MEMORANDUM

TO: **TECHNICAL ADVISORY COMMITTEE**

FROM: KALEE WHITEHOUSE, PROJECT MANAGER, and SAM DENT, TECHNICAL LEAD - VEIC

SUBJECT: V10.0 ERRATA MEASURES EFFECTIVE 01/01/2022

DATE: 9/28/2022

Cc: CELIA JOHNSON, SAG

This memo documents Final errata changes to Version 10.0 of the Illinois Technical Reference Manual (TRM) that the Technical Advisory Committee (TAC) recommends be made effective 01/01/2022.

VEIC has provided a summary table below showing the errata measures and a brief summary of what was changed, followed by the v10.0 measures themselves.

TRM Policy Document, Section 3.2.1, states that,

> "TAC participants should notify the TAC when a TRM mistake or omission is found. If a significant mistake or omission is found in the TRM that results in an unreasonable savings estimate, the Program Administrators, Evaluators, TRM Administrator, and TAC will strive to reach consensus on a solution that will result in a reasonable savings estimate. For example, an unreasonable savings estimate may result from an error or omission in the TRM.
>
> "In these limited cases where consensus is reached, the TRM Administrator shall inform the Evaluators to use corrected TRM algorithms and inputs to calculate energy and capacity savings, in addition to using the Commission-approved TRM algorithms and inputs to calculate savings. If the corrected TRM algorithms and inputs are stipulated for acceptance by all the parties in the Program Administrator's savings docket, then the corrected TRM savings verification values may be used for the purpose of measuring savings toward compliance with the Program Administrator's energy savings goals. Errors and omissions found in the TRM will be officially corrected through the annual TRM Update proceeding and will be identified as 'Errata'."

It is our belief and understanding that the following measures have been determined to be consensus errata by the Program Administrators, Evaluators, and the entire TAC. The term 'errata' is used to describe these measures, and in accordance with the TRM Policy Document, the Evaluators may use this version of the measures during evaluation of the current program year (in addition to the measures currently in Version 10.0 of the TRM).

Summary of Errata Measures

Section	Measure Name	Measure Code	Brief Summary of Change	TAC Reviewed and Approved As of
Volume 1: Section 3.13	Electrification and Fossil Fuel Baselines (Public Act 102-0662)	N/A	New section provided in Volume 1 that provides details of the electrification provisions provided in CEJA, and the appropriate baseline assumptions for fossil fuels not already characterized within the TRM.	9/26/2022
Volume 1: Section 3.13.2	Fuel Units and Conversion Factors	N/A	Provides policy manual defined energy content of fuels and conversion factors from therms.	8/16/2022
3.14	Secondary kWh Savings from Fossil Fuel Saving Measures	N/A	States that secondary savings for fossil fuel savings measures can be claimed regardless of fossil fuel in question even if natural gas specifically mentioned in measure.	8/16/2022
4.1.11	Commercial LED Grow Lights	CI-AGE-GROW-V04-220101	Clarification that WHFe would be 1 if no cooling.	9/26/2022
4.4.9	Air and Water Source Heat Pump Systems	CI-HVC-HPSY-V09-220101	$Capacity_{heat}$ is incorrectly labelled as input capacity, but should be output capacity. Note all other HP measures are correct.	6/24/2022
4.4.44	Commercial Ground Source and Ground Water Source Heat Pump	CI-HVC-GSHP-V06-220101	Within the fuel switch section, the $GSHPSiteWaterImpact_{Electric}$ algorithm used to calculate MMBtu impact when there is an electric water heater, has a 3412 BTU/kWh term included that incorrectly results in the calculation of kWh as opposed to MMBtu. This term is therefore removed.	6/24/2022
4.4.48	Small Commercial Thermostats	CI-HVC-THST-V04-220101	In the ΔkWh algorithm, the term (1 - %ElectricHeat) is incorrectly applied twice since it is already applied in the ΔTherms algorithm.	10/27/2021
4.5.4	LED Bulbs and Fixtures	CI-LTG-LEDB-V14-220101	Clarification that the Center Beam Candle Power methodology for determining $Watts_{Base}$ is the preferred approach, and that the new default assumptions added in v10 are for use only when the necessary information is not available. Edits to deferred install section such that v10 assumptions will be used for all deferred installs claimed in 2023 and 2024.	12/16/2021 7/11/2022
5.3.8	Ground Source Heat Pump	RS-HVC-GSHP-V12-220101	Within the fuel switch section, the $GSHPSiteWaterImpact_{Electric}$ algorithm used to calculate MMBtu impact when	6/24/2022

			there is an electric water heater, has a 3412 BTU/kWh term included that incorrectly results in the calculation of kWh as opposed to MMBtu. This term is therefore removed.	
5.5.6	LED Specialty Lamps	RS-LTG-LEDD-V14-220101	Edits to deferred install section such that v10 assumptions will be used for all deferred installs claimed in 2023 and 2024.	7/11/2022
5.5.8	LED Screw Based Omnidirectional Bulbs	RS-LTG-LEDA-V13-220101	Edits to deferred install section such that v10 assumptions will be used for all deferred installs claimed in 2023 and 2024.	7/11/2022
5.7.3	Level 2 Electric Vehicle Charger	RS-MSC-L2CH-V02-220101	Fixing error in Summer Coincident Peak Demand Savings algorithm to reflect savings from charger as opposed to adding load of electric car.	8/16/2022

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3.132 Electrification and Fossil Fuel Baselines (Public Act 102-0662)

On September 15, 2021, the Climate and Equitable Jobs Act (CEJA) was signed into law, effective immediately. Section 220 ILCS 5/8-103B(b-27) of CEJA states that beginning in 2022 an electric utility may:

> *"...offer and promote measures that electrify space heating, water heating, cooling, drying, cooking, industrial processes, and other building and industrial end uses that would otherwise be served by combustion of fossil fuel at the premises, provided that the electrification measures reduce total energy consumption at the premises. The electric utility may count the reduction in energy consumption at the premises toward achievement of its annual savings goals. The reduction in energy consumption at the premises shall be calculated as the difference between: (A) the reduction in Btu consumption of fossil fuels as a result of electrification, converted to kilowatt-hour equivalents by dividing by 3,412 Btu's per kilowatt hour; and (B) the increase in kilowatt hours of electricity consumption resulting from the displacement of fossil fuel consumption as a result of electrification measures under this subsection".*

3.13.1 Fossil Fuel Baseline Efficiencies for Electric Efficiency Measures

The energy savings for an electric efficiency measure with a fossil fuel baseline is the difference in energy consumption between the fossil fuel baseline and the efficient electric measure.

Use the following approach to define the baseline for efficient electric measures that would otherwise be served by combustion of fossil fuel at the premise:

1. If available, apply the baseline efficiency assumptions included in the TRM.

2. If not available, apply the following assumptions:
    a. For Time of Sale and New Construction applications, apply the minimum efficiency available in Illinois on the new equipment market for the fossil fuel.
    b. For Early Replacement:
        i. If the existing system is known:
            1. For the remaining life of the existing equipment, use the rated efficiency of the existing system.
            2. For the remaining measure life after the existing equipment would have been replaced, use the minimum efficiency available in Illinois on the new equipment market for the fossil fuel.
        ii. If the existing system is unknown:
            1. Use the best available information for existing equipment efficiency. If no information is available, use the minimum efficiency available in Illinois on the new equipment market for the fossil fuel.

Where a measure includes both fuel switch savings and non-fuel switch savings, the characterization will clearly separate the two types to allow appropriate tracking. In addition, a separate section entitled 'Cost Effectiveness Screening' is provided in all fuel switch measures to outline the actual meter level impacts of a fuel switch measure for use in cost effectiveness screening calculations. An example fuel switch calculation is provided below (from 5.1.10 ENERGY STAR Clothes Dryer):

An example of the fuel switch calculation is provided below (from 5.1.10 ENERGY STAR Clothes Dryer):

An ENERGYSTAR Most Efficient Heat Pump clothes dryer with $CEFeff_{Elec}$ of 5.7 purchased in place of a baseline gas dryer:

SiteEnergySavings (MMBTUs) = [FuelSwitchSavings] + [NonFuelSwitchSavings]

FuelSwitchSavings = [(Load/$CEFbase_{Gas}$ * Ncycles * MMBtu_convert * $\%Gas_{Gas}$] - [Load/$CEFeff_{Elec}$ * Ncycles * $\%Gas_{Gas}$ * 3412/1,000,000]

= (8.45/2.84 * 283 * 0.003412 * 0.84) - (8.45/5.7 * 283 * 0.84 * 3412/1000000)

= 1.21 MMBtu

NonFuelSwitchSavings = [(Load/$CEFbase_{Gas}$ * Ncycles * MMBtu_convert * $\%Electric_{Gas}$] - [Load/$CEFeff_{Elec}$ * Ncycles * $\%Electric_{Gas}$ * 3412/1,000,000]

= (8.45/2.84 * 283 * 0.003412 * 0.16) - (8.45/5.7 * 283 * 0.16 * 3412/1000000)

= 0.23 MMBtu

SiteEnergySavings (MMBTUs) = 1.21 + 0.23

= 1.44 MMBtu

If supported by an electric utility: ΔkWh = ΔSiteEnergySavings * 1,000,000 / 3,412

= 1.44 * 1,000,000/3412

= 422.5 kWh

SiteEnergySavings (MMBTUs) = [GasConsumptionReplaced] + [ElectricConsumptionReplaced] – [ElectricConsumptionAdded]

= [(Load/$CEFbase_{Gas}$ * Ncycles * MMBtu_convert * $\%Gas_{Gas}$] + [Load/$CEFeff_{Gas}$ * Ncycles * $\%Electric_{Gas}$ * 3412/1,000,000] – [Load/$CEFeff_{Elec}$ * Ncycles * $\%Electric_{Electric}$ * 3412/1,000,000]

= [8.45/2.84 * 283 * 0.003412 * 0.84] + [8.45/2.84 * 283 * 0.16 * 3412/1,000,000] – [8.45/5.7 * 283 * 1 * 3412/1,000,000]

= 2.41 + 0.46 - 1.43

= 1.44 MMBtu

If supported by an electric utility: ΔkWh = ΔSiteEnergySavings * 1,000,000 / 3,412

= 1.44 * 1,000,000/3412

= 422.5 kWh

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3.13.2 Fuel Units and Conversion Factors

Savings presented in the "Fossil Fuel Savings" section of the TRM will always be provided in Therms. Conversion to other fuel units should be based on site energy use, utilizing the conversion factors displayed below:

Fuel	Energy Units	BTUs per Energy Unit	Conversion Multiplier from Therms to Energy Unit
Natural Gas	Therms	100,000	1.0
Propane Gas	Gallons	91,333	1.095
Fuel Oil	Gallons	138,500	0.722
Diesel	Gallons	138,500	0.722
Electric	kWh	3,412	29.3

3.14 Secondary kWh Savings from Fossil Fuel Saving Measures

Up until v10, only natural gas savings were detailed within the measure characterizations. A number of measures provide secondary electric savings due to the reduction in heating consumption (for example furnace fan savings resulting from shell improvements in a fossil fuel heated home, typically labelled as kWh_heating Gas). These secondary savings can be claimed regardless of the fossil fuel in question (e.g. shell improvements to a home with oil heat) even if natural gas is specifically mentioned within the characterization.

4.1.11 Commercial LED Grow Lights

DESCRIPTION

LED lamp technology offers reduced energy and maintenance costs when compared with conventional light sources. LED technology has a significantly longer useful life lasting 30,000 hours or more and significantly reduces maintenance costs. The savings and costs for this measure are evaluated with the replacement of HID grow lights with LED fixtures. LED lamps offer a more robust lighting source, longer lifetime, and greater electrical efficiency than conventional supplemental grow lights.

This measure is designed for other interior horticultural applications that use artificial light stimulation in an indoor conditioned space.

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

LED fixtures must have a reduced wattage, be listed on the Design Lights Consortium (DLC) qualified products list,[1] be UL Listed, have a power factor (PF) ≥0.90, a photosynthetic photon efficacy (PPE) of no less than 1.9 micromoles per joule, a minimum rated lifetime of 50,000 hours, and a minimum warranty of 5 years. If DLC PPE requirements for LED grow lighting exceeds the current requirements, the new PPE will become the efficient equipment standard.

DEFINITION OF BASELINE EQUIPMENT

The baseline equipment is the industry established grow light based on the horticultural application, as detailed in the table below. HID fixtures are assumed for flowering and vegetative crops. T5 high-output fixtures are assumed for seedling and microgreen crops.

Crop Type	Baseline Technology Type	Baseline PPE (µmol/J)[2]	Baseline Watts per Square Foot[3]	Baseline Fixture Wattage[4]
Flowering Crops (Tomatoes and Peppers)	High Pressure Sodium	1.7	68.8	1,100 W
Vegetative Growth	Metal Halide	1.25[5]	40	640 W
Microgreens[6]	T5 HO Fixture	0.84[7]	22.4	358 W
Propagation[8]	T5 HO Fixture	0.84[9]	14.6	234 W
Medical Cannabis –	High Pressure	1.7	68.8	1,100 W

1 Design Light Consortium – Horticultural Lighting, Testing and Reporting Requirements for LED-Based Horticultural Lighting, version 2.1, effective July 1, 2021. To date, all horticultural lamps certified by the DLC specification are LEDs.

2 Erik Runkle and Bruce Bugbee "Plant Lighting Efficiency and Efficacy: µmols per joule". Accessed 4/21/2020.

3 Jesse Remillard and Nick Collins, "Trends and Observations of Energy Use in the Cannabis Industry," ACEEE, accessed April 17, 2020. Baseline watts per square foot were taken by using typical fixture technology by crop type and dividing by 16 sqft per fixture (a 4'x4' area is a typical coverage amount for one grow light fixture).

4 Jesse Remillard and Nick Collins, "Trends and Observations of Energy Use in the Cannabis Industry," ACEEE, accessed April 17, 2020. Baseline watts per square foot were taken by using typical fixture technology by crop type and dividing by 16 sqft per fixture (a 4'x4' area is a typical coverage amount for one grow light fixture).

5 Jacob A. Nelson, Bruce Bugbee, "Economic Analysis of Greenhouse Lighting: Light Emitting Diodes vs. High Intensity Discharge Fixtures." Utah State University. Accessed 5/6/2020.

6 Microgreens T5 fixture is based on a 6-lamp high output fixture, based on program experience.

7 Jacob A. Nelson, Bruce Bugbee, "Economic Analysis of Greenhouse Lighting: Light Emitting Diodes vs. High Intensity Discharge Fixtures." Utah State University. Accessed 5/6/2020.

8 Propagation T5 fixture is based on a 4-lamp high output fixture, based on program experience.

9 Jacob A. Nelson, Bruce Bugbee, "Economic Analysis of Greenhouse Lighting: Light Emitting Diodes vs. High Intensity Discharge Fixtures." Utah State University. Accessed 5/6/2020.

Crop Type	Baseline Technology Type	Baseline PPE (µmol/J)[2]	Baseline Watts per Square Foot[3]	Baseline Fixture Wattage[4]
Flowering Stage	Sodium			
Recreational Cannabis – Flowering Stage	HID/LED/Other	2.2[10]	36	576 W[11]

Cannabis cultivation facilities have a separate equipment definition due to Illinois legislation.[12] See cannabis cultivation code from "Cannabis Regulation and Tax Act, Illinois HB 1438:

"The Lighting Power Densities (LPD) for cultivation space commits to not exceed an average of 36 watts per gross square foot of active and growing space canopy, or all installed lighting technology shall meet a photosynthetic photon efficacy (PPE) of no less than 2.2 micromoles per joule fixture and shall be featured on the Design Lights Consortium (DLC) Horticultural Specification Qualified Products List (QPL)."

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is 9.5 years (average rated life of 50,000 hours).[13]

DEEMED MEASURE COST

LED Fixture Costs:[14]

≤ 250 Watts = $ 325.87 per fixture

> 250 Watts = $ 535.04 per fixture

LOADSHAPE

Loadshape C65 – Non-Residential Indoor Agriculture Vegetative Room

Loadshape C66 – Non-Residential Indoor Agriculture Flowering Room

COINCIDENCE FACTOR

Summer coincidence factor for vegetative rooms = 0.95

Summer coincidence factor for flowering rooms = 0.76

[10] Recreational cannabis baseline PPE requirement is either 36 W/sqft or 2.2 µmol/J and DLC listed. Per HB 1438.

[11] Recreational cannabis baseline wattage was back calculated using 36 W/sqft and 16 sqft coverage area to get 576 W per fixture.

[12] Illinois legislation Public Act 101-0027 the Cannabis Regulation and Tax Act, Article 20: Adult Use Cultivation Centers, (Section 20-15 (a) (23) a commitment to a technology standard for resource efficiency of the cultivation center facility (B) Lighting)

[13] Based on 50,000 hours lifetime and 5,250 hours per year of use (average hours of use per year using flowering and vegetative rooms).

[14] Focus on Energy Evaluation Business Programs: Measure Life Study Final Report: August 25, 2009

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS

Grow Space Square Footage Method:

$$\Delta kWh = ((W/sqft_{BASE} - W/sqft_{EE})/1000) \times Area \times Hours \times WHF_e$$

Per Fixture Method:

$$\Delta kWh = ((Watts_{BASE} - Watts_{EE})/1000) \times Hours \times WHF_e$$

Where:

$W/sqft_{BASE}$ = Baseline wattage per square foot. If unknown, typical baseline watts per square feet by crop type can be found in the baseline equipment definition.

$$W/sqft_{BASE} = Watts_{BASE}/Fixture\ Area$$

$Watts_{BASE}$ = Baseline fixture wattage, see typical baseline wattages by crop type in baseline equipment definition.

$W/sqft_{EE}$ = Efficient wattage per square foot

= Actual

$$W/sqft_{EE} = Watts_{EE}/Area$$

$Watts_{EE}$ = Efficient fixture wattage.

Fixture Area = Square footage of grow canopy covered by one fixture.

= 16 sqft.[15]

Area = Illuminated area in square feet of active and growing space canopy

= Actual.

Hours = Annual operating hours. See table below for typical hours of operation breakdown by crop type.

[15] Assumes a 4' x 4' canopy

Crop Types	Hours of Operation per Day[16]	Annual Hours of Operation[17]
Flowering Crops (Tomatoes/Peppers)	12	4,200
Vegetative/Propagation Growth	18	6,300
Microgreens	18	6,300
Medical Cannabis – Flower Stage	12	4,200
Recreational Cannabis – Flowering Stage	12	4,200

WHFe = 1.21[18] if cooling or unknown or 1.00 if none; waste heat factor for energy to account for cooling savings from efficient lighting in cooled buildings.

1000 = Watts to kW conversion factor

Heating Penalty

If electrically heated building:

Grow Space Square Footage Method

$$\Delta kWh_{heat\ penalty}{}^{19} = ((W/sqft_{BASE} - W/sqft_{EE})/1000) \times Area \times Hours\ \times -IFkWh$$

Per Fixture Method:

$$\Delta kWh_{heat\ penalty} = ((Watts_{BASE} - Watts_{EE})/1000) \times Hours\ \times -IFkWh$$

Where:

IFkWh = 0 if gas heating, 0.284 if electric resistance heating, 0.124 if electric heat pump heating; lighting-HVAC Interactive Factor for electric heating impacts; this factor represents the increased electric space heating requirements due to the reduction of waste heat rejected by the efficent lighting.

SUMMER COINCIDENT PEAK DEMAND SAVINGS

Grow Space Square Footage Method:

$$\Delta kW = ((W/sqft_{BASE} - W/sqft_{EE})/1000) \times Area \times CF\ \times WHF_d$$

Per Fixture Method:

$$\Delta kW = ((Watts_{BASE} - Watts_{EE})/1000) \times CF\ \times WHF_d$$

[16] Sole-Source Lighting of Plants. Technically Speaking by Erik Runkle. Michigan State University Extension. September 2017. Accessed: 7/29/2019.

[17] Annual hours of operation were found by multiplying hours per day by 350 operating days per year. Assuming 5 crop cycles with 3 days of downtime between each cycle

[18] Waste heat factor for cooling savings calculation can be found in the Indoor Agriculture Loadshapes excel file.

[19] Negative value because this is an increase in heating consumption due to the efficient lighting

Where:

WHF_d = 1.22 if cooling or 1.00 if none; waste heat factor for demand to account for cooling savings from efficient lighting in cooled buildings.

CF = 0.95 for vegetative crops or 0.76 for flowering crops

NATURAL GAS SAVINGS

Heating Penalty if fossil fuel heated building (or if heating fuel is unknown):

Grow Space Square Footage Method:

$$\Delta Therms = ((W/sqft_{BASE} - W/sqft_{EE})/1000) \times Area \times Hours \times -IFTherms$$

Per Fixture Method:

$$\Delta Therms = ((Watt_{BASE} - Watt_{EE})/1000) \times Hours \times -IFTherms$$

Where:

IFTherms = 0.043 if gas heating, 0 if other heating; lighting-HVAC Interactive 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.

WATER AND OTHER NON-ENERGY IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

Any costs associated with moving the LED lighting fixture to different heights throughout the different growing phases should also be included as an O&M consideration.

MEASURE CODE: CI-AGE-GROW-V04~~3~~-220101

REVIEW DEADLINE: 1/1/2024

4.4.9 Air and Water Source Heat Pump Systems

DESCRIPTION

This measure applies to the installation of high-efficiency air cooled and water 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, 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 high-efficiency air cooled or water source, heat pump system that exceeds the baseline and meets program requirements.

DEFINITION OF BASELINE EQUIPMENT

New construction / Time of Sale: To calculate savings with an electric baseline, the baseline equipment is assumed to be a standard-efficiency air cooled or water source heat pump system that meets the Code energy efficiency requirements (IECC or Code of Federal Regulations whichever is higher) in effect on the date of equipment purchase (if date unknown assume current Code minimum). The rating conditions for the baseline and efficient equipment efficiencies must be equivalent.

To calculate savings with a furnace/ AC baseline, the baseline equipment is assumed to meet the Code energy efficiency requirements (IECC or Code of Federal Regulations whichever is higher).

Where unknown, the baseline should be determined via EM&V and the algorithms are provided to allow savings to be calculated from any baseline condition.

Note: IECC 2018 is baseline for all New Construction permits from July 1, 2019 and if permit date unknown.

Note: new Federal Standards affecting heat pumps become effective January 1, 2023.

Early replacement / Retrofit: The baseline for this measure is the efficiency of the *existing* heating and cooling equipment for the assumed remaining useful life of the existing unit and a new baseline heating and cooling system meeting the code energy efficiency requirements (IECC or Code of Federal Regulations whichever is higher) for the remainder of the measure life.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 16 years.[20]

Remaining life of existing equipment is assumed to be 6 years for ASHP and Central AC, 6 years for furnace, 8 years for boilers[21] and 16 years for electric resistance.[22]

DEEMED MEASURE COST

New Construction and Time of Sale: For analysis purposes, the incremental capital cost for this measure is assumed

[20] Consistent with Residential measure and based on 2016 DOE Rulemaking Technical Support document, as recommended in Guidehouse 'ComEd Effective Useful Life Research Report', May 2018.

[21] Assumed to be one third of effective useful life of replaced equipment.

[22] Assume full measure life (16 years) for replacing electric resistance as we would not expect that resistance heat would fail during the lifetime of the efficient measure.

as $100 per ton for air-cooled units.[23] The incremental cost for all other equipment types should be determined on a site-specific basis.

Early Replacement: The actual full installation cost of the Heat Pump (including any necessary electrical or distribution upgrades required) should be used. The assumed deferred cost of replacing existing equipment with a new baseline unit should also be incorporated.

LOADSHAPE

Loadshape C05 - Commercial Electric Heating and Cooling

COINCIDENCE FACTOR

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

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

= 91.3% [24]

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

= 47.8% [25]

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

Non fuel switch measures:

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

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

$$\text{Annual kWh Savings}_{cool} = (\text{Capacity}_{cool} * EFLH_{cool} * (1/SEER_{base} - 1/(SEER_{ee} * SEER_{adj}))/1000$$

$$\text{Annual kWh Savings}_{heat} = (\text{HeatLoad} * (1/HSPF_{base} - 1/(HSPF_{ee} * HSPF_{adj}))/1000$$

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

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

$$\text{Annual kWh Savings}_{cool} = (\text{Capacity}_{cool} * EFLH_{cool} * (1/EER_{base} - 1/EER_{ee}))/1000$$

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

[24] 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.

