576>

The following table has default savings for various tank capacity and pre and post R-VALUES.

Capacity (gal)	Rbase	Rinsul	Abase (ft ²) ⁷⁴⁸	Ainsul (ft ²) ⁷⁴⁹	ΔkWh	ΔkW
30	8	16	19.16	20.94	171	0.0195
30	10	18	19.16	20.94	118	0.0135
30	12	20	19.16	20.94	86	0.0099
30	8	18	19.16	20.94	194	0.0221
30	10	20	19.16	20.94	137	0.0156
30	12	22	19.16	20.94	101	0.0116
40	8	16	23.18	25.31	207	0.0236
40	10	18	23.18	25.31	143	0.0164
40	12	20	23.18	25.31	105	0.0120
40	8	18	23.18	25.31	234	0.0268
40	10	20	23.18	25.31	165	0.0189
40	12	22	23.18	25.31	123	0.0140
50	8	16	24.99	27.06	225	0.0257
50	10	18	24.99	27.06	157	0.0179
50	12	20	24.99	27.06	115	0.0131
50	8	18	24.99	27.06	255	0.0291
50	10	20	24.99	27.06	180	0.0206
50	12	22	24.99	27.06	134	0.0153
80	8	16	31.84	34.14	290	0.0331
80	10	18	31.84	34.14	202	0.0231
80	12	20	31.84	34.14	149	0.0170
80	8	18	31.84	34.14	328	0.0374
80	10	20	31.84	34.14	232	0.0265
80	12	22	31.84	34.14	173	0.0198

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = \Delta kWh / 8766 * CF$$

Where:

ΔkWh = kWh savings from tank wrap installation

8766 = Number of hours in a year (since savings are assumed to be constant over year).

CF = Summer Coincidence Factor for this measure

= 1.0

The table above has default kW savings for various tank capacity and pre and post R-values.

⁷⁴⁸ 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.

⁷⁴⁹ Assumptions from PA TRM. A_{insul} was calculated by assuming that the water heater wrap is a 2" thick fiberglass material.

NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HWE-WRAP-V01-120601

5.5 Lighting End Use

5.5.1 ENERGY STAR Compact Fluorescent Lamp (CFL)

OFFICIAL MEASURE CODE

DESCRIPTION

A low wattage ENERGY STAR qualified compact fluorescent screw-in bulb (CFL) is installed in place of an incandescent screw-in bulb.

This characterization assumes that the CFL is installed in a residential location. If the implementation strategy does not allow for the installation location to be known (e.g. an upstream retail program), evaluation data could be used to determine an appropriate residential v commercial split. If this is not available, it is recommended to use this residential characterization for all installs in unknown locations to be appropriately conservative in savings assumptions.

Federal legislation stemming from the Energy Independence and Security Act of 2007 will require all general-purpose light bulbs between 40 and 100W to be approximately 30% more energy efficient than current incandescent bulbs. Production of 100W, standard efficacy incandescent lamps ends in 2012, followed by restrictions on 75W in 2013 and 60W and 40W in 2014. The baseline for this measure will therefore become bulbs (improved incandescent or halogen) that meet the new standard.

To account for these new standards and the expected delay in clearing retail inventory, the first year annual savings for this measure is reduced for 100W equivalent bulbs in June 2012, for 75W equivalent bulbs in June 2013 and for 60 and 40W equivalent bulbs in June 2014.

In addition, since during the lifetime of a CFL, the baseline bulb will be replaced multiple times, the annual savings claim must also be reduced within the life of the measure. For example, for 60W equivalent bulbs installed in 2012, the full savings (as calculated below in the Algorithm) should be claimed for the first two years, but a reduced annual savings based on the EISA-compliant baseline should be claimed for the remainder of the measure life. The appropriate adjustment factors are provided in the 'Mid Life Baseline Adjustment' section below.

Finally, a provision in the EISA regulations requires that by January 1, 2020, all lamps meet efficiency criteria of at least 45 lumens per watt, in essence making the baseline equivalent to a current day CFL. Therefore the measure life (number of years that savings should be claimed) should be reduced once the assumed lifetime of the bulb exceeds 2020. Due to expected delay in clearing retail inventory and to account for the operating life of a halogen incandescent potentially spanning over 2020, this shift is assumed not to occur until mid-2020.

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

DEFINITION OF EFFICIENT EQUIPMENT

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

DEFINITION OF BASELINE EQUIPMENT

The baseline equipment is assumed to be a standard incandescent light bulb, up until when EISA regulations dictate higher efficiency baseline bulbs. A 100W baseline bulb becomes a 72W bulb in June 2012, a 75W bulb becomes 53W in June 2012 and 60W and 40W bulbs become 43W and 29W respectively in June 2014. Annual

savings are reduced to account for this baseline shift within the life of a measure and the measure life is reduced to account for the baseline replacements becoming equivalent to a current day CFL by June 2020.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life (number of years that savings should be claimed) for bulbs installed June 2012 – May 2013 is assumed to be 5.2 years⁷⁵⁰. 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 year⁷⁵¹.

DEEMED MEASURE COST

For the Retail (Time of Sale) measure, the incremental capital cost is \$1.90, from June 2012 – May 2013, \$1.80 from June 2013 – May 2014 and \$1.50 from June 2014 – May 2015⁷⁵².

For the Direct Install measure, the full cost of \$2.50 per bulb should be used.

DEEMED O&M COST ADJUSTMENTS

Residential and in-unit Multi Family:

The Net Present Value of the baseline replacement costs for each CFL lumen range and installation year (2012 - 2016) are presented below⁷⁵³:

Lumen Range	NPV of baseline replacement costs		
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015
1490-2600	\$5.41	\$5.41	\$5.41
1050-1489	\$5.41	\$5.41	\$5.41
750-1049	\$4.48	\$5.41	\$5.41
310-749	\$4.48	\$5.41	\$5.41

⁷⁵⁰ 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.

⁷⁵¹ 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.

⁷⁵² Based on Northeast Regional Residential Lighting Strategy (RLS) report, prepared by EFG, D&R International, Ecova and Optimal Energy, applying sales weighting and phase-in of EISA regulations. Assumption is \$2.50 for CFL over three years and \$0.6 for baseline in 2012, \$0.70 in 2013 and \$1.00 in 2014 as more expensive EISA qualified bulbs become baseline.

⁷⁵³ See 'RES Standard CFL O&M calc.xls' for more details.

The annual levelized baseline replacement costs using the statewide real discount rate of 5.23% are presented below:

Lumen Range	Levelized annual replacement cost savings		
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015
1490-2600	\$1.22	\$1.22	\$1.22
1050-1489	\$1.22	\$1.22	\$1.22
750-1049	\$1.01	\$1.22	\$1.22
310-749	\$1.01	\$1.22	\$1.22

Multi Family common areas:

The Net Present Value of the baseline replacement costs for each CFL lumen range and installation year (2012 - 2016) are presented below:

Lumen Range	NPV of baseline replacement costs		
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015
1490-2600	\$13.09	\$13.09	\$13.09
1050-1489	\$8.24	\$13.09	\$13.09
750-1049	\$4.36	\$8.24	\$13.09
310-749	\$4.36	\$8.24	\$13.09

The annual levelized baseline replacement costs using the statewide real discount rate of 5.23% are presented below:

Lumen Range	Levelized annual replacement cost savings		
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015
1490-2600	\$8.34	\$8.34	\$8.34
1050-1489	\$5.25	\$8.34	\$8.34
750-1049	\$2.78	\$5.25	\$8.34
310-749	\$2.78	\$5.25	\$8.34

LOADSHAPE

- Loadshape R06 - Residential Indoor Lighting
- Loadshape R07 - Residential Outdoor Lighting
- Loadshape C06 - Commercial Indoor Lighting⁷⁵⁴

⁷⁵⁴ For Multi Family common area lighting.

COINCIDENCE FACTOR

The summer peak coincidence factor is assumed to be 9.5%⁷⁵⁵ for Residential and in-unit Multi Family bulbs and 75%⁷⁵⁶ for Multi Family common area bulbs.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = ((WattsBase - WattsEE) / 1000) * ISR * Hours * WHFe$$

Where:

WattsBase = Based on lumens of CFL bulb and program year purchased / installed:

Minimum Lumens	Maximum Lumens	Incandescent Equivalent Pre-EISA 2007 (Watts _{Base})	Incandescent Equivalent Post-EISA 2007 (Watts _{Base})	Effective date from which Post – EISA 2007 assumption should be used
1490	2600	100	72	June 2012
1050	1489	75	53	June 2013
750	1049	60	43	June 2014
310	749	40	29	June 2014

WattsEE = Actual wattage of CFL purchased / installed

⁷⁵⁵ Based on lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation. “ComEd Residential Energy Star Lighting Program Metering Study: Overview of Study Protocols” <http://www.icc.illinois.gov/downloads/public/edocket/303835.pdf>

“Memo RE: Lighting Logger Study Results – Version 2, Date: May 27, 2011, To: David Nichols and ComEd Residential Lighting Interested Parties, From: Amy Buege and Jeremy Eddy; Navigant Evaluation Team” <http://www.icc.illinois.gov/downloads/public/edocket/303834.pdf>

⁷⁵⁶ Coincidence factor is based on healthcare/clinic value (used as proxy for multi family common area lighting with similar hours of use) developed using Equest models for various building types averaged across 5 climate zones for Illinois for the following building types.

ISR = In Service Rate, the percentage of units rebated that are actually in service.

Program	Weighted Average 1 st year In Service Rate (ISR)	2 nd year Installations	3 rd year Installations	Final Lifetime In Service Rate
Retail (Time of Sale)	69.5% ⁷⁵⁷	15.4%	13.1%	98.0% ⁷⁵⁸
Direct Install	96.9% ⁷⁵⁹			

Hours = Average hours of use per year

Installation Location	Hours
Residential and in-unit Multi Family	938 ⁷⁶⁰
Multi Family Common Areas	5,950 ⁷⁶¹
Exterior	1,825 ⁷⁶²
Unknown	1,000 ⁷⁶³

⁷⁵⁷ 1st year in service rate is based upon review of PY1-3 evaluations from ComEd and Ameren (see 'IL RES Lighting ISR.xls' for more information. The average first year ISR for each utility was calculated weighted by the number of bulbs in the each year's survey. This was then weighted by annual sales to give a statewide assumption.

⁷⁵⁸ 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.

⁷⁵⁹ 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>.

⁷⁶⁰ Based on lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation.

⁷⁶¹ Multi family common area lighting assumption is 16.3 hours per day (5950 hours per year) based on Focus on Energy Evaluation, ACES Deemed Savings Desk Review, November 2010.

⁷⁶² Based on lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation.

⁷⁶³ Assumes 7% exterior lighting, based on lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation.

WHFe = Waste heat factor for energy to account for cooling energy savings from efficient lighting

Bulb Location	WHFe
Interior single family or unknown location	1.06 ⁷⁶⁴
Multi family in unit	1.04 ⁷⁶⁵
Multi family common area	1.04 ⁷⁶⁶
Exterior or uncooled location	1.0

MID LIFE BASELINE ADJUSTMENT

During the lifetime of a CFL, a baseline incandescent bulb would need to be replaced multiple times. Since the baseline bulb changes over time the annual savings claim must be reduced within the life of the measure to account for this baseline shift.

For example, for 60W equivalent bulbs installed in 2012, the full savings (as calculated above in the Algorithm) should be claimed for the first two years, but a reduced annual savings claimed for the remainder of the measure life. The appropriate adjustment factors are provided below.

Lumen Range	Pre EISA WattsBase	Post EISA WattsBase	CFL Equivalent	Delta Watts Before EISA	Delta Watts After EISA	Mid Life Adjustment	Adjustment made from date
1490-2600	100	72	25	75	47	63%	N/A (2012 is already post EISA)
1050-1489	75	53	20	55	33	60%	June, 2013
750-1049	60	43	14	46	29	63%	June, 2014
310-749	40	29	11	29	18	62%	June, 2014

⁷⁶⁴ 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 $(-0.02 * SEER^2) + (1.12 * SEER)$ (from Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder), 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>)

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 Ibid.

For example, a 20W standard CFL, 1200 lumen is purchased in 2012 and installed in a single family interior location:

First Year Installs:

$$\begin{aligned} \Delta\text{kWh}_{1\text{st year}} &= ((75 - 20) / 1000) * 0.695 * 938 * 1.06 \\ &= 38 \text{ kWh} \end{aligned}$$

This value should be claimed in June 2012 – May 2013, but from June 2013 on savings for that same bulb should be reduced to (38 * 0.6 =) 22.8kWh for the remainder of the measure life. Note these adjustments should be applied to kW and fuel impacts.

Second Year Installs:

$$\begin{aligned} \Delta\text{kWh}_{2\text{nd year}} &= ((53 - 20) / 1000) * 0.154 * 938 * 1.06 \\ &= 5.0 \text{ kWh} \end{aligned}$$

Note since this is now being installed in 2013 the baseline wattage is adjusted to 53W due to the EISA legislation.

Third Year Installs:

$$\begin{aligned} \Delta\text{kWh}_{3\text{rd year}} &= ((53 - 20) / 1000) * 0.131 * 938 * 1.06 \\ &= 4.3 \text{ kWh} \end{aligned}$$

HEATING PENALTY

If electric heated home (if heating fuel is unknown assume gas, see Natural Gas section):

$$\Delta\text{kWh}^{767} = -(((\text{WattsBase} - \text{WattsEE}) / 1000) * \text{ISR} * \text{Hours} * \text{HF}) / \eta_{\text{Heat}}$$

Where:

- HF = Heating Factor or percentage of light savings that must be heated
- = 49%⁷⁶⁸ for interior or unknown location
- = 0% for exterior or unheated location

⁷⁶⁷ Negative value because this is an increase in heating consumption due to the efficient lighting.

⁷⁶⁸ 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.

η_{Heat} = Efficiency in COP of Heating equipment
 = actual. If not available use⁷⁶⁹:

System Type	Age of Equipment	HSPF Estimate	η_{Heat} (COP Estimate)
Heat Pump	Before 2006	6.8	2.00
	After 2006	7.7	2.26
Resistance	N/A	N/A	1.00

For example, a 20W standard CFL, 1200 lumen is purchased in 2012 and installed in home with 2.0 COP Heat Pump:

$$\Delta \text{kWh}_{1\text{st year}} = - ((75 - 20) / 1000) * 0.695 * 938 * 0.49) / 2.0$$

$$= - 8.8 \text{ kWh}$$

Second and third year savings should be calculated using the appropriate ISR and baseline shift adjustment.

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta \text{kW} = ((\text{WattsBase} - \text{WattsEE}) / 1000) * \text{ISR} * \text{WHFd} * \text{CF}$$

Where:

WHFd = Waste heat factor for demand to account for cooling savings from efficient lighting.