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

$$\text{Annual kWh Savings}_{heat} = (\text{HeatLoad}/3412 * (1/\text{COP}_{base} - 1/\text{COP}_{ee})$$

Fuel switch measures:

Fuel switch measures must produce positive total lifecycle fuel savings (i.e., reduction in Btus at the premises) in order to qualify. This is determined as follows (note for early replacement measures the lifetime savings should be calculated by calculating savings for the remaining useful life of the existing equipment and for the remaining measure life):

$$\text{SiteEnergySavings (MMBTUs)} = \text{GasHeatReplaced} + \text{FurnaceFanSavings} - \text{HPSiteHeatConsumed} + \text{HPSiteCoolingImpact}$$

$$\text{GasHeatReplaced} = (\text{HeatLoad} * 1/\text{AFUE}_{base}) / 1{,}000{,}000$$

$$\text{FurnaceFanSavings} = (\text{FurnaceFlag} * \text{HeatLoad} * 1/\text{AFUE}_{base} * F_e) / 1{,}000{,}000$$

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

$$\text{HPSiteHeatConsumed} = ((\text{HeatLoad} * (1/(\text{HSPF}_{ee} * \text{HSPF}_{adj}))) /1000 * 3412)/ 1{,}000{,}000$$

$$\text{HPSiteCoolingImpact} = (\text{FLHcool} * \text{Capacity}_{cool} * (1/\text{SEER}_{base} - 1/(\text{SEER}_{ee} * \text{SEER}_{adj})))/1000 * 3412/ 1{,}000{,}000$$

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

$$\text{HPSiteHeatConsumed} = (\text{HeatLoad} * (1/\text{COP}_{ee})) / 1{,}000{,}000$$

$$\text{HPSiteCoolingImpact} = (\text{FLHcool} * \text{Capacity}_{cool} * (1/\text{EER}_{base} - 1/\text{EER}_{ee}))/1000 * 3412/ 1{,}000{,}000$$

If SiteEnergySavings calculated above is positive, the measure is eligible.

The appropriate savings claim is dependent on which utilities are supporting the measure as provided in a table below:

Measure supported by:	Electric Utility claims (kWh):	Gas Utility claims (therms):
Electric utility only	SiteEnergySavings * 1,000,000/3,412	N/A
Electric and gas utility (Note utilities may make alternative agreements to how savings are allocated as long as total MMBtu savings remains the same).	%IncentiveElectric * SiteEnergySavings * 1,000,000/3,412	%IncentiveGas * SiteEnergySavings * 10
Gas utility only	N/A	SiteEnergySavings * 10

Note for Early Replacement measures, the efficiency terms of the existing unit should be used for the remaining useful life of the existing equipment (6 years for ASHP and Central AC, 6 years for furnace, 8 years for boilers, 15 years for electric resistance), and the efficiency terms for a new baseline unit should be used for the remaining years of the measure. See assumptions below.

Where:

$Capacity_{cool}$ = input capacity of the cooling equipment in Btu per hour (1 ton of cooling capacity equals 12,000 Btu/hr).

= Actual installed

$SEER_{base}$ =Seasonal Energy Efficiency Ratio of the baseline equipment

= SEER from tables below, based on the applicable Code on the date of equipment purchase (if unknown assume current Code).

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

= Actual installed

$SEER_{adj}$ = Adjustment percentage to account for in-situ performance of the unit[26]

$= [(0.805 \times \left(\frac{EER_{ee}}{SEER_{ee}}\right) + 0.367]$

$EFLH_{cool}$ = Equivalent Full Load Hours for cooling in Existing Buildings or New Construction are provided in section 4.4 HVAC End Use.

$HSPF_{base}$ = Heating Seasonal Performance Factor of the baseline equipment

= HSPF from tables below, based on the applicable Code on the date of equipment purchase (if unknown assume current Code).

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

= Actual installed. If rating is COP, HSPF = COP * 3.413

$HSPF_{adj}$ = Adjustment percentage to account for the heating capacity ratio of the efficient unit[27]

$= \left[\left(\frac{17\,°F\ Capacity}{47\,°F\ Capacity}\right) \times 0.158 + 0.899\right]$

= Actual using AHRI lookup values for efficient unit heating capacities rated at 17°F and 47°F. If not available assume 1.[28]

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[26] In situ performance based on Opinion Dynamics and Cadmus metering study of Ameren HVAC program participants; See 'AIC HVAC Metering Study Memo FINAL 2_28_2018'.
[27] In situ performance based on Opinion Dynamics and Cadmus metering study of Ameren HVAC program participants; See 'AIC HVAC Metering Study Memo FINAL 2_28_2018'.
[28] In situ performance based on Guidehouse review of 201 ASHP installs. While the data indicated an average of 1.006, the range was 0.9 to 1.06 so calculation of this value should be done where possible.

EER_{base} = Energy Efficiency Ratio of the baseline equipment

= EER from tables below, based on the applicable Code on the date of equipment purchase (if unknown assume current Code). For air-cooled units < 65 kBtu/hr, assume the following conversion from SEER to EER for calculation of peak savings:[29]

$$EER = (-0.02 * SEER^2) + (1.12 * SEER)$$

EER_{ee} = Energy Efficiency Ratio of the energy efficient equipment. For air-cooled units < 65 kBtu/hr, if the actual EER_{ee} is unknown, assume the conversion from SEER to EER as provided above.

= Actual installed

HeatLoad = Calculated heat load for the building

= $EFLH_{heat}$ * $Capacity_{heat}$

$EFLH_{heat}$ = heating mode equivalent full load hours in Existing Buildings or New Construction are provided in section 4.4 HVAC End Use.

$Capacity_{heat}$ = ~~input~~ output capacity of the heat pump equipment in Btu per hour.

= Actual installed

3412 = Btu per kWh.

COP_{base} = coefficient of performance of the baseline equipment

= COP from tables below, based on the applicable Code on the date of equipment purchase (if unknown assume current Code). If rating is HSPF, COP = HSPF / 3.413

COP_{ee} = coefficient of performance of the energy efficient equipment.

= Actual installed. If rating is HSPF, COP = HSPF / 3.413

$AFUE_{base}$ = Baseline Annual Fuel Utilization Efficiency Rating. For early replacement measures, use actual AFUE rating for the remaining useful life of the existing equipment (6 years for furnace, 8 years for boilers). For new systems (time of sale, new construction or remaining years of early replacement), use appropriate code level efficiency.

FurnaceFlag = 1 if system replaced is a gas furnace, 0 if not.

F_e = Furnace Fan energy consumption as a percentage of annual fuel consumption

= 7.7%[30]

[29] 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.

[30] F_e is estimated using TRM models for the three most popular building types for programmable thermostats: low-rise office (10.2%), sit-down restaurant (8.6%), and retail – strip mall (4.4%). 7.7% reflects the average Fe of the three building types. See "Fan Energy Factor Example Calculation 2021-06-23.xlsx" for reference.

%IncentiveElectric = % of total incentive paid by electric utility

= Actual

%IncentiveGas = % of total incentive paid by gas utility

= Actual

Code of Federal Redulations (baseline effective 1/1/2019):

Equipment type	Cooling capacity	Heating type	Cooling Efficiency level	Heating Efficiency level	Compliance date
Small Commercial Packaged Air Conditioning and Heating Equipment (Air-Cooled)	≥65,000 Btu/h and <135,000 Btu/h	Electric Resistance Heating or No Heating	IEER = 12.2	N/A	1/1/2018
		All Other Types of Heating	IEER = 12.0	COP = 3.3	1/1/2018
Large Commercial Packaged Air Conditioning and Heating Equipment (Air-Cooled)	≥135,000 Btu/h and <240,000 Btu/h	Electric Resistance Heating or No Heating	IEER = 11.6	N/A	1/1/2018
		All Other Types of Heating	IEER = 11.4	COP = 3.2	1/1/2018
Very Large Commercial Packaged Air Conditioning and Heating Equipment (Air-Cooled)	≥240,000 Btu/h and <760,000 Btu/h	Electric Resistance Heating or No Heating	IEER = 10.6	N/A	1/1/2018
		All Other Types of Heating	IEER = 10.4	COP = 3.2	1/1/2018
Small Commercial Package Air-Conditioning and Heating Equipment (Air-Cooled, 3-Phase, Split-System)	<65,000 Btu/h	All	SEER = 14.0	HSPF = 8.2	1/1/2017
Small Commercial Package Air-Conditioning and Heating Equipment (Air-Cooled, 3-Phase, Single-Package)	<65,000Btu/h	All	SEER = 14.0	HSPF = 8.0	1/1/2017
Small Commercial Packaged Air-Conditioning and Heating Equipment (Water Source: Water-to-Air, Water-Loop)	<17,000 Btu/h	All	EER = 12.2	COP = 4.3	10/9/2015
	≥17,000 Btu/h and <65,000 Btu/h	All	EER = 13.0	COP = 4.3	10/9/2015
	≥65,000 Btu/h and <135,000Btu/h	All	EER = 13.0	COP = 4.3	10/9/2015

Minimum Efficiency Requirements: 2015 IECC (baseline effective 1/1/2016 to 3/30/2019)

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

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY Before 1/1/2016	MINIMUM EFFICIENCY As of 1/1/2016	TEST PROCEDURE[a]
Air cooled (cooling mode)	< 65,000 Btu/h[b]	All	Split System	13.0 SEER[c]	14.0 SEER[c]	AHRI 210/240
			Single Package	13.0 SEER[c]	14.0 SEER[c]	
Through-the-wall, air cooled	≤ 30,000 Btu/h[b]	All	Split System	12.0 SEER	12.0 SEER	
			Single Package	12.0 SEER	12.0 SEER	
Single-duct high-velocity air cooled	< 65,000 Btu/h[b]	All	Split System	11.0 SEER	11.0 SEER	
Air cooled (cooling mode)	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER 11.2 IEER	11.0 EER 12.0 IEER	AHRI 340/360
		All other	Split System and Single Package	10.8 EER 11.0 IEER	10.8 EER 11.8 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	10.6 EER 10.7 IEER	10.6 EER 11.6 IEER	
		All other	Split System and Single Package	10.4 EER 10.5 IEER	10.4 EER 11.4 IEER	
	≥ 240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	9.5 EER 9.6 IEER	9.5 EER 10.6 IEER	
		All other	Split System and Single Package	9.3 EER 9.4 IEER	9.3 EER 9.4 IEER	
Water to Air: Water Loop (cooling mode)	< 17,000 Btu/h	All	86°F entering water	12.2 EER	12.2 EER	ISO 13256-1
	≥ 17,000 Btu/h and < 65,000 Btu/h	All	86°F entering water	13.0 EER	13.0 EER	
	≥ 65,000 Btu/h and < 135,000 Btu/h	All	86°F entering water	13.0 EER	13.0 EER	
Water to Air: Ground Water (cooling mode)	< 135,000 Btu/h	All	59°F entering water	18.0 EER	18.0 EER	ISO 13256-1
Brine to Air: Ground Loop (cooling mode)	< 135,000 Btu/h	All	77°F entering water	14.1 EER	14.1 EER	ISO 13256-1
Water to Water: WaterLoop (cooling mode)	< 135,000 Btu/h	All	86°F entering water	10.6 EER	10.6 EER	ISO 13256-2
Water to Water: Ground Water (cooling mode)	< 135,000 Btu/h	All	59°F entering water	16.3 EER	16.3 EER	
Brine to Water: Ground Loop (cooling mode)	< 135,000 Btu/h	All	77°F entering fluid	12.1 EER	12.1 EER	

(continued)

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

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY		TEST PROCEDURE[a]
				Before 1/1/2016	As of 1/1/2016	
Air cooled (heating mode)	< 65,000 Btu/h[b]	—	Split System	7.7 HSPF[c]	8.2 HSPF[c]	AHRI 210/240
		—	Single Package	7.7 HSPF[c]	8.0 HSPF[c]	
Through-the-wall, (air cooled, heating mode)	≤ 30,000 Btu/h[b] (cooling capacity)	—	Split System	7.4 HSPF	7.4 HSPF	
		—	Single Package	7.4 HSPF	7.4 HSPF	
Small-duct high velocity (air cooled, heating mode)	< 65,000 Btu/h[b]	—	Split System	6.8 HSPF	6.8 HSPF	
Air cooled (heating mode)	≥ 65,000 Btu/h and < 135,000 Btu/h (cooling capacity)	—	47°F db/43°F wb outdoor air	3.3 COP	3.3 COP	AHRI 340/360
			17°F db/15°F wb outdoor air	2.25 COP	2.25 COP	
	≥ 135,000 Btu/h (cooling capacity)	—	47°F db/43°F wb outdoor air	3.2 COP	3.2 COP	
			17°F db/15°F wb outdoor air	2.05 COP	2.05 COP	
Water to Air: Water Loop (heating mode)	< 135,000 Btu/h (cooling capacity)	—	68°F entering water	4.3 COP	4.3 COP	ISO 13256-1
Water to Air: Ground Water (heating mode)	< 135,000 Btu/h (cooling capacity)	—	50°F entering water	3.7 COP	3.7 COP	
Brine to Air: Ground Loop (heating mode)	< 135,000 Btu/h (cooling capacity)	—	32°F entering fluid	3.2 COP	3.2 COP	
Water to Water: Water Loop (heating mode)	< 135,000 Btu/h (cooling capacity)	—	68°F entering water	3.7 COP	3.7 COP	ISO 13256-2
Water to Water: Ground Water (heating mode)	< 135,000 Btu/h (cooling capacity)	—	50°F entering water	3.1 COP	3.1 COP	
Brine to Water: Ground Loop (heating mode)	< 135,000 Btu/h (cooling capacity)	—	32°F entering fluid	2.5 COP	2.5 COP	

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

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

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

c. Minimum efficiency as of January 1, 2015.

Minimum Efficiency Requirements: 2018 IECC (baseline effective 7/1/2019 for New Construction measures)

TABLE C403.3.2(2)
MINIMUM EFFICIENCY REQUIREMENTS: ELECTRICALLY OPERATED UNITARY AND APPLIED HEAT PUMPS

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
Air cooled (cooling mode)	< 65,000 Btu/h[b]	All	Split System	14.0 SEER	AHRI 210/240
			Single Package	14.0 SEER	
Through-the-wall, air cooled	≤ 30,000 Btu/h[b]	All	Split System	12.0 SEER	
			Single Package	12.0 SEER	
Single-duct high-velocity air cooled	< 65,000 Btu/h[b]	All	Split System	11.0 SEER	
Air cooled (cooling mode)	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER 12.0 IEER	AHRI 340/360
		All other	Split System and Single Package	10.8 EER 11.8 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	10.6 EER 11.6 IEER	
		All other	Split System and Single Package	10.4 EER 11.4 IEER	
	≥ 240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	9.5 EER 10.6 IEER	
		All other	Split System and Single Package	9.3 EER 9.4 IEER	
Water to Air: Water Loop (cooling mode)	< 17,000 Btu/h	All	86°F entering water	12.2 EER	ISO 13256-1
	≥ 17,000 Btu/h and < 65,000 Btu/h	All	86°F entering water	13.0 EER	
	≥ 65,000 Btu/h and < 135,000 Btu/h	All	86°F entering water	13.0 EER	
Water to Air: Ground Water (cooling mode)	< 135,000 Btu/h	All	59°F entering water	18.0 EER	ISO 13256-1
Brine to Air: Ground Loop (cooling mode)	< 135,000 Btu/h	All	77°F entering water	14.1 EER	ISO 13256-1
Water to Water: Water Loop (cooling mode)	< 135,000 Btu/h	All	86°F entering water	10.6 EER	ISO 13256-2
Water to Water: Ground Water (cooling mode)	< 135,000 Btu/h	All	59°F entering water	16.3 EER	
Brine to Water: Ground Loop (cooling mode)	< 135,000 Btu/h	All	77°F entering fluid	12.1 EER	

IECC2018 Table C403.3.2(2) continued from previous page:

Air cooled (heating mode)	< 65,000 Btu/h[b]	—	Split System	8.2 HSPF	AHRI 210/240
		—	Single Package	8.0 HSPF	
Through-the-wall, (air cooled, heating mode)	≤ 30,000 Btu/h[b] (cooling capacity)	—	Split System	7.4 HSPF	
		—	Single Package	7.4 HSPF	
Small-duct high velocity (air cooled, heating mode)	< 65,000 Btu/h[b]	—	Split System	6.8 HSPF	
Air cooled (heating mode)	≥ 65,000 Btu/h and < 135,000 Btu/h (cooling capacity)	—	47°F db/43°F wb outdoor air	3.3 COP	AHRI 340/360
			17°Fdb/15°F wb outdoor air	2.25 COP	
	≥ 135,000 Btu/h (cooling capacity)	—	47°F db/43°F wb outdoor air	3.2 COP	
			17°Fdb/15°F wb outdoor air	2.05 COP	
Water to Air: Water Loop (heating mode)	< 135,000 Btu/h (cooling capacity)	—	68°F entering water	4.3 COP	ISO 13256-1
Water to Air: Ground Water (heating mode)	< 135,000 Btu/h (cooling capacity)	—	50°F entering water	3.7 COP	
Brine to Air: Ground Loop (heating mode)	< 135,000 Btu/h (cooling capacity)	—	32°F entering fluid	3.2 COP	
Water to Water: Water Loop (heating mode)	< 135,000 Btu/h (cooling capacity)	—	68°F entering water	3.7 COP	ISO 13256-2
Water to Water: Ground Water (heating mode)	< 135,000 Btu/h (cooling capacity)	—	50°F entering water	3.1 COP	
Brine to Water: Ground Loop (heating mode)	< 135,000 Btu/h (cooling capacity)	—	32°F entering fluid	2.5 COP	

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

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

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

Non Fuel Switch example, a 5-ton cooling unit with 60,000 btu heating, an efficient SEER of 16, and an efficient HSPF of 9.5, at a restaurant in Chicago with a building permit dated after 1/1/2016 saves:

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

Annual kWh $Savings_{cool}$ = ($Capacity_{cool}$ * $EFLH_{cool}$ * (1/$SEER_{base}$ – 1/$SEER_{ee}$))/1000

Annual kWh $Savings_{heat}$ = (HeatLoad * (1/$HSPF_{base}$ – 1/$HSPF_{ee}$)/1000

ΔkWh = (60,000 * 1134 * (1/14 – 1/16))/1000 + (60,000 * 1354 * (1/8.2 – 1/9.5))/1000
= 1963.2 kWh

Fuel Switch Illustrative Examples

[for illustrative purposes 50:50 Incentive is used for joint programs]

New construction using gas furnace and central AC baseline:

For example, a 60,000 Btu, 16 SEER, 9.5 HSPF Air Site Heat Pump installed in a Chicago restaurant, in place of a 120,000 Btuh natural gas furnace and 5 ton Central AC unit:

SiteEnergySavings (MMBTUs) = GasHeatReplaced + FurnaceFanSavings - HPSiteHeatConsumed + HPSiteCoolingImpact

GasHeatReplaced = (HeatLoad * 1/$AFUE_{base}$) / 1,000,000

= (60,000 * 1354 * 1/0.8) / 1000000

= 101.6 MMBtu

FurnaceFanSavings = (FurnaceFlag * HeatLoad * 1/$AFUE_{base}$ * F_e) / 1,000,000

= (1 * 60,000 * 1354 * 1/0.8 * 0.077) / 1,000,000

= 7.8 MMBtu

HPSiteHeatConsumed = ((HeatLoad * (1/($HSPF_{ee}$ * $HSPF_{adj}$))) /1000 * 3412)/ 1,000,000

= ((60,000 * 1354 * (1/(9.5 * 1.001))) / 1000 * 3412) / 1,000,000
= 29.1 MMBtu

HPSiteCoolingImpact = ((FLHcool * $Capacity_{cool}$ * (1/SEERbase - 1/($SEER_{ee}$ * $SEER_{adj}$)))/1000 * 3412) / 1,000,000

Fuel Switch Illustrative Example continued

Savings would be claimed as follows:

Measure supported by:	Electric Utility claims:	Gas Utility claims:
Electric utility only	82.8 * 1,000,000/3412 = 24,267 kWh	N/A
Electric and gas utility	0.5 * 82.8 * 1,000,000/3412 = 12,134 kWh	0.5 * 82.8 * 10 = 414 Therms
Gas utility only	N/A	82.8 * 10 = 828 Therms

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$\Delta kW = ((kBtu/hr_{cool}) * (1/EER_{base} – 1/EER_{ee})) * CF$

Where CF value is chosen between:

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

= 91.3% [31]

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

= 47.8% [32]

For example, a 5 ton cooling unit with 60 kbtu heating, an efficient EER of 12.5 with a building permit dated after 1/1/2016 saves:

$\Delta kW = (60 * (1/11 – 1/12.5)) * 0.913$

$= 0.598$ kW

FOSSIL FUEL SAVINGS

Calculation provided together with Electric Energy Savings above.

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

COST EFFECTIVENESS SCREENING AND LOAD REDUCTION FORECASTING WHEN FUEL SWITCHING

This measure can involve fuel switching from gas to electric.

[31] 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.

[32] 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 the purposes of forecasting load reductions due to fuel switch ASHP projects per Section 16-111.5B, changes in site energy use at the customer's meter (using ΔkWh algorithm below) adjusted for utility line losses (at-the-busbar savings), customer switching estimates, NTG, and any other adjustment factors deemed appropriate, should be used.

The inputs to cost effectiveness screening should reflect the actual impacts on the electric and fuel consumption at the customer meter and, for fuel switching measures, this will not match the output of the calculation/allocation methodology presented in the "Electric Energy Savings" and "Fossil Fuel Savings" sections above. Therefore in addition to the calculation of savings claimed, the following values should be used to assess the cost effectiveness of the measure. For Early Replacement measures, the efficiency terms of the existing unit should be used for the remaining useful life of the existing equipment (6 years for ASHP and Central AC, 7 years for furnace, 8 years for boilers or GSHP, 15 years for electric resistance), and the efficiency terms for a new baseline unit should be used for the remaining years of the measure.

ΔTherms = [Heating Consumption Replaced]

$= [(HeatLoad * 1/AFUE_{base}) / 100{,}000]$

ΔkWh = [FurnaceFanSavings] - [HP heating consumption] + [Cooling savings]

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

$= [FurnaceFlag * HeatLoad * 1/AFUE_{base} * F_e * 0.000293] - [(HeatLoad * (1/(HSPF_{ee} * HSPF_{adj}))/1000] + [(Capacity_{cool} * EFLH_{cool} * (1/SEER_{base} - 1/(SEER_{ee} * SEER_{adj})))/1000]$

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

$= [FurnaceFlag * HeatLoad * 1/AFUE_{base} * F_e * 0.000293] - [HeatLoad/3412 * (1/COP_{ee})] + [(Capacity_{cool} * EFLH_{cool} * (1/EER_{base} - 1/EER_{ee}))/1000]$

MEASURE CODE: CI-HVC-HPSY-V09~~8~~-220101

REVIEW DEADLINE: 1/1/2023

4.4.44 Commercial Ground Source and Ground Water Source Heat Pump

DESCRIPTION

This measure characterizes the installation of a Ground Source Heat Pump under the following scenarios:

A. New Construction:
   i. The installation of a new Ground Source Heat Pump system meeting ENERGY STAR efficiency standards presented below in a new C&I building.
   ii. Note the baseline in this case should be determined via EM&V and the algorithms are provided to allow savings to be calculated from any baseline condition.
B. Time of Sale:
   i. The planned installation of a new Ground Source Heat Pump system meeting ENERGY STAR efficiency standards presented below to replace an existing system(s) that does not meet the criteria for early replacement described in section C below.
   ii. Note the baseline in this case is an equivalent replacement system to that which exists currently in the building. Where unknown, the baseline should be determined via EM&V and the algorithms are provided to allow savings to be calculated from any baseline condition. The calculation of savings is dependent on whether an incentive for the installation has been provided by both a gas and electric utility, only an electric utility or only a gas utility.
   iii. DHW savings are calculated based upon the fuel type and efficiency of the existing unit.
C. Early Replacement/Retrofit:
   i. The early removal of functioning electric or gas space heating and/or cooling systems from service, prior to the natural end of life, and replacement with a new high efficiency Ground Source Heat Pump system.
   ii. Note the baseline in this case is the existing equipment being replaced. The calculation of savings is dependent on whether an incentive for the installation has been provided by both a gas and electric utility, only an electric utility or only a gas utility. DHW savings are calculated based upon the fuel and efficiency of the existing unit.
   iii. Early Replacement determination will be based on meeting the following conditions:
      - The existing unit is operational when replaced, or
      - The existing unit requires minor repairs to be operational, defined as costing less than:[33]

Existing System	Maximum repair cost
Air Source Heat Pump	$263/ton
Chiller	$308/ton
Boiler (Steam)	$3.87/ kBtu
Boiler (Hot Water)	$4.25/ kBtu
Furnace	$2.49/ kBtu
Ground Source Heat Pump	$2,185/ton

      - All other conditions will be considered Time of Sale.

   The Baseline efficiency of the existing unit replaced:

      - Use actual existing efficiency whenever possible.
      - If the efficiency of the existing unit is unknown, use assumptions based on the federal minimum standards provided in tables below.
      - If the operational status or repair cost of the existing unit is unknown use time of sale

[33] The Technical Advisory Committee agreed that if the cost of repair is less than 20% of the new baseline replacement cost (defined in the Measure Costs section), it can be considered early replacement.

assumptions.

The installation of the GSHP should meet the following design parameters to ensure a properly sized circulation pump. If the GSHP design does not meet the following parameters, a custom calculation should be performed to account for the motor energy consumed by the circulation pump. Optimal design parameters are:

- Circulation pump is included in the manufacturer assembly of the GSHP system
  Or;
- Circulation pump flow rate less than or equal to 3.0 GPM per system ton
- Variable flow controls on pumps serving systems greater than 10 tons. Variable flow controls include one of the following:
  - A variable speed system pump controlled from differential pressure and 2-way water flow control valves on each heat pump.
  - Individual on/off pumps on each heat pump controlled by heat pump demand. The heat pumps may be decoupled from the ground heat exchanger using a separate variable speed pump controlled by differential temperature across the ground loop.
- On/off or variable flow controls on pumps for systems less than 10 tons. On/off pump controls shall operate only when heat pump(s) are running.
- System pumping head less than 80 feet. For systems 10 tons or smaller system pumping head should not exceed 40 feet.

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

For these products, the baseline equipment includes Air Conditioning, Space Heating and Domestic Hot Water Heating.

New Construction:

To calculate savings with an electric baseline, the baseline equipment is assumed to be an Air Source Heat Pump meeting the Federal Standard efficiency level as outlined in Table 2 (effective 1/1/2016 to 6/30/2019) or Table 7 (effective 7/1/2019); and a Federal Standard electric hot water heater efficiency level as outlined in Table 6 (effective 1/1/2016 to 6/30/2019) or Table 11 (effective 7/1/2019).

To calculate savings with a chiller/unitary cooling systems and boiler/furnace baseline, the baseline equipment is assumed to meet the minimum standard efficiencies as outlined in the Table 3 (effective 1/1/2016 to 6/30/2019) or Table 8 (effective 7/1/2019)

Tablefor chillers/unitary cooling systems, and Table 4 (effective 1/1/2016 to 6/30/2019) or Table 9 (effective 7/1/2019) for boilers or Table 5 (effective 1/1/2016 to 6/30/2019) or Table 10 (effective 7/1/2019) for furnaces. If a desuperheater is installed, the domestic hot water heater minimum standard efficiency is calculated as per Table 6 (effective 1/1/2016 to 6/30/2019) or Table 11 (effective 7/1/2019) below.

Note IECC 2018 became effective July 1, 2019 and is the baseline for all New Construction permits from that date.

Table2: IECC 2015 ASHP Minimum Efficiency Requirements (effective 1/1/2016 to 6/30/2019)**:**

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY		TEST PROCEDURE[a]
				Before 1/1/2016	As of 1/1/2016	
Air cooled (cooling mode)	< 65,000 Btu/h[b]	All	Split System	13.0 SEER[c]	14.0 SEER[c]	AHRI 210/240
			Single Package	13.0 SEER[c]	14.0 SEER[c]	
Through-the-wall, air cooled	≤ 30,000 Btu/h[b]	All	Split System	12.0 SEER	12.0 SEER	
			Single Package	12.0 SEER	12.0 SEER	
Single-duct high-velocity air cooled	< 65,000 Btu/h[b]	All	Split System	11.0 SEER	11.0 SEER	
Air cooled (cooling mode)	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER 11.2 IEER	11.0 EER 12.0 IEER	AHRI 340/360
		All other	Split System and Single Package	10.8 EER 11.0 IEER	10.8 EER 11.8 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	10.6 EER 10.7 IEER	10.6 EER 11.6 IEER	
		All other	Split System and Single Package	10.4 EER 10.5 IEER	10.4 EER 11.4 IEER	
	≥ 240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	9.5 EER 9.6 IEER	9.5 EER 10.6 IEER	
		All other	Split System and Single Package	9.3 EER 9.4 IEER	9.3 EER 9.4 IEER	
Air cooled (heating mode)	< 65,000 Btu/h[b]	—	Split System	7.7 HSPF[c]	8.2 HSPF[c]	AHRI 210/240
		—	Single Package	7.7 HSPF[c]	8.0 HSPF[c]	
Through-the-wall, (air cooled, heating mode)	≤ 30,000 Btu/h[b] (cooling capacity)	—	Split System	7.4 HSPF	7.4 HSPF	
		—	Single Package	7.4 HSPF	7.4 HSPF	
Small-duct high velocity (air cooled, heating mode)	< 65,000 Btu/h[b]	—	Split System	6.8 HSPF	6.8 HSPF	
Air cooled (heating mode)	≥ 65,000 Btu/h and < 135,000 Btu/h (cooling capacity)	—	47°F db/43°F wb outdoor air	3.3 COP	3.3 COP	AHRI 340/360
			17°Fdb/15°F wb outdoor air	2.25 COP	2.25 COP	
	≥ 135,000 Btu/h (cooling capacity)	—	47°F db/43°F wb outdoor air	3.2 COP	3.2 COP	
			17°Fdb/15°F wb outdoor air	2.05 COP	2.05 COP	

Table 3: IECC 2015 Electric Chillers, Air-Cooled and Water-Cooled minimum efficiencies (effective 1/1/2016 to 6/30/2019)

EQUIPMENT TYPE	SIZE CATEGORY	UNITS	BEFORE 1/1/2015		AS OF 1/1/2015		TEST PROCEDURE[c]
			Path A	Path B	Path A	Path B	
Air-cooled chillers	< 150 Tons	EER (Btu/W)	≥ 9.562 FL	NA[c]	≥ 10.100 FL	≥ 9.700 FL	AHRI 550/590
			≥ 12.500 IPLV		≥ 13.700 IPLV	≥ 15,800 IPLV	
	≥ 150 Tons		≥ 9.562 FL	NA[c]	≥ 10.100 FL	≥ 9.700 FL	
			≥ 12.500 IPLV		≥ 14.000 IPLV	≥ 16.100 IPLV	
Air cooled without condenser, electrically operated	All capacities	EER (Btu/W)	Air-cooled chillers without condenser shall be rated with matching condensers and complying with air-cooled chiller efficiency requirements.				
Water cooled, electrically operated positive displacement	< 75 Tons	kW/ton	≤ 0.780 FL	≤ 0.800 FL	≤ 0.750 FL	≤ 0.780 FL	
			≤ 0.630 IPLV	≤ 0.600 IPLV	≤ 0.600 IPLV	≤ 0.500 IPLV	
	≥ 75 tons and < 150 tons		≤ 0.775 FL	≤ 0.790 FL	≤ 0.720 FL	≤ 0.750 FL	
			≤ 0.615 IPLV	≤ 0.586 IPLV	≤ 0.560 IPLV	≤ 0.490 IPLV	
	≥ 150 tons and < 300 tons		≥ 0.680 FL	≥ 0.718 FL	≥ 0.660 FL	≥ 0.680 FL	
			≥ 0.580 IPLV	≥ 0.540 IPLV	≥ 0.540 IPLV	≥ 0.440 IPLV	
	≥ 300 tons and < 600 tons		≤ 0.620 FL	≤ 0.639 FL	≤ 0.610 FL	≤ 0.625 FL	
			≤ 0.540 IPLV	≤ 0.490 IPLV	≤ 0.520 IPLV	≤ 0.410 IPLV	
	≥ 600 tons		≤ 0.620 FL	≤ 0.639 FL	≤ 0.560 FL	≤ 0.585 FL	
			≤ 0.540 IPLV	≤ 0.490 IPLV	≤ 0.500 IPLV	≤ 0.380 IPLV	
Water cooled, electrically operated centrifugal	< 150 Tons	kW/ton	≤ 0.634 FL	≤ 0.639 FL	≤ 0.610 FL	≤ 0.695 FL	
			≤ 0.596 IPLV	≤ 0.450 IPLV	≤ 0.550 IPLV	≤ 0.440 IPLV	
	≥ 150 tons and < 300 tons		≤ 0.634 FL	≤ 0.639 FL	≤ 0.610 FL	≤ 0.635 FL	
			≤ 0.596 IPLV	≤ 0.450 IPLV	≤ 0.550 IPLV	≤ 0.400 IPLV	
	≥ 300 tons and < 400 tons		≤ 0.576 FL	≤ 0.600 FL	≤ 0.560 FL	≤ 0.595 FL	
			≤ 0.549 IPLV	≤ 0.400 IPLV	≤ 0.520 IPLV	≤ 0.390 IPLV	
	≥ 400 tons and < 600 tons		≤ 0.576 FL	≤ 0.600 FL	≤ 0.560 FL	≤ 0.585 FL	
			≤ 0.549 IPLV	≤ 0.400 IPLV	≤ 0.500 IPLV	≤ 0.380 IPLV	
	≥ 600 Tons		≤ 0.570 FL	≤ 0.590 FL	≤ 0.560 FL	≤ 0.585 FL	
			≤ 0.539 IPLV	≤ 0.400 IPLV	≤ 0.500 IPLV	≤ 0.380 IPLV	
Air cooled, absorption, single effect	All capacities	COP	≥ 0.600 FL	NA[c]	≥ 0.600 FL	NA[c]	AHRI 560
Water cooled absorption, single effect	All capacities	COP	≥ 0.700 FL	NA[c]	≥ 0.700 FL	NA[c]	
Absorption, double effect, indirect fired	All capacities	COP	≥ 1.000 FL	NA[c]	≥ 1.000 FL	NA[c]	
			≥ 1.050 IPLV		≥ 1.050 IPLV		
Absorption double effect direct fired	All capacities	COP	≥ 1.000 FL	NA[c]	≥ 1.000 FL	NA[c]	
			≥ 1.000 IPLV		≥ 1.050 IPLV		

Table 4: IECC 2015 Boiler minimum efficiency requirements (effective 1/1/2016 to 6/30/2019)

EQUIPMENT TYPE[a]	SUBCATEGORY OR RATING CONDITION	SIZE CATEGORY (INPUT)	MINIMUM EFFICIENCY[d, e]	TEST PROCEDURE
Boilers, hot water	Gas-fired	< 300,000 Btu/h	80% AFUE	10 CFR Part 430
		≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[b]	80% E_t	10 CFR Part 431
		> 2,500,000 Btu/h[a]	82% E_c	
	Oil-fired[c]	< 300,000 Btu/h	80% AFUE	10 CFR Part 430
		≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[b]	82% E_t	10 CFR Part 431
		> 2,500,000 Btu/h[a]	84% E_c	
Boilers, steam	Gas-fired	< 300,000 Btu/h	75% AFUE	10 CFR Part 430
	Gas-fired- all, except natural draft	≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[b]	79% E_t	10 CFR Part 431
		> 2,500,000 Btu/h[a]	79% E_t	
	Gas-fired-natural draft	≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[b]	77% E_t	
		> 2,500,000 Btu/h[a]	77% E_t	
	Oil-fired[c]	< 300,000 Btu/h	80% AFUE	10 CFR Part 430
		≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[b]	81% E_t	10 CFR Part 431
		> 2,500,000 Btu/h[a]	81% E_t	

Table 5: IECC 2015 Warm-air Furnace minimum efficiency standards (effective 1/1/2016 to 6/30/2019)

EQUIPMENT TYPE	SIZE CATEGORY (INPUT)	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY[d, e]	TEST PROCEDURE[a]
Warm-air furnaces, gas fired	< 225,000 Btu/h	—	78% AFUE or 80%E_t[c]	DOE 10 CFR Part 430 or ANSI Z21.47
	≥ 225,000 Btu/h	Maximum capacity[c]	80%E_t[f]	ANSI Z21.47
Warm-air furnaces, oil fired	< 225,000 Btu/h	—	78% AFUE or 80%E_t[c]	DOE 10 CFR Part 430 or UL 727
	≥ 225,000 Btu/h	Maximum capacity[b]	81%E_t[g]	UL 727
Warm-air duct furnaces, gas fired	All capacities	Maximum capacity[b]	80%E_c	ANSI Z83.8
Warm-air unit heaters, gas fired	All capacities	Maximum capacity[b]	80%E_c	ANSI Z83.8
Warm-air unit heaters, oil fired	All capacities	Maximum capacity[b]	80%E_c	UL 731

Table 6: IECC 2015 Water Heaters mininmum performance (effective 1/1/2016 to 6/30/2019)

EQUIPMENT TYPE	SIZE CATEGORY (input)	SUBCATEGORY OR RATING CONDITION	PERFORMANCE REQUIRED[a, b]	TEST PROCEDURE
Water heaters, electric	≤ 12 kW[d]	Resistance	0.97 - 0.00 132V, EF	DOE 10 CFR Part 430
	> 12 kW	Resistance	$(0.3 + 27/V_m)$, %/h	ANSI Z21.10.3
	≤ 24 amps and ≤ 250 volts	Heat pump	0.93 - 0.00 132V, EF	DOE 10 CFR Part 430
Storage water heaters, gas	≤ 75,000 Btu/h	≥ 20 gal	0.67 - 0.0019V, EF	DOE 10 CFR Part 430
	> 75,000 Btu/h and ≤ 155,000 Btu/h	< 4,000 Btu/h/gal	80% E_t $(Q/800 + 110\sqrt{V})$SL, Btu/h	ANSI Z21.10.3
	> 155,000 Btu/h	< 4,000 Btu/h/gal	80% E_t $(Q/800 + 110\sqrt{V})$SL, Btu/h	
Instantaneous water heaters, gas	> 50,000 Btu/h and < 200,000 Btu/h[c]	≥ 4,000 (Btu/h)/gal and < 2 gal	0.62 - 0.00 19V, EF	DOE 10 CFR Part 430
	≥ 200,000 Btu/h	≥ 4,000 Btu/h/gal and < 10 gal	80% E_t	ANSI Z21.10.3
	≥ 200,000 Btu/h	≥ 4,000 Btu/h/gal and ≥ 10 gal	80% E_t $(Q/800 + 110\sqrt{V})$SL, Btu/h	

Table7: IECC 2018 ASHP Minimum Efficiency Requirements (effective 7/1/2019)

TABLE C403.3.2(2)
MINIMUM EFFICIENCY REQUIREMENTS: ELECTRICALLY OPERATED UNITARY AND APPLIED HEAT PUMPS

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
Air cooled (cooling mode)	< 65,000 Btu/h[b]	All	Split System	14.0 SEER	AHRI 210/240
			Single Package	14.0 SEER	
Through-the-wall, air cooled	≤ 30,000 Btu/h[b]	All	Split System	12.0 SEER	
			Single Package	12.0 SEER	
Single-duct high-velocity air cooled	< 65,000 Btu/h[b]	All	Split System	11.0 SEER	
Air cooled (cooling mode)	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER 12.0 IEER	AHRI 340/360
		All other	Split System and Single Package	10.8 EER 11.8 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	10.6 EER 11.6 IEER	
		All other	Split System and Single Package	10.4 EER 11.4 IEER	
	≥ 240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	9.5 EER 10.6 IEER	
		All other	Split System and Single Package	9.3 EER 9.4 IEER	
Water to Air: Water Loop (cooling mode)	< 17,000 Btu/h	All	86°F entering water	12.2 EER	ISO 13256-1
	≥ 17,000 Btu/h and < 65,000 Btu/h	All	86°F entering water	13.0 EER	
	≥ 65,000 Btu/h and < 135,000 Btu/h	All	86°F entering water	13.0 EER	
Water to Air: Ground Water (cooling mode)	< 135,000 Btu/h	All	59°F entering water	18.0 EER	ISO 13256-1
Brine to Air: Ground Loop (cooling mode)	< 135,000 Btu/h	All	77°F entering water	14.1 EER	ISO 13256-1
Water to Water: Water Loop (cooling mode)	< 135,000 Btu/h	All	86°F entering water	10.6 EER	ISO 13256-2
Water to Water: Ground Water (cooling mode)	< 135,000 Btu/h	All	59°F entering water	16.3 EER	
Brine to Water: Ground Loop (cooling mode)	< 135,000 Btu/h	All	77°F entering fluid	12.1 EER	

Table 7 continued:

Air cooled (heating mode)	< 65,000 Btu/h[b]	—	Split System	8.2 HSPF	AHRI 210/240
		—	Single Package	8.0 HSPF	
Through-the-wall, (air cooled, heating mode)	≤ 30,000 Btu/h[b] (cooling capacity)	—	Split System	7.4 HSPF	
		—	Single Package	7.4 HSPF	
Small-duct high velocity (air cooled, heating mode)	< 65,000 Btu/h[b]	—	Split System	6.8 HSPF	
Air cooled (heating mode)	≥ 65,000 Btu/h and < 135,000 Btu/h (cooling capacity)	—	47°F db/43°F wb outdoor air	3.3 COP	AHRI 340/360
			17°Fdb/15°F wb outdoor air	2.25 COP	
	≥ 135,000 Btu/h (cooling capacity)	—	47°F db/43°F wb outdoor air	3.2 COP	
			17°Fdb/15°F wb outdoor air	2.05 COP	
Water to Air: Water Loop (heating mode)	< 135,000 Btu/h (cooling capacity)	—	68°F entering water	4.3 COP	ISO 13256-1
Water to Air: Ground Water (heating mode)	< 135,000 Btu/h (cooling capacity)	—	50°F entering water	3.7 COP	
Brine to Air: Ground Loop (heating mode)	< 135,000 Btu/h (cooling capacity)	—	32°F entering fluid	3.2 COP	
Water to Water: Water Loop (heating mode)	< 135,000 Btu/h (cooling capacity)	—	68°F entering water	3.7 COP	ISO 13256-2
Water to Water: Ground Water (heating mode)	< 135,000 Btu/h (cooling capacity)	—	50°F entering water	3.1 COP	
Brine to Water: Ground Loop (heating mode)	< 135,000 Btu/h (cooling capacity)	—	32°F entering fluid	2.5 COP	

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

a. Chapter 6 contains a complete specification of the referenced test procedure, including the reference year version of the test procedure.
b. Single-phase, air-cooled heat pumps less than 65,000 Btu/h are regulated by NAECA. SEER and HSPF values are those set by NAECA.

Table 8: IECC 2018 Electric Chillers, Air-Cooled and Water-Cooled minimum efficiencies (effective 7/1/2019)

TABLE C403.3.2(7)
WATER CHILLING PACKAGES — EFFICIENCY REQUIREMENTS[a, b, d]

EQUIPMENT TYPE	SIZE CATEGORY	UNITS	BEFORE 1/1/2015		AS OF 1/1/2015		TEST PROCEDURE[c]
			Path A	Path B	Path A	Path B	
Air-cooled chillers	< 150 Tons	EER (Btu/W)	≥ 9.562 FL	NA[c]	≥ 10.100 FL	≥ 9.700 FL	AHRI 550/590
			≥ 12.500 IPLV		≥ 13.700 IPLV	≥ 15,800 IPLV	
	≥ 150 Tons		≥ 9.562 FL	NA[c]	≥ 10.100 FL	≥ 9.700 FL	
			≥ 12.500 IPLV		≥ 14.000 IPLV	≥ 16.100 IPLV	
Air cooled without condenser, electrically operated	All capacities	EER (Btu/W)	Air-cooled chillers without condenser shall be rated with matching condensers and complying with air-cooled chiller efficiency requirements.				
Water cooled, electrically operated positive displacement	< 75 Tons	kW/ton	≤ 0.780 FL	≤ 0.800 FL	≤ 0.750 FL	≤ 0.780 FL	
			≤ 0.630 IPLV	≤ 0.600 IPLV	≤ 0.600 IPLV	≤ 0.500 IPLV	
	≥ 75 tons and < 150 tons		≤ 0.775 FL	≤ 0.790 FL	≤ 0.720 FL	≤ 0.750 FL	
			≤ 0.615 IPLV	≤ 0.586 IPLV	≤ 0.560 IPLV	≤ 0.490 IPLV	
	≥ 150 tons and < 300 tons		≥ 0.680 FL	≥ 0.718 FL	≥ 0.660 FL	≥ 0.680 FL	
			≥ 0.580 IPLV	≥ 0.540 IPLV	≥ 0.540 IPLV	≥ 0.440 IPLV	
	≥ 300 tons and < 600 tons		≤ 0.620 FL	≤ 0.639 FL	≤ 0.610 FL	≤ 0.625 FL	
			≤ 0.540 IPLV	≤ 0.490 IPLV	≤ 0.520 IPLV	≤ 0.410 IPLV	
	≥ 600 tons		≤ 0.620 FL	≤ 0.639 FL	≤ 0.560 FL	≤ 0.585 FL	
			≤ 0.540 IPLV	≤ 0.490 IPLV	≤ 0.500 IPLV	≤ 0.380 IPLV	
Water cooled, electrically operated centrifugal	< 150 Tons	kW/ton	≤ 0.634 FL	≤ 0.639 FL	≤ 0.610 FL	≤ 0.695 FL	
			≤ 0.596 IPLV	≤ 0.450 IPLV	≤ 0.550 IPLV	≤ 0.440 IPLV	
	≥ 150 tons and < 300 tons		≤ 0.634 FL	≤ 0.639 FL	≤ 0.610 FL	≤ 0.635 FL	
			≤ 0.596 IPLV	≤ 0.450 IPLV	≤ 0.550 IPLV	≤ 0.400 IPLV	
	≥ 300 tons and < 400 tons		≤ 0.576 FL	≤ 0.600 FL	≤ 0.560 FL	≤ 0.595 FL	
			≤ 0.549 IPLV	≤ 0.400 IPLV	≤ 0.520 IPLV	≤ 0.390 IPLV	
	≥ 400 tons and < 600 tons		≤ 0.576 FL	≤ 0.600 FL	≤ 0.560 FL	≤ 0.585 FL	
			≤ 0.549 IPLV	≤ 0.400 IPLV	≤ 0.500 IPLV	≤ 0.380 IPLV	
	≥ 600 Tons		≤ 0.570 FL	≤ 0.590 FL	≤ 0.560 FL	≤ 0.585 FL	
			≤ 0.539 IPLV	≤ 0.400 IPLV	≤ 0.500 IPLV	≤ 0.380 IPLV	
Air cooled, absorption, single effect	All capacities	COP	≥ 0.600 FL	NA[c]	≥ 0.600 FL	NA[c]	AHRI 560
Water cooled absorption, single effect	All capacities	COP	≥ 0.700 FL	NA[c]	≥ 0.700 FL	NA[c]	
Absorption, double effect, indirect fired	All capacities	COP	≥ 1.000 FL	NA[c]	≥ 1.000 FL	NA[c]	
			≥ 1.050 IPLV		≥ 1.050 IPLV		
Absorption double effect direct fired	All capacities	COP	≥ 1.000 FL	NA[c]	≥ 1.000 FL	NA[c]	
			≥ 1.000 IPLV		≥ 1.050 IPLV		

Table 9: IECC 2018 Boiler minimum efficiency requirements (effective 7/1/2019)

Note Code of Federal Regulations for gas -fired hot water boilers manufactured after January 15, 2021 require <300,000Btuh hot water boilers to be 84% AFUE and <300,000 Btuh steam boilers to be 82% AFUE (10 CFR 432(e)(3)). This should be assumed baseline from 1/1/2022.