Bulb Location	WHFd
Interior single family or unknown location	1.11 ⁷⁷⁰
Multi family in unit	1.07 ⁷⁷¹
Multi family common area	1.07 ⁷⁷²
Exterior or uncooled location	1.0

CF = Summer Peak Coincidence Factor for measure.

⁷⁶⁹ 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.

⁷⁷⁰ 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.

⁷⁷¹ 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>.

⁷⁷² Ibid

Bulb Location	CF
Interior single family or unknown location	9.5% ⁷⁷³
Multi family in unit	9.5% ⁷⁷⁴
Multi family common area	75% ⁷⁷⁵

Other factors as defined above

For example, a 20W standard CFL, 1200 lumen is purchased and installed in a single family interior location in 2012:

$$\begin{aligned} \Delta kW &= ((75 - 20) / 1000) * 0.695 * 1.11 * 0.095 \\ &= 0.004 \text{ kW} \end{aligned}$$

Second and third year savings should be calculated using the appropriate ISR and baseline shift adjustment.

NATURAL GAS SAVINGS

Heating Penalty if Natural Gas heated home (or if heating fuel is unknown):

$$\Delta \text{Therms}^{776} = - (((\text{WattsBase} - \text{WattsEE}) / 1000) * \text{ISR} * \text{Hours} * \text{HF} * 0.03412) / \eta \text{Heat}$$

Where:

- HF = Heating Factor or percentage of light savings that must be heated
= 49%⁷⁷⁷ for interior or unknown location
= 0% for exterior or unheated location
- 0.03412 = Converts kWh to Therms
- ηHeat = Efficiency of heating system
= 70%⁷⁷⁸

⁷⁷³ Based on lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation. "ComEd Residential Energy Star Lighting Program Metering Study: Overview of Study Protocols" <http://www.icc.illinois.gov/downloads/public/edocket/303835.pdf>

"Memo RE: Lighting Logger Study Results – Version 2, Date: May 27, 2011, To: David Nichols and ComEd Residential Lighting Interested Parties, From: Amy Buege and Jeremy Eddy; Navigant Evaluation Team" <http://www.icc.illinois.gov/downloads/public/edocket/303834.pdf>

⁷⁷⁴ Ibid.

⁷⁷⁵ Coincidence factor is based on healthcare/clinic value (used as proxy for multi family common area lighting with similar hours of use) developed using Equest models for various building types averaged across 5 climate zones for Illinois for the following building types.

⁷⁷⁶ Negative value because this is an increase in heating consumption due to the efficient lighting.

⁷⁷⁷ This means that heating loads increase by 49% of the lighting savings. This is based on the average result from REMRate modeling of several different configurations and IL locations of homes.

For example, a 20W standard CFL, 1200 lumen is purchased and installed in a home in 2012:

$$\begin{aligned} \Delta\text{Therms} &= - ((75 - 20) / 1000) * 0.695 * 938 * 0.49 * 0.03412) / 0.7 \\ &= - 0.86 \text{ Therms} \end{aligned}$$

Second and third year savings should be calculated using the appropriate ISR and baseline shift adjustment.

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

In order to account for the shift in baseline due to the Energy Independence and Security Act of 2007, an equivalent annual levelized baseline replacement cost over the lifetime of the CFL is calculated (see RES Standard CFL O&M calc.xls). The key assumptions used in this calculation are documented below:

	Standard Incandescent	Efficient Incandescent
Replacement Cost	\$0.50	\$1.50
Component Rated Life (hrs)	1000	1000 ⁷⁷⁹

⁷⁷⁸ 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:

$(0.24 * 0.92) + (0.76 * 0.8) * (1 - 0.15) = 0.70$

⁷⁷⁹ The manufacturers of the new minimally compliant EISA Halogens are using regular incandescent lamps with halogen fill gas rather than halogen infrared to meet the standard and so the component rated life is equal to the standard incandescent.

Residential and in-unit Multi Family:

The Net Present Value of the baseline replacement costs for each CFL lumen range and installation year (2012 - 2016) are presented below:

Lumen Range	NPV of baseline replacement costs		
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015
1490-2600	\$5.41	\$5.41	\$5.41
1050-1489	\$5.41	\$5.41	\$5.41
750-1049	\$4.48	\$5.41	\$5.41
310-749	\$4.48	\$5.41	\$5.41

The annual levelized baseline replacement costs using the statewide real discount rate of 5.23% are presented below:

Lumen Range	Levelized annual replacement cost savings		
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015
1490-2600	\$1.22	\$1.22	\$1.22
1050-1489	\$1.22	\$1.22	\$1.22
750-1049	\$1.01	\$1.22	\$1.22
310-749	\$1.01	\$1.22	\$1.22

Multi Family common areas:

The Net Present Value of the baseline replacement costs for each CFL lumen range and installation year (2012 - 2016) are presented below:

Lumen Range	NPV of baseline replacement costs		
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015
1490-2600	\$13.09	\$13.09	\$13.09
1050-1489	\$8.24	\$13.09	\$13.09
750-1049	\$4.36	\$8.24	\$13.09
310-749	\$4.36	\$8.24	\$13.09

The annual levelized baseline replacement costs using the statewide real discount rate of 5.23% are presented below:

Lumen Range	Levelized annual replacement cost savings		
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015
1490-2600	\$8.34	\$8.34	\$8.34
1050-1489	\$5.25	\$8.34	\$8.34
750-1049	\$2.78	\$5.25	\$8.34
310-749	\$2.78	\$5.25	\$8.34

MEASURE CODE: RS-LTG-ESCF-V01-120601

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. Specialty CFL bulbs are defined as lamps for general illumination that use fluorescent light emitting technology and an integrated electronic ballast with or without a standard Edison screw-base. Specialty bulbs defined in this characterization are exempt of the EISA 2007 standard and may include the following bulb types: three-way, plant light, daylight bulb, bug light, post light, globes G40, candelabra base, vibration service bulb, decorative candle with medium or intermediate base, shatter resistant, reflector (the exemption on reflector bulbs is expected to expire in 2014 for the following wattage and bulb type: 45 W (R20 and BR 19); 50W (R30, ER 30, BR 40, and ER 40); 65W (BR30, BR40, and ER 404)).

This characterization assumes that the specialty CFL is installed in a residential location. If the implementation strategy does not allow for the installation location to be known (e.g. an upstream retail program) evaluation data could be used to determine an appropriate residential vs. commercial split. If this is not available, it is recommended to use this residential characterization for all installs in unknown locations, to be appropriately conservative in savings assumptions.

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

DEFINITION OF EFFICIENT EQUIPMENT

Energy Star qualified specialty CFL bulb as defined above that is exempt from EISA 2007. Due to A-line and dimmable bulbs not being exempt from EISA, this measure characterization will be used most often for flood light/reflector/spotlight (until exemption expires), and globes, which make up the majority of specialty program bulbs.⁷⁸⁰

DEFINITION OF BASELINE EQUIPMENT

The baseline is a specialty incandescent light bulb.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 6.8 year⁷⁸¹.

DEEMED MEASURE COST

For the Retail (Time of Sale) measure, the incremental capital cost for this measure is \$5⁷⁸².

For the Direct Install measure, the full cost of \$8.50 should be used.

⁷⁸⁰ Lighting and Appliance Evaluation – PY 2, Ameren Illinois, Prepared by The Cadmus Group Inc. / Energy Services, December 2010.

⁷⁸¹ 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).

⁷⁸² NEEP Residential Lighting Survey, 2011

DEEMED O&M COST ADJUSTMENTS

Life of the baseline bulb is assumed to be 1.07 year⁷⁸³; baseline replacement cost is assumed to be \$3.5⁷⁸⁴.

LOADSHAPE

- Loadshape R06 - Residential Indoor Lighting
- Loadshape R07 - Residential Outdoor Lighting
- Loadshape C06 - Commercial Indoor Lighting⁷⁸⁵

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 below⁷⁸⁶

Bulb Type	Peak CF
Three-way	0.081
A-bulb (covered)	***
Dimmable	***
Interior reflector (incl. dimmable)	0.095
Exterior reflector	0.184
Candelabra base and candle medium and intermediate base	0.122
Bug light	0.184
Post light (>100W)	0.184
Daylight	0.095
Plant light	0.095
Globe	0.116
Vibration or shatterproof	0.095
Specialty - Generic	0.095

***N/A, not exempt from EISA, use the standard bulb measure characterization

⁷⁸³ Assuming 1000 hour rated life for incandescent bulb: 1000/938 = 1.07

⁷⁸⁴ NEEP Residential Lighting Survey, 2011

⁷⁸⁵ For Multi Family common area lighting.

⁷⁸⁶ Lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation, results were used to calculate the average coincident peak factor in the rooms where the specialty bulbs are most likely to be installed. <http://www.icc.illinois.gov/downloads/public/edocket/303834.pdf>

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = ((WattsBase - WattsEE) / 1000) * ISR * Hours * WHFe$$

Where:

WattsBase = Actual wattage equivalent of incandescent specialty bulb, use the table below to obtain the incandescent bulb equivalent wattage⁷⁸⁷; use 60W if unknown⁷⁸⁸

Incandescent Bulbs (watts)	Minimum Light Output (lumens)	Common ENERGY STAR Qualified Bulbs (Watts)
25	250	4 to 9
40	450	9 to 13
60	800	13 to 15
75	1,110	18 to 25
100	1,600	23 to 30
125	2,000	22 to 40
150	2,600	40 to 45

WattsEE = Actual wattage of energy efficient specialty bulb purchased, use 15W if unknown⁷⁸⁹

⁷⁸⁷ Based on ENERGY STAR equivalence table; http://www.energystar.gov/index.cfm?c=cfls.pr_cfls_lumens

⁷⁸⁸ 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)

⁷⁸⁹ 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).

ISR = In Service Rate, the percentage of units rebated that are actually in service.

Program	Weighted Average 1 st year In Service Rate (ISR)	2 nd year Installations	3 rd year Installations	Final Lifetime In Service Rate
Retail (Time of Sale)	79.5% ⁷⁹⁰	10.0%	8.5%	98.0% ⁷⁹¹
Direct Install	96.9% ⁷⁹²			

Hours = Average hours of use per year, varies by bulb type as presented below:⁷⁹³

Bulb Type	Annual hours of use (HOU)
Three-way	897
A-bulb (covered)	***
Dimmable	***
Interior reflector (incl. dimmable)	938
Exterior reflector	1825
Candelabra base and candle medium and intermediate base	1328
Bug light	1825
Post light (>100W)	1825
Daylight	938
Plant light	938
Globe	1240
Vibration or shatterproof	938
Specialty - Generic	938

***N/A, not exempt from EISA, use the standard bulb measure characterization

WHFe = Waste heat factor for energy to account for cooling savings from efficient lighting

⁷⁹⁰ 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.

⁷⁹¹ 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.

⁷⁹² 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>.

⁷⁹³ Hours of use by specialty bulb type calculated using the average hours of use in locations or rooms where each type of specialty bulb is most commonly found. Annual hours of use by location in the home from Docket No. 10-0520, ICC Staff Exhibit 1.4, RE: Lighting Logger Study Results – Version 2, Navigant, May 27, 2011. <http://www.icc.illinois.gov/downloads/public/edocket/303834.pdf>

Bulb Location	WHPe
Interior single family or unknown location	1.06 ⁷⁹⁴
Multi family in unit	1.04 ⁷⁹⁵
Exterior or uncooled location	1.0

For example, a 15W specialty CFL replacing a 60W incandescent specialty bulb in single family interior location:

First Year Installs:

$$\begin{aligned} \Delta\text{kWh}_{1\text{st year}} &= ((60 - 15) / 1000) * 0.795 * 938 * 1.06 \\ &= 35.6 \text{ kWh} \end{aligned}$$

Second Year Installs:

$$\begin{aligned} \Delta\text{kWh}_{2\text{nd year}} &= ((60 - 15) / 1000) * 0.1 * 938 * 1.06 \\ &= 4.5 \text{ kWh} \end{aligned}$$

Third Year Installs:

$$\begin{aligned} \Delta\text{kWh}_{3\text{rd year}} &= ((60 - 15) / 1000) * 0.085 * 938 * 1.06 \\ &= 3.8 \text{ kWh} \end{aligned}$$

HEATING PENALTY

If electric heated home (if heating fuel is unknown assume gas, see Natural Gas section):

$$\Delta\text{kWh}^{796} = - (((\text{WattsBase} - \text{WattsEE}) / 1000) * \text{ISR} * \text{Hours} * \text{HF}) / \eta_{\text{Heat}}$$

⁷⁹⁴ 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 $(-0.02 * \text{SEER}^2) + (1.12 * \text{SEER})$ (from Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder), converted to $\text{COP} = \text{EER} / 3.412 = 2.8\text{COP}$) 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>)

⁷⁹⁵ 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>

Where:

- HF = Heating Factor or percentage of light savings that must be heated
 = 49%⁷⁹⁷ for interior or unknown location
 = 0% for exterior location
- η Heat = Efficiency in COP of Heating equipment
 = actual. If not available use⁷⁹⁸:

System Type	Age of Equipment	HSPF Estimate	η Heat (COP Estimate)
Heat Pump	Before 2006	6.8	2.00
	After 2006	7.7	2.26
Resistance	N/A	N/A	1.00

For example, a 15W specialty CFL replacing a 60W incandescent specialty bulb installed in home with 2.0 COP Heat Pump:

$$\Delta kWh_{1st\ year} = - ((60 - 15) / 1000) * 0.795 * 938 * 0.49) / 2.0$$

$$= - 8.2\ kWh$$

Second and third year savings should be calculated using the appropriate ISR.

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = ((WattsBase - WattsEE) / 1000) * ISR * WHFd * CF$$

Where:

⁷⁹⁶ Negative value because this is an increase in heating consumption due to the efficient lighting.

⁷⁹⁷ 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.

⁷⁹⁸ These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Heat Pumps was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate.

WHFd = Waste heat factor for demand to account for cooling savings from efficient lighting. The cooling savings are only added to the summer peak savings.

Bulb Location	WHFd
Interior single family or unknown location	1.11 ⁷⁹⁹
Multi family in unit	1.07 ⁸⁰⁰
Exterior or uncooled location	1.0

CF = Summer Peak Coincidence Factor for measure. Coincidence factors by bulb types are presented below⁸⁰¹

Bulb Type	Peak CF
Three-way	0.081
A-bulb (covered)	***
Dimmable	***
Interior reflector (incl. dimmable)	0.095
Exterior reflector	0.184
Candelabra base and candle medium and intermediate base	0.122
Bug light	0.184
Post light (>100W)	0.184
Daylight	0.095
Plant light	0.095
Globe	0.116
Vibration or shatterproof	0.095
Specialty - Generic	0.095

***N/A, not exempt from EISA, use the standard bulb measure characterization

Other factors as defined above

For example, a 15W specialty CFL replacing a 60W incandescent specialty bulb:

$$\Delta kW_{1st\ year} = ((60 - 15) / 1000) * 0.795 * 1.11 * 0.095$$

$$= 0.004\ kW$$

Second and third year savings should be calculated using the appropriate ISR.