TABLE C403.3.2(5)
MINIMUM EFFICIENCY REQUIREMENTS: GAS- AND OIL-FIRED BOILERS

EQUIPMENT TYPE[a]	SUBCATEGORY OR RATING CONDITION	SIZE CATEGORY (INPUT)	MINIMUM EFFICIENCY[d, e]	TEST PROCEDURE
Boilers, hot water	Gas-fired	< 300,000 Btu/h[f, g]	82% AFUE	10 CFR Part 430
		≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[b]	80% E_t	10 CFR Part 431
		> 2,500,000 Btu/h[a]	82% E_c	
	Oil-fired[c]	< 300,000 Btu/h[g]	84% AFUE	10 CFR Part 430
		≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[b]	82% E_t	10 CFR Part 431
		> 2,500,000 Btu/h[a]	84% E_c	
Boilers, steam	Gas-fired	< 300,000 Btu/h[f]	80% AFUE	10 CFR Part 430
	Gas-fired- all, except natural draft	≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[b]	79% E_t	10 CFR Part 431
		> 2,500,000 Btu/h[a]	79% E_t	
	Gas-fired-natural draft	≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[b]	77% E_t	
		> 2,500,000 Btu/h[a]	77% E_t	
	Oil-fired[c]	< 300,000 Btu/h	82% AFUE	10 CFR Part 430
		≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[b]	81% E_t	10 CFR Part 431
		> 2,500,000 Btu/h[a]	81% E_t	

Table 10: IECC 2018 Warm-air Furnace minimum efficiency standards (effective 7/1/2019)

TABLE C403.3.2(4)
WARM-AIR FURNACES AND COMBINATION WARM-AIR FURNACES/AIR-CONDITIONING UNITS, WARM-AIR DUCT FURNACES AND UNIT HEATERS, MINIMUM EFFICIENCY REQUIREMENTS

EQUIPMENT TYPE	SIZE CATEGORY (INPUT)	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY[d, e]	TEST PROCEDURE[a]
Warm-air furnaces, gas fired	< 225,000 Btu/h	—	80% AFUE or 80%E^c_t	DOE 10 CFR Part 430 or ANSI Z21.47
	≥ 225,000 Btu/h	Maximum capacity[c]	80%E_t^f	ANSI Z21.47
Warm-air furnaces, oil fired	< 225,000 Btu/h	—	83% AFUE or 80%E^c_t	DOE 10 CFR Part 430 or UL 727
	≥ 225,000 Btu/h	Maximum capacity[b]	81%E_t^g	UL 727
Warm-air duct furnaces, gas fired	All capacities	Maximum capacity[b]	80%E_c	ANSI Z83.8
Warm-air unit heaters, gas fired	All capacities	Maximum capacity[b]	80%E_c	ANSI Z83.8
Warm-air unit heaters, oil fired	All capacities	Maximum capacity[b]	80%E_c	UL 731

Table 11: IECC 2018 Water Heaters minimum performance (effective 7/1/2019)

TABLE C404.2
MINIMUM PERFORMANCE OF WATER-HEATING EQUIPMENT

EQUIPMENT TYPE	SIZE CATEGORY (input)	SUBCATEGORY OR RATING CONDITION	PERFORMANCE REQUIRED[a, b]	TEST PROCEDURE
Water heaters, electric	≤ 12 kW[d]	Tabletop[e], ≥ 20 gallons and ≤ 120 gallons	0.93 - 0.00132*V*, EF	DOE 10 CFR Part 430
		Resistance ≥ 20 gallons and ≤ 55 gallons	0.960 - 0.0003*V*, EF	
		Grid-enabled[f] > 75 gallons and ≤ 120 gallons	1.061 - 0.00168V, EF	
	> 12 kW	Resistance	$(0.3 + 27/V_m)$, %/h	ANSI Z21.10.3
	≤ 24 amps and ≤ 250 volts	Heat pump > 55 gallons and ≤ 120 gallons	2.057 - 0.00113V, EF	DOE 10 CFR Part 430
Storage water heaters, gas	≤ 75,000 Btu/h	≥ 20 gallons and > 55 gallons	0.675 - 0.0015V, EF	DOE 10 CFR Part 430
		> 55 gallons and ≤ 100 gallons	0.8012 - 0.00078V, EF	
	> 75,000 Btu/h and ≤ 155,000 Btu/h	< 4,000 Btu/h/gal	80% E_t	ANSI Z21.10.3
	> 155,000 Btu/h	< 4,000 Btu/h/gal	80% E_t	
Instantaneous water heaters, gas	> 50,000 Btu/h and < 200,000 Btu/h[c]	≥ 4,000 (Btu/h)/gal and < 2 gal	0.82 - 0.00 19V, EF	DOE 10 CFR Part 430
	≥ 200,000 Btu/h	≥ 4,000 Btu/h/gal and < 10 gal	80% E_t	ANSI Z21.10.3
	≥ 200,000 Btu/h	≥ 4,000 Btu/h/gal and ≥ 10 gal	80% E_t	

Time of Sale: The baseline for this measure is a new replacement unit of the same system type as the existing unit, meeting the minimum standard efficiencies provided above.

Early replacement / Retrofit: The baseline for this measure is the efficiency of the *existing* heating, cooling and hot water equipment for the assumed remaining useful life of the existing unit, and a new baseline heating and cooling system for the remainder of the measure life (as provided in table above).

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life of the ground source heat pump is assumed to be 25 years.[34]

The expected measure life of the ground loop field is assumed to be 50 years.[35]

For early replacement, the remaining life of existing equipment is assumed to be 6 years for ASHP and Central AC, 7 years for furnace, 8 years for boilers and GSHP,[36] and 25 years for electric resistance.[37]

DEEMED MEASURE COST

New Construction and Time of Sale: Incremental costs of the Ground Source Heat Pump should be used. This would be the actual installed cost of the Ground Source Heat Pump, well drilling, building retrofit, and system commissioning costs (default of $10,923 per ton),[38] minus the assumed installation cost of the baseline equipment ($1,316 per ton for ASHP,[39] or $12.43 per kBtu capacity for a new baseline efficient furnace or $19.33 per kBtu capacity for a new efficient steam boiler or $21.27 per kBtu capacity for a new efficient hot water boiler,[40] and $1,539 per ton for new baseline chiller replacement[41]).

Early Replacement: The actual installed cost of the Ground Source Heat Pump should be used (default cost for total system retrofit provided above). The assumed deferred cost (after 8 years) of replacing existing equipment with a new baseline unit is assumed to be $1,316 per ton for a new baseline Air Source Heat Pump, or $12.43 per kBtu capacity for a new baseline efficient furnace or $19.33 per kBtu capacity for a new efficient steam boiler or $21.27 per kBtu capacity for a new efficient hot water boiler and $1,539 per ton for new baseline chiller replacement. This future cost should be discounted to present value using the nominal societal discount rate.

LOADSHAPE

Loadshape C04 – Commercial Electric Heating (if replacing building with no existing cooling)

Loadshape C05 - Commercial Electric Heating and Cooling

Note for the purpose of cost effectiveness screening for a fuel switch scenario, the heating kWh increase and cooling kWh decrease should be calculated separately such that the appropriate loadshape (i.e., Loadshape C04 - Commercial Electric Heating and Loadshape C03 – Commercial Cooling respectively) can be applied.

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

34 System life of indoor components as per US DOE estimates from the Office of Energy Efficiency & Renewable Energy. The ground loop has a much longer life, but the compressor and other mechanical components are the same as an ASHP.

35 U.S. DOE Office of Energy Efficiency & Renewable Energy, Energy Saver details and descriptions for Geothermal Heat Pumps

36 Assumed to be one third of effective useful life of replaced equipment.

37 Assume full measure life (16 years) for replacing electric resistance as we would not expect that resistance heat would fail during the lifetime of the efficient measure.

38 Average calculated based on reviewing cost information received from Chicagoland GSHP installers.

39 Average calculated from Energy Star and RSMeans Mechanical Cost Data 2015.

40 Average calculated based on RSMeans Mechanical Cost Data 2015.

41 Average calculated based on RSMeans Mechanical Cost Data 2015 for Scroll, air cooled condenser chillers.

the *average* savings over the defined summer peak period and is presented so that savings can be bid into PJM's capacity market. Both values provided are based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren.

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

= 91.3% [42]

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

= 47.8% [43]

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS AND FOSSIL FUEL SAVINGS

Non-fuel switch measures:

ΔkWh = [Cooling savings] + [Heating savings] + [DHW savings]

Cooling Savings = $(Capacity_{cool} * EFLH_{Cool} * (1/EER_{base} - 1/EER_{GSHP}))/1000$

Heating Savings = $(Capacity_{Heat} * EFLH_{Heat} * (1/HSPF_{base} - 1/(COP_{GSHP} * 3.412)))/1000$

DHW Savings = $Elec_{DHW} * (\%DHW * ((1/EF_{elecbase}) * HotWaterUse_{Gallon} * \gamma Water * (Tout - Tin) * 1/3412))$

Fuel switch measures:

Fuel switch measures must produce positive total lifecycle fuel savings (i.e., reduction in Btus at the premises) in order to qualify. This is determined as follows (note for early replacement measures the lifetime savings should be calculated by calculating savings for the remaining useful life of the existing equipment and for the remaining measure life):

SiteEnergySavings (MMBTUs) = GasHeatReplaced + FurnaceFanSavings – GSHPSiteHeatConsumed + GSHPSiteCoolingImpact + GSHPSiteWaterImpact

GasHeatReplaced = $(HeatLoad * 1/AFUE_{base}) / 1{,}000{,}000$

FurnaceFanSavings = $(FurnaceFlag * HeatLoad * 1/AFUE_{base} * F_e) / 1{,}000{,}000$

GSHPSiteHeatConsumed = $(HeatLoad * 1/COP_{GSHP})/ 1{,}000{,}000$

GSHPSiteCoolingImpact = $(EFLH_{cool} * Capacity_{Cool} * (1/EER_{base} - 1/EER_{GSHP})/1000 * 3412)/ 1{,}000{,}000$

$GSHPSiteWaterImpact_{Gas}$ = $(\%DHWDisplaced * ((1/EF_{Gas} * GPD * Household * 365.25 * \gamma Water * (T_{OUT} -$

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[42] 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.

[43] 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.

T_{IN}) * 1.0) / 1,000,000

GSHPSiteWaterImpact$_{Electric}$ = (%DHWDisplaced * ((1/EF$_{Elec}$ * GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0 ~~* 3412~~)/ 1,000,000

If SiteEnergySavings calculated above is positive, the measure is eligible.

The appropriate savings claim is dependent on which utilities are supporting the measure as provided in a table below:

Measure supported by:	Electric Utility claims (kWh):	Gas Utility claims (therms):
Electric utility only	SiteEnergySavings * 1,000,000/3,412	N/A
Electric and gas utility (Note utilities may make alternative agreements to how savings are allocated as long as total MMBtu savings remains the same).	%IncentiveElectric * SiteEnergySavings * 1,000,000/3,412	%IncentiveGas * SiteEnergySavings * 10
Gas utility only	N/A	SiteEnergySavings * 10

Note for Early Replacement measures, the efficiency terms of the existing unit should be used for the remaining useful life of the existing equipment (6 years for ASHP and Central AC, 6 years for furnace, 8 years for boilers or GSHP, 15 years for electric resistance), and the efficiency terms for a new baseline unit should be used for the remaining years of the measure. See assumptions below.

Where:

Capacity$_{cool}$ = Cooling Output Capacity of Ground Source Heat Pump (Btu/hr)
= Actual installed

EFLH$_{cool}$ = Cooling Equivalent Full Load Hours
Dependent on building type and Existing Buildings or New Construction, provided in section 4.4 HVAC End Use

EER$_{Base}$ = Energy Efficiency Ratio (EER) of existing cooling unit (kBtu/hr / kW).
For early replacement, use actual EER rating for the remaining useful life of the existing equipment (6 years for ASHP and Central AC, 8 years for GSHP). If EER unknown but SEER available, convert using the equation:[44] $EER_{exist} = (-0.02 * SEER_{exist}^2) + (1.12 * SEER_{exist})$.

For TOS, NC, and the remaining measure life of early replacement, use minimum standard efficiencies as specified in tables in 'Definition of Baseline Equipment' section.

EER$_{GSHP}$ = Part Load Energy Efficiency Ratio efficiency of efficient GSHP unit[45]

[44] From Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder.

[45] From Res GSHP measure of the IL-TRM: As per conversations with David Buss territory manager for Connor Co, the EER rating

= Actual installed

HeatLoad = Calculated heat load for the building

= $EFLH_{Heat}$ * $Capacity_{Heat}$

$Capacity_{Heat}$ = Heating Output Capacity of Ground Source Heat Pump (Btu/hr)
= Actual installed

$EFLH_{Heat}$ = Heating Equivalent Full Load Hours of heat pump
Dependent on building type and Existing Buildings or New Construction, provided in section 4.4 HVAC End Use

$HSPF_{Base}$ = Heating System Performance Factor of baseline electric heating system (kBtu/kWh)
For early replacement, use actual EER rating for the remaining useful life of the existing equipment (6 years for ASHP and Central AC, 8 years for GSHP or 15 years for electric resistance). For electric resistance, assume 3.41.[46].

For TOS, NC, and the remaining measure life of early replacement, use minimum standard efficiencies as specified in tables in 'Definition of Baseline Equipment' section.

COP_{GSHP} = Part Load Coefficient of Performance of efficient GSHP[47]

= Actual installed

3.412 = Constant to convert the COP of the unit to the Heating Season Performance Factor (HSPF)

$Elec_{DHW}$ = 1 if building has electric DHW
= 0 if building has non electric DHW
= 0 if one to one replacement of existing Ground Source Heat Pump

%DHW = Percentage of total DHW load that the GSHP will provide
= Actual if known
= If unknown and if desuperheater installed, assume 44%[48]
= 0% if no desuperheater installed

$EF_{elecbase}$ = Energy Factor of baseline electric DHW
= Actual. If unknown or for new construction, assume federal standard as defined in applicable table in 'Definition of Baseline Equipment' section.

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

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

1. Consumption per usable storage tank capacity

of an ASHP equate most appropriately with the full load EER of a GSHP.

[46] Electric resistance has a COP of 1.0 which equals 1/0.293 = 3.41 HSPF.

[47] As per Res GSHP measure.

[48] Assumes that the desuperheater can provide two thirds of hot water needs for eight months of the year (2/3 * 2/3 = 44%). Based on input from Doug Dougherty, Geothermal Exchange Organization.

= Capacity * Consumption/cap

Where:

Capacity = Usable capacity of hot water storage tank in gallons

= Actual

Consumption/cap = Estimate of consumption per gallon of usable tank capacity, based on building type:[49]

Building Type[50]	Consumption/Cap
Convenience	528
Education	568
Grocery	528
Health	788
Large Office	511
Large Retail	528
Lodging	715
Other Commercial	341
Restaurant	622
Small Office	511
Small Retail	528
Warehouse	341
Nursing	672
Multi-Family	894

2. Consumption per unit area by building type
= (Area/1000) * Consumption/1,000 sq.ft.

Where:

Area = Area in sq.ft that is served by DHW boiler

= Actual

Consumption/1,000 sq.ft. = Estimate of DHW consumption per 1,000 sq.ft. based on building type:[51]

[49] Methodology based on Cadmus analysis. Annual hot water usage in gallons based on CBECS (2012) and RECS (2009) consumption data of East North Central (removed outliers of 1,000 kBtuh or less) to calculate hot water usage. Annual hot water gallons per tank size gallons based on the tank sizing methodology found in ASHRAE 2011 HVAC Applications. Chapter 50 Service Water Heating. Demand assumptions (gallons per day) for each building type based on ASHRAE Chapter 50 and to LBNL White Paper. LBL-37398 Technology Data Characterizing Water Heating in Commercial Buildings: Application to End Use Forecasting. Assumes hot water heater efficiency of 80%.

[50] According to CBECS 2012 "Lodging" buildings include Dormitories, Hotels, Motel or Inns and other Lodging and "Nursing" buildings include Assisted Living and Nursing Homes.

[51] Methodology based on Cadmus analysis. Annual hot water usage in gallons based on CBECS (2012) and RECS (2009) consumption data of East North Central (removed outliers of 1,000 kBtuh or less) to calculate hot water usage. Annual hot water gallons per tank size gallons based on the tank sizing methodology found in ASHRAE 2011 HVAC Applications. Chapter 50 Service Water Heating. Demand assumptions (gallons per day) for each building type based on ASHRAE Chapter 50 and to LBNL White Paper. LBL-37398 Technology Data Characterizing Water Heating in Commercial Buildings: Application to End Use Forecasting. Assumes hot water heater efficiency of 80%.

Building Type[52]	Consumption/1,000 sq.ft.
Convenience	4,594
Education	7,285
Grocery	697
Health	24,540
Large Office	1,818
Large Retail	1,354
Lodging	29,548
Other Commercial	3,941
Restaurant	44,439
Small Office	1,540
Small Retail	6,111
Warehouse	1,239
Nursing	30,503
Multi-Family	15,434

γWater = Density of water

= 8.33 pounds per gallon

T_{out} = Tank temperature

= 125°F

T_{in} = Incoming water temperature from well or municiplal system

= 50.7°F [53]

1 = Heat Capacity of water (1 Btu/lb*°F)

3.412 = Conversion from Btu to kWh

$AFUE_{base}$ = Baseline Annual Fuel Utilization Efficiency Rating.
For early replacement measures, use actual AFUE rating for the remaining useful life of the existing equipment (6 years for furnace, 8 years for boilers).

For TOS, NC, and the remaining measure life of early replacement, use minimum standard efficiencies as specified in tables in 'Definition of Baseline Equipment' section.

FurnaceFlag = 1 if system replaced is a gas furnace, 0 if not.

F_e = Furnace Fan energy consumption as a percentage of annual fuel consumption

= 7.7%[54]

[52] According to CBECS 2012 "Lodging" buildings include Dormitories, Hotels, Motel or Inns and other Lodging and "Nursing" buildings include Assisted Living and Nursing Homes.
[53] Table 4 in Chen, et. al., "Calculating Average Hot Water Mixes of Residential Plumbing Fixtures", June 2020, reports a value of 50.7°F for inlet water temperature for U.S. Census Division 3.
[54] F_e is estimated using TRM models for the three most popular building types for programmable thermostats: low-rise office (10.2%), sit-down restaurant (8.6%), and retail – strip mall (4.4%). 7.7% reflects the average Fe of the three building types. See "Fan Energy Factor Example Calculation 2021-06-23.xlsx" for reference.

$EF_{GasBase}$ = Energy factor of Baseline natural gas DHW heater

= Actual. If unknown or New Construction, assume federal standard as defined in applicable table in 'Definition of Baseline Equipment' section.

3412 = Btu per kWh

%IncentiveElectric = % of total incentive paid by electric utility

= Actual

%IncentiveGas = % of total incentive paid by gas utility

= Actual

Non Fuel Switch Illustrative Examples

New Construction using ASHP baseline:

For example, a 10 ton closed loop unit with Part Load EER rating of 20 and Part Load COP of 4.4, with desuperheater installed, and with a 100 gallon electric water heater in an Assisted living building in Chicago:

ΔkWh = [120,000 * 1,457 * (1/11 – 1/20) / 1000] + [1,646* 120,000 * (1/11 – 1/(4.4*3.412)) / 1000] + [1 * 0.44 * ((1/0.9568 * (100*672) * 8.33 * (125-50.7) * 1)/3412)]

= 7,153 + 4,800 +5,606 = 17,559 kWh

Early Replacement:

For example, a 10 ton closed loop unit with Part Load EER rating of 20 and Part Load COP of 4.4 and with desuperheater installed in in an Assisted living building in Chicago with a 100 gallon electric water heater, replacing an existing working Air Source Heat Pump with efficiency ratings of 8.2 EER and 7.7 HSPF:

ΔkWH for remaining life of existing unit (1st 8 years):

= [120,000 * 1,457 * (1/8.2 – 1/20) / 1000] + [1,646* 120,000 * (1/7.7 – 1/(4.4*3.412)) / 1000] + [1 * 0.44 * ((1/0.9568 * (100*672) * 8.33 * (125-50.7) * 1)/3412)]

= 12,580 + 12,495 +5606 = 30,681 kWh

ΔkWH for remaining measure life (next 17 years):

= [120,000 * 1,457 * (1/11 – 1/20) / 1000] + [1,646* 120,000 * (1/11 – 1/(4.4*3.412)) / 1000] + [1 * 0.44 * ((1/0.9568 * (100*672) * 8.33 * (125-50.7) * 1)/3412)]

= 7,153 + 4,800 +5,606 = 17,559 kWh

Fuel Switch Illustrative Example

[for illustrative purposes a 50:50 Incentive is used for joint programs]

Early Replacement fuel switch:

A 10 ton closed loop unit with Part Load EER rating of 20 and Part Load COP of 4.4 in an Assisted Living building in Chicago with a 100 gallon gas water heater replaces an existing working natural gas boiler with 75% efficiency and central AC of 9.5 EER, and desuperheater installed with natural gas existing DHW heater:

LifetimeSiteEnergySavings (MMBTUs) = LifetimeGasHeatReplaced + LifetimeFurnaceFanSavings – LifetimeGSHPSiteHeatConsumed + LifetimeGSHPSiteCoolingImpact + LifetimeGSHPSiteWaterImpact

LifetimeGasHeatReplaced = ((HeatLoad * 1/$AFUE_{exist}$) / 1,000,000 * 8 years) + ((HeatLoad * 1/$AFUE_{base}$) / 1,000,000 * 17 years)

= ((120,000 * 1,646 * 1/0.75) / 1,000,000 * 8) + ((120,000 * 1,646 * 1/0.8) / 1,000,000 * 17)

= 6304.2 MMBtu

LifetimeFurnaceFanSavings = ((FurnaceFlag * HeatLoad * 1/$AFUE_{exist}$ * F_e) / 1,000,000 * 8 years) + ((FurnaceFlag * HeatLoad * 1/$AFUE_{base}$ * F_e_New) / 1,000,000 * 17 years)

= 0 MMBtu

LifetimeGSHPSiteHeatConsumed = (HeatLoad * 1/COP_{GSHP}) / 1,000,000 * 25 years

= (120,000 * 1,646 * 1/4.4)/1,000,000 * 25

= 1122.3 MMBtu

Fuel Switch Illustrative Example continued

LifetimeGSHPSiteCoolingImpact = $(((EFLH_{cool} * Capacity_{Cool} * (1/EER_{exist} – 1/EER_{GSHP}))/1000 * 3412) / 1{,}000{,}000 * 6 \text{ years}) + (((EFLH_{cool} * Capacity_{Cool} * (1/EER_{base}– 1/EER_{GSHP}))/1000 * 3412) / 1{,}000{,}000 * 19 \text{ years})$

= (((120000 * 1,457 * (1/9.5 – 1/20)) / 1000 * 3412)/1,000,000 * 6) + (((120000 * 1,457 * (1/11 – 1/20)) / 1000) * 3412)/1,000,000 * 19)

= 661.5 MMBtu

$LifetimeGSHPSiteWaterImpact_{Gas}$ = $((\%DHWDisplaced * ((1/EF_{Gas} * GPD * Household * 365.25 * \gamma Water * (T_{OUT} – T_{IN}) * 1.0) / 1{,}000{,}000) * 25 \text{ years}$

= (0.44 * (1/ 0.8 * (100*672) * 8.33 * (125-50.7) * 1) / 1,000,000) * 25

= 571.9 MMBtu

LifetimeSiteEnergySavings (MMBTUs) = 6304.2 + 0 – 1122.3 + 661.5 + 571.9 = 6,415 MMBtu [Measure is eligible]

First 6 years:

SiteEnergySavings_FirstYear (MMBTUs) = GasHeatReplaced + FurnaceFanSavings – GSHPSiteHeatConsumed + GSHPSiteCoolingImpact + GSHPSiteWaterImpact

GasHeatReplaced = $(HeatLoad * 1/AFUE_{exist}) / 1{,}000{,}000$

= (120,000 * 1,646 * 1/0.75) / 1,000,000

= 263.4 MMBtu

FurnaceFanSavings = $(FurnaceFlag * HeatLoad * 1/AFUE_{exist} * F_e) / 1{,}000{,}000$

= 0 MMBtu

GSHPSiteHeatConsumed = $(HeatLoad * 1/COP_{GSHP}) / 1{,}000{,}000$

= (120,000 * 1,646 * 1/4.4)/ 1,000,000

= 44.9 MMBtu

GSHPSiteCoolingImpact = $((EFLH_{cool} * Capacity_{Cool} * (1/EER_{exist}– 1/EER_{GSHP}))/1000 * 3412)/1{,}000{,}000$

= ((120000 * 1,457 * (1/9.5 – 1/20)) / 1000 * 3412)/1,000,000

= 33.0 MMBtu

$GSHPSiteWaterImpact_{Gas}$ = $(\%DHWDisplaced * ((1/EF_{Gas} * GPD * Household * 365.25 * \gamma Water * (T_{OUT} – T_{IN}) * 1.0) / 1{,}000{,}000$

Fuel Switch Illustrative Example continued

Remaining 10 years:

SourceEnergySavings_PostAdj (MMBTUs) = GasHeatReplaced + FurnaceFanSavings – GSHPSourceHeatConsumed + GSHPSourceCoolingImpact + GSHPSourceWaterImpact

GasHeatReplaced = (HeatLoad * 1/$AFUE_{exist}$) / 1,000,000

= (120,000 * 1,646 * 1/0.8) / 1,000,000

= 246.9 MMBtu

FurnaceFanSavings = (FurnaceFlag * HeatLoad * 1/$AFUE_{exist}$ * F_e) / 1,000,000

= 0 MMBtu

GSHPSiteHeatConsumed = (HeatLoad * 1/COP_{GSHP}) / 1,000,000

= (120,000 * 1,646 * 1/4.4)/ 1,000,000

= 44.9 MMBtu

GSHPSiteCoolingImpact = (($EFLH_{cool}$ * $Capacity_{Cool}$ * (1/EER_{exist}– 1/EER_{GSHP}))/1000 * 3412)/1,000,000

= ((120000 * 1,457 * (1/11 – 1/20)) / 1000 * 3412)/1,000,000

= 24.4 MMBtu

$GSHPSiteWaterImpact_{Gas}$ = (%DHWDisplaced * ((1/EF_{Gas} * GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0) / 1,000,000

= (0.44 * (1/ 0.8 * (100*672) * 8.33 * (125-50.7) * 1) / 1,000,000

= 22.9 MMBtu

SourceEnergySavings_PostAdj (MMBTUs) = 246.9 + 0 – 44.9 + 24.4 + 22.9 = 249.3 MMBtu

Savings would be claimed as follows:

Measure supported by:	Electric Utility claims:	Gas Utility claims:
Electric utility only	First 6 years: 274.4 * 1,000,000/3412 = 80,422 kWh Remaining 10 years: 249.3 * 1,000,000/3412 = 73,066 kWh	N/A
Electric and gas utility	First 6 years: 0.5 * 274.4 * 1,000,000/3412 = 40,211 kWh Remaining 10 years: 0.5 * 249.3 * 1,000,000/3412 = 36,533 kWh	First 6 years: 0.5 * 274.4 * 10 = 1372 Therms Remaining 10 years: 0.5 * 249.3 * 10 = 1247 Therms
Gas utility only	N/A	First 6 years: 274.4 * 10 = 2744 Therms Remaining 10 years: 249.3 * 10 = 2493 Therms

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = (Capacity_{Cool} * (1/EER_{base} - 1/EER_{GSHP}))/1000 * CF$$

Where:

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)
= 91.3%[55]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)
= 47.8%[56]

New Construction or Time of Sale:

For example, a 10 ton closed loop unit with Full Load EER rating of 20:

ΔkW_{SSP} = (120,000 * (1/11 – 1/20))/1000 * 0.913
= 4.482kW

ΔkW_{PJM} = (36,000 * (1/11 – 1/20))/1000 * 0.478
= 2.347kW

Early Replacement:

For example, a 10 ton closed loop unit with Full Load 20 EER replaces an existing working Air Source Heat Pump with 8.2 EER:

ΔkW_{SSP} for remaining life of existing unit (1st 8 years):
= (120,000 * (1/8.2 – 1/20))/1000 * 0.913
= 7.883 kW

ΔkW_{SSP} for remaining measure life (next 17 years):
= (120,000 * (1/11– 1/20))/1000 * 0.913
= 4.482kW

ΔkW_{PJM} for remaining life of existing unit (1st 8 years):
= (120,000 * (1/8.2 – 1/20))/1000 * 0.478
= 4.127 kW

ΔkW_{PJM} for remaining measure life (next 17 years):
= (120,000 * (1/11 – 1/20))/1000 * 0.478
= 2.347kW

FOSSIL FUEL SAVINGS

Calculation provided together with Electric Energy Savings above.

[55] 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.

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

WATER AND OTHER NON-ENERGY IMPACT DESCRIPTIONS AND CALCULATION
N/A

DEEMED O&M COST ADJUSTMENT CALCULATION
N/A

COST EFFECTIVENESS SCREENING AND LOAD REDUCTION FORECASTING WHEN FUEL SWITCHING
This measure can involve fuel switching from gas to electric.

For the purposes of forecasting load reductions due to fuel switch GSHP projects; changes in site energy use at the customer's meter (using ΔkWh algorithm below) adjusted for utility line losses (at-the-busbar savings), customer switching estimates, NTG, and any other adjustment factors deemed appropriate, should be used.

The inputs to cost effectiveness screening should reflect the actual impacts on the electric and fuel consumption at the customer meter and, for fuel switching measures, this will not match the output of the calculation/allocation methodology presented in the "Electric Energy Savings" and "Fossil Fuel Savings" sections above. Therefore in addition to the calculation of savings claimed, the following values should be used to assess the cost effectiveness of the measure. For Early Replacement measures, the efficiency terms of the existing unit should be used for the remaining useful life of the existing equipment (6 years for ASHP and Central AC, 7 years for furnace, 8 years for boilers or GSHP, 15 years for electric resistance), and the efficiency terms for a new baseline unit should be used for the remaining years of the measure.

ΔTherms = [Heating Consumption Replaced] + [DHW Savings if existing natural gas DHW]

= [(HeatLoad * 1 $AFUE_{base}$)/ 100,000] + [(1 – ElecDHW) * %DHW * (1/ $EF_{GasBase}$ * $HotWaterUse_{Gallon}$ * γWater * (T_{OUT} – T_{IN}) * 1.0) / 100,000)]

ΔkWh = [FurnaceFanSavings] - [GSHP heating consumption] + [Cooling savings] + [DHW savings if existing electric DHW]

= [FurnaceFlag * HeatLoad * 1/$AFUE_{base}$ * F_e * 0.000293] - [(HeatLoad * (1/ COP_{GSHP} * 3.412))/1000] + [($EFLH_{cool}$ * $Capacity_{Cool}$ * (1/EER_{base} - 1/EER_{GSHP}))/1000] + [ElecDHW * %DHW * ((1/EF_{ELEC} * $HotWaterUse_{Gallon}$ * γWater * (T_{OUT} – T_{IN}) * 1.0) / 3412)]

Illustrative Example of Cost Effectiveness Inputs for Fuel Switching:

For example, a 10 ton unit with Part Load EER rating of 20 and Part Load COP of 4.4 in an Assisted living building in Chicago with a 100 gallon gas water heater replaces an existing working natural gas boiler with 75% efficiency and air-cooled chiller of 9.5 EER. [Note the calculation provides the annual savings for the first 8 years of the measure life, an additional calculation (not shown) would be required to calculate the annual savings for the remaining life (years 9-25)]:

ΔTherms =[HeatLoad * 1 $AFUE_{base}$)/ 100,000] + [(1 – ElecDHW) * %DHW * (1/ $EF_{GasBase}$ * $HotWaterUse_{Gallon}$ * γWater * (T_{OUT} – T_{IN}) * 1.0) / 100,000)]

= [(120,000 * 1,646 * 1/0.75)/100,000] + [((1 - 0) * 0.44 * (1/0.8 * (100*672) * 8.33 * (125-50.7) * 1)/100000)]

= 2,634 + 229

= 2,863 therms

ΔkWh = [FurnaceFlag * HeatLoad * 1/$AFUE_{base}$ * F_e * 0.000293] - [(HeatLoad * (1/ COP_{GSHP} * 3.412))/1000] + [($EFLH_{cool}$ * $Capacity_{Cool}$ * (1/EER_{base} - 1/EER_{GSHP}))/1000] + [ElecDHW * %DHW * ((1/EF_{ELEC} * $HotWaterUse_{Gallon}$ * γWater * (T_{OUT} – T_{IN}) * 1.0) / 3412)]

= 0 - [(1646 * 120000 * (1/ 4.4 * 3.412))/1000] + [(1457* 120000 * (1/11 - 1/20))/1000] + [0 * (0.44 * ((1/0.9568) * (100*672) * 8.33 * (125 - 50.7) * 1 /3412))]

= 0 - 153,168 + 7153 + 0

= -146,015 kWh

MEASURE CODE: CI-HVC-GSHP-V06~~5~~-220101

REVIEW DEADLINE: 1/1/2025

4.4.48 Small Commercial Thermostats

DESCRIPTION

This measure characterizes the energy savings from the installation of either a Programmable or an advanced Thermostat to reduce heating and cooling consumption in a small commercial building.

The thermostat must be installed to control a single-zone HVAC system. This measure is limited to packaged HVAC units 10 tons or less. This measure should not be used when HVAC systems are being replaced, in new construction and whenever code compliance is required.

The savings associated with small commercial installations of thermostats had not been well evaluated at the time this measure was created for TRM Version 8.0. In the absence of assumptions specific to small commercial customers, the percent savings derived from Illinois Residential evaluations were used. In version 9.0 the cooling savings percentage was updated based on research conducted on small commercial programmable thermostat applications.[57] In CY2020, additional research was performed to support a potential update to the heating savings percentage. The results did not provide a sufficient statistically significant basis for changing the current assumption.

Note that while these devices and service could potentially be used as part of a demand response program, the costs, delivery, impacts, and other aspects of DR-specific program delivery are not included in this characterization at this time, though they could be added in the future.

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

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

DEFINITION OF EFFICIENT EQUIPMENT

The criteria for this measure are established by replacement of a manual-only thermostat, with one that has the capability to establish a schedule of time and/or temperature setpoints, or replacement of a programmable thermostat with an Advanced Thermostat.

DEFINITION OF BASELINE EQUIPMENT

The baseline is assumed to be a manual or programmable thermostat.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 11 years.[58]

DEEMED MEASURE COST

For DI and other programs for which installation services are provided, the actual material, labor, and other costs should be used. If unknown then the average incremental cost for the new installation measure is assumed to be $175.

LOADSHAPE

Loadshape C05 - Commercial Electric Heating and Cooling, or

Loadshape C03 - Commercial Cooling

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57 See "Small Commercial Thermostats Research," memorandum from Guidehouse to ComEd dated May 15, 2020.

58 Based on 2017 Residential Smart Thermostat Workpaper, prepared by SCE and Nest for SCE (Work Paper SCE17HC054, Revision #0). Estimate ability of smart systems to continue providing savings after disconnection and conduct statistical survival analysis which yields 9.2-13.8 year range.

COINCIDENCE FACTOR

In the absence of conclusive results from empirical studies on peak savings, the TAC agreed to a temporary assumption of 50% of the cooling coincidence factor, acknowledging that while the savings from the Thermostat will track with the cooling load, the impact during peak periods may be lower. This is an assumption that could use future evaluation to improve these estimates.

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

= 45.7 [59]

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

= 23.9% [60]

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS

Heating savings are provided based upon the percentage savings from the Residential version of this measure. Cooling savings are based on research on small commercial programmable thermostat installations. Future research on heating savings percentages for small commercial applications, and heating and cooling savings percentages for Advanced Thermostat applications, should be used to improve this assumption.

ΔkWh[61] = $ΔkWh_{heating}$ + $ΔkWh_{cooling}$

$ΔkWh_{heating}$ = (%ElecHeat * $kBtu/hr_{heat}$ * 1/HSPF * $EFLH_{heat}$ * Heating_Reduction * BAF) + (~~(1 – %ElecHeat) *~~ ΔTherms * F_e * 29.3)

$ΔkWh_{cool}$ = $kBtu/hr_{cool}$ * 1/SEER * $EFLH_{cool}$ * Cooling_Reduction * BAF

Where:

%ElecHeat = Percentage of heating savings assumed to be electric

= 1 if electric heat, 0 if gas heat. If unknown assumu 0.08[62].

$kBtu/hr_{heat}$ = capacity of the heating equipment in kBtu per hour.

= Actual. If unknown assume 114.5[63]

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[59] 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. Multiplied by 50%.

[60] 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. Multiplied by 50%.

[61] Electrical savings are a function of both heating and cooling energy usage reductions. For heating this is a function of the percent of electric heat (heat pumps) and fan savings in the case of a natural gas furnace.

[62] Based on percentage of customers in ComEd Small Business Thermostat program with electric heat.

[63] Average capacity of 705 installs of thermostats in Ameren Illinois territory installed from 2015-2020.

HSPFbase = Heating Seasonal Performance Factor of the baseline equipment

= Actual, if unknown assume Code base

$EFLH_{heat}$ = Heating mode equivalent full load hours in Existing Buildings are provided in section 4.4 HVAC End Use.

Heating_Reduction = Assumed percentage reduction in total building heating energy consumption due to thermostat

= 8.8%[64]

ΔTherms = Therm savings if Natural Gas heating system

= See calculation in Natural Gas section below

F_e = Furnace Fan energy consumption as a percentage of annual fuel consumption

= 7.7%[65]

29.3 = kWh per therm

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

= Actual. If unknown assume 61.0[66]

SEER = Seasonal Energy Efficiency Ratio of the cooling equipment

= Actual, is unknown assume Code base

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

Cooling_Reduction = Average percentage reduction in total building cooling energy consumption due to installation of thermostat:

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64 Assumed equal to assumption for Residential Advanced Thermostats with manual thermostat baseline, before adding savings from Thermostat Optimization (which is not applicable to small commercial customers). Note that a Guidehouse billing study in CY2020 did not find a statistically significant basis for adjusting this assumption for commercial applications, see "Small Commercial Thermostats TRM Research" memo. April 21, 2021.
Estimates of heating and cooling reduction factors are based on consumption data analyses with matching to non-participants and are therefore net with respect to participant spillover and between net and gross with respect to free ridership. Like all consumption data analyses, they are gross with respect to non-participant spillover. For more detail, see Table 5-3 in Volume 4 of the IL-TRM. Consistent with Section 7.2 of the Illinois EE Policy Manual, applicable net-to-gross adjustments to these factors will be determined as part of the annual SAG net-to-gross process.

65 F_e is estimated using TRM models for the three most popular building types for programmable thermostats: low-rise office (10.2%), sit-down restaurant (8.6%), and retail – strip mall (4.4%). 7.7% reflects the average Fe of the three building types. See "Fan Energy Factor Example Calculation 2021-06-23.xlsx" for reference.

66 Average capacity of 639 installs of thermostats on units <=10tons in Ameren Illinois territory installed from 2015-2020 and 706 installs on units <=10tons in ComEd territory in 2021.

= 17.7%[67]

BAF = Baseline adjustment factor.

= 1.0, if the baseline thermostat was manual type

= 0.6, if the baseline thermostat was programmable type[68]

= 0.8, if the baseline is unknown[69]

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$\Delta kW = kBtu/hr_{cool} * 1/EER * Cooling\_Reduction * BAF * CF$

Where:

EER = Energy Efficiency Ratio of the equipment

= Actual, if unknown assume current Code. For air-cooled units < 65 kBtu/hr, assume the following conversion from SEER to EER for calculation of peak savings:[70]

$$EER = (-0.02 * SEER^2) + (1.12 * SEER)$$

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

= 45.7 [71]

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

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[67] Based on research conducted by Guidehouse on a sample of IL Small Commercial programmable thermostat installations, which found a range of savings values depending on the modeling assumptions used. Guidehouse recommended selecting the midpoint of this range, which it deemed preferable to continuing to rely on Residential assumptions, while also accounting for the relative uncertainties involved. See "Small Commercial Thermostats Research" memo completed in 2020.
Estimates of heating and cooling reduction factors are based on consumption data analyses with matching to non-participants and are therefore net with respect to participant spillover and between net and gross with respect to free ridership. Like all consumption data analyses, they are gross with respect to non-participant spillover. For more detail, see Table 5-3 in Volume 4 of the IL-TRM. Consistent with Section 7.2 of the Illinois EE Policy Manual, applicable net-to-gross adjustments to these factors will be determined as part of the annual SAG net-to-gross process.

[68] This factor represents the ratio of thermostat adjustment savings to thermostat replacement savings. It is based on actual thermostat algorithm data (i.e., degrees of setback, hours values, fan modes) from two years of ComEd AirCare Plus Program data (PY9+ and CY2018), including 382 thermostat adjustment installations and 3,847 thermostat replacement installations. An analysis of the data showed that on average, thermostat adjustments saved 61% and 59% of the thermostat replacement cooling savings and heating savings, respectively. For simplicity, a value of 0.6 was selected for both cooling and heating savings adjustment. See IL TRM Workpaper "4.4.48 Small Commercial Thermostats", Guidehouse, 6/23/2021 for details.

[69] Review of ComEd's 2020 Baseline Study and 2019-2020 Program Data indicates that approximately half of installs are in buildings with existing manual thermostats, and half with existing programmable thermostats.

[70] 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.

[71] 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. Multiplied by 50%.

= 23.9%[72]

Other variables as provided above.

NATURAL GAS SAVINGS

$$\Delta Therms = ((1 - \%ElectricHeat) * EFLH_{heat} * Capacity * 1/AFUE * Heating\_Reduction * BAF) / 100{,}000 Btu/Therm$$

Where:

Capacity = Nominal Heating Input Capacity (Btu/hr) of heating system

= Actual

AFUE = Annual Fuel Utilization Efficiency Rating

= Actual, if unknown assume code baseline.

Other variables as provided above.

WATER AND OTHER NON-ENERGY IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-THST-V0~~3~~4-220101

REVIEW DEADLINE: 1/1/2025

[72] 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. Multiplied by 50%.

4.5.4 LED Bulbs and Fixtures

DESCRIPTION

This characterization provides savings assumptions for a variety of LED lamps including Omnidirectional (e.g., A-Type lamps), Decorative (e.g., Globes and Torpedoes) and Directional (PAR Lamps, Reflectors, MR16), TLEDs and fixtures including refrigerated case, recessed and outdoor/garage fixtures.

If the implementation strategy does not allow for the installation location to be known, for Residential targeted programs (e.g., an upstream retail program), a deemed split of 97% Residential and 3% Commercial assumptions should be used,[73] and for Commercial targeted programs a deemed split of 97% Commercial and 3% Residential for non-linear LED Bulbs and 100% Commercial and 0% Residential for LED Fixtures and TLEDs should be used.[74]

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

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

DEFINITION OF EFFICIENT EQUIPMENT

In order for this characterization to apply, new lamps must be ENERGY STAR in accordance with ENERGY STAR specification v2.1 (effective 1/2/2017) or be listed on the Design Lights Consortium Qualifying Product List.[75]

DEFINITION OF BASELINE EQUIPMENT

The Standard Rx Program will assume a Time of Sale baseline for all one to one replacements, and early replacement for lighting redesign and early retirement for delamping.

For early replacement, the baseline is the existing fixture being replaced.

If the existing fixture is a T12: In July 14, 2012, Federal Standards were enacted that were expected to eliminate T-12s as an option for linear fluorescent fixtures. Through v3.0 of the TRM, it was assumed that the T-12 would no longer be baseline for retrofits from 1/1/2016. However, due to significant loopholes in the legislation, T-12 compliant product is still freely available and in Illinois T-12s continue to hold a significant share of the existing and replacement lamp market. From v8.0 on, a midlife adjustment is applied after the remaining useful life of the T12 fixture (calculated as 1/3 of the 40,000 hour ballast life/ hours). This assumes that T12 replacement lamps will continue to be available until then. See 'Early Replacement Measures with T12 baseline' section.

For Time of Sale, refer to the baseline tables at the end of this measure.

In 2012, Federal legislation stemming from the Energy Independence and Security Act of 2007 (EIAS) required all general-purpose light bulbs (defined as omni-directional or standard A-lamps) between 40 watts and 100 watts to have ~30% increased efficiency, essentially phasing out standard incandescent technology. In 2012, the 100 w lamp standards went in to effect followed by the 75 w lamp standards in 2013 and 60 w and 40 w lamps in 2014.

Additionally, an EISA backstop provision was included that would require replacement baseline lamps to meet an efficacy requirement of 45 lumens/watt or higher beginning on 1/1/2020.

However, in December 2019, DOE issued a final determination for General Service Incandescent Lamps (GSILs),

[73] RES v C&I split is based on a weighted (by sales volume) average of ComEd PY8, PY9 and CY2018 and Ameren PY8 in store intercept survey results. See 'RESvCI Split_2019.xlsx.

[74] Based on ComEd's Instant Discounts program CY2018, CY2019 and CY2020 (Rounds 1 and 2) Purchaser Survey analysis. See ComEd Instant Discounts Enduser Survey TRM Updates.xlsx. For Residential installations, hours of use assumptions from '5.5.6 LED Downlights' should be used for LED fixtures and '5.5.8 LED Screw Based Omnidirectional Bulbs' should be used for LED bulbs.

[75] ENERGY STAR Program Requirements Product Specifications for Lamps (Light Bulbs), version 2.1, effective January 2, 2017.

finding that this more stringent standard was not economically justified.

The natural growth of LED market share however, has and will continue to grow over the lifetime of the LED measures installed. The TAC convened a Lamp Forecast Working Group to develop a forecast of the baseline growth of LED, based upon historical growth rates provided via CREED LightTracker data, comparisons with no-program states and review of projections provided by the Department of Energy.[76] The TAC determined that using the Residential-derived forecast is appropriate for the small commercial participants likely to be purchasing lamps through the efficiency programs.

This baseline forecast was then used to estimate how replacement lamps would change over the lifetime of an LED. A single mid-life adjustment is calculated that results in an equivalent net present value of lifetime savings as the forecast decline in annual savings.

Specialty and Directional lamps were not included in the original definition of General Service Lamps in the Energy Independence and Security Act of 2007 (EISA). Therefore, the initial baseline is an incandescent / halogen lamp described in the tables below.

A DOE Final Rule released on 1/19/2017 updated the EISA regulations to remove the exemption for these lamp types such that they become subject to the backstop provision defined within the original legislation. However, in September 2019 this decision was revoked in a new DOE Final Rule. The natural growth of LED market share of specialty and directional lamps was also estimated by the Working Group and applied to those lamp types.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

For fixtures, the 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).

For lamps lifetime is calculated as the rated lifetime of the product (actual if available, otherwise assume 20,000 hours for Omnidirectional, 17,000 hours for decorative and 25,000 for directional lamps based on average rated life of lamps on the ENERGY STAR Qualified Products list (accessed 6/16/2020)) divided by the reported operating hours, capped at 10 years.[77]

DEEMED MEASURE COST

Wherever possible, actual incremental costs should be used. Refer to reference table “LED component Cost & Lifetime” for defaults.

LOADSHAPE

Loadshape C06 - Commercial Indoor Lighting
Loadshape C07 - Grocery/Conv. Store Indoor Lighting
Loadshape C08 - Hospital Indoor Lighting
Loadshape C09 - Office Indoor Lighting
Loadshape C10 - Restaurant Indoor Lighting
Loadshape C11 - Retail Indoor Lighting
Loadshape C12 - Warehouse Indoor Lighting
Loadshape C13 - K-12 School Indoor Lighting

[76] US Department of Energy, “Energy Savings Forecast of Solid State Lighting in General Illumination Applications”, December 2019. The resultant forecast is provided on the SharePoint site “Lamp Forecast Workbook.xls”.
[77] Based on recommendation in the Dunsky Energy Consulting, Livingston Energy Innovations and Opinion Dynamics Corporation; NEEP Emerging Technology Research Report, p 6-18.

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
Loadshape C60 – Non-Residential Agriculture Lighting – 6 Hours
Loadshape C61 – Non-Residential Agriculture Lighting – 8 Hours
Loadshape C62 – Non-Residential Agriculture Lighting – 12 Hours
Loadshape C63 – Non-Residential Dairy Long Day Lighting – 17 Hours
Loadshape C64 – Non-Residential Agriculture Lighting – 24 Hours

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 (for early replacement) or baseline system. Reference the "LED New and Baseline Assumptions" table for default values.

$Watts_{EE}$ = Actual wattage of LED purchased / installed. If unknown, use default provided below:

For ENERGY STAR rated lamps the following lumen equivalence tables should be used:[78]

Omnidirectional Lamps - ENERGY STAR Minimum Luminous Efficacy = 80Lm/W for <90 CRI lamps and 70Lm/W for >=90 CRI lamps.

Minimum Lumens	Maximum Lumens	LED Wattage (WattsEE)	Baseline (WattsBase)	Delta Watts (WattsEE)
120	399	4.0	25	21.0
400	749	6.6	29	22.4
750	899	9.6	43	33.4
900	1,399	13.1	53	39.9

[78] See file "LED Lamp Updates 2021-06-09" for details on Guidehouse lamp wattage calculations based on equivalent baseline wattage and LED wattage of available ENERGY STAR product

Minimum Lumens	Maximum Lumens	LED Wattage (WattsEE)	Baseline (WattsBase)	Delta Watts (WattsEE)
1,400	1,999	16.0	72	56.0
2,000	2,999	21.8	150	128.2
3,000	3,999	28.9	200	171.1
4,000	5,000	35.7	300	264.3

Decorative Lamps - ENERGY STAR Minimum Luminous Efficacy = 65Lm/W for all lamps

Bulb Type	Minimum Lumens	Maximum Lumens	LED Wattage ($Watts_{EE}$)	Baseline ($Watts_{Base}$)	Delta Watts (WattsEE)
Omni-Directional 3-Way	1,100	1,999	14.7	100	85.3
	2,000	2,700	22.6	150	127.4
Globe (medium and intermediate bases less than 750 lumens)	150	349	3.0	25	22
	350	499	4.7	40	35.3
	500	574	5.7	60	54.3
	575	649	6.5	75	68.5
	650	1,000	8.2	100	91.8
Globe (candelabra bases less than 1050 lumens)	150	349	3.5	25	21.5
	350	499	4.4	40	35.6
	500	574	5.5	60	54.5
Decorative (Shapes B, BA, C, CA, DC, F, G, medium and intermediate bases less than 750 lumens)	160	299	2.6	25	22.4
	300	499	4.3	40	35.7
	500	800	5.8	60	54.2
Decorative (Shapes B, BA, C, CA, DC, F, G, candelabra bases less than 1050 lumens)	120	159	1.5	15	13.5
	160	299	2.7	25	22.3
	300	499	4.2	40	35.8
	500	650	5.5	60	54.5

Directional Lamps - ENERGY STAR Minimum Luminous Efficacy = 70Lm/W for <90 CRI lamps and 61 Lm/W for >=90CRI lamps.