⁷⁹⁹ 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.

⁸⁰⁰ 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>.

⁸⁰¹ Lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation, results were used to calculate the average coincident peak factor in the rooms where the specialty bulbs are most likely to be installed.

NATURAL GAS SAVINGS

Heating Penalty if Natural Gas heated home (or if heating fuel is unknown):

$$\Delta\text{Therms}^{802} = - (((\text{WattsBase} - \text{WattsEE}) / 1000) * \text{ISR} * \text{Hours} * \text{HF} * 0.03412) / \eta\text{Heat}$$

Where:

- HF = Heating Factor or percentage of light savings that must be heated
= 49%⁸⁰³ for interior or unknown location
= 0% for exterior location
- 0.03412 = Converts kWh to Therms
- ηHeat = Efficiency of heating system
= 70%⁸⁰⁴

For example, a 15W specialty CFL replacing a 60W incandescent specialty bulb:

$$\begin{aligned} \Delta\text{Therms} &= - (((60 - 15) / 1000) * 0.795 * 938 * 0.49 * 0.03412) / 0.7 \\ &= - 0.80 \text{ Therms} \end{aligned}$$

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

N/A

⁸⁰² Negative value because this is an increase in heating consumption due to the efficient lighting.

⁸⁰³ 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.

⁸⁰⁴ 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:

$$(0.24 * 0.92) + (0.76 * 0.8) * (1 - 0.15) = 0.70$$

MEASURE CODE: RS-LTG-ESCC-V01-120601

5.5.3 ENERGY STAR Torchiera

DESCRIPTION

A high efficiency ENERGY STAR fluorescent torchiera 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 torchiera 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 years⁸⁰⁵.

DEEMED MEASURE COST

The incremental cost for this measure is assumed to be \$5⁸⁰⁶.

DEEMED O&M COST ADJUSTMENTS

Life of the baseline bulb is assumed to be 1.83 years⁸⁰⁷ for residential and multifamily in unit and 0.34 years⁸⁰⁸ for multifamily common area. Baseline bulb cost replacement is assumed to be \$6⁸⁰⁹.

LOADSHAPE

Loadshape R06 - Residential Indoor Lighting
Loadshape R07 - Residential Outdoor Lighting
Loadshape C06 - Commercial Indoor Lighting⁸¹⁰

COINCIDENCE FACTOR

The summer peak coincidence factor for this measure is 9.5%⁸¹¹ for Residential and in-unit Multi Family bulbs and

⁸⁰⁵ Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007.

⁸⁰⁶ DEER 2008 Database Technology and Measure Cost Data (www.deeresources.com) and consistent with Efficiency Vermont TRM.

⁸⁰⁷ Based on assumption of baseline bulb (mix of incandescent and halogen) average rated life of 2000 hours, $2000/1095 = 1.83$ years.

⁸⁰⁸ $2000/5950 = 0.34$ years

⁸⁰⁹ Derived from Efficiency Vermont TRM.

⁸¹⁰ For Multi Family common area lighting.

⁸¹¹ Based on lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation.

75%⁸¹² for Multi Family common area bulbs.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = ((\Delta Watts) / 1000) * ISR * HOURS * WHFe$$

Where:

$\Delta Watts$ = Average delta watts per purchased ENERGY STAR torchiere
 = 115.8⁸¹³

ISR = In Service Rate or percentage of units rebated that get installed.
 = 0.86⁸¹⁴

HOURS = Average hours of use per year

Installation Location	Hours
Residential and in-unit Multi Family	1095 (3.0 hrs per day) ⁸¹⁵
Multi Family Common Areas	5950 ⁸¹⁶

“ComEd Residential Energy Star Lighting Program Metering Study: Overview of Study Protocols”

<http://www.icc.illinois.gov/downloads/public/edocket/303835.pdf>

“Memo RE: Lighting Logger Study Results – Version 2, Date: May 27, 2011, To: David Nichols and ComEd Residential Lighting Interested Parties, From: Amy Buege and Jeremy Eddy; Navigant Evaluation Team”

<http://www.icc.illinois.gov/downloads/public/edocket/303834.pdf>

⁸¹² Coincidence factor is based on healthcare/clinic value (used as proxy for multi family common area lighting with similar hours of use) developed using Equest models for various building types averaged across 5 climate zones for Illinois for the following building types.

⁸¹³ 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)

⁸¹⁴ 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

⁸¹⁵ 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)

⁸¹⁶ Multi family common area lighting assumption is 16.3 hours per day (5950 hours per year) based on Focus on Energy Evaluation, ACES Deemed Savings Desk Review, November 2010.

WHFe = Waste Heat Factor for Energy to account for cooling savings from efficient lighting.

Bulb Location	WHFe
Interior single family or unknown location	1.06 ⁸¹⁷
Multi family in unit	1.04 ⁸¹⁸
Multi family common area	1.04 ⁸¹⁹
Exterior or uncooled location	1.0

For single family buildings:

$$\begin{aligned} \Delta\text{kWh} &= (115.8 / 1000) * 0.86 * 1095 * 1.06 \\ &= 116 \text{ kWh} \end{aligned}$$

For multi family in unit:

$$\begin{aligned} \Delta\text{kWh} &= (115.8 / 1000) * 0.86 * 1095 * 1.04 \\ &= 113 \text{ kWh} \end{aligned}$$

For multi family common area:

$$\begin{aligned} \Delta\text{kWh} &= (115.8 / 1000) * 0.86 * 5950 * 1.04 \\ &= 616 \text{ kWh} \end{aligned}$$

HEATING PENALTY

If electric heated home (if heating fuel is unknown assume gas, see Natural Gas section):

$$\Delta\text{kWh}^{820} = - ((\Delta\text{Watts}) / 1000) * \text{ISR} * \text{HOURS} * \text{HF} / \eta_{\text{Heat}}$$

⁸¹⁷ 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>)

⁸¹⁸ 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>

⁸¹⁹ Ibid.

⁸²⁰ Negative value because this is an increase in heating consumption due to the efficient lighting.

Where:

HF = Heating Factor or percentage of light savings that must be heated

= 49%⁸²¹ for interior or unknown location

η_{Heat} = Efficiency in COP of Heating equipment

= Actual. If not available use defaults provided below⁸²²:

System Type	Age of Equipment	HSPF Estimate	η_{Heat} (COP Estimate)
Heat Pump	Before 2006	6.8	2.00
	After 2006	7.7	2.26
Resistance	N/A	N/A	1.00

For example, an ES torchiere installed in a house with a newer heat pump:

$$\Delta \text{kWh} = - ((115.8) / 1000) * 0.86 * 1095 * 0.49) / 2.26$$

$$= - 23.6 \text{ kWh}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta \text{kW} = ((\Delta \text{Watts}) / 1000) * \text{ISR} * \text{WHFd} * \text{CF}$$

Where:

⁸²¹ 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.

⁸²² These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Heat Pumps was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate.

WHFd = Waste Heat Factor for Demand to account for cooling savings from efficient lighting

Bulb Location	WHFd
Interior single family or unknown location	1.11 ⁸²³
Multi family in unit	1.07 ⁸²⁴
Multi family common area	1.07 ⁸²⁵
Exterior or uncooled location	1.0

CF = Summer Peak Coincidence Factor for measure

Bulb Location	CF
Interior single family or unknown location	9.5% ⁸²⁶
Multi family in unit	9.5% ⁸²⁷
Multi family common area	75% ⁸²⁸

For single family buildings:

$$\Delta kW = (115.8 / 1000) * 0.86 * 1.11 * 0.095$$

$$= 0.011kW$$

For multi family in unit:

$$\Delta kW = (115.8 / 1000) * 0.86 * 1.07 * 0.095$$

$$= 0.010 kW$$

For multi family common area:

$$\Delta kW = (115.8 / 1000) * 0.86 * 1.07 * 0.75$$

⁸²³ 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.

⁸²⁴ 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>.

⁸²⁵ Ibid

⁸²⁶ Based on lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation. "ComEd Residential Energy Star Lighting Program Metering Study: Overview of Study Protocols"

<http://www.icc.illinois.gov/downloads/public/edocket/303835.pdf>

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⁸²⁷ Ibid.

⁸²⁸ Coincidence factor is based on healthcare/clinic value (used as proxy for multi family common area lighting with similar hours of use) developed using Equest models for various building types averaged across 5 climate zones for Illinois for the following building types.

$$= 0.080 \text{ kW}$$

NATURAL GAS SAVINGS

Heating penalty if Natural Gas heated home, or if heating fuel is unknown.

$$\Delta\text{Therms}_{\text{WH}} = - ((\Delta\text{Watts}) / 1000) * \text{ISR} * \text{HOURS} * 0.03412 * \text{HF} / \eta\text{Heat}$$

Where:

$$\Delta\text{Therms}_{\text{WH}} = \text{gross customer annual heating fuel increased usage for the measure from the reduction in lighting heat in therms.}$$

$$0.03412 = \text{conversion from kWh to therms}$$

$$\text{HF} = \text{Heating Factor or percentage of light savings that must be heated}$$

$$= 49\%^{829}$$

$$\eta\text{Heat} = \text{average heating system efficiency}$$

$$= 70\%^{830}$$

$$\Delta\text{Therms}_{\text{WH}} = - ((115.8 / 1000) * 0.86 * 1095 * 0.03412 * 0.49) / 0.70$$

$$= - 2.60 \text{ therms}$$

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

Life of the baseline bulb is assumed to be 1.83 years⁸³¹ for residential and multifamily in unit and 0.34 years⁸³² for

⁸²⁹ 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.

⁸³⁰ 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:

$$(0.24 * 0.92) + (0.76 * 0.8) * (1 - 0.15) = 0.70$$

⁸³¹ Based on VEIC assumption of baseline bulb (mix of incandescent and halogen) average rated life of 2000 hours, 2000/1095 = 1.83 years.

⁸³² 2000/5950 = 0.34 years

multifamily common area. Baseline bulb cost replacement is assumed to be \$6.⁸³³

MEASURE CODE: RS-LTG-ESTO-V01-120601

⁸³³ 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 will require all general-purpose light bulbs between 40 and 100W to be approximately 30% more energy efficient than current incandescent bulbs. Production of 100W, standard efficacy incandescent lamps ends in 2012, followed by restrictions on 75W in 2013 and 60W and 40W in 2014. The baseline for this measure will therefore become bulbs (improved incandescent or halogen) that meet the new standard.

To account for these new standards and the expected delay in clearing retail inventory, the first year annual savings for this measure is reduced for 100W equivalent bulbs in June 2012, for 75W equivalent bulbs in June 2013 and for 60 and 40W equivalent bulbs in June 2014.

In addition, since during the lifetime of a CFL, the baseline bulb will be replaced multiple times, the annual savings claim must also be reduced within the life of the measure. For example, for 60W equivalent bulbs installed in 2012, the full savings (as calculated below in the Algorithm) should be claimed for the first two years, but a reduced annual savings based on the EISA-compliant baseline should be claimed for the remainder of the measure life. The appropriate adjustment factors are provided in the 'Mid Life Baseline Adjustment' section below.

Finally, a provision in the EISA regulations requires that by January 1, 2020, all lamps meet efficiency criteria of at least 45 lumens per watt, in essence making the baseline equivalent to a current day CFL. Therefore the measure life (number of years that savings should be claimed) should be reduced once the assumed lifetime of the bulb exceeds 2020. Due to expected delay in clearing retail inventory and to account for the operating life of a halogen incandescent potentially spanning over 2020, this shift is assumed not to occur until mid-2020.

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

DEFINITION OF EFFICIENT EQUIPMENT

The efficient condition is an ENERGY STAR lighting exterior fixture for pin-based compact fluorescent lamps.

DEFINITION OF BASELINE EQUIPMENT

The baseline condition is a standard incandescent exterior fixture.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected life of an interior fixture is 20 years⁸³⁴. 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 –

⁸³⁴ 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.

May 2014, this would be reduced to 7 years and should be reduced each year⁸³⁵.

DEEMED MEASURE COST

The incremental cost for an interior fixture is assumed to be \$17⁸³⁶.

DEEMED O&M COST ADJUSTMENTS

The Net Present Value of the baseline replacement costs for each CFL lumen range and installation year (2012 - 2016) are presented below⁸³⁷:

Lumen Range	NPV of replacement costs per bulb			
	Baseline			Efficient
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015	All
1490-2600	\$18.34	\$16.28	\$14.12	\$1.90
1050-1489	\$17.36	\$16.28	\$14.12	
750-1049	\$15.50	\$15.30	\$14.12	
310-749	\$15.50	\$15.30	\$14.12	

The annual levelized baseline replacement costs using the statewide real discount rate of 5.23% are presented below:

Lumen Range	Levelized annual replacement costs per bulb			
	Baseline			Efficient
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015	All
1490-2600	\$2.86	\$2.54	\$2.20	\$0.30
1050-1489	\$2.71	\$2.54	\$2.20	
750-1049	\$2.42	\$2.39	\$2.20	
310-749	\$2.42	\$2.39	\$2.20	

LOADSHAPE

Loadshape R07 - Residential Outdoor Lighting

COINCIDENCE FACTOR

The summer peak coincidence factor is assumed to be 0.4%⁸³⁸.

⁸³⁵ 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.

⁸³⁶ ENERGY STAR Qualified Lighting Savings Calculator default incremental cost input for exterior fixture (http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/LightingCalculator.xlsx?b299-55ae&b299-55ae)

⁸³⁷ See 'RES CFL Fixture O&M calc.xls' for more details.

⁸³⁸ Estimated based on Commercial Outdoor Lighting coincidence factor calculation from analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. Residential Outdoor Lighting is not provided in

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = ((WattsBase - WattsEE) / 1000) * ISR * Hours$$

Where:

WattsBase = Based on lumens of CFL bulb and program year purchased:

Minimum Lumens	Maximum Lumens	Incandescent Equivalent Pre-EISA 2007 (Watts _{Base})	Incandescent Equivalent Post-EISA 2007 (Watts _{Base})	Effective date from which Post – EISA 2007 assumption should be used
1490	2600	100	72	June 2012
1050	1489	75	53	June 2013
750	1049	60	43	June 2014
310	749	40	29	June 2014

WattsEE = Actual wattage of CFL purchased

this data set.

ISR = In Service Rate or the percentage of units rebated that get installed.

Program	Weighted Average 1 st year In Service Rate (ISR)	2 nd year Installations	3 rd year Installations	Final Lifetime In Service Rate
Retail (Time of Sale)	87.5% ⁸³⁹	5.7%	4.8%	98.0% ⁸⁴⁰

Hours = Average hours of use per year

=1643 (4.5 hrs per day)⁸⁴¹

MID LIFE BASELINE ADJUSTMENT

During the lifetime of a CFL, a baseline incandescent bulb would need to be replaced multiple times. Since the baseline bulb changes over time the annual savings claim must be reduced within the life of the measure to account for this baseline shift.