For Directional R, BR, ~~and~~ ER, PAR, MR and MRX lamp types. Note the Center Beam Candle Power (CBCP) methodology described below the default table is the preferred methodology for PAR, MR and MRX lamps and should be used where data allows. Defaults for use when this information is not available are provided below:

Bulb Type	Minimum Lumens	Maximum Lumens	LED Wattage ($Watts_{EE}$)	Baseline ($Watts_{Base}$)	Delta Watts (WattsEE)
Reflector lamp types with medium screw bases (PAR20, PAR30(S,L), PAR38, R40, etc.) w/ diameter >2.25" (*see exceptions below)	400	649	7.0	50	43
	650	899	10.7	75	64.3
	900	1,049	13.9	90	76.1
	1,050	1,199	13.8	100	86.2
	1,200	1,499	15.9	120	104.1
	1,500	1,999	18.9	150	131.1
	2,000	4,200	27.3	250	222.7
Reflector lamp types with medium screw bases (PAR16, R14, R16, etc.) w/ diameter <2.25" (*see exceptions below)	280	374	4.6	35	30.4
	375	600	6.4	50	43.6
*BR30, BR40, or ER40	650	949	9.3	65	55.7
	950	1,099	12.7	75	62.3
	1,100	1,399	14.4	85	70.6
	1,400	1,600	16.6	100	83.4
	1,601	1,800	22.2	120	97.8
*R20	450	524	6.0	40	34.0
	525	750	7.1	45	37.9
*MR16	250	324	3.8	20.0	16.2
	325	369	4.8	25.0	20.2
	370	400	4.9	25.0	20.1

For PAR, MR, and MRX Lamps Types:

For these highly focused directional lamp types, it is necessary to have Center Beam Candle Power (CBCP) and beam angle measurements to accurately estimate the equivalent baseline wattage. The formula below is based on the Energy Star Center Beam Candle Power tool.[79] If CBCP and beam angle information are not available or if the equation below returns a negative value (or undefined), use the manufacturer's recommended baseline wattage equivalent.[80]

$$\text{Wattsbase} =$$

$$375.1 - 4.355(D) - \sqrt{227{,}800 - 937.9(D) - 0.9903(D^2) - 1479(BA) - 12.02(D * BA) + 14.69(BA^2) - 16{,}720 * \ln(CBCP)}$$

Where:

D	= Bulb diameter (e.g. for PAR20 D = 20)
BA	= Beam angle
CBCP	= Center beam candle power

[79] ENERGY STAR Lamps Center Beam Intensity Benchmark Tool and Calculator

[80] The Energy Star Center Beam Candle Power tool does not accurately model baseline wattages for lamps with certain bulb characteristic combinations – specifically for lamps with very high CBCP.

The result of the equation above should be rounded DOWN to the nearest wattage established by Energy Star:

Diameter	Permitted Wattages
16	20, 35, 40, 45, 50, 60, 75
20	50
30S	40, 45, 50, 60, 75
30L	50, 75
38	40, 45, 50, 55, 60, 65, 75, 85, 90, 100, 120, 150, 250

Additional EISA non-exempt bulb types:

Bulb Type	Minimum Lumens	Maximum Lumens	LED Wattage ($Watts_{EE}$)	Baseline ($Watts_{Base}$)	Delta Watts (WattsEE)
Dimmable Twist, Globe (less than 5" in diameter and > 749 lumens), candle (shapes B, BA, CA > 749 lumens), Candelabra Base Lamps (>1049 lumens), Intermediate Base Lamps (>749 lumens)	120	399	4.0	25	21.0
	400	749	6.6	29	22.4
	750	899	9.6	43	33.4
	900	1,399	13.1	53	39.9
	1,400	1,999	16.0	72	56.0

Hours = Average hours of use per year are provided in the Reference Table in Section 4.5 for each building type. If unknown, use the Miscellaneous value.

WHFe = Waste heat factor for energy to account for cooling energy savings from efficient lighting are provided below for each building type in the Referecne Table in Section 4.5. If unknown, use the Miscellaneous value.

ISR = In Service Rate -the percentage of units rebated that actually get installed.

=100% if application form completed with sign off that equipment is not placed into storage.[81] If sign off form not completed, assume the following 3 year ISR assumptions, if program survey data is not available:

Type	Weighted Average 1st year In Service Rate (ISR)	2nd year Installations	3rd year Installations	Final Lifetime In Service Rate
LED Bulbs	82.5%[82]	8.4%	7.1%	98.0%[83]

[81] 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.

[82] Based on ComEd's Instant Discounts program CY2019 and CY2020 (Rounds 1 and 2) Purchaser Survey analysis. See ComEd Instant Discounts Enduser Survey TRM Updates.xlsx

[83] In the absence of any data for LEDs specifically it is assumed that the same proportion of bulbs eventually get installed as for CFLS. The 98% CFL assumption is based upon review of two evaluations:
'Nexus Market Research, RLW Analytics and GDS Associates study; "New England Residential Lighting Markdown Impact

Type	Weighted Average 1st year In Service Rate (ISR)	2nd year Installations	3rd year Installations	Final Lifetime In Service Rate
LED Fixtures (Energy Star Fixtures)	92.9%[84]	2.8%	2.3%	98.0%
TLEDs	83.1%[85]	8.1%	6.8%	98.0%
Efficiency Kits	70.9%[86]	11.9%	10.2%	93.0%[87]

Mid Life Baseline Adjustment

Omnidirectional, Decorative and Directional Lamps

During the lifetime of an LED, the baseline incandescent/halogen bulb would need to be replaced multiple times. Natural growth of LED market share has, and will continue to grow over the lifetime of the measure, and so a single mid-life adjustment is calculated that results in an equivalent net present value of lifetime savings as the forecast decline in annual savings. See 'Lamp Forecast Workbook_2021.xls' for details.

The calculated mid-life adjustments for 2021 are provided below for each population:

Lamp Type	Year from which adjustment is applied	Adjustment Factor applied to Annual kWh Savings
Omnidirectional	2026	34%
Decorative	2026	70%
Directional	2026	61%

Evaluation, January 20, 2009' and 'KEMA Inc, Feb 2010, Final Evaluation Report: Upstream Lighting Program, Volume 1.' This implies that only 2% of bulbs purchased are never installed. The second and third year installations are based upon Ameren analysis of the Californian KEMA study showing that 54% of future installs occur in year 2 and 46% in year 3. The 2nd and 3rd year installations should be counted as part of those future program year savings. Note that this Final Install Rate does NOT account for leakage of purchased bulbs being installed outside of the utility territory. EM&V should assess how and if data from evaluation should adjust this final installation rate to account for this impact.

[84] Based on ComEd's Instant Discounts program CY2019 and CY2020 (Rounds 1 and 2) Purchaser Survey analysis. See ComEd Instant Discounts Enduser Survey TRM Updates.xlsx

[85] Based on ComEd's Instant Discounts program CY2019 and CY2020 (Rounds 1 and 2) Purchaser Survey analysis. See ComEd Instant Discounts Enduser Survey TRM Updates.xlsx

[86] First year ISR is average ISR from CY2018, CY2019 and CY2020 ComEd Small Business Kit participant installation surveys. Please see file "SB Kits Survey Analysis TRMv10 Support.xlsx"

[87] Same lifetime as direct mail residential kits. The second and third year ISRs use the ratios from the direct mail residential kits. Please see file "SB Kits Survey Analysis TRMv10 Support.xlsx"

For example, a 1000 lumen omnidirectional lamp installed in a high school in 2021. ΔkWh (2021 – 2024) = ((53-11.4)/1000) * 2327 * 1.15 * 1 = 111.3 kWh ΔkWh (2025 on) = 111.3 * 0.34 = 37.8k kWh

Early Replacement Measures with T12 Baseline

For early replacement measures replacing existing T12 fixtures the full savings (as calculated above in the Algorithm section) will be claimed for the remaining useful life of the T12 fixture. This should be calculated as follows:

RUL of existing T12 fixture = (1/3 * 40,000)/Hours

A savings adjustment should then be applied to the annual savings for the remainder of the measure life. The adjustment factor to be applied for each T12 installation is 57%.[88]

For example, for an existing 68W T12 fixture in a college is replaced by a 3000 lumen LED 2x2 Recessed Light Fixture (25.4W), a mid life adjustment of 57% should be applied after (1/3 * 40000)/3395 = 3.9 years.

HEATING PENALTY

If electrically heated building:

$\Delta kWh_{heatpenalty}$[89] = (((WattsBase-WattsEE)/1000) * ISR * Hours * -IFkWh

Where:

IFkWh = Lighting-HVAC Interation Factor for electric heating impacts; this factor represents the increased electric space heating requirements due to the reduction of waste heat rejected by the efficent lighting. Values are provided in the Reference Table in Section 4.5. If unknown, use the Miscellaneous value.

For example, a 9W LED omnidirectional lamp, 450 lumens, is installed in a heat pump heated office in 2014 and sign off form provided: $\Delta kWh_{heatpenalty}$ = ((29-6.7)/1000)*1.0*3088* -0.151 = - 10.4 kWh

DEFERRED INSTALLS

For v9 and v10 of this measure, deferred installs claimed in 2023 and 2024 should use all assumptions provided in

88 The appropriate T12 midlife adjustment factor was developed by the TAC Lighting Working Group. The results of a 2019 ComEd study provided survey response data on the planned replacement upon the burnout of a T12 ballast. This was adjusted by first year NTG to remove first year freeriders and therefore estimate what the non-freerider population would do at the end of T12 life. See "Linear Forecast Workbook_2020.xls" for information on calculation.

89 Negative value because this is an increase in heating consumption due to the efficient lighting.

v10 of the measure, with the exception of the year of midlife adjustment. This should be claimed as follows:

Install Year	Lamp Type	2023		2024	
		Year from which adjustment is applied	Adjustment Factor applied to Annual kWh Savings	Year from which adjustment is applied	Adjustment Factor applied to Annual kWh Savings
2021 Installs (v9)	Omnidirectional	2027	34%	N/A	
	Decorative	2027	70%		
	Directional	2027	61%		
2022 Installs (v10)	Omnidirectional	2027	34%	2028	34%
	Decorative	2027	70%	2028	70%
	Directional	2027	61%	2028	61%

~~As presented above, if a sign off form is not completed the characterization assumes that a percentage of bulbs purchased are not installed until Year 2 and Year 3 (see ISR assumption above). The Illinois Technical Advisory Committee has determined the following methodology for calculating the savings of these future installs.~~

~~Year 1 (Purchase Year) installs:~~ ~~Characterized using assumptions provided above or evaluated assumptions if available.~~

~~Year 2 and 3 installs:~~ ~~Characterized using delta watts assumption and hours of use from the Install Year, i.e., the actual deemed (or evaluated if available) assumptions active in Year 2 and 3 should be applied.~~

~~The NTG factor for the Purchase Year should be applied.~~

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SUMMER COINCIDENT PEAK DEMAND SAVINGS

$\Delta kW = ((Watts_{base} - Watts_{EE})/1000) * ISR * WHF_d * CF$

Where:

WHFd = Waste Heat Factor for Demand to account for cooling savings from efficient lighting in cooled buildings is provided in Referecne Table in Section 4.5. If unknown, use the Miscellaneous value.

CF = Summer Peak Coincidence Factor for measure is provided in the Reference Table in Section 4.5. If unknown, use the Miscellaneous value.

For example, a 9W LED omnidirectional lamp, 450 lumens, is installed in an office in 2014 and sign off form provided:

$\Delta kW = ((29-6.7)/1000)* 1.0*1.3*0.66$

NATURAL GAS ENERGY SAVINGS

Heating Penalty if fossil fuel heated building (or if heating fuel is unknown):

$\Delta Therms = ((WattsBase-WattsEE)/1000) * ISR * Hours * - IFTherms$

Where:

IFTherms = Lighting-HVAC Integration Factor for gas heating impacts; this factor represents the increased gas space heating requirements due to the reduction of waste heat rejected by the efficient lighting. Values are provided in the Referecne Table in Section 4.5. If unknown, use the Miscellaneous value.

For example, a 9W LED omnidirectional lamp, 450 lumens, is installed in an office in 2014 and sign off form provided:

ΔTherms = ((29-6.7)/1000)*1.0*3088* -0.016

= - 1.10 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

For fixture measures, the individual component lifetimes and costs are provided in the reference table section below.[90]

For lamps in order to account for the natural growth of LED over the lifetime of the measure, an equivalent annual levelized baseline replacement cost is calculated and applied over the life of the measure as described above.

The NPV for replacement lamps and annual levelized replacement costs using the societal real discount rate of 0.42% are presented below. It is important to note that for cost-effectiveness screening purposes, the O&M cost adjustments should only be applied in cases where the light bulbs area actually in service and so should be multiplied by the appropriate ISR:

Lamp Type	Location	NPV of replacement costs for period	Levelized annual replacement cost savings
		2021	2021
Omnidirectional	Commercial	$11.88	$2.18
	Multifamily common areas	$19.57	$5.88
Decorative	Commercial	$15.91	$3.43
	Multifamily common areas	$22.77	$8.04
Directional	Commercial	$41.54	$6.11
	Multifamily common areas	$73.43	$17.69

For halogen bulbs, we assume the same replacement cycle as incandescent bulbs.[91] The replacement cycle is based on the miscellaneous hours of use. Both incandescent and halogen lamps are assumed to last for 1,000 hours before needing replacement and CFLs after 10,000 hours.

REFERENCE TABLES

LED Bulb Assumptions

Wherever possible, actual incremental costs should be used. If unavailable assume the following incremental costs:[92]

---

[90] See IL LED Lighting Systems TRM Reference Tables_2018.xlsx for breakdown of component cost assumptions.

[91] 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.

[92] Baseline and LED lamp costs are based on field data collected by CLEAResult and provided by ComEd. See ComEd Pricing Projections 06302016.xlsx for analysis. Given LED prices are expected to continue declining assumed costs should be reassessed

Bulb Type	Year	LED	Incandescent	Incremental Cost
Omnidirectional	2017	$3.21	$1.25	$1.96
	2018	$3.21		$1.96
	2019	$3.11		$1.86
	2020	$2.70		$1.45
Directional	2017	$6.24	$3.53	$2.71
	2018+	$5.18		$1.65
Decorative and Globe	2017	$3.50	$1.60	$1.90
	2018+	$3.40	$1.74	$1.66

LED Fixture Wattage, TOS Baseline and Incremental Cost Assumptions[93]

LED Category	EE Measure Description	$Watts_{EE}$	Baseline Description	$Watts_{BASE}$	Incremental Cost
LED Downlight Fixtures	LED Recessed, Surface, Pendant Downlights	17.6	Baseline Recessed, Surface, Pendant Downlights	54.3	$27
LED Interior Directional	LED Track Lighting	12.2	Baseline Track Lighting	60.4	$59
	LED Wall-Wash Fixtures	8.3	Baseline Wall-Wash Fixtures	17.7	$59
LED Display Case[94]	LED Display Case Light Fixture	4 per ft	Baseline Display Case Light Fixture	36.2 per ft	$11/ft
	LED Undercabinet Shelf-Mounted Task Light Fixtures	4 per ft	Baseline Undercabinet Shelf-Mounted Task Light Fixtures	36.2 per ft	$11/ft
	LED Refrigerated Case Light, Horizontal or Vertical	4 per ft	Baseline Refrigerated Case Light, Horizontal or Vertical (per foot)	15.2 per ft	$11/ft
	LED Freezer Case Light, Horizontal or Vertical	4 per ft	Baseline Freezer Case Light, Horizontal or Vertical (per foot)	18.7 per ft	$11/ft
LED Linear Replacement Lamps	T8 LED Replacement Lamp (TLED), < 1200 lumens	8.9	F17T8 Standard Lamp - 2 foot	15.0	$13
	T8 LED Replacement Lamp (TLED), 1200-2400 lumens	15.8	F32T8 Standard Lamp - 4 foot	28.2	$15
	T8 LED Replacement Lamp (TLED), > 2400 lumens	22.9	F32T8/HO Standard Lamp - 4 foot	41.8	$13

on an annual basis and replaced with IL specific LED program information when available.

[93] Watt, lumen, lamp life, and ballast factor assumptions for efficient measures are based upon Consortium for Energy Efficiency (CEE) Commercial Lighting Qualifying Product Lists alongside past Efficiency Vermont projects and PGE refrigerated case study. Watt, lumen, lamp life, and ballast factor assumptions for baseline fixtures are based upon manufacturer specification sheets. Baseline cost data comes from lighting suppliers, past Efficiency Vermont projects, and professional judgment. Efficient cost data comes from 2012 DOE "Energy Savings Potential of Solid-State Lighting in General Illumination Applications", Table A.1. See "LED Lighting Systems TRM Reference Tables_2018.xlsx" for more information and specific product links.

[94] LED Case Lighting is based on an average of DLC Horizontal and Vertical Lighting less than 80 W. This filter was intended to exclude vaportight fixtures from the average. The horizontal and vertical averages, provided by Guidehouse in 5/2020, were 4. 1 W/ft and 3.7 W/ft, respectively.

LED Category	EE Measure Description	$Watts_{EE}$	Baseline Description	$Watts_{BASE}$	Incremental Cost
LED Troffers	LED 2x2 Recessed Light Fixture, 2000-3500 lumens	25.4	2-Lamp 32w T8 (BF < 0.89)	57.0	$53
	LED 2x2 Recessed Light Fixture, 3501-5000 lumens	36.7	3-Lamp 32w T8 (BF < 0.88)	84.5	$69
	LED 2x4 Recessed Light Fixture, 3000-4500 lumens	33.3	2-Lamp 32w T8 (BF < 0.89)	57.0	$55
	LED 2x4 Recessed Light Fixture, 4501-6000 lumens	44.8	3-Lamp 32w T8 (BF < 0.88)	84.5	$76
	LED 2x4 Recessed Light Fixture, 6001-7500 lumens	57.2	4-Lamp 32w T8 (BF < 0.88)	112.6	$104
	LED 1x4 Recessed Light Fixture, 1500-3000 lumens	21.8	1-Lamp 32w T8 (BF <0.91)	29.1	$22
	LED 1x4 Recessed Light Fixture, 3001-4500 lumens	33.7	2-Lamp 32w T8 (BF < 0.89)	57.0	$75
	LED 1x4 Recessed Light Fixture, 4501-6000 lumens	43.3	3-Lamp 32w T8 (BF < 0.88)	84.5	$83
LED Linear Ambient Fixtures	LED Surface & Suspended Linear Fixture, <= 3000 lumens	19.5	1-Lamp 32w T8 (BF <0.91)	29.1	$10
	LED Surface & Suspended Linear Fixture, 3001-4500 lumens	32.1	2-Lamp 32w T8 (BF < 0.89)	57.0	$52
	LED Surface & Suspended Linear Fixture, 4501-6000 lumens	43.5	3-Lamp 32w T8 (BF < 0.88)	84.5	$78
	LED Surface & Suspended Linear Fixture, 6001-7500 lumens	56.3	T5HO 2L-F54T5HO - 4'	120.0	$131
	LED Surface & Suspended Linear Fixture, > 7500 lumens	82.8	T5HO 3L-F54T5HO - 4'	180.0	$173
LED High & Low Bay Fixtures	LED Low-Bay Fixtures, <= 10,000 lumens	61.6	3-Lamp T8HO Low-Bay	157.0	$44
	LED High-Bay Fixtures, 10,001-15,000 lumens	99.5	4-Lamp T8HO High-Bay	196.0	$137
	LED High-Bay Fixtures, 15,001-20,000 lumens	140.2	6-Lamp T8HO High-Bay	294.0	$202

LED Category	EE Measure Description	$Watts_{EE}$	Baseline Description	$Watts_{BASE}$	Incremental Cost
	LED High-Bay Fixtures, 20,001-30,000 lumens	193.8	8-Lamp T8HO High-Bay	392.0	$264
	LED High-Bay Fixtures, 30,001-40,000 lumens	250	750 Watts Metal Halide	850	$400
	LED High-Bay Fixtures 40,001-50,000 lumens	295	1000 Watts Metal Halide	1080	$425
	LED High-Bay Fixtures >50,000 lumens	435	1500 Watts Metal Halide	1610	$550
LED Agricultural Interior Fixtures	LED Ag Interior Fixtures, <= 2,000 lumens	12.9	25% 73 Watt EISA Inc, 75% 1L T8	42.0	$18
	LED Ag Interior Fixtures, 2,001-4,000 lumens	29.7	25% 146 Watt EISA Inc, 75% 2L T8	81.0	$48
	LED Ag Interior Fixtures, 4,001-6,000 lumens	45.1	25% 217 Watt EISA Inc, 75% 3L T8	121.0	$57
	LED Ag Interior Fixtures, 6,001-8,000 lumens	59.7	25% 292 Watt EISA Inc, 75% 4L T8	159.0	$88
	LED Ag Interior Fixtures, 8,001-12,000 lumens	84.9	200W Pulse Start Metal Halide	227.3	$168
	LED Ag Interior Fixtures, 12,001-16,000 lumens	113.9	320W Pulse Start Metal Halide	363.6	$151
	LED Ag Interior Fixtures, 16,001-20,000 lumens	143.7	350W Pulse Start Metal Halide	397.7	$205
	LED Ag Interior Fixtures, > 20,000 lumens	193.8	(2) 320W Pulse Start Metal Halide	727.3	$356
LED Exterior Fixtures	LED Exterior Fixtures, <= 5,000 lumens	34.1	100W Metal Halide	113.6	$80
	LED Exterior Fixtures, 5,001-10,000 lumens	67.2	175W Pulse Start Metal Halide	198.9	$248
	LED Exterior Fixtures, 10,001-15,000 lumens	108.8	250W Pulse Start Metal Halide	284.1	$566
	LED Exterior Fixtures, 15,001-30,000 lumens	183.9	400W Pulse Start Metal Halide	454.5	$946
	LED Exterior Fixtures, 30,001-40,000 lumens	250	750 W Metal Halide	850	$700
	LED Exterior Fixtures, 40,001-50,000 lumens	295	1000 W Metal Halide	1080	$850
	LED Exterior Fixtures, > 50,000 lumens	435	1500 W Metal Halide	1610	$1100

LED Fixture Component Costs & Lifetime[95]

		EE Measure				Baseline			
LED Category	EE Measure Description	Lamp Life (hrs)	Total Lamp Replacement Cost	LED Driver Life (hrs)	Total LED Driver Replacement Cost	Lamp Life (hrs)	Total Lamp Replacement Cost	Ballast Life (hrs)	Total Ballast Replacement Cost
LED Downlight Fixtures	LED Recessed, Surface, Pendant Downlights	50,000	$30.75	70,000	$47.50	2,500	$8.86	40,000	$14.40
LED Interior Directional	LED Track Lighting	50,000	$39.00	70,000	$47.50	2,500	$12.71	40,000	$11.00
	LED Wall-Wash Fixtures	50,000	$39.00	70,000	$47.50	2,500	$9.17	40,000	$27.00
LED Display Case	LED Display Case Light Fixture	50,000	$9.75/ft	70,000	$11.88/ft	2,500	$6.70	40,000	$5.63
	LED Undercabinet Shelf-Mounted Task Light Fixtures	50,000	$9.75/ft	70,000	$11.88/ft	2,500	$6.70	40,000	$5.63
	LED Refrigerated Case Light, Horizontal or Vertical	50,000	$8.63/ft	70,000	$9.50/ft	15,000	$1.13	40,000	$8.00
	LED Freezer Case Light, Horizontal or Vertical	50,000	$7.88/ft	70,000	$7.92/ft	12,000	$0.94	40,000	$6.67
LED Linear Replacement Lamps	T8 LED Replacement Lamp (TLED), < 1200 lumens	50,000	$5.76	70,000	$13.67	30,000	$6.17	40,000	$11.96
	T8 LED Replacement Lamp (TLED), 1200-2400 lumens	50,000	$8.57	70,000	$13.67	24,000	$6.17	40,000	$11.96
	T8 LED Replacement Lamp (TLED), > 2400 lumens	50,000	$8.57	70,000	$13.67	18,000	$6.17	40,000	$11.96
LED Troffers	LED 2x2 Recessed Light Fixture, 2000-3500 lumens	50,000	$78.07	70,000	$40.00	24,000	$26.33	40,000	$35.00
	LED 2x2 Recessed Light Fixture, 3501-5000 lumens	50,000	$89.23	70,000	$40.00	24,000	$39.50	40,000	$35.00
	LED 2x4 Recessed Light Fixture,	50,000	$96.10	70,000	$40.00	24,000	$12.33	40,000	$35.00

[95] Note that some measures have blended baselines (T12:T8 18:82). All values are provided to enable calculation of appropriate O&M impacts. Total costs include lamp, labor and disposal cost assumptions where applicable, see IL LED Lighting Systems TRM Reference Tables_2018.xlsx for more information.