For example, for 60W equivalent bulbs installed in 2012, the full savings (as calculated above in the Algorithm) should be claimed for the first two years, but a reduced annual savings claimed for the remainder of the measure life. The appropriate adjustment factors are provided below.

Lumen Range	Pre EISA WattsBase	Post EISA WattsBase	CFL Equivalent	Delta Watts Before EISA	Delta Watts After EISA	Mid Life Adjustment	Adjustment made from date
1490-2600	100	72	25	75	47	63%	N/A (2012 is already post EISA)
1050-1489	75	53	20	55	33	60%	June, 2013
750-1049	60	43	14	46	29	63%	June, 2014
310-749	40	29	11	29	18	62%	June, 2014

⁸³⁹ 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.

⁸⁴⁰ 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.

⁸⁴¹ Updated results from above study, presented in 2005 memo;

http://publicservice.vermont.gov/energy/ee_files/efficiency/eval/marivtfinalresultsmemodelivered.pdf

For example, a 2 x 20W 1200 lumen lamp CFL fixture is purchased in 2012:

First Year Installs:

$$\begin{aligned} \Delta kWh &= ((150 - 40) / 1000) * 0.875 * 1643 \\ &= 158 \text{ kWh} \end{aligned}$$

This value should be claimed in June 2012 – May 2013, but from June 2013 on savings for that same bulb should be reduced to (158 * 0.6) 94.8 kWh for the remainder of the measure life. Note these adjustments should be applied to kW and fuel impacts.

Second Year Installs:

$$\begin{aligned} \Delta kWh_{2nd \text{ year}} &= ((106 - 40) / 1000) * 0.057 * 1643 \\ &= 6.2 \text{ kWh} \end{aligned}$$

Note since this is now being installed in 2013 the baseline is adjusted to 2*53W due to EISA legislation

Third Year Installs:

$$\begin{aligned} \Delta kWh_{3rd \text{ year}} &= ((106 - 40) / 1000) * 0.048 * 1643 \\ &= 5.2 \text{ kWh.} \end{aligned}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = ((\text{WattsBase} - \text{WattsEE}) / 1000) * \text{ISR} * \text{CF}$$

Where:

$$\begin{aligned} \text{CF} &= \text{Summer Peak Coincidence Factor for measure.} \\ &= 0.4\%^{842} \end{aligned}$$

Other factors as defined above

⁸⁴² Estimated based on Commercial Outdoor Lighting coincidence factor calculation from analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. Residential Outdoor Lighting is not provided in this data set.

For example, a 2 x 20W 1200 lumen lamp CFL fixture is purchased in 2012:

$$\begin{aligned} \Delta kW_{1st\ year} &= ((150 - 40) / 1000) * 0.875 * 0.004 \\ &= 0.0004\ kW \end{aligned}$$

Second and third year savings should be calculated using the appropriate ISR and baseline shift adjustment.

NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

In order to account for the shift in baseline due to the Energy Independence and Security Act of 2007, an equivalent annual levelized baseline replacement cost over the lifetime of the CFL is calculated (see 'RES CFL Fixture O&M calc.xls'). The key assumptions used in this calculation are documented below⁸⁴³:

	Standard Incandescent	Efficient Incandescent	CFL
Replacement Cost	\$0.50	\$1.50	\$2.50
Component Rated Life (hrs)	1000	1000 ⁸⁴⁴	8000

The Net Present Value of the baseline replacement costs for each CFL lumen range and installation year (2012 - 2016) are presented below:

Lumen Range	NPV of replacement costs per bulb			
	Baseline			Efficient
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015	
1490-2600	\$18.34	\$16.28	\$14.12	\$1.90
1050-1489	\$17.36	\$16.28	\$14.12	
750-1049	\$15.50	\$15.30	\$14.12	
310-749	\$15.50	\$15.30	\$14.12	

The annual levelized baseline replacement costs using the statewide real discount rate of 5.23% are presented

⁸⁴³ See 'RES CFL Fixture O&M calc.xls' for more details.

⁸⁴⁴ 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.

below:

Lumen Range	Levelized annual replacement costs per bulb			
	Baseline			Efficient
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015	All
1490-2600	\$2.86	\$2.54	\$2.20	\$0.30
1050-1489	\$2.71	\$2.54	\$2.20	
750-1049	\$2.42	\$2.39	\$2.20	
310-749	\$2.42	\$2.39	\$2.20	

MEASURE CODE: RS-LTG-EFIX-V01-120601

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 will require all general-purpose light bulbs between 40 and 100W to be approximately 30% more energy efficient than current incandescent bulbs. Production of 100W, standard efficacy incandescent lamps ends in 2012, followed by restrictions on 75W in 2013 and 60W and 40W in 2014. The baseline for this measure will therefore become bulbs (improved incandescent or halogen) that meet the new standard.

To account for these new standards and the expected delay in clearing retail inventory, the first year annual savings for this measure is reduced for 100W equivalent bulbs in June 2012, for 75W equivalent bulbs in June 2013 and for 60 and 40W equivalent bulbs in June 2014.

In addition, since during the lifetime of a CFL, the baseline bulb will be replaced multiple times, the annual savings claim must also be reduced within the life of the measure. For example, for 60W equivalent bulbs installed in 2012, the full savings (as calculated below in the Algorithm) should be claimed for the first two years, but a reduced annual savings based on the EISA-compliant baseline should be claimed for the remainder of the measure life. The appropriate adjustment factors are provided in the 'Mid Life Baseline Adjustment' section below.

Finally, a provision in the EISA regulations requires that by January 1, 2020, all lamps meet efficiency criteria of at least 45 lumens per watt, in essence making the baseline equivalent to a current day CFL. Therefore the measure life (number of years that savings should be claimed) should be reduced once the assumed lifetime of the bulb exceeds 2020. Due to expected delay in clearing retail inventory and to account for the operating life of a halogen incandescent potentially spanning over 2020, this shift is assumed not to occur until mid-2020.

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

DEFINITION OF EFFICIENT EQUIPMENT

The efficient condition is an ENERGY STAR lighting interior fixture for pin-based compact fluorescent lamps.

DEFINITION OF BASELINE EQUIPMENT

The baseline condition is a standard incandescent interior fixture.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected life of an interior fixture is 20 years⁸⁴⁵. 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

⁸⁴⁵ 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.

June 2013 – May 2014, this would be reduced to 7 years and should be reduced each year⁸⁴⁶.

DEEMED MEASURE COST

The incremental cost for an interior fixture is assumed to be \$32⁸⁴⁷.

DEEMED O&M COST ADJUSTMENTS⁸⁴⁸

Residential and in-unit Multi Family:

The Net Present Value of the baseline replacement costs for each CFL lumen range and installation year (2012 - 2016) are presented below:

Lumen Range	NPV of replacement costs per bulb			
	Baseline			Efficient
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015	All
1490-2600	\$8.44	\$7.41	\$6.32	\$0.00 (No replacements within measure life)
1050-1489	\$8.44	\$7.41	\$6.32	
750-1049	\$7.50	\$7.41	\$6.32	
310-749	\$7.50	\$7.41	\$6.32	

The annual levelized baseline replacement costs using the statewide real discount rate of 5.23% are presented below:

Lumen Range	Levelized annual replacement costs per bulb			
	Baseline			Efficient
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015	All
1490-2600	\$1.32	\$1.16	\$0.99	\$0.00 (No replacements within measure life)
1050-1489	\$1.32	\$1.16	\$0.99	
750-1049	\$1.17	\$1.16	\$0.99	
310-749	\$1.17	\$1.16	\$0.99	

Multi Family common areas:

The Net Present Value of the baseline replacement costs for each CFL lumen range and installation year (2012 - 2016) are presented below:

⁸⁴⁶ 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.

⁸⁴⁷ ENERGY STAR Qualified Lighting Savings Calculator default incremental cost input for interior fixture (http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/LightingCalculator.xlsx?b299-55ae&b299-55ae)

⁸⁴⁸ See 'RES CFL Fixture O&M calc.xls' for more details.

Lumen Range	NPV of replacement costs			
	Baseline			Efficient
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015	All
1490-2600	\$57.47	\$51.35	\$44.90	\$4.89
1050-1489	\$52.62	\$51.35	\$44.90	
750-1049	\$47.08	\$46.50	\$44.90	
310-749	\$47.08	\$46.50	\$44.90	

The annual levelized baseline replacement costs using the statewide real discount rate of 5.23% are presented below:

Lumen Range	Levelized annual replacement cost savings			
	Baseline			Efficient
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015	All
1490-2600	\$8.97	\$8.02	\$7.01	\$0.76
1050-1489	\$8.22	\$8.02	\$7.01	
750-1049	\$7.35	\$7.26	\$7.01	
310-749	\$7.35	\$7.26	\$7.01	

LOADSHAPE

- Loadshape R06 - Residential Indoor Lighting
- Loadshape C06 - Commercial Indoor Lighting⁸⁴⁹

COINCIDENCE FACTOR

The summer peak coincidence factor is assumed to be 9.5%⁸⁵⁰ for Residential and in-unit Multi Family bulbs and 75%⁸⁵¹ for Multi Family common area bulbs.

⁸⁴⁹ For Multi Family common area lighting.

⁸⁵⁰ Based on lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation. "ComEd Residential Energy Star Lighting Program Metering Study: Overview of Study Protocols" <http://www.icc.illinois.gov/downloads/public/edocket/303835.pdf>

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⁸⁵¹ Coincidence factor is based on healthcare/clinic value (used as proxy for multi family common area lighting with similar hours of use) developed using Equest models for various building types averaged across 5 climate zones for Illinois for the following building types.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = ((Watts_{Base} - Watts_{EE}) / 1000) * ISR * Hours * WHFe$$

Where:

WattsBase = Based on lumens of CFL bulb and program year purchased:

Minimum Lumens	Maximum Lumens	Incandescent Equivalent Pre-EISA 2007 (Watts _{Base})	Incandescent Equivalent Post-EISA 2007 (Watts _{Base})	Effective date from which Post – EISA 2007 assumption should be used
1490	2600	100	72	June 2012
1050	1489	75	53	June 2013
750	1049	60	43	June 2014
310	749	40	29	June 2014

WattsEE = Actual wattage of CFL purchased

ISR = In Service Rate or the percentage of units rebated that get installed.

Program	Weighted Average 1 st year In Service Rate (ISR)	2 nd year Installations	3 rd year Installations	Final Lifetime In Service Rate
Retail (Time of Sale)	87.5% ⁸⁵²	5.7%	4.8%	98.0% ⁸⁵³

⁸⁵² 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.

⁸⁵³ The 98% Lifetime ISR assumption is consistent with the assumption for standard CFLs (in the absence of evidence that it should be different for this bulb type) based upon review of two evaluations: 'Nexus Market Research, RLW Analytics and GDS Associates study; "New England Residential Lighting Markdown Impact Evaluation, January 20, 2009' and 'KEMA Inc, Feb 2010, Final Evaluation Report:, Upstream Lighting Program, Volume 1.' This implies that only 2% of bulbs purchased are never installed. The second and third year installations are based upon Ameren analysis of the Californian KEMA study showing that 54% of future installs occur in year 2 and 46% in year 3. The 2nd and 3rd year installations should be counted as part of those future program year savings.

Hours = Average hours of use per year

Installation Location	Hours
Residential and in-unit Multi Family	938 ⁸⁵⁴
Multi Family Common Areas	5950 ⁸⁵⁵

WHFe = Waste heat factor for energy to account for cooling energy savings from efficient lighting

Bulb Location	WHFe
Interior single family or unknown location	1.06 ⁸⁵⁶
Multi family in unit	1.04 ⁸⁵⁷
Multi family common area	1.04 ⁸⁵⁸
Exterior or uncooled location	1.0

MID LIFE BASELINE ADJUSTMENT

During the lifetime of a CFL, a baseline incandescent bulb would need to be replaced multiple times. Since the baseline bulb changes over time the annual savings claim must be reduced within the life of the measure to account for this baseline shift.

⁸⁵⁴ Based on lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation.

⁸⁵⁵ Multi family common area lighting assumption is 16.3 hours per day (5950 hours per year) based on Focus on Energy Evaluation, ACES Deemed Savings Desk Review, November 2010.

⁸⁵⁶ 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>)

⁸⁵⁷ 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>

⁸⁵⁸ Ibid.

For example, for 60W equivalent bulbs installed in 2012, the full savings (as calculated above in the Algorithm) should be claimed for the first two years, but a reduced annual savings claimed for the remainder of the measure life. The appropriate adjustment factors are provided below.

Lumen Range	Pre EISA WattsBase	Post EISA WattsBase	CFL Equivalent	Delta Watts Before EISA	Delta Watts After EISA	Mid Life Adjustment	Adjustment made from date
1490-2600	100	72	25	75	47	63%	N/A (2012 is already post EISA)
1050-1489	75	53	20	55	33	60%	June, 2013
750-1049	60	43	14	46	29	63%	June, 2014
310-749	40	29	11	29	18	62%	June, 2014

For example, a 2 x 20W 1200 lumen lamp CFL fixture is purchased in 2012 and installed in single family interior location:

First Year Installs:

$$\begin{aligned} \Delta kWh &= ((150 - 40) / 1000) * 0.875 * 938 * 1.06 \\ &= 95.7 \text{ kWh} \end{aligned}$$

This value should be claimed in June 2012 – May 2013, but from June 2013 on savings for that same bulb should be reduced to $(95.7 * 0.6 =) 57.4 \text{ kWh}$ for the remainder of the measure life. Note these adjustments should be applied to kW and fuel impacts.

Second Year Installs:

$$\begin{aligned} \Delta kWh_{2nd \text{ year}} &= ((106 - 40) / 1000) * 0.057 * 938 * 1.06 \\ &= 3.7 \text{ kWh} \end{aligned}$$

Note since this is now being installed in 2013 the baseline is adjusted to 2*53W due to EISA legislation

Third Year Installs:

$$\begin{aligned} \Delta kWh_{3rd \text{ year}} &= ((106 - 40) / 1000) * 0.048 * 938 * 1.06 \\ &= 3.1 \text{ kWh} \end{aligned}$$

HEATING PENALTY

If electric heated building:

$$\Delta kWh^{859} = - (((WattsBase - WattsEE) / 1000) * ISR * Hours * HF) / \eta_{Heat}$$

Where:

- HF = Heating Factor or percentage of light savings that must be heated
 = 49%⁸⁶⁰ for interior or unknown location
 = 0% for unheated location
- η_{Heat} = Efficiency in COP of Heating equipment
 = actual. If not available use⁸⁶¹:

System Type	Age of Equipment	HSPF Estimate	η_{Heat} (COP Estimate)
Heat Pump	Before 2006	6.8	2.00
	After 2006	7.7	2.26
Resistance	N/A	N/A	1.00

For example, a 2 x 20W 1200 lumen lamp CFL is purchased in 2012 and installed in home with 2.0 COP Heat Pump:

$$\Delta kWh_{1st\ year} = - (((150 - 40) / 1000) * 0.875 * 938 * 0.49) / 2.0$$

$$= - 22\ kWh$$

Second and third year savings should be calculated using the appropriate ISR and baseline shift adjustment

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = ((WattsBase - WattsEE) / 1\ 000) * ISR * WHFd * CF$$

Where:

⁸⁵⁹ Negative value because this is an increase in heating consumption due to the efficient lighting.

⁸⁶⁰ 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.

⁸⁶¹ These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Heat Pumps was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate.

WHFd = Waste heat factor for demand to account for cooling savings from efficient lighting.

Bulb Location	WHFd
Interior single family or unknown location	1.11 ⁸⁶²
Multi family in unit	1.07 ⁸⁶³
Multi family common area	1.07 ⁸⁶⁴
Exterior or uncooled location	1.0

CF = Summer Peak Coincidence Factor for measure.

Bulb Location	CF
Interior single family or unknown location	9.5% ⁸⁶⁵
Multi family in unit	9.5% ⁸⁶⁶
Multi family common area	75% ⁸⁶⁷

Other factors as defined above

For example, a 2 x 20W 1200 lumen lamp CFL is purchased in 2012 and installed in home with 2.0 COP Heat Pump:

$$\Delta kW_{1st\ year} = ((150 - 40) / 1000) * 0.875 * 1.11 * 0.095$$

$$= 0.01\ kW$$

Second and third year savings should be calculated using the appropriate ISR and baseline shift adjustment.

NATURAL GAS SAVINGS

$$\Delta Therms^{868} = - (((WattsBase - WattsEE) / 1000) * ISR * Hours * HF * 0.03412) / \eta_{Heat}$$

⁸⁶² 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.

⁸⁶³ 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> .

⁸⁶⁴ Ibid

⁸⁶⁵ Based on lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation. "ComEd Residential Energy Star Lighting Program Metering Study: Overview of Study Protocols"

<http://www.icc.illinois.gov/downloads/public/edocket/303835.pdf>

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<http://www.icc.illinois.gov/downloads/public/edocket/303834.pdf>

⁸⁶⁶ Ibid.

⁸⁶⁷ Coincidence factor is based on healthcare/clinic value (used as proxy for multi family common area lighting with similar hours of use) developed using Equest models for various building types averaged across 5 climate zones for Illinois for the following building types.

Where:

- HF = Heating Factor or percentage of light savings that must be heated
= 49%⁸⁶⁹ for interior or unknown location
= 0% for unheated location
- 0.03412 = Converts kWh to Therms
- η_{Heat} = Efficiency of heating system
= 70%⁸⁷⁰

For example, a 2 x 20W 1200 lumen lamp CFL is purchased in 2012 and installed in home with gas heat at 70% efficiency:

$$\Delta \text{Therms}_{\text{1st year}} = -((150 - 40) / 1000) * 0.875 * 938 * 0.49 * 0.03412) / 0.7$$

$$= - 2.2 \text{ Therms}$$

Second and third year savings should be calculated using the appropriate ISR and baseline shift adjustment

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

In order to account for the shift in baseline due to the Energy Independence and Security Act of 2007, an equivalent annual levelized baseline replacement cost over the lifetime of the CFL is calculated (see 'RES CFL Fixture O&M calc.xls'). The key assumptions used in this calculation are documented below:

	Standard Incandescent	Efficient Incandescent	CFL
Replacement Cost	\$0.50	\$1.50	\$2.50

⁸⁶⁸ Negative value because this is an increase in heating consumption due to the efficient lighting.

⁸⁶⁹ This means that heating loads increase by 49% of the lighting savings. This is based on the average result from REMRate modeling of several different configurations and IL locations of homes.

⁸⁷⁰ 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:

$$(0.24 * 0.92) + (0.76 * 0.8) * (1 - 0.15) = 0.70$$

Component Rated Life (hrs)	1000	1000 ⁸⁷¹	8000 (or 10,000 for multifamily common areas)
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Residential and in-unit Multi Family:

The Net Present Value of the baseline replacement costs for each CFL lumen range and installation year (2012 - 2016) are presented below:

Lumen Range	NPV of replacement costs per bulb			
	Baseline			Efficient
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015	All
1490-2600	\$8.44	\$7.41	\$6.32	\$0.00 (No replacements within measure life)
1050-1489	\$8.44	\$7.41	\$6.32	
750-1049	\$7.50	\$7.41	\$6.32	
310-749	\$7.50	\$7.41	\$6.32	

The annual levelized baseline replacement costs using the statewide real discount rate of 5.23% are presented below:

Lumen Range	Levelized annual replacement costs per bulb			
	Baseline			Efficient
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015	All
1490-2600	\$1.32	\$1.16	\$0.99	\$0.00 (No replacements within measure life)
1050-1489	\$1.32	\$1.16	\$0.99	
750-1049	\$1.17	\$1.16	\$0.99	
310-749	\$1.17	\$1.16	\$0.99	

Multi Family common areas:

The Net Present Value of the baseline replacement costs for each CFL lumen range and installation year (2012 - 2016) are presented below:

Lumen Range	NPV of replacement costs			
	Baseline			Efficient
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015	All
1490-2600	\$57.47	\$51.35	\$44.90	\$4.89
1050-1489	\$52.62	\$51.35	\$44.90	

⁸⁷¹ 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.

750-1049	\$47.08	\$46.50	\$44.90	
310-749	\$47.08	\$46.50	\$44.90	

The annual levelized baseline replacement costs using the statewide real discount rate of 5.23% are presented below:

Lumen Range	Levelized annual replacement cost savings			
	Baseline			Efficient
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015	All
1490-2600	\$8.97	\$8.02	\$7.01	\$0.76
1050-1489	\$8.22	\$8.02	\$7.01	
750-1049	\$7.35	\$7.26	\$7.01	
310-749	\$7.35	\$7.26	\$7.01	

MEASURE CODE: RS-LTG-IFIX-V01-120601

5.5.6 LED Downlights

DESCRIPTION

This measure describes savings from a variety of LED downlight lamp types. Other LED lamp types are currently available (e.g. A-lamps) but the significant incremental cost and minimal efficacy improvements over CFLs mean that they are unlikely to represent a viable measure at this time. As prices continue to drop and improvements in efficacy continue, this will be revisited in future versions.

This characterization assumes that the LED lamp or fixture is installed in a residential location. Where the implementation strategy does not allow for the installation location to be known (e.g. an upstream retail program) evaluation data could be used to determine an appropriate residential v commercial split. If this is not available, it is recommended to use this residential characterization for all installs in unknown locations to be appropriately conservative in savings assumptions.

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

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed equipment must be an ENERGY STAR LED lamp or fixture.

DEFINITION OF BASELINE EQUIPMENT

The baseline condition is assumed to be an incandescent/halogen lamp for all lamp types.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is given in the following table.⁸⁷²

Bulb Type	Measure Life (yr)
PAR20, PAR30, PAR38 screw-in lamps	10
MR16/PAR16 pin-based lamps	10
Recessed downlight luminaries	15
Track lights	15

⁸⁷² Limited by persistence. NEEP EMV Emerging Technologies Research Report (December 2011)

DEEMED MEASURE COST

The price of LED lamps is falling quickly. Where possible the actual cost should be used and compared to the baseline cost provided below. If the incremental cost is unknown, assume the following⁸⁷³:

Bulb Type	Baseline Cost	LED Cost	Incremental Cost
PAR20, PAR30, PAR38 screw-in lamps	\$4.00	\$44.00	\$40.00
MR16/PAR16 pin-based lamps	\$3.00	\$28.00	\$25.00
Recessed downlight luminaries	\$4.00	\$94.00	\$90.00
Track lights	\$4.00	\$60.00	\$56.00

DEEMED O&M COST ADJUSTMENTS

The life of the baseline bulb and the cost of its replacement is presented in the following table:

Lamp Type	Baseline Lamp Life (hours)	Baseline Life (years) (Single Family and in unit Multifamily - 1010 hours)	Baseline Life (years) (Common Area Multifamily - 5950 hours)	Baseline Replacement Cost
PAR20, PAR30, PAR38 screw-in lamps	2000	2.0	0.3	\$4.00
MR16/PAR16 pin-based lamps	2000	2.0	0.3	\$3.00
Recessed downlight luminaries	2000	2.0	0.3	\$4.00
Track lights	2000	2.0	0.3	\$4.00

LOADSHAPE

- Loadshape R06 - Residential Indoor Lighting
- Loadshape R07 - Residential Outdoor Lighting
- Loadshape C06 - Commercial Indoor Lighting⁸⁷⁴

COINCIDENCE FACTOR

The summer Peak Coincidence Factor is assumed to be 9.5%⁸⁷⁵ for Residential and in-unit Multi Family bulbs and 75%⁸⁷⁶ for Multi Family common area bulbs.

⁸⁷³ Costs are provided as the best estimate from VEIC and are based on review of available product and of price reports provided to Efficiency Vermont by a number of manufacturers and retailers.

⁸⁷⁴ For Multi Family common area lighting.

⁸⁷⁵ Based on lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation.

“ComEd Residential Energy Star Lighting Program Metering Study: Overview of Study Protocols”

<http://www.icc.illinois.gov/downloads/public/edocket/303835.pdf>

“Memo RE: Lighting Logger Study Results – Version 2, Date: May 27, 2011, To: David Nichols and ComEd Residential Lighting Interested Parties, From: Amy Buege and Jeremy Eddy; Navigant Evaluation Team”

<http://www.icc.illinois.gov/downloads/public/edocket/303834.pdf>

⁸⁷⁶ Coincidence factor is based on healthcare/clinic value (used as proxy for multi family common area lighting with similar hours of use) developed using Equest models for various building types averaged across 5 climate zones for Illinois for the following building types.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = ((WattsBase - WattsEE) / 1000) * ISR * Hours * WHFe$$

Where:

WattsBase = Baseline lamp wattage of equivalent lumens, see “Bulb Types” table – default baseline assumption (incandescent/halogen) is in bold and highlighted yellow

WattsEE = Actual wattage of energy efficient LED lamp purchased

Bulb Type	Efficacy (lumen/Watt) ⁸⁷⁷	Lumens	LED Watts (WattsEE)	Incandescent/Halogen Watts	EISA compliant Incandescent Watts	CFL Watts
PAR20 screw-in lamps	10-15 (incandescent/halogen) 35-45 (CFL reflector) 40-60 (LED)	460-810	13	46		18
PAR30 screw-in lamps		600-1005	15	67		20
PAR38 screw-in lamps		630-1170	18	78		23
MR16/PAR16 pin-based lamps	15-25 (Incandescent) 50 (LED)	300-500	8	20		
		525-875	14	35		
		750-1250	20	50		
Recessed downlight luminaries	35 (fixture efficacy with a CFL lamp) 42-86 (LED fixture)	540	11	50		15
		500-650	12	65		18
		1000	13	100		25
Track lights (R20)	10-15 ⁸⁷⁸ (incandescent/halogen) 35-45 (CFL reflector) 40-60 (LED)	320-675	8	45		10
Track lights (BR30 and BR40)		440-975	11	65		18

⁸⁷⁷ Data source for most efficacies: Energy Savings Estimates of Light Emitting Diodes in Niche Lighting Applications, Navigrant Consulting, January 2011, http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/nichefinalreport_january2011.pdf

⁸⁷⁸ The exemption to EISA for reflector bulbs is expected to expire in 2014 for the following wattage and bulb type: 45 W (R20 and BR 19); 50W (R30, ER 30, BR 40, and ER 40); 65W (BR30, BR40, and ER 404)

ISR = In Service Rate or the percentage of units rebated that get installed⁸⁷⁹

Bulb Type	ISR
PAR20, PAR30, PAR38 screw-in lamps	0.95
MR16/PAR16 pin-based lamps	0.95
Recessed downlight luminaires	1.0
Track lights	1.0

Hours = Average hours of use per year

Installation Location	Hours
Residential and in-unit Multi Family	1,010 ⁸⁸⁰
Multi Family Common Areas	5950 ⁸⁸¹

WHFe = Waste heat factor for energy to account for cooling savings from efficient lighting

Bulb Location	WHFe
Interior single family or unknown location	1.06 ⁸⁸²
Multi family in unit	1.04 ⁸⁸³
Multi family common area	1.04 ⁸⁸⁴
Exterior or uncooled location	1.0

For example, a 13W PAR20 LED is installed in place of a 46W PAR20 incandescent screw-in lamp installed in single family interior location:

$$\Delta kWh = ((46 - 13) / 1000) * 0.95 * 1010 * 1.06$$

⁸⁷⁹ NEEP EMV Emerging Technologies Research Report (December 2011)

⁸⁸⁰ NEEP EMV Emerging Technologies Research Report (December 2011)

⁸⁸¹ Multi family common area lighting assumption is 16.3 hours per day (5950 hours per year) based on Focus on Energy Evaluation, ACES Deemed Savings Desk Review, November 2010.

⁸⁸² 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 $(-0.02 * SEER^2) + (1.12 * SEER)$ (from Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder), 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>)

⁸⁸³ 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>

⁸⁸⁴ Ibid.

= 33.6 kWh

HEATING PENALTY

If electric heated home (if heating fuel is unknown assume gas, see Natural Gas section):

$$\Delta kWh^{885} = - (((WattsBase - WattsEE) / 1000) * ISR * Hours * HF) / \eta Heat$$

Where:

HF = Heating Factor or percentage of light savings that must be heated

= 49%⁸⁸⁶ for interior or unknown location

= 0% for exterior location

$\eta Heat$ = Efficiency in COP of Heating equipment

= Actual. If not available use.⁸⁸⁷

System Type	Age of Equipment	HSPF Estimate	$\eta Heat$ (COP Estimate)
Heat Pump	Before 2006	6.8	2.00
	After 2006	7.7	2.26
Resistance	N/A	N/A	1.00

For example, a 13W PAR20 LED is installed in place of a 46W PAR20 incandescent screw-in lamp installed in single family interior location:

$$\begin{aligned} \Delta kWh &= - ((46 - 13) / 1000) * 0.95 * 1010 * 0.49 / 2.26 \\ &= - 6.87 \text{ kWh} \end{aligned}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = ((WattsBase - WattsEE) / 1000) * ISR * WHFd * CF$$

Where:

WHFd = Waste heat factor for demand to account for cooling savings from efficient lighting.

⁸⁸⁵ Negative value because this is an increase in heating consumption due to the efficient lighting.

⁸⁸⁶ 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.

⁸⁸⁷ These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Heat Pumps was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate.

Bulb Location	WHFd
Interior single family or unknown location	1.11 ⁸⁸⁸
Multi family in unit	1.07 ⁸⁸⁹
Multi family common area	1.07 ⁸⁹⁰
Exterior or uncooled location	1.0

CF = Summer Peak Coincidence Factor for measure, see above for values.