LED Category	EE Measure Description	EE Measure: Lamp Life (hrs)	EE Measure: Total Lamp Replacement Cost	EE Measure: LED Driver Life (hrs)	EE Measure: Total LED Driver Replacement Cost	Baseline: Lamp Life (hrs)	Baseline: Total Lamp Replacement Cost	Baseline: Ballast Life (hrs)	Baseline: Total Ballast Replacement Cost
	3000-4500 lumens								
	LED 2x4 Recessed Light Fixture, 4501-6000 lumens	50,000	$114.37	70,000	$40.00	24,000	$18.50	40,000	$35.00
	LED 2x4 Recessed Light Fixture, 6001-7500 lumens	50,000	$137.43	70,000	$40.00	24,000	$24.67	40,000	$35.00
	LED 1x4 Recessed Light Fixture, 1500-3000 lumens	50,000	$65.43	70,000	$40.00	24,000	$6.17	40,000	$35.00
	LED 1x4 Recessed Light Fixture, 3001-4500 lumens	50,000	$100.44	70,000	$40.00	24,000	$12.33	40,000	$35.00
	LED 1x4 Recessed Light Fixture, 4501-6000 lumens	50,000	$108.28	70,000	$40.00	24,000	$18.50	40,000	$35.00
LED Linear Ambient Fixtures	LED Surface & Suspended Linear Fixture, <= 3000 lumens	50,000	$62.21	70,000	$40.00	24,000	$6.17	40,000	$35.00
	LED Surface & Suspended Linear Fixture, 3001-4500 lumens	50,000	$93.22	70,000	$40.00	24,000	$12.33	40,000	$35.00
	LED Surface & Suspended Linear Fixture, 4501-6000 lumens	50,000	$114.06	70,000	$40.00	24,000	$18.50	40,000	$35.00
	LED Surface & Suspended Linear Fixture, 6001-7500 lumens	50,000	$152.32	70,000	$40.00	30,000	$26.33	40,000	$60.00
	LED Surface & Suspended Linear Fixture, > 7500 lumens	50,000	$183.78	70,000	$40.00	30,000	$39.50	40,000	$60.00
LED High & Low Bay Fixtures	LED Low-Bay Fixtures, <= 10,000 lumens	50,000	$90.03	70,000	$62.50	18,000	$64.50	40,000	$92.50
	LED High-Bay Fixtures, 10,001-	50,000	$122.59	70,000	$62.50	18,000	$86.00	40,000	$92.50

LED Category	EE Measure Description	EE Measure: Lamp Life (hrs)	EE Measure: Total Lamp Replacement Cost	EE Measure: LED Driver Life (hrs)	EE Measure: Total LED Driver Replacement Cost	Baseline: Lamp Life (hrs)	Baseline: Total Lamp Replacement Cost	Baseline: Ballast Life (hrs)	Baseline: Total Ballast Replacement Cost
	15,000 lumens								
	LED High-Bay Fixtures, 15,001-20,000 lumens	50,000	$157.22	70,000	$62.50	18,000	$129.00	40,000	$117.50
	LED High-Bay Fixtures, 20,001 – 30,000 lumens	50,000	$228.52	70,000	$62.50	18,000	$172.00	40,000	$142.50
	LED High-Bay Fixtures, 30,001-40,000 lumens	50,000	$294.00	70,000	$62.50	15,000	$82.00	40,000	$143.00
	LED High-Bay Fixtures, 40,001-50,000 lumens	50,000	$324.00	70,000	$62.50	15,000	$88.00	40,000	$149.00
	LED High-Bay Fixtures, > 50,000 lumens	50,000	$382.00	70,000	$62.50	15,000	$96.00	40,000	$200.00
LED Agricultural Interior Fixtures	LED Ag Interior Fixtures, <= 2,000 lumens	50,000	$41.20	70,000	$40.00	1,000	$1.23	40,000	$26.25
	LED Ag Interior Fixtures, 2,001-4,000 lumens	50,000	$65.97	70,000	$40.00	1,000	$1.43	40,000	$26.25
	LED Ag Interior Fixtures, 4,001-6,000 lumens	50,000	$80.08	70,000	$40.00	1,000	$1.62	40,000	$26.25
	LED Ag Interior Fixtures, 6,001-8,000 lumens	50,000	$105.54	70,000	$40.00	1,000	$1.81	40,000	$26.25
	LED Ag Interior Fixtures, 8,001-12,000 lumens	50,000	$179.81	70,000	$62.50	15,000	$63.00	40,000	$112.50
	LED Ag Interior Fixtures, 12,001-16,000 lumens	50,000	$190.86	70,000	$62.50	15,000	$68.00	40,000	$122.50
	LED Ag Interior Fixtures, 16,001-20,000 lumens	50,000	$237.71	70,000	$62.50	15,000	$73.00	40,000	$132.50
	LED Ag Interior Fixtures, > 20,000 lumens	50,000	$331.73	70,000	$62.50	15,000	$136.00	40,000	$202.50
LED Exterior Fixtures	LED Exterior Fixtures, <= 5,000 lumens	50,000	$73.80	70,000	$62.50	15,000	$58.00	40,000	$102.50
	LED Exterior Fixtures, 5,001-10,000 lumens	50,000	$124.89	70,000	$62.50	15,000	$63.00	40,000	$112.50
	LED Exterior	50,000	$214.95	70,000	$62.50	15,000	$68.00	40,000	$122.50

		EE Measure				Baseline			
LED Category	EE Measure Description	Lamp Life (hrs)	Total Lamp Replacement Cost	LED Driver Life (hrs)	Total LED Driver Replacement Cost	Lamp Life (hrs)	Total Lamp Replacement Cost	Ballast Life (hrs)	Total Ballast Replacement Cost
	Fixtures, 10,001-15,000 lumens								
	LED Exterior Fixtures, 15,000-30,000 lumens	50,000	$321.06	70,000	$62.50	15,000	$73.00	40,000	$132.50
	LED Exterior Fixtures, 30,001-40,000 lumens	50,000	$546.00	70,000	$62.50	15,000	$82.00	40,000	$143.00
	LED Exterior Fixtures, 40,001-50,000 lumens	50,000	$722.00	70,000	$62.50	15,000	$88.00	40,000	$149.00
	LED Exterior Fixtures, > 50,000 lumens	50,000	$870.00	70,000	$62.50	15,000	$96.00	40,000	$200.00

MEASURE CODE: CI-LTG-LEDB-V1~~3~~4-220101

REVIEW DEADLINE: 1/1/2023

5.3.8 Ground Source Heat Pump

DESCRIPTION

This measure characterizes the installation of a Ground Source Heat Pump under the following scenarios:

a) New Construction:
   - iii. The installation of a new residential sized Ground Source Heat Pump system meeting ENERGY STAR efficiency standards presented below in a new home.
   - iv. Note the baseline in this case should be determined via EM&V and the algorithms are provided to allow savings to be calculated from any baseline condition.

b) Time of Sale:
   - iv. The planned installation of a new residential sized Ground Source Heat Pump system meeting ENERGY STAR efficiency standards presented below to replace an existing system(s) that does not meet the criteria for early replacement described in section c below.
   - v. Note the baseline in this case is an equivalent replacement system to that which exists currently in the home. Where unknown, the baseline should be determined via EM&V and the algorithms are provided to allow savings to be calculated from any baseline condition. The calculation of savings is dependent on whether an incentive for the installation has been provided by both a gas and electric utility, just an electric utility or just a gas utility.
   - vi. Additional DHW savings are calculated based upon the fuel and efficiency of the existing unit.

c) Early Replacement/Retrofit:
   - iv. The early removal of functioning either electric or gas space heating and/or cooling systems from service, prior to the natural end of life, and replacement with a new high efficiency Ground Source Heat Pump system.
   - v. Note the baseline in this case is the existing equipment being replaced. The calculation of savings is dependent on whether an incentive for the installation has been provided by both a gas and electric utility, just an electric utility or just a gas utility.
   - vi. Additional DHW savings are calculated based upon the fuel and efficiency of the existing unit.
   - vii. Early Replacement determination will be based on meeting the following conditions:
     - The existing unit is operational when replaced, or
     - The existing unit requires minor repairs, defined as costing less than:[96]

Existing System	Maximum repair cost
Air Source Heat Pump	$276 per ton
Central Air Conditioner	$190 per ton
Boiler	$709
Furnace	$528
Ground Source Heat Pump	<$249 per ton

     - All other conditions will be considered Time of Sale.
   - viii. The Baseline efficiency of the existing unit replaced:
     - If the efficiency of the existing unit is less than the maximum shown below, the Baseline efficiency is the actual efficiency value of the unit replaced. If the efficiency is greater than the maximum, the Baseline efficiency is shown in the "New Baseline" column below:

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

Existing System	Maximum efficiency for Actual	New Baseline
Air Source Heat Pump	10 SEER	14 SEER
Central Air Conditioner	10 SEER	13 SEER
Boiler	75% AFUE	84% AFUE
Furnace	75% AFUE	80% AFUE
Ground Source Heat Pump	10 SEER	14 SEER

- If the efficiency of the existing unit is unknown, use assumptions in variable list below (SEER, HSPF or AFUE exist).
- If the operational status or repair cost of the existing unit is unknown use time of sale assumptions.

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

DEFINITION OF EFFICIENT EQUIPMENT

In order for this characterization to apply, the efficient equipment must be a Ground Source Heat Pump unit meeting the minimum ENERGY STAR efficiency level standards effective at the time of installation as detailed below:

ENERGY STAR Requirements (Effective January 1, 2012)

Product Type	Cooling EER	Heating COP
Water-to-air		
Closed Loop	17.1	3.6
Open Loop	21.1	4.1
Water-to-Water		
Closed Loop	16.1	3.1
Open Loop	20.1	3.5
DGX	16	3.6

DEFINITION OF BASELINE EQUIPMENT

For these products, baseline equipment includes Air Conditioning, Space Heating and Water Heating.

New Construction:

To calculate savings with an electric baseline, the baseline equipment is assumed to be an Air Source Heat Pump meeting the Federal Standard efficiency level; 14 SEER, 8.2 HSPF and 11.0 EER[97] and a Federal Standard electric hot water heater.

To calculate savings with a furnace/central AC baseline, the baseline equipment is assumed to be an 80% AFUE Furnace and central AC meeting the Federal Standard efficiency level; 13 SEER, 10.5 EER[98]. If a gas water heater, the Federal Standard baseline is calculated as follows; 0.6483 – (0.0017 * storage capacity in gallons) for tanks<=55 gallons and 0.7897 − (0.0004 × storage capacity in gallons) for greater than 55 gallon storage water heaters.[99] For a 40-gallon storage water heater this would be 0.58 EF.

Time of Sale: The baseline for this measure is a new replacement unit of the same system type as the existing unit,

[97] The Federal Standard does not include an EER requirement. The value provided is based on Opinion Dynamics and Cadmus metering study of Ameren HVAC program participants; See 'AIC HVAC Metering Study Memo FINAL 2_28_2018'.
[98] The Federal Standard does not include an EER requirement. The value provided is based on Opinion Dynamics and Cadmus metering study of Ameren HVAC program participants; See 'AIC HVAC Metering Study Memo FINAL 2_28_2018'.
[99] Minimum Federal standard as of 4/16/2015.

meeting the baselines provided below.

Unit Type	Efficiency Standard
ASHP	14 SEER, 11.8 EER, 8.2 HSPF
Gas Furnace	80% AFUE
Gas Boiler	84% AFUE
Central AC	13 SEER, 11 EER

Early replacement / Retrofit: The baseline for this measure is the efficiency of the *existing* heating, cooling and hot water equipment for the assumed remaining useful life of the existing unit and a new baseline heating and cooling system for the remainder of the measure life (as provided in table above).

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 25 years.[100]

For early replacement, the remaining life of existing equipment is assumed to be 6 years for ASHP and Central AC, 7 years for furnace, 8 years for boilers and GSHP[101] and 25 years for electric resistance.[102]

DEEMED MEASURE COST

New Construction and Time of Sale: The actual installed cost of the Ground Source Heat Pump (including any necessary electrical or distribution upgrades required) should be used (default of $3957 per ton),[103] minus the assumed installation cost of the baseline equipment ($1381 per ton for ASHP[104] or $2011 for a new baseline 80% AFUE furnace, or $4053 for a new 84% AFUE boiler,[105] and $952 per ton for new baseline Central AC replacement [106]).

Early Replacement: The actual full installation cost of the Ground Source Heat Pump should be used (including any necessary electrical or distribution upgrades required). If the install cost is unknown a default is provided above, however because these assumptions do not include any additional costs that may be required for fuel switch scenarios, these defaults should not be used and actual costs should always be used for fuel switch measures.

The assumed deferred cost (after 8 years) of replacing existing equipment with a new baseline unit is assumed to be $1,518 per ton for a new baseline Air Source Heat Pump, or $2,296 for a new baseline 80% AFUE furnace, or $4,627 for a new 84% AFUE boiler, and 1,047 per ton for new baseline Central AC replacement.[107] This future cost should be discounted to present value using the nominal societal discount rate.

LOADSHAPE

Loadshape R10 - Residential Electric Heating and Cooling (if replacing gas heat and central AC)[108]

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100 System life of indoor components as per DOE estimate (see 'Geothermal Heat Pumps Department of Energy'). The ground loop has a much longer life, but the compressor and other mechanical components are the same as an ASHP.

101 Assumed to be one third of effective useful life of replaced equipment.

102 Assume full measure life (16 years) for replacing electric resistance as we would not expect that resistance heat would fail during the lifetime of the efficient measure.

103 Based on data provided in 'Results of HomE geothermal and air source heat pump rebate incentives documented by IL electric cooperatives'.

104 Baseline cost per ton derived from DEER 2008 Database Technology and Measure Cost Data. See 'ASHP_Revised DEER Measure Cost Summary.xls' for calculation.

105 Furnace and boiler costs are based on data provided in Appendix E of the Appliance Standards Technical Support Documents including equipment cost and installation labor.

106 Based on 3 ton initial cost estimate for a conventional unit from ENERGY STAR Central AC calculator.

107 All baseline replacement costs are consistent with their respective measures and include inflation rate of 1.91%.

108 The baseline for calculating electric savings is an Air Source Heat Pump.

Loadshape R09 - Residential Electric Space Heat (if replacing electric heat with no cooling)

Loadshape R10 - Residential Electric Heating and Cooling (if replacing ASHP)

Note for purpose of cost effectiveness screening a fuel switch scenario, the heating kWh increase and cooling kWh decrease should be calculated separately such that the appropriate loadshape (i.e., Loadshape R09 - Residential Electric Space Heat and Loadshape R08 – Residential Cooling respectively) can be applied.

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 capacity market.

CF_{SSP} = Summer System Peak Coincidence Factor for Heat Pumps (during utility peak hour)

= 72%[109]

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

= 46.6%[110]

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS AND FOSSIL FUEL SAVINGS

Non-fuel switch measures:

ΔkWh = [Cooling savings] + [Heating savings] + [DHW savings]

= [FLHcool * Capacity_cooling * (1/$SEER_{base}$ – 1/EER_{PL})/1000] + [HeatLoad* (1/$HSPF_{base}$ – 1/(COP_{PL} * 3.412))/1000] + [ElecDHW * %DHWDisplaced * ((1/EF_{ELEC} * GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0) / 3412)]

Fuel switch measures:

Fuel switch measures must produce positive total lifecycle fuel savings (i.e., reduction in Btus at the premises) in order to qualify. This is determined as follows (note for early replacement measures the lifetime savings should be calculated by calculating savings for the remaining useful life of the existing equipment and for the remaining measure life):

SiteEnergySavings (MMBTUs) = GasHeatReplaced + FurnaceFanSavings – GSHPSiteHeatConsumed + GSHPSiteCoolingImpact + GSHPSiteWaterImpact

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[109] Based on analysis of metering results from 24 heat pumps in Ameren Illinois service territory in PY5 coincident with AIC's 2010 system peak; 'Impact and Process Evaluation of Ameren Illinois Company's Residential HVAC Program (PY5)'.

[110] 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.

GasHeatReplaced = [(HeatLoad * 1/$AFUE_{base}$) / 1,000,000]

FurnaceFanSavings = (FurnaceFlag * HeatLoad * 1/$AFUE_{base}$ * F_e) / 1,000,000

GSHPSiteHeatConsumed = [HeatLoad * (1/(COP_{PL} * 3.412))/1000] * 3412) / 1,000,000

GSHPSiteCoolingImpact = [FLHcool * Capacity_GSHPcool * (1/$SEER_{base}$ – 1/EER_{PL})/1000] * 3412) / 1,000,000

$GSHPSiteWaterImpact_{Gas}$ = (%DHWDisplaced * (1/EF_{Gas} * GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0)) / 1,000,000

$GSHPSiteWaterImpact_{Electric}$ = (%DHWDisplaced * ((1/EF_{Elec} * GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0))) ~~* 3412)~~ / 1,000,000

If SiteEnergySavings calculated above is positive, the measure is eligible.

The appropriate savings claim is dependent on which utilities are supporting the measure as provided in a table below:

Measure supported by:	Electric Utility claims (kWh):	Gas Utility claims (therms):
Electric utility only	SiteEnergySavings * 1,000,000/3,412	N/A
Electric and gas utility (Note utilities may make alternative agreements to how savings are allocated as long as total MMBtu savings remains the same).	%IncentiveElectric * SiteEnergySavings * 1,000,000/3,412	%IncentiveGas * SiteEnergySavings * 10
Gas utility only	N/A	SiteEnergySavings * 10

Note for Early Replacement measures, the efficiency and Fe terms of the existing unit should be used for the remaining useful life of the existing equipment (6 years for ASHP and Central AC, 6 years for furnace, 8 years for boilers or GSHP, 15 years for electric resistance), and the efficiency and Fe terms for a new baseline unit should be used for the remaining years of the measure. See assumptions below.

Where:

FLHcool = Full load cooling hours

Dependent on location as below:[111]

[111] Based on Full Load Hours from ENERGY STAR with adjustments made in a Navigant Evaluation, other cities were scaled using those results and CDD. There is a county mapping table in Volume 1, Section 3.7 providing the appropriate city to use for each county of Illinois.

Climate Zone (City based upon)	FLHcool Single Family	FLHcool Multifamily	FLH_cooling (weatherized multifamily) [112]
1 (Rockford)	512	467	299
2 (Chicago)	570	506	324
3 (Springfield)	730	663	425
4 (Belleville)	1,035	940	603
5 (Marion)	903	820	526
Weighted Average[113]	629	564	362

Use Multifamily if: Building has shared HVAC or meets utility's definition for multifamily

Capacity_GSHPcool = Cooling Output Capacity of Ground Source Heat Pump (Btu/hr)

= Actual (1 ton = 12,000Btu/hr)

SEERbase = SEER Efficiency of baseline unit. For early replacment measures, the actual SEER rating where it is possible to measure or reasonably estimate should be used for the remaining useful life of the existing equipment (6 years for ASHP and Central AC, 8 years for GSHP). If using rated efficiencies, derate efficiency value by 1% per year (maximum of 30 years) to account for degradation over time,[114] or if unknown assume default provided below:

Baseline/Existing Cooling System	SEERbase		
	Early Replacement (Remaining useful life of existing equipment)	Early Replacement (Remaining measure life)	Time of Sale or New Construction
Air Source Heat Pump	9.3[115]	14[116]	
Ground Source Heat Pump	14[117]	14	
Central AC	9.3[118]	13[119]	
No central cooling	13 [120]	13[121]	

EER_{PL} = Part Load EER Efficiency of efficient GSHP unit[122]

[112] *All-Electric Homes PY6 Metering Results: Multifamily HVAC Systems*, Cadmus, October 2015. The multifamily units within this study had undergone significant shell improvements (air sealing and insulation) and therefore this set of assumptions is only appropriate for units that have recently participated in a weatherization or other shell program. Note that the FLHcool where recalculated based on existing efficiencies consistent with the TRM rather than from the metering study.

[113] Weighted based on number of occupied residential housing units in each zone.

[114] Justification for degradation factors can be found on page 14 of 'AIC HVAC Metering Study Memo FINAL 2_28_2018'. Estimate efficiency as (Rated Efficiency * (1-0.01)^Equipment Age).

[115] Based on Opinion Dynamics and Cadmus metering study of Ameren HVAC program participants; See 'AIC HVAC Metering Study Memo FINAL 2_28_2018'

[116] Minimum Federal Standard as of 1/1/2015

[117] Estimate of existing GSHP efficiency is based converting 12 EER (estimate based upon Navigant, 2018 "EIA – Technology Forecast Updates – Residential and Commercial Building Technologies – Reference Case") to SEER.

[118] Based on Opinion Dynamics and Cadmus metering study of Ameren HVAC program participants; See 'AIC HVAC Metering Study Memo FINAL 2_28_2018'

[119] Minimum Federal Standard; Federal Register, Vol. 66, No. 14, Monday, January 22, 2001/Rules and Regulations, p. 7170-7200.

[120] Assumes that the decision to replace existing systems includes desire to add cooling.

[121] Assumes that the decision to replace existing systems includes desire to add cooling.

[122] As per conversations with David Buss territory manager for Connor Co, the SEER and COP ratings of an ASHP equate most

= Actual installed

HeatLoad = Calculated heat load for the building

= FLH_GSHPheat * Capacity_GSHPheat

FLH_GSHPheat = Full load hours of heat pump heating

Dependent on location as below:[123]

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[124]	1,821

Capacity_GSHPheat = Heating Output Capacity of Ground Source Heat Pump (Btu/hr)

= Actual (1 ton = 12,000Btu/hr)

$HSPF_{base}$ =Heating System Performance Factor of baseline heating system (kBtu/kWh). For early replacement measures, use actual HSPF rating where it is possible to measure or reasonably estimate for the remaining useful life of the existing equipment (6 years for ASHP, 8 years for GSHP or 15 years for electric resistance). If using rated efficiencies, derate efficiency value by 1% per year (maximum of 30 years) to account for degradation over time,[125] or if unknown assume default:

Baseline/ Existing Heating System	HSPF_base		
	Early Replacement (Remaining useful life of existing equipment)	Early Replacement (Remaining measure life)	Time of Sale or New Construction
Air Source Heat Pump	5.54[126]	8.2	
Ground Source Heat Pump	8.2[127]	8.2	
Electric Resistance	3.41[128]		

appropriately with the part load EER and COP of a GSHP.

123 Heating EFLH based on ENERGY STAR EFLH for Rockford, Chicago, and Springfield and on NCDC/NOAA HDD for the other two cities. In all cases, the hours were adjusted based on average natural gas heating consumption in IL. There is a county mapping table in Volume 1, Section 3.7 providing the appropriate city to use for each county of Illinois.

124 Weighted based on number of occupied residential housing units in each zone.

125 Justification for degradation factors can be found on page 14 of 'AIC HVAC Metering Study Memo FINAL 2_28_2018'. Estimate efficiency as (Rated Efficiency * (1-0.01)^Equipment Age).

126 Based on Opinion Dynamics and Cadmus metering study of Ameren HVAC program participants; See 'AIC HVAC Metering Study Memo FINAL 2_28_2018'

127 Estimate of existing GSHP efficiency is assumed equivalent to a new baseline ASHP. It is recommended that this value be evaluated and adjusted for a future version.

128 Electric resistance has a COP of 1.0 which equals 1/0.293 = 3.41 HSPF.

COP_{PL} = Part Load Coefficient of Performance of efficient unit[129]

= Actual Installed

3.412 = Constant to convert the COP of the unit to the Heating Season Performance Factor (HSPF)

ElecDHW = 1 if existing DHW is electrically heated

= 0 if existing DHW is not electrically heated

%DHWDisplaced = Percentage of total DHW load that the GSHP will provide

= Actual if known

= If unknown and if desuperheater installed, assume 44%[130]

= 0% if no desuperheater installed

EF_{ELEC} = Energy Factor (efficiency) of electric water heater

= Actual. If unknown or for new construction, assume federal standard:[131]

For <=55 gallons: 0.96 – (0.0003 * rated volume in gallons)

For >55 gallons: 2.057 – (0.00113 * rated volume in gallons)

GPD = Gallons Per Day of hot water use per person

= 45.5 gallons hot water per day per household/2.59 people per household[132]

= 17.6

Household = Average number of people per household

Household Unit Type	Household
Single-Family - Deemed	2.56[133]
Multifamily - Deemed	2.1[134]
Custom	Actual Occupancy or Number of

[129] As per conversations with David Buss territory manager for Connor Co, the SEER and COP ratings of an ASHP equate most appropriately with the part load EER and COP of a GSHP.
[130] Assumes that the desuperheater can provide two thirds of hot water needs for eight months of the year (2/3 * 2/3 = 44%). Based on input from Doug Dougherty, Geothermal Exchange Organization.
[131] Minimum Federal Standard as of 4/1/2015;.
[132] Deoreo, B., and P. Mayer. Residential End Uses of Water Study Update. Forthcoming. ©2015 Water Research Foundation. Reprinted With Permission.
[133] 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
[134] ComEd PY3 Multifamily Evaluation Report REVISED DRAFT v5 2011-12-08.docx

Household Unit Type	Household
	Bedrooms[135]

Use Multifamily if: Building meets utility's definition for multifamily

365.25 = Days per year

γWater = Specific weight of water

= 8.33 pounds per gallon

T_{OUT} = Tank temperature

= 125°F

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

= 50.7°F [136]

1.0 = Heat Capacity of water (1 Btu/lb*°F)

3412 = Conversion from Btu to kWh

AFUEbase = Baseline Annual Fuel Utilization Efficiency Rating. For early replacement measures, use actual AFUE rating where it is possible to measure or reasonably estimate for the remaining useful life of the existing equipment (6 years for furnace, 8 years for boilers). If using rated efficiencies, derate efficiency value by 1% per year (maximum of 30 years) to account for degradation over time,[137] or if unknown assume default:

Baseline/ Existing Heating System	AFUEbase		
	Early Replacement (Remaining useful life of existing equipment)[138]	Early Replacement (Remaining measure life)	Time of Sale or New Construction
Furnace	64.4%	80%	80%
Boiler	61.6%	84%	84%

FurnaceFlag = 1 if system replaced is a gas furnace, 0 if not.

F_e = Furnace Fan energy consumption as a percentage of annual fuel consumption

For Early Replacement (1st 6 years) F_e_Exist = 3.14%[139]

135 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.