Bulb Location	CF
Interior single family or unknown location	9.5% ⁸⁹¹
Multi family in unit	9.5% ⁸⁹²
Multi family common area	75% ⁸⁹³

Other factors as defined above

For example, a 13W PAR20 LED is installed in place of a 46W PAR20 incandescent screw-in lamp installed in single family interior location:

$$\Delta kW = ((46 - 13) / 1000) * 0.95 * 1.11 * 0.095$$

$$= 0.0033 \text{ kW}$$

NATURAL GAS SAVINGS

Heating penalty if Natural Gas heated home, or if heating fuel is unknown.

$$\Delta \text{therms} = -(((\text{WattsBase} - \text{WattsEE}) / 1000) * \text{ISR} * \text{Hours} * \text{HF} * 0.03412) / \eta_{\text{Heat}}$$

Where:

⁸⁸⁸ 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.

⁸⁸⁹ 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>.

⁸⁹⁰ Ibid

⁸⁹¹ Based on lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation. “ComEd Residential Energy Star Lighting Program Metering Study: Overview of Study Protocols”

<http://www.icc.illinois.gov/downloads/public/edocket/303835.pdf>

“Memo RE: Lighting Logger Study Results – Version 2, Date: May 27, 2011, To: David Nichols and ComEd Residential Lighting Interested Parties, From: Amy Buege and Jeremy Eddy; Navigant Evaluation Team”

<http://www.icc.illinois.gov/downloads/public/edocket/303834.pdf>

⁸⁹² Ibid.

⁸⁹³ Coincidence factor is based on healthcare/clinic value (used as proxy for multi family common area lighting with similar hours of use) developed using Equest models for various building types averaged across 5 climate zones for Illinois for the following building types.

- HF = Heating factor, or percentage of lighting savings that must be replaced by heating system.
 = 49%⁸⁹⁴ for interior or unknown location
 = 0% for exterior location
- 0.03412 = Converts kWh to Therms
- η Heat = Average heating system efficiency.
 = 0.70⁸⁹⁵

Other factors as defined above

For example, a 13W PAR20 LED is installed in place of a 46W PAR20 incandescent screw-in lamp installed in single family interior location with gas heating at 70% total efficiency:

$$\Delta \text{therms} = - ((46 - 13) / 1000) * 0.95 * 1010 * 0.49 * 0.03412 / 0.70$$

$$= - 0.756 \text{ therms}$$

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

The life of the baseline bulb and the cost of its replacement is presented in the following table:

Lamp Type	Baseline Lamp Life (hours)	Baseline Life (Single Family and in unit Multifamily - 1010 hours)	Baseline Life (Common Area Multifamily - 5950 hours)	Baseline Replacement Cost
PAR20, PAR30, PAR38 screw-in lamps	2000	2.0	0.3	\$4.00
MR16/PAR16 pin-based lamps	2000	2.0	0.3	\$3.00
Recessed downlight luminaries	2000	2.0	0.3	\$4.00

⁸⁹⁴ Average result from REMRate modeling of several different configurations and IL locations of homes

⁸⁹⁵ 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:

$(0.24 * 0.92) + (0.76 * 0.8) * (1 - 0.15) = 0.70$

Track lights	2000	2.0	0.3	\$4.00
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MEASURE CODE: RS-LTG-LEDD-V01-120601

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 years⁸⁹⁶.

DEEMED MEASURE COST

The incremental cost for this measure is assumed to be \$30⁸⁹⁷.

DEEMED O&M COST ADJUSTMENTS

The annual O&M Cost Adjustment savings is calculated using component costs and lifetimes presented below.

LOADSHAPE

Loadshape C53 - Flat

COINCIDENCE FACTOR

The summer peak coincidence factor for this measure is assumed to be 100%⁸⁹⁸.

⁸⁹⁶ 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Effective/Remaining Useful Life Values", California Public Utilities Commission, December 16, 2008.

⁸⁹⁷ NYSERDA Deemed Savings Database, Labor cost assumes 25 minutes @ \$18/hr.

⁸⁹⁸ 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 ⁸⁹⁹
Fluorescent	11W ⁹⁰⁰
Unknown (e.g. time of sale)	11W

WattsEE = Actual wattage if known, if unknown assume 2W⁹⁰¹

HOURS = Annual operating hours
= 8766

WHF_e = Waste heat factor for energy; accounts for cooling savings from efficient lighting.
= 1.04⁹⁰² for multi family buildings

Default if replacing incandescent fixture

$$\begin{aligned} \Delta kWh &= (35 - 2)/1000 * 8766 * 1.04 \\ &= 301 kWh \end{aligned}$$

⁸⁹⁹ Based on review of available product.

⁹⁰⁰ Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010

⁹⁰¹ Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010

⁹⁰² 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>

Default if replacing fluorescent fixture

$$\begin{aligned} \Delta\text{kWh} &= (11 - 2)/1000 * 8766 * 1.04 \\ &= 82 \text{ kWh} \end{aligned}$$

HEATING PENALTY

If electric heated building (if heating fuel is unknown assume gas, see Natural Gas section):

$$\Delta\text{kWh}^{903} = -(((\text{WattsBase} - \text{WattsEE}) / 1000) * \text{Hours} * \text{HF}) / \eta\text{Heat}$$

Where:

HF = Heating Factor or percentage of light savings that must be heated
 = 49%⁹⁰⁴

ηHeat = Efficiency in COP of Heating equipment
 = Actual. If not available use.⁹⁰⁵

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: $\Delta\text{kWh} = -((35 - 2)/1000 * 8766 * 0.49) / 2$
 = -71 kWh

If fluorescent fixture $\Delta\text{kWh} = -((11 - 2)/1000 * 8766 * 0.49) / 2$
 = -19 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta\text{kW} = ((\text{WattsBase} - \text{WattsEE}) / 1000) * \text{WHF}_d * \text{CF}$$

⁹⁰³ Negative value because this is an increase in heating consumption due to the efficient lighting.

⁹⁰⁴ 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.

⁹⁰⁵ These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Heat Pumps was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate.

Where:

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.

= 1.07⁹⁰⁶ for multi family buildings

CF = Summer Peak Coincidence Factor for measure

= 1.0

Default if incandescent fixture

$\Delta kW = (35 - 2)/1000 * 1.07 * 1.0$

= 0.035 kW

Default if fluorescent fixture

$\Delta kW = (11 - 2)/1000 * 1.07 * 1.0$

= 0.0096 kW

NATURAL GAS SAVINGS

Heating penalty if Natural Gas heated building, or if heating fuel is unknown.

$\Delta \text{therms} = - ((\text{WattsBase} - \text{WattsEE}) / 1000) * \text{Hours} * \text{HF} * 0.03412) / \eta \text{Heat}$

Where:

HF = Heating factor, or percentage of lighting savings that must be replaced by heating system.

= 49%⁹⁰⁷

0.03412 = Converts kWh to Therms

ηHeat = Average heating system efficiency.

= 0.70⁹⁰⁸

⁹⁰⁶ 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.

⁹⁰⁷ Average result from REMRate modeling of several different configurations and IL locations of homes

⁹⁰⁸ 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

Other factors as defined above

Default if incandescent fixture

$$\begin{aligned} \Delta \text{therms} &= - ((35 - 2) / 1000) * 8766 * 0.49 * 0.03412 / 0.70 \\ &= -6.9 \text{ therms} \end{aligned}$$

Default if fluorescent fixture

$$\begin{aligned} \Delta \text{therms} &= - ((11 - 2) / 1000) * 8766 * 0.49 * 0.03412 / 0.70 \\ &= -1.9 \text{ therms} \end{aligned}$$

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	\$7.00 ⁹⁰⁹	1.37 years ⁹¹⁰

MEASURE CODE: RS-LTG-LEDE-V01-120601

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:

$$(0.24 * 0.92) + (0.76 * 0.8) * (1 - 0.15) = 0.70$$

⁹⁰⁹ 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).

⁹¹⁰ Assumes a lamp life of 12,000 hours and 8766 run hours 12000/8766 = 1.37 years.

5.6 Shell End Use

5.6.1 Air Sealing

DESCRIPTION

Thermal shell air leaks are sealed through strategic use and location of air-tight materials. Leaks are detected and leakage rates measured with the assistance of a blower-door. The algorithm for this measure can be used when the program implementation does not allow for more detailed forecasting through the use of residential modeling software.

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

DEFINITION OF EFFICIENT EQUIPMENT

Air sealing materials and diagnostic testing should meet all eligibility program qualification criteria. The initial and final tested leakage rates should be performed in such a manner that the identified reductions can be properly discerned, particularly in situations wherein multiple building envelope measures may be implemented simultaneously.

DEFINITION OF BASELINE EQUIPMENT

The existing air leakage should be determined through approved and appropriate test methods using a blower door. The baseline condition of a building upon first inspection significantly impacts the opportunity for cost-effective energy savings through air-sealing.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 15 years.⁹¹¹

DEEMED MEASURE COST

The actual capital cost for this measure should be used in screening.

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

- Loadshape R08 - Residential Cooling
- Loadshape R09 - Residential Electric Space Heat
- Loadshape R10 - Residential Electric Heating and Cooling

COINCIDENCE FACTOR

The summer peak coincidence factor for cooling is provided in two different ways below. The first is used to estimate peak savings during the utility peak hour and is most indicative of actual peak benefits, and the second

⁹¹¹ Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007

represents the *average* savings over the defined summer peak period, and is presented so that savings can be bid into PJM's Forward Capacity Market. Both values provided are based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren.

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during utility peak hour)
 = 91.5%⁹¹²

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)
 = 46.6%⁹¹³

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = \Delta kWh_{cooling} + \Delta kWh_{heating}$$

Where:

$\Delta kWh_{cooling}$ = If central cooling, reduction in annual cooling requirement due to air sealing

$$= \left[\frac{((CFM50_{existing} - CFM50_{new}) / N_{cool}) * 60 * 24 * CDD * DUA * 0.018}{(1000 * \eta_{Cool})} \right] * LM$$

$CFM50_{existing}$ = 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

⁹¹² 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.

⁹¹³ Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.

N_cool = Conversion factor from leakage at 50 Pascal to leakage at natural conditions
 =Dependent on exposure:⁹¹⁴

Climate Zone	Exposure	N-Factor
Zone 2	Well Shielded	22.2
	Normal	18.5
	Exposed	16.7
Zone 3	Well Shielded	25.8
	Normal	21.5
	Exposed	19.4

60 * 24 = Converts Cubic Feet per Minute to Cubic Feet per Day

CDD = Cooling Degree Days
 = Dependent on location⁹¹⁵:

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).

= 0.75⁹¹⁶

0.018 = Specific Heat Capacity of Air (BTU/ft³*°F)

1000 = Converts Btu to kBtu

⁹¹⁴ N-factor is used to convert 50-pascal blower door air flows to natural air flows and is dependent on geographic location and exposure of the home to wind (impacts of stack effect based on height of building will not be significant because of reduced delta T during the cooling season) , based on methodology developed by Lawrence Berkeley Laboratory (LBL). N-factor values copied from J. Krigger, C. Dorsi; “Residential Energy: Cost Savings and Comfort for Existing Buildings”, p284.

⁹¹⁵ National Climatic Data Center, calculated from 1981-2010 climate normals with a base temp of 65°F.

⁹¹⁶ 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.

η_{Cool} = Efficiency (SEER) of Air Conditioning equipment (kBtu/kWh)
 = Actual (where it is possible to measure or reasonably estimate). If unknown assume the following⁹¹⁷:

Age of Equipment	SEER Estimate
Before 2006	10
After 2006	13

LM = Latent multiplier to account for latent cooling demand
 = dependent on location:⁹¹⁸

Climate Zone (City based upon)	LM
1 (Rockford)	8.5
2 (Chicago)	6.2
3 (Springfield)	6.6
4 (St. Louis, MO)	5.8
5 (Evansville, IN)	6.6

$\Delta kWh_{heating}$ = If electric heat (resistance or heat pump), reduction in annual electric heating due to air sealing

$$= (((CFM50_{existing} - CFM50_{new}) / N_{heat}) * 60 * 24 * HDD * 0.018) / (\eta_{Heat} * 3,412)$$

⁹¹⁷ 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.

⁹¹⁸ The Latent Multiplier is used to convert the sensible cooling savings calculated to a value representing sensible and latent cooling loads. The values are derived from Harriman et al "Dehumidification and Cooling Loads From Ventilation Air", ASHRAE Journal, by adding the latent and sensible loads to determine the total, then dividing the total by the sensible load. Where this specialized data was not available, a nearby city was chosen.

N_{heat} = Conversion factor from leakage at 50 Pascal to leakage at natural conditions
 = Based on climate zone, building height and exposure level:⁹¹⁹

		# Stories:	1	1.5	2	3
Zone 2	Well Shielded		22.2	20.0	17.8	15.5
	Normal		18.5	16.7	14.8	13.0
	Exposed		16.7	15.0	13.3	11.7
Zone 3	Well Shielded		25.8	23.2	20.6	18.1
	Normal		21.5	19.4	17.2	15.1
	Exposed		19.4	17.4	15.5	13.5

HDD = Heating Degree Days
 = Dependent on location:⁹²⁰

Climate Zone (City based upon)	HDD 65
1 (Rockford)	6,569
2 (Chicago)	6,339
3 (Springfield)	5,497
4 (Belleville)	4,379
5 (Marion)	4,476

⁹¹⁹ N-factor is used to convert 50-pascal blower door air flows to natural air flows and is dependent on geographic location, height of building (stack effect) and exposure of the home to wind, based on methodology developed by Lawrence Berkeley Laboratory (LBL). N-factor values copied from J. Krigger, C. Dorsi; "Residential Energy: Cost Savings and Comfort for Existing Buildings", p284.

⁹²⁰ National Climatic Data Center, calculated from 1981-2010 climate normals with a base temp of 65°F. The base temperature was selected to account for the fact that homes receiving airsealing efforts are likely to be more leaky homes where the inside and outside air temperature is more consistent and therefore is more likely to require heating as temperatures drop below 65 degrees. Using this base temperature also reconciles the resulting savings estimates with the results of more sophisticated modeling software.

η_{Heat} = Efficiency of heating system

= Actual. If not available refer to default table below⁹²¹:

System Type	Age of Equipment	HSPF Estimate	η_{Heat} (Effective COP Estimate)= (HSPF/3.413)*0.85
Heat Pump	Before 2006	6.8	1.7
	After 2006	7.7	1.92
Resistance	N/A	N/A	1

3412 = Converts Btu to kWh

For example, a well shielded, 2 story single family home in Chicago with 10.5 SEER central cooling and a heat pump with COP of 2 (1.92 including distribution losses), has pre and post blower door test results of 3,400 and 2,250:

$$\begin{aligned} \Delta \text{kWh} &= \Delta \text{kWh}_{\text{cooling}} + \Delta \text{kWh}_{\text{heating}} \\ &= \left[\left(\frac{(3,400 - 2,250)}{22.2} \right) * 60 * 24 * 842 * 0.75 * 0.018 \right] / (1000 * 10.5) * 6.2 + \left[\left(\frac{(3,400 - 2,250)}{17.8} \right) * 60 * 24 * 6339 * 0.018 / (1.92 * 3,412) \right] \\ &= 501 + 1620 \\ &= 2,121 \text{ kWh} \end{aligned}$$

⁹²¹ These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Heat Pumps was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time means that using the minimum standard is appropriate. An 85% distribution efficiency is then applied to account for duct losses for heat pumps.

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = (\Delta kWh_{cooling} / FLH_{cooling}) * CF$$

Where:

FLH_{cooling} = Full load hours of air conditioning

= Dependent on location⁹²²:

Climate Zone (City based upon)	Single Family	Multifamily
1 (Rockford)	512	467
2 (Chicago)	570	506
3 (Springfield)	730	663
4 (Belleville)	1,035	940
5 (Marion)	903	820

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)

= 91.5%⁹²³

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)

= 46.6%⁹²⁴

Other factors as defined above

⁹²² Full load hours for Chicago, Moline and Rockford are provided in “Final Evaluation Report: Central Air Conditioning Efficiency Services (CACES), 2010, Navigant Consulting”, http://ilsag.org/yahoo_site_admin/assets/docs/ComEd_PY2_CACES_Evaluation_Report_2010-10-18.299122020.pdf p.33. An average FLH/Cooling Degree Day (from NCDC) ratio was calculated for these locations and applied to the CDD of the other locations in order to estimate FLH.

⁹²³ 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.

⁹²⁴ Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.

For example, a well shielded, 2 story single family home in Chicago with 10.5 SEER central cooling and a heat pump with COP of 2.0, has pre and post blower door test results of 3,400 and 2,250:

$$\Delta kW_{SSP} = 501 / 570 * 0.915$$

$$= 0.804 \text{ kW}$$

$$\Delta kW_{PJM} = 501 / 570 * 0.466$$

$$= 0.410 \text{ kW}$$

NATURAL GAS SAVINGS

If Natural Gas heating:

$$\Delta \text{Therms} = (((\text{CFM50_existing} - \text{CFM50_new}) / \text{N_heat}) * 60 * 24 * \text{HDD} * 0.018) / (\eta_{\text{Heat}} * 100,000)$$

Where:

N_heat = Conversion factor from leakage at 50 Pascal to leakage at natural conditions

= Based on climate zone, building height and exposure level⁹²⁵:

		# Stories:	1	1.5	2	3
Zone 2	Well Shielded		22.2	20.0	17.8	15.5
	Normal		18.5	16.7	14.8	13.0
	Exposed		16.7	15.0	13.3	11.7
Zone 3	Well Shielded		25.8	23.2	20.6	18.1
	Normal		21.5	19.4	17.2	15.1
	Exposed		19.4	17.4	15.5	13.5

⁹²⁵ N-factor is used to convert 50-pascal blower door air flows to natural air flows and is dependent on geographic location, height of building (stack effect) and exposure of the home to wind, based on methodology developed by Lawrence Berkeley Laboratory (LBL). N-factor values copied from J. Krigger, C. Dorsi; "Residential Energy: Cost Savings and Comfort for Existing Buildings", p284.

HDD = Heating Degree Days
 = dependent on location⁹²⁶:

Climate Zone (City based upon)	HDD 65
1 (Rockford)	6,569
2 (Chicago)	6,339
3 (Springfield)	5,497
4 (Belleville)	4,379
5 (Marion)	4,476

η_{Heat} = Efficiency of heating system
 = Equipment efficiency * distribution efficiency
 = Actual⁹²⁷. If not available use 70%⁹²⁸.

Other factors as defined above

For example, a well shielded, 2 story single family home in Chicago with a gas furnace with system efficiency of 70%, has pre and post blower door test results of 3,400 and 2,250:

$$\Delta \text{Therms} = ((3,400 - 2,250) / 17.8) * 60 * 24 * 6339 * 0.018 / (0.7 * 100,000)$$

$$= 152 \text{ therms}$$

⁹²⁶ 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..

⁹²⁷ 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.

⁹²⁸ This has been estimated assuming that natural gas central furnace heating is typical for Illinois residences (66% of Illinois homes have a Natural Gas Furnace (based on Energy Information Administration, 2009 Residential Energy Consumption Survey:

<http://www.eia.gov/consumption/residential/data/2009/xls/HC6.9%20Space%20Heating%20in%20Midwest%20Region.xls>)

In 2000, 24% of furnaces purchased in Illinois were condensing (based on data from GAMA, provided to Department of Energy during the federal standard setting process for residential heating equipment - see Furnace Penetration.xls). Furnaces tend to last up to 20 years and so units purchased 10 years ago provide a reasonable proxy for the current mix of furnaces in the State. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows:

$(0.24 * 0.92) + (0.76 * 0.8) * (1 - 0.15) = 0.70$

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-SHL-AIRS-V01-120601

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 years⁹²⁹.

DEEMED MEASURE COST

The actual installed cost for this measure should be used in screening.

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape R08 - Residential Cooling

Loadshape R09 - Residential Electric Space Heat

Loadshape R10 - Residential Electric Heating and Cooling

COINCIDENCE FACTOR

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

⁹²⁹ Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during utility peak hour)
 = 91.5%⁹³⁰

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)
 = 46.6%⁹³¹

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = \Delta kWh_{cooling} + \Delta kWh_{heating}$$

Where:

$\Delta kWh_{cooling}$ = If central cooling, reduction in annual cooling requirement due to insulation

$$= (((1/R_{old_AG} - 1/(R_{added}+R_{old_AG})) * L_{basement_wall_total} * H_{basement_wall_AG} * (1-Framing_factor)) * 24 * CDD * DUA) / (1000 * \eta_{Cool})$$

R_{added} = R-value of additional spray foam, rigid foam, or cavity insulation.

R_{old_AG} = R-value value of foundation wall above grade.
 = 2.25⁹³²

$L_{basement_wall_total}$ = Length of basement wall around the entire insulated perimeter (ft)

$H_{basement_wall_AG}$ = Height of insulated basement wall above grade (ft)

$Framing_factor$ = Adjustment to account for area of framing when cavity insulation is used
 = 0% if Spray Foam or External Rigid Foam
 = 15% if studs and cavity insulation⁹³³

24 = Converts hours to days

CDD = Cooling Degree Days
 = Dependent on location and whether basement is conditioned:⁹³⁴

⁹³⁰ 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.

⁹³¹ Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.

⁹³² 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/ORNLCON-295.pdf>

⁹³³ Based on Oak Ridge National Lab, Technology Fact Sheet for Wall Insulation.

Climate Zone (City based upon)	Conditioned CDD 65	Unconditioned CDD 65 ⁹³⁵
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 ⁹³⁶	947	325

DUA = Discretionary Use Adjustment (reflects the fact that people do not always operate their AC when conditions may call for it).

$$= 0.75^{937}$$

1000 = Converts Btu to kBtu

η_{Cool} = Seasonal Energy Efficiency Ratio of cooling system (kBtu/kWh)

= Actual (where it is possible to measure or reasonably estimate). If unknown assume the following:⁹³⁸

Age of Equipment	η_{Cool} Estimate
Before 2006	10
After 2006	13

$\Delta kWh_{heating}$ = If electric heat (resistance or heat pump), reduction in annual electric heating due to insulation

$$= [((1/R_{old_AG} - 1/(R_{added}+R_{old_AG})) * L_{basement_wall_total} * H_{basement_wall_AG} * (1-Framing_factor)) + ((1/R_{old_BG} - 1/(R_{added}+R_{old_BG})) * L_{basement_wall_total} * (H_{basement_wall_total} - H_{basement_wall_AG}) * (1-Framing_factor))] * 24 * HDD / (3,412 * \eta_{Heat})$$

R_{old_BG} = R-value value of foundation wall below grade (including thermal resistance of

⁹³⁴ National Climatic Data Center, calculated from 1981-2010 climate normals with a base temp of 65°F. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

⁹³⁵ 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.

⁹³⁶ Weighted based on number of occupied residential housing units in each zone.

⁹³⁷ 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.

⁹³⁸ 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.

the earth)⁹³⁹

= dependent on depth of foundation (H_{basement_wall_total} - H_{basement_wall_AG}):

Below Grade R-value									
Depth below grade (ft)	0	1	2	3	4	5	6	7	8
Earth R-value (°F-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-ft ² -h/Btu)	2.44	3.47	4.41	5.41	6.42	7.46	8.46	9.53	10.69
Total BG R-value (earth + R-2.25 foundation)	4.69	5.72	6.66	7.66	8.67	9.71	10.71	11.78	12.94

H_{basement_wall_total} = Total height of basement wall (ft)

HDD = Heating Degree Days

= dependent on location and whether basement is conditioned⁹⁴⁰:

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 ⁹⁴¹	4,860	2,895

η_{Heat} = Efficiency of heating system

= Actual. If not available refer to default table below⁹⁴²:

⁹³⁹ Adapted from Table 1, page 24.4, of the 1977 ASHRAE Fundamentals Handbook

⁹⁴⁰ National Climatic Data Center, calculated from 1981-2010 climate normals with a base temp of 60°F for a conditioned basement and 50°F for an unconditioned basement), consistent with the findings of Belzer and Cort, Pacific Northwest National Laboratory in "Statistical Analysis of Historical State-Level Residential Energy Consumption Trends," 2004. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

⁹⁴¹ Weighted based on number of occupied residential housing units in each zone.

⁹⁴² 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.

System Type	Age of Equipment	HSPF Estimate	η_{Heat} (Effective COP Estimate) (HSPF/3.413)*0.85
Heat Pump	Before 2006	6.8	1.7
	After 2006	7.7	1.92
Resistance	N/A	N/A	1

For example, a home in Chicago with a 20 by 25 by 7 foot unconditioned basement, with 3 feet above grade, insulated with R-13 of interior spray foam, 10.5 SEER Central AC and 2.26 COP Heat Pump:

$$\begin{aligned} \Delta kWh &= \Delta kWh_{\text{cooling}} + \Delta kWh_{\text{heating}} \\ &= [(((1/2.25 - 1/(13 + 2.25)) * (20+25+20+25) * 3 * (1 - 0)) * 24 * 281 * 0.75)/(1000 * 10.5)] + \\ &\quad [(((1/2.25 - 1/(13 + 2.25)) * (20+25+20+25) * 3 * (1-0)) + ((1 / 8.67 - 1 / (13 + 8.67)) * \\ &\quad (20+25+20+25) * 4 * (1-0))) * 24 * 3079) / (3412 * 1.92)] \\ &= 49.3 + 1435 \\ &= 1480 \text{ kWh} \end{aligned}$$

SUMMER COINCIDENT PEAK DEMAND

$$\Delta kW = (\Delta kWh_{\text{cooling}} / \text{FLH}_{\text{cooling}}) * \text{CF}$$

Where:

FLH_{cooling} = Full load hours of air conditioning
 = dependent on location⁹⁴³:

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 ⁹⁴⁴	629	564

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)

$$= 91.5\%^{945}$$

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)

$$= 46.6\%^{946}$$

For example, a single family home in Chicago with a 20 by 25 by 7 foot unconditioned basement, with 3 feet above grade, insulated with R-13 of interior spray foam, 10.5 SEER Central AC and 2.26 COP Heat Pump:

$$\Delta kW_{SSP} = 49.3 / 570 * 0.915$$

$$= 0.0791 \text{ kW}$$

$$\Delta kW_{PJM} = 49.3 / 570 * 0.466$$

$$= 0.0403 \text{ kW}$$

NATURAL GAS SAVINGS

If Natural Gas heating:

⁹⁴³ Full load hours for Chicago, Moline and Rockford are provided in “Final Evaluation Report: Central Air Conditioning Efficiency Services (CACES), 2010, Navigant Consulting”, http://ilsag.org/yahoo_site_admin/assets/docs/ComEd_PY2_CACES_Evaluation_Report_2010-10-18.299122020.pdf, p.33. An average FLH/Cooling Degree Day (from NCDC) ratio was calculated for these locations and applied to the CDD of the other locations in order to estimate FLH. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

⁹⁴⁴ Weighted based on number of occupied residential housing units in each zone.

⁹⁴⁵ 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.

⁹⁴⁶ Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.

$$\Delta\text{Therms} = ((1/R_{\text{old_AG}} - 1/(R_{\text{added}}+R_{\text{old_AG}})) * L_{\text{basement_wall_total}} * H_{\text{basement_wall_AG}} * (1-\text{Framing_factor}) + (1/(R_{\text{old_BG}} - 1/(R_{\text{added}}+R_{\text{old_BG}})) * L_{\text{basement_wall_total}} * (H_{\text{basement_wall_total}} - H_{\text{basement_wall_AG}}) * (1-\text{Framing_factor})) * 24 * \text{HDD}) / (\eta_{\text{Heat}} * 100,067)$$

- η_{Heat} = Efficiency of heating system
- = Equipment efficiency * distribution efficiency
- = Actual. If unknown assume 70%⁹⁴⁷

Other factors as defined above

For example, a home in Chicago with a 20 by 25 by 7 foot unconditioned basement, with 3 feet above grade, insulated with R-13 of interior spray foam, and a 70% efficient furnace:

$$= ((1/2.25 - 1/(13 + 2.25)) * (20+25+20+25) * 3 * (1-0) + (1/8.67 - 1/(13 + 8.67)) * (20+25+20+25) * 4 * (1 - 0)) * 24 * 3079 / (0.7 * 100,067)$$

= 134 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-SHL-BINS-V01-120601

⁹⁴⁷ 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: $(0.24*0.92) + (0.76*0.8) * (1-0.15) = 0.70$

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 years⁹⁴⁸.

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

⁹⁴⁸ Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007

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

$$CF_{SSP} = \text{Summer System Peak Coincidence Factor for Central A/C (during utility peak hour)}$$

$$= 91.5\%^{949}$$

$$CF_{PJM} = \text{PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)}$$

$$= 46.6\%^{950}$$

Algorithm

CALCULATION OF SAVINGS

Electric ENERGY SAVINGS

$$\Delta kWh = \Delta kWh_{cooling} + \Delta kWh_{heating}$$

Where:

$$\Delta kWh_{cooling} = \text{If central cooling, reduction in annual cooling requirement due to insulation}$$

$$= \left(\left(\frac{1}{R_{old}} - \frac{1}{R_{added} + R_{old}} \right) * \text{Area} * (1 - \text{Framing_factor}) \right) * 24 * \text{CDD} * \text{DUA} / (1000 * \eta_{Cool})$$

$$R_{old} = \text{R-value value of floor before insulation, assuming 3/4" plywood subfloor and carpet with pad}$$

$$= 4.94^{951}$$

$$R_{added} = \text{R-value of additional spray foam, rigid foam, or cavity insulation.}$$

$$\text{Area} = \text{Total floor area to be insulated}$$

$$\text{Framing_factor} = \text{Adjustment to account for area of framing}$$

$$= 15\%^{952}$$

$$24 = \text{Converts hours to days}$$

⁹⁴⁹ 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.

⁹⁵⁰ 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.

⁹⁵¹ Based on 2005 ASHREA Handbook – Fundamentals: assuming 2x8 joists, 16" OC, ¾" subfloor, ½" carpet with rubber pad, and accounting for a still air film above and below: 0.85 cavity share of area * (0.68 + 0.94 + 1.23 + 0.68) + 0.15 framing share * (0.68 + 7.5" * 1.25 R/in + 0.94 + 1.23 + 0.68) = 4.94

⁹⁵² Based on Oak Ridge National Lab, Technology Fact Sheet for Wall Insulation.

CDD = Cooling Degree Days

Climate Zone (City based upon)	Unconditioned CDD ⁹⁵³
1 (Rockford)	263
2 (Chicago)	281
3 (Springfield)	436
4 (Belleville)	538
5 (Marion)	570
Weighted Average ⁹⁵⁴	325

DUA = Discretionary Use Adjustment (reflects the fact that people do not always operate their AC when conditions may call for it).

$$= 0.75^{955}$$

1000 = Converts Btu to kBtu

η Cool = Seasonal Energy Efficiency Ratio of cooling system (kBtu/kWh)

= Actual (where it is possible to measure or reasonably estimate). If unknown assume the following:⁹⁵⁶

Age of Equipment	η Cool Estimate
Before 2006	10
After 2006	13

Δ kWh_heating = If electric heat (resistance or heat pump), reduction in annual electric heating due to insulation

$$= ((1/R_{old} - 1/(R_{added} + R_{old})) * Area * (1-Framing_factor) * 24 * HDD) / (3,412 * \eta_{Heat})$$

HDD = Heating Degree Days⁹⁵⁷

Climate Zone (City based upon)	Unconditioned HDD
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⁹⁵³ 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.

⁹⁵⁴ Weighted based on number of occupied residential housing units in each zone.

⁹⁵⁵ Energy Center of Wisconsin, May 2008 metering study; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research", p31.

⁹⁵⁶ 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.

⁹⁵⁷ National Climatic Data Center, Heating Degree Days with a base temp of 50°F to account for lower impact of unconditioned space on heating system. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

1 (Rockford)	3,322
2 (Chicago)	3,079
3 (Springfield)	2,550
4 (Belleville)	1,789
5 (Marion)	1,796
Weighted Average ⁹⁵⁸	2,895

η_{Heat} = Efficiency of heating system

= Actual. If not available refer to default table below:⁹⁵⁹

System Type	Age of Equipment	HSPF Estimate	η_{Heat} (Effective COP Estimate) (HSPF/3.413)*0.85
Heat Pump	Before 2006	6.8	1.7
	After 2006	7.7	1.92
Resistance	N/A	N/A	1

Other factors as defined above

For example, a home in Chicago with a 20 by 25 footprint, insulated with R-30 spray foam above the crawlspace, a 10.5 SEER Central AC and a newer heat pump:

$$\begin{aligned} \Delta kWh &= \Delta kWh_{cooling} + \Delta kWh_{heating} \\ &= (((1/4.94 - 1/(30+4.94)) * (20*25) * (1-0.15) * 24 * 281 * 0.75) / (1000 * 10.5)) + ((1/4.94 - 1/(30+4.94)) * (20*25) * (1-0.15) * 24 * 3079) / (3412 * 1.92) \\ &= 35.6 + 833 \\ &= 869 \text{ kWh} \end{aligned}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = (\Delta kWh_{cooling} / FLH_{cooling}) * CF$$

Where:

FLH_{cooling} = Full load hours of air conditioning

⁹⁵⁸ Weighted based on number of occupied residential housing units in each zone.

⁹⁵⁹ 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.

= Dependent on location⁹⁶⁰:

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 ⁹⁶¹	629	564

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)

= 91.5%⁹⁶²

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)

= 46.6%⁹⁶³

For example, a single family home in Chicago with a 20 by 25 footprint, insulated with R-30 spray foam above the crawlspace, a 10.5 SEER Central AC and a newer heat pump:

$$\Delta kW_{SSP} = 35.6 / 570 * 0.915$$

$$= 0.057 \text{ kW}$$

$$\Delta kW_{SSP} = 35.6 / 570 * 0.466$$

$$= 0.029 \text{ kW}$$

⁹⁶⁰ Full load hours for Chicago, Moline and Rockford are provided in “Final Evaluation Report: Central Air Conditioning Efficiency Services (CACES), 2010, Navigant Consulting”, http://ilsag.org/yahoo_site_admin/assets/docs/ComEd_PY2_CACES_Evaluation_Report_2010-10-18.299122020.pdf, p.33. An average FLH/Cooling Degree Day (from NCDC) ratio was calculated for these locations and applied to the CDD of the other locations in order to estimate FLH. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

⁹⁶¹ Weighted based on number of occupied residential housing units in each zone.

⁹⁶² 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.

⁹⁶³ Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.

NATURAL GAS SAVINGS

If Natural Gas heating:

$$\Delta\text{Therms} = (1/R_{\text{old}} - 1/(R_{\text{added}}+R_{\text{old}})) * \text{Area} * (1-\text{Framing_factor}) * 24 * \text{HDD} / (100,000 * \eta_{\text{Heat}}) *$$

- η_{Heat} = Efficiency of heating system
- = Equipment efficiency * distribution efficiency
- = Actual. If unknown assume 70%⁹⁶⁴

Other factors as defined above

For example, a single family home in Chicago with a 20 by 25 footprint, insulated with R-30 spray foam above the crawlspace, and a 70% efficient furnace:

$$\Delta\text{Therms} = (1 / 4.94 - 1 / (30 + 4.94)) * (20 * 25) * (1 - 0.15) * 24 * 3079 / (100,000 * 0.70)$$

$$= 78.0 \text{ therms}$$

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-SHL-FINS-V01-120601

⁹⁶⁴ 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:
 $(0.24*0.92) + (0.76*0.8) * (1-0.15) = 0.70$

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 years⁹⁶⁵.

DEEMED MEASURE COST

The actual installed cost for this measure should be used in screening.

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape R08 - Residential Cooling

Loadshape R09 - Residential Electric Space Heat

Loadshape R10 - Residential Electric Heating and Cooling

COINCIDENCE FACTOR

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

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during utility peak hour)

⁹⁶⁵ Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007

$$= 91.5\%^{966}$$

$$CF_{PJM} = \text{PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)}$$
$$= 46.6\%^{967}$$

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = \Delta kWh_{\text{cooling}} + \Delta kWh_{\text{heating}}$$

Where:

$\Delta kWh_{\text{cooling}}$ = If central cooling, reduction in annual cooling requirement due to insulation

$$= \left[\left(\frac{1}{R_{\text{old}}} - \frac{1}{R_{\text{wall}}} \right) * A_{\text{wall}} * (1 - \text{Framing_factor}) + \left(\frac{1}{R_{\text{old}}} - \frac{1}{R_{\text{attic}}} \right) * A_{\text{attic}} * \left(\frac{1 - \text{Framing_factor}}{2} \right) \right] * 24 * \text{CDD} * \text{DUA} / (1000 * \eta_{\text{Cool}})$$

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 assemblies⁹⁶⁸)

A_{wall} = Total area of insulated wall (ft²)

A_{attic} = Total area of insulated ceiling/attic (ft²)

Framing_factor = Adjustment to account for area of framing
= 15%⁹⁶⁹

24 = Converts hours to days

CDD = Cooling Degree Days

⁹⁶⁶ 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.

⁹⁶⁷ 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.

⁹⁶⁸ 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).

⁹⁶⁹ Based on Oak Ridge National Lab, Technology Fact Sheet for Wall Insulation. Factor is used directly for walls, but reduced by 1/2 for attics, assuming that the average joist is 5.5" and R-38 requires 11" of cellulose, therefore at each joist, 1/2 the thickness of insulation has been added as between the joists.

= dependent on location⁹⁷⁰:

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 ⁹⁷¹	947

DUA = Discretionary Use Adjustment (reflects the fact that people do not always operate their AC when conditions may call for it).

= 0.75⁹⁷²

1000 = Converts Btu to kBtu

η_{Cool} = Seasonal Energy Efficiency Ratio of cooling system (kBtu/kWh)

= Actual (where it is possible to measure or reasonably estimate). If unknown assume the following⁹⁷³:

Age of Equipment	η_{Cool} Estimate
Before 2006	10
After 2006	13

kWh_heating = If electric heat (resistance or heat pump), reduction in annual electric heating due to insulation

= $[(1/R_{old} - 1/R_{wall}) * A_{wall} * (1 - Framing_factor) + (1/R_{old} - 1/R_{attic}) * A_{attic} * (1 - Framing_factor/2)] * 24 * HDD / (\eta_{Heat} * 3412)$

HDD = Heating Degree Days

= Dependent on location⁹⁷⁴:

⁹⁷⁰ National Climatic Data Center, Cooling Degree Days are based on a base temp of 65°F. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

⁹⁷¹ Weighted based on number of occupied residential housing units in each zone.

⁹⁷² 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.

⁹⁷³ 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.

⁹⁷⁴ 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

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 ⁹⁷⁵	4,860

η_{Heat} = Efficiency of heating system

= Actual. If not available refer to default table below⁹⁷⁶:

System Type	Age of Equipment	HSPF Estimate	η_{Heat} (Effective COP Estimate) (HSPF/3.413)*0.85
Heat Pump	Before 2006	6.8	1.7
	After 2006	7.7	1.92
Resistance	N/A	N/A	1

3412 = Converts Btu to kWh

For example, a single family home in Chicago with 990 ft² of R-5 walls insulated to R-11 and 700 ft² of R-5 attic insulated to R-38, 10.5 SEER Central AC and 2.26 (1.92 including distribution losses) COP Heat Pump:

$$\begin{aligned} \Delta\text{kWh} &= \Delta\text{kWh}_{\text{cooling}} + \Delta\text{kWh}_{\text{heating}} \\ &= \left[\left(\left(\frac{1}{5} - \frac{1}{11} \right) * 990 * (1-0.15) \right) + \left(\left(\frac{1}{5} - \frac{1}{38} \right) * 700 * (1-0.15/2) \right) * 842 * 0.75 * 24 \right] / (1000 * 10.5) + \left[\left(\left(\frac{1}{5} - \frac{1}{11} \right) * 990 * (1-0.15) \right) + \left(\frac{1}{5} - \frac{1}{38} \right) * 700 * (1-0.15/2) \right] * 5113 * 24 / (1.92 * 3412) \\ &= 295 + 3826 \\ &= 4120 \text{ kWh} \end{aligned}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta\text{kW} = (\Delta\text{kWh}_{\text{cooling}} / \text{FLH}_{\text{cooling}}) * \text{CF}$$

State-Level Residential Energy Consumption Trends,” 2004. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

⁹⁷⁵ Weighted based on number of occupied residential housing units in each zone.

⁹⁷⁶ 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.

Where:

FLH_{cooling} = Full load hours of air conditioning
 = Dependent on location as below⁹⁷⁷:

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 ⁹⁷⁸	629	564

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)
 = 91.5%⁹⁷⁹

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)
 = 46.6%⁹⁸⁰

For example, a single family home in Chicago with 990 ft² of R-5 walls insulated to R-11 and 700 ft² of R-5 attic insulated to R-38, 10.5SEER Central AC and 2.26 COP Heat Pump:

$$\begin{aligned} \Delta kW_{SSP} &= 295 / 570 * 0.915 \\ &= 0.474 \text{ kW} \end{aligned}$$

$$\begin{aligned} \Delta kW_{PJM} &= 295 / 570 * 0.466 \\ &= 0.241 \text{ kW} \end{aligned}$$

NATURAL GAS SAVINGS

If Natural Gas heating:

⁹⁷⁷ Based on Full Load Hours from ENERGY Star with adjustments made in a Navigant Evaluation, other cities were scaled using those results and CDD. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

⁹⁷⁸ Weighted based on number of occupied residential housing units in each zone.

⁹⁷⁹ 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.

⁹⁸⁰ Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.

$$\Delta\text{Therms} = (((1/R_{\text{old}} - 1/R_{\text{wall}}) * A_{\text{wall}} * (1 - \text{Framing_factor}) + (1/R_{\text{old}} - 1/R_{\text{attic}}) * A_{\text{attic}} * (1 - \text{Framing_factor}/2)) * 24 * \text{HDD}) / (\eta_{\text{Heat}} * 100,067 \text{ Btu/therm})$$

Where:

HDD = Heating Degree Days

= Dependent on location⁹⁸¹:

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 ⁹⁸²	4,860

η_{Heat} = Efficiency of heating system

= Equipment efficiency * distribution efficiency

= Actual⁹⁸³. If unknown assume 70%⁹⁸⁴.

Other factors as defined above

⁹⁸¹ National Climatic Data Center, calculated from 1981-2010 climate normals with a base temp of 60°F, consistent with the findings of Belzer and Cort, Pacific Northwest National Laboratory in “Statistical Analysis of Historical State-Level Residential Energy Consumption Trends,” 2004. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

⁹⁸² Weighted based on number of occupied residential housing units in each zone.

⁹⁸³ 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.

⁹⁸⁴ This has been estimated assuming that natural gas central furnace heating is typical for Illinois residences (66% of Illinois homes have a Natural Gas Furnace (based on Energy Information Administration, 2009 Residential Energy Consumption Survey:

<http://www.eia.gov/consumption/residential/data/2009/xls/H6.9%20Space%20Heating%20in%20Midwest%20Region.xls>). In 2000, 24% of furnaces purchased in Illinois were condensing (based on data from GAMA, provided to Department of Energy during the federal standard setting process for residential heating equipment - see Furnace Penetration.xls). Furnaces tend to last up to 20 years and so units purchased 10 years ago provide a reasonable proxy for the current mix of furnaces in the State. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows:

$(0.24 * 0.92) + (0.76 * 0.8) * (1 - 0.15) = 0.70$

For example, a single family home in Chicago with 990 ft² of R-5 walls insulated to R-11 and 700 ft² of R-5 attic insulated to R-38, with a gas furnace with system efficiency of 66%:

$$\begin{aligned}\Delta\text{Therms} &= \Delta\text{kWh_cooling} + \Delta\text{kWh_heating} \\ &= (((1/5 - 1/11) * 990 * (1-0.15) + (1/5 - 1/38) * 700 * (1-0.15/2)) * 24 * 5113) / \\ &\quad (0.66 * 100,067) \\ &= 380 \text{ therms}\end{aligned}$$

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-SHL-AINS-V01-120601