136 Table 4 in Chen, et. al., "Calculating Average Hot Water Mixes of Residential Plumbing Fixtures", June 2020, reports a value of 50.7°F for inlet water temperature for U.S. Census Division 3.

137 Justification for degradation factors can be found on page 14 of 'AIC HVAC Metering Study Memo FINAL 2_28_2018'. Estimate efficiency as (Rated Efficiency * (1-0.01)^Equipment Age).

138 Average nameplate efficiencies of all Early Replacement qualifying equipment in Ameren PY3-PY4.

139 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.

For New Construction, Time of Sale and early replacement (remaining 10 years)

F_e_New = 1.88%[140]

$EF_{GAS\ EXIST}$ = Energy Factor (efficiency) of existing gas water heater

= Actual. If unknown, assume federal standard:[141]

For <=55 gallons: 0.6483 – (0.0017 * storage capacity in gallons)

For > 55 gallons 0.7897 − (0.0004 * storage capacity in gallons)

= If tank size unknown, assume 40 gallons and EF_Baseline of 0.58

3412 = Btu per kWh

%IncentiveElectric = % of total incentive paid by electric utility

= Actual

%IncentiveGas = % of total incentive paid by gas utility

= Actual

See "Programmable Thermostats Furnace Fan Analysis.xlsx" for reference.

[140] New furnaces are required to have ECM fan motors installed. Comparing Eae to Ef for furnaces on the AHRI directory as above, indicates that Fe for new furnaces is on average 1.88%.

[141] Minimum Federal Standard as of 4/1/2015.

Non Fuel Switch Illustrative Examples

New Construction using ASHP baseline:

For example, a 3 ton unit with Part Load EER rating of 19 and Part Load COP of 4.4 with desuperheater is installed with a 50 gallon electric water heater in single family house in Springfield:

ΔkWh = [730 * 36,000 * (1/14 – 1/19) / 1000] + [1754* 36,000 * (1/8.2 – 1/(4.4*3.412)) / 1000] + [1 * 0.44 * ((1/0.945 * 17.6 * 2.56 *365.25 * 8.33 * (125-50.7) * 1)/3412)]

= 494 + 3494 + 1390

= 5378 kWh

Early Replacement

For example, a 3 ton unit with Part Load EER rating of 19 and Part Load COP of 4.4 with desuperheater is installed in single family house in Springfield with a 50 gallon electric water heater replacing an existing working Air Source Heat Pump with unknown efficiency ratings:

ΔkWH for remaining life of existing unit (1st 8 years):

= [730 * 36,000 * (1/9.3 - 1/19) / 1000] + [1754 * 36,000 * (1/5.54 - 1/(4.4 * 3.412)) / 1000] + [0.44 * 1 * ((1/0.945 * 17.6 * 2.56 *365.25 * 8.33 * (125-50.7) * 1)/3412)]

= 1443 + 7191 + 1390

= 10,024 kWh

ΔkWH for remaining measure life (next 17 years):

= (730 * 36,000 * (1/14 – 1/19) / 1000] + [1967 * 36,000 * (1/8.2 – 1/ (4.4 * 3.412)) / 1000] + [0.44 * 1 * ((1/0.945 * 17.6 * 2.56 *365.25 * 8.33 * (125-50.7) * 1)/3412)]

= 494 + 3494 + 1390

= 5378 kWh

Fuel Switch Illustrative Example

[for illustrative purposes 50:50 Incentive is used for joint programs]

New construction using gas furnace and central AC baseline:

For example, a 3 ton unit with Part Load EER rating of 19 and Part Load COP of 4.4 in single family house in Springfield with a 40 gallon gas water heater is installed in place of a natural gas furnace and 3 ton Central AC unit:

SiteEnergySavings (MMBTUs) = GasHeatReplaced + FurnaceFanSavings – GSHPSiteHeatConsumed + GSHPSiteCoolingImpact + GSHPSiteWaterImpact

GasHeatReplaced = (HeatLoad * 1/$AFUE_{base}$) / 1,000,000

= (1754 * 36,000 * 1/0.8) / 1,000,000 = 78.9 MMBtu

FurnaceFanSavings = (FurnaceFlag * HeatLoad * 1/$AFUE_{base}$ * F_e_New) / 1,000,000

= (1 * 1754 * 36,000 * 1/0.8 * 0.0188) / 1,000,000

= 1.5 MMBtu

GSHPSiteHeatConsumed = (HeatLoad * 1/COP_{PL})/ 1,000,000

= (1754 * 36,000 * 1/4.4) /1,000,000 = 14.3 MMBtu

Fuel Switch Illustrative Example continued

GSHPSiteCoolingImpact = (FLHcool * Capacity_GSHPcool * (1/$SEER_{base}$ – 1/EER_{PL})/1000 * 3412)/ 1,000,000

= (730 * 36,000 * (1/13 – 1/19) / 1000 * 3412) /1,000,000 = 2.2 MMBtu

GSHPSiteWaterImpact$_{Gas}$ = ((%DHWDisplaced * ((1/EF_{Gas} * GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0) / 1,000,000)

= (0.44 * (1/ 0.58 * 17.6 * 2.56 *365.25 * 8.33 * (125-50.7) * 1)) / 1,000,000 = 7.7 MMBtu

SiteEnergySavings (MMBTUs) = 78.9 + 1.5 – 14.3 + 2.2 + 7.7 = 76.0 MMBtu (Measure is eligible)

Savings would be claimed as follows:

Measure supported by:	Electric Utility claims:	Gas Utility claims:
Electric utility only	76.0 * 1,000,000/3412 = 22,274 kWh	N/A
Electric and gas utility	0.5 * 76.0 * 1,000,000/3412 = 11,137 kWh	0.5 * 76.0 * 10 = 380 Therms
Gas utility only	N/A	76.0 * 10 = 760 Therms

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = (Capacity_cooling * (1/EERbase - 1/EER_{FL}))/1000 * CF

Where:

EERbase = Energy Efficiency Ratio of baseline unit (kBtu/kWh). For early replacment measures, the actual EER rating where it is possible to measure or reasonably estimate should be used for the remaining useful life of the existing equipment (6 years for ASHP and Central AC). If using rated efficiencies, derate efficiency value by 1% per year (maximum of 30 years) to account for degradation over time.[142] If unknown, assume default provided below:

Baseline/Existing Cooling System	EER_base		
	Early Replacement (Remaining useful life of existing equipment)	Early Replacement (Remaining measure life)	Time of Sale or New Construction
Air Source Heat Pump	7.5[143]	11[144]	
Ground Source Heat Pump	12	12	

[142] Justification for degradation factors can be found on page 14 of 'AIC HVAC Metering Study Memo FINAL 2_28_2018'. Estimate efficiency as (Rated Efficiency * (1-0.01)^Equipment Age).
[143] Based on Opinion Dynamics and Cadmus metering study of Ameren HVAC program participants; See 'AIC HVAC Metering Study Memo FINAL 2_28_2018'
[144] The Federal Standard does not include an EER requirement, so it is approximated with the conversion formula from Wassmer, M. 2003 thesis referenced below.

Baseline/Existing Cooling System	EER_base		
	Early Replacement (Remaining useful life of existing equipment)	Early Replacement (Remaining measure life)	Time of Sale or New Construction
Central AC	7.5[145]	10.5[146]	
No central cooling	10.5[147]	10.5	

EER_{FL} = Full Load EER Efficiency of ENERGY STAR GSHP unit [148]

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)

= 72%[149]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)

= 46.6%[150]

145 Based on Opinion Dynamics and Cadmus metering study of Ameren HVAC program participants; See 'AIC HVAC Metering Study Memo FINAL 2_28_2018'

146 The federal Standard does not currently include an EER component. The value provided is based on Opinion Dynamics and Cadmus metering study of Ameren HVAC program participants; See 'AIC HVAC Metering Study Memo FINAL 2_28_2018'.

147 Assumes that the decision to replace existing systems includes desire to add cooling.

148 As per conversations with David Buss territory manager for Connor Co, the EER rating of an ASHP equate most appropriately with the full load EER of a GSHP.

149 Based on analysis of metering results from 24 heat pumps in Ameren Illinois service territory in PY5 coincident with AIC's 2010 system peak; 'Impact and Process Evaluation of Ameren Illinois Company's Residential HVAC Program (PY5)'.

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

New Construction or Time of Sale:

For example, a 3 ton unit with Full Load EER rating of 19:

ΔkW_{SSP} = (36,000 * (1/11.8 – 1/19))/1000 * 0.72

= 0.83 kW

ΔkW_{PJM} = (36,000 * (1/11 – 1/19))/1000 * 0.466

= 0.54 kW

Early Replacement:

For example, a 3 ton Full Load 19 EER replaces an existing working Air Source Heat Pump with unknown efficiency ratings in Marion:

ΔkW_{SSP} for remaining life of existing unit (1st 8 years):

= (36,000 * (1/7.5 – 1/19))/1000 * 0.72

= 2.09 kW

ΔkW_{SSP} for remaining measure life (next 17 years):

= (36,000 * (1/11.8 – 1/19))/1000 * 0.72

= 0.83 kW

ΔkW_{PJM} for remaining life of existing unit (1st 8 years):

= (36,000 * (1/7.5 – 1/19))/1000 * 0.466

= 1.35 kW

ΔkW_{PJM} for remaining measure life (next 17 years):

= (36,000 * (1/11.8 – 1/19))/1000 * 0.466

= 0.54 kW

FOSSIL FUEL SAVINGS

Calculation provided together with Electric Energy Savings above

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

COST EFFECTIVENESS SCREENING AND LOAD REDUCTION FORECASTING WHEN FUEL SWITCHING

This measure can involve fuel switching from gas to electric.

For the purposes of forecasting load reductions due to fuel switch GSHP projects per Section 16-111.5B, changes in site energy use at the customer's meter (using ΔkWh algorithm below) adjusted for utility line losses (at-the-busbar savings), customer switching estimates, NTG, and any other adjustment factors deemed appropriate, should be used.

The inputs to cost effectiveness screening should reflect the actual impacts on the electric and fuel consumption at the customer meter and, for fuel switching measures, this will not match the output of the calculation/allocation methodology presented in the "Electric Energy Savings" and "Fossil Fuel Savings" sections above. Therefore in addition to the calculation of savings claimed, the following values should be used to assess the cost effectiveness of the measure. For Early Replacement measures, the efficiency terms of the existing unit should be used for the remaining useful life of the existing equipment (6 years for ASHP and Central AC, 6 years for furnace, 8 years for boilers or GSHP, 15 years for electric resistance), and the efficiency terms for a new baseline unit should be used for the remaining years of the measure.

ΔTherms = [Heating Consumption Replaced] + [DHW Savings if gas]

= [(HeatLoad * 1/$AFUE_{base}$) / 100,000] + [(1 – ElecDHW) * %DHWDisplaced * (1/ $EF_{GAS\ EXIST}$ * GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0) / 100,000)]

ΔkWh = [FurnaceFanSavings] - [GSHP heating consumption] + [Cooling savings] + [DHW savings if electric]

= [FurnaceFlag * HeatLoad * 1/$AFUE_{base}$ * F_e * 0.000293] - [(HeatLoad * (1/COP_{PL} * 3.412))/1000] + [(FLHcool * Capacity_GSHPcool * (1/SEERbase - 1/EER_{PL}))/1000] + [ElecDHW * %DHWDisplaced * ((1/EF_{ELEC} * GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0) / 3412)]

Illustrative Example of Cost Effectiveness Inputs for Fuel Switching

For example, a 3 ton unit with Part Load EER rating of 19 and Part Load COP of 4.4 in single family house in Springfield with a 40 gallon gas water heater replaces an existing working natural gas furnace and 3 ton Central AC unit with unknown efficiency ratings. [Note the calculation provides the annual savings for the first 6 years of the measure life, an additional calculation (not shown) would be required to calculated the annual savings for the remaining life (years 7-25)]:

ΔTherms = [(HeatLoad * 1/$AFUE_{exist}$) / 100,000] + [(1 – ElecDHW) * %DHWDisplaced * (1/ $EF_{GAS\ EXIST}$ * GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0) / 100,067)]

= [1754 * 36,000 * 1/0.644) / 100,000] + [((1 – 0) * 0.44 * (1/ 0.58 * 17.6 * 2.56 *365.25 * 8.33 * (125-54) * 1) / 100,0067)]

= 980 + 74

= 1054 therms

ΔkWh = [FurnaceFlag * HeatLoad * 1/$AFUE_{base}$ * F_e_Exist * 0.000293] - [(HeatLoad * (1/COP_{PL} * 3.412))/1000] + [(FLHcool * Capacity_GSHPcool * (1/SEERexist - 1/EER_{PL}))/1000] + [ElecDHW * %DHWDisplaced * (((1/EF_{ELEC}) * GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0) / 3412)]

= [1 * 1754 * 3600 * 1/0.644 * 0.0314 * 0.000293] - [(1754 * 36,000 * (1/(4.4 * 3.412)))/ 1000] + [(730 * 36,000 * (1/9.3 - 1/19))/ 1000)] + [0 * 0.44 * (((1/0.904) * 17.6 * 2.56 *365.25 * 8.33 * (125-50.7) * 1)/3412)]

= 90 - 4206 + 1443 + 0

= -2673 kWh

MEASURE CODE: RS-HVC-GSHP-V1~~1~~2-220101

REVIEW DEADLINE: 1/1/2025

5.5.6 LED Specialty Lamps

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DESCRIPTION

This measure describes savings from a variety of specialty LED lamp types (including globe, decorative and downlights). This characterization assumes that the LED lamp is installed in a residential location. Where the implementation strategy does not allow for the installation location to be known (e.g., an upstream retail program) a deemed split of 96% Residential and 4% Commercial assumptions should be used.[151]

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

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

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed equipment must be an ENERGY STAR LED lamp or fixture. Note a new ENERGY STAR specification v2.1 becomes effective on 1/2/2017.

DEFINITION OF BASELINE EQUIPMENT

Specialty and Directional lamps were not included in the original definition of General Service Lamps in the Energy Independence and Security Act of 2007 (EISA). Therefore, the initial baseline is an incandescent / halogen lamp described in the table below.

A DOE Final Rule released on 1/19/2017 updated the EISA regulations to remove the exemption for these lamp types such that they become subject to the backstop provision defined within the original legislation. However, in September 2019 this decision was revoked in a new DOE Final Rule.

The natural growth of LED market share however, has and will continue to grow over the lifetime of the LED measures installed. The TAC convened a Lamp Forecast Working Group to develop a forecast of the baseline growth of LED, based upon historical growth rates provided via CREED LightTracker data, comparisons of with and no-program states and review of projections provided by the Department of Energy.[152]

This baseline forecast was then used to estimate how replacement lamps would change over the lifetime of an LED. A single mid-life adjustment is calculated that results in an equivalent net present value of lifetime savings as the forecast decline in annual savings.

Income Eligible Program Adjustments

The Lamp Forecast Working Group also developed forecasts for estimated Income Eligible market growth in LEDs. These forecasts are used to provide a separate mid-life adjustment for programs supporting income eligible populations. Note that upstream lighting programs in DIY, Warehouse, and Big Box stores located in income eligible neighborhoods should not assume that all customers are from income eligible populations, as data has indicated that the product selection and low prices found in these stores attract customers from beyond.[153] A weighted blend of the two measure types (Income eligible and non-income eligible) can be used for DIY, Warehouse, and Big Box stores located in income eligible neighborhoods based upon primary evaluation research at these store types, or using a default of 30% income eligible customers.[154]

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[151] RES v C&I split is based on a weighted (by sales volume) average of ComEd PY8, PY9 and CY2018 in store intercept survey results. See 'RESvCI Split_2019.xlsx'.

[152] US Department of Energy, "Energy Savings Forecast of Solid State Lighting in General Illumination Applications", December 2019. The resultant forecast is provided on the SharePoint site "Lamp Forecast Workbook.xls".

[153] Navigant and Itron, "CY2018 ComEd Income Eligible Product Discounts – Lighting NTG Recommendations".

[154] 30% of the respondents at the three Income Eligible Program stores where in-store intercepts were conducted met ComEd's income eligible definition; Navigant and Itron, "CY2018 ComEd Income Eligible Product Discounts – Lighting NTG

New Construction Programs

Since IECC 2015 energy code, there has been mandatory requirements for lighting in New Construction: *"Not less than 75 percent (90 percent in IECC 2018) of the lamps in permanently installed lighting fixtures shall be high-efficacy lamps or not less than 75 percent (90 percent in IECC 2018) of the permanently installed lighting fixtures shall contain only high-efficacy lamps"*. To meet the 'high efficacy' requirements, lamps need to be CFL or LED, however since CFLs are no longer commonly purchased (only 1% baseline forecast) it is assumed that 75% (IECC 2015) or 90% (IECC 2018) of the New Construction baseline is an LED and therefore savings are reduced by that percentage for bulbs provided in New Construction projects.

Early Replacement

The baseline for the early replacement measure is the existing bulb being replaced.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The average rated life for Decorative lamps on the ENERGY STAR Qualified Products list (accessed 6/16/2020) is approximately 17,000 hours, and for Directional Lamps is approximately 25,000 hours.

The deemed measure life is 6.9 years for exterior application of decorative lamps, and lifetimes are capped at 10 years for all other applications.[155]

For early replacement measures, if replacing a halogen or incandescent bulb, the remaining life is assumed to be 333 hours. For CFLs, the remaining life is 3,333 hours.[156]

DEEMED MEASURE COST

The price of LED lamps is falling quickly. Where possible, the actual cost should be used and compared to the baseline cost provided below. If the incremental cost is unknown, assume the following:[157]

Bulb Type	Year	Incandescent	LED	Incremental Cost	Incremental Cost for New Construction (IECC 2015)	Incremental Cost for New Construction (IECC 2015)
Directional	2019 and on	$3.53	$5.18	$1.65	$0.41	$0.17
Decorative and Globe	2019 and on	$1.74	$3.40	$1.66	$0.42	$0.17

LOADSHAPE

Loadshape R06 - Residential Indoor Lighting

Loadshape R07 - Residential Outdoor Lighting

COINCIDENCE FACTOR

The summer peak coincidence factor is assumed to be 0.109 for residential and in-unit multifamily bulbs,[158], 0.273

Recommendations".

[155] Based on recommendation in the Dunsky Energy Consulting, Livingston Energy Innovations and Opinion Dynamics Corporation; NEEP Emerging Technology Research Report, p 6-18.

[156] Representing a third of the expected lamp lifetime.

[157] Baseline and LED lamp costs for both directional and decorative and globe are based on field data collected by CLEAResult and provided by ComEd. See ComEd Pricing Projections 06302016.xlsx for analysis.

[158] Based on the IL Statewide LED Lighting Logger study conducted as part of the PY8/PY9 evaluations of the Ameren Illinois and

for exterior bulbs[159] and 0.117 for unknown[160]. Use Multifamily if the building meets the utility's definition for multifamily.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

ΔkWh = ((WattsBase - WattsEE) / 1000) * ISR * (1-Leakage) * Hours * WHFe

Where:

$Watts_{base}$ = Input wattage of the existing or baseline system. Reference the table below for default values.[161]

$Watts_{EE}$ = Actual wattage of LED purchased / installed. If unknown, use default provided below.

ComEd Residential Lighting programs.

[159] Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation. the IL Statewide LED Lighting Logger study conducted as part of the PY8/PY9 evaluations of the Ameren Illinois and ComEd Residential Lighting programs was unable to provide coincidence factors for specialty LEDs in exterior applications.

[160] Based on a weighted average of coincidence factors in interior and exterior applications, assuming 5% exterior lighting. The distribution of LEDs is based on the on-site lighting inventory conducted as part of the IL Statewide LED Lighting Logger study.

[161] See file "LED Lamp Updates 2021-06-09" for details on Guidehouse lamp wattage calculations based on equivalent baseline wattage and LED wattage of available ENERGY STAR product.

Decorative Lamps – ENERGY STAR Minimum Luminous Efficacy = 65Lm/W for all lamps

Bulb Type	Minimum Lumens	Maximum Lumens	LED Wattage ($Watts_{EE}$)	Baseline ($Watts_{Base}$)	Baseline for New Construction ($Watts_{Base}$)		Delta Watts (WattsEE)	Delta Watts for New Construction (WattsEE)	
					IECC 2015	IECC 2018		IECC 2015	IECC 2018
Omni-Directional 3-Way	1,100	1,999	14.7	100	36.0	23.2	85.3	21.3	8.5
	2,000	2,700	22.6	150	54.5	35.3	127.4	31.9	12.7
Globe (medium and intermediate bases less than 750 lumens)	150	349	3.0	25	8.5	5.2	22	5.5	2.2
	350	499	4.7	40	13.5	8.2	35.3	8.8	3.5
	500	574	5.7	60	19.3	11.1	54.3	13.6	5.4
	575	649	6.5	75	23.6	13.4	68.5	17.1	6.9
	650	1,000	8.2	100	31.2	17.4	91.8	23.0	9.2
Globe (candelabra bases less than 1050 lumens)	150	349	3.5	25	8.9	5.7	21.5	5.4	2.2
	350	499	4.4	40	13.3	8.0	35.6	8.9	3.6
	500	574	5.5	60	19.1	11.0	54.5	13.6	5.5
Decorative (Shapes B, BA, C, CA, DC, F, G, medium and intermediate bases less than 750 lumens)	160	299	2.6	25	8.2	4.8	22.4	5.6	2.2
	300	499	4.3	40	13.2	7.9	35.7	8.9	3.6
	500	800	5.8	60	19.4	11.2	54.2	13.6	5.4
Decorative (Shapes B, BA, C, CA, DC, F, G, candelabra bases less than 1050 lumens)	120	159	1.5	15	4.9	2.9	13.5	3.4	1.4
	160	299	2.7	25	8.3	4.9	22.3	5.6	2.2
	300	499	4.2	40	13.2	7.8	35.8	9.0	3.6
	500	650	5.5	60	19.1	11.0	54.5	13.6	5.5

Directional Lamps - ENERGY STAR Minimum Luminous Efficacy = 70Lm/W for <90 CRI lamps and 61 Lm/W for >=90CRI lamps.

For Directional R, BR, and ER lamp types:[162]

[162] From pg. 13 of the ENERGY STAR Specification for lamps v2.1

Bulb Type	Minimum Lumens	Maximum Lumens	LED Wattage ($Watts_{EE}$)	Baseline ($Watts_{Base}$)	Baseline for New Construction ($Watts_{Base}$)		Delta Watts (WattsEE)	Delta Watts for New Construction (WattsEE)	
					IECC 2015	IECC 2018		IECC 2015	IECC 2018
Reflector lamp types with medium screw bases (PAR20, PAR30(S,L), PAR38, R40, etc.) w/ diameter >2.25" (*see exceptions below)	400	649	7.0	50	17.8	11.3	43	10.8	4.3
	650	899	10.7	75	26.8	17.1	64.3	16.1	6.4
	900	1,049	13.9	90	32.9	21.5	76.1	19.0	7.6
	1,050	1,199	13.8	100	35.4	22.4	86.2	21.6	8.6
	1,200	1,499	15.9	120	41.9	26.3	104.1	26.0	10.4
	1,500	1,999	18.9	150	51.7	32.0	131.1	32.8	13.1
	2,000	4,200	27.3	250	83.0	49.6	222.7	55.7	22.3
Reflector lamp types with medium screw bases (PAR16, R14, R16, etc.) w/ diameter <2.25" (*see exceptions below)	280	374	4.6	35	12.2	7.6	30.4	7.6	3.0
	375	600	6.4	50	17.3	10.8	43.6	10.9	4.4
*BR30, BR40, or ER40	650	949	9.3	65	23.2	14.9	55.7	13.9	5.6
	950	1,099	12.7	75	28.3	18.9	62.3	15.6	6.2
	1,100	1,399	14.4	85	32.1	21.5	70.6	17.7	7.1
	1,400	1,600	16.6	100	37.5	24.9	83.4	20.9	8.3
	1,601	1,800	22.2	120	46.7	32.0	97.8	24.5	9.8
*R20	450	524	6.0	40	14.5	9.4	34.0	8.5	3.4
	525	750	7.1	45	16.6	10.9	37.9	9.5	3.8
*MR16	250	324	3.8	20.0	7.9	5.4	16.2	4.1	1.6
	325	369	4.8	25.0	9.9	6.8	20.2	5.1	2.0
	370	400	4.9	25.0	9.9	6.9	20.1	5.0	2.0

For PAR, MR, and MRX Lamps Types:

For these highly focused directional lamp types, it is necessary to have Center Beam Candle Power (CBCP) and beam angle measurements to accurately estimate the equivalent baseline wattage. The formula below is based on the ENERGY STAR Center Beam Candle Power tool.[163] If CBCP and beam angle information are not available or if the equation below returns a negative value (or undefined), use the manufacturer's recommended baseline wattage equivalent.[164]

$$\text{Wattsbase} =$$

$$375.1 - 4.355(D) - \sqrt{227{,}800 - 937.9(D) - 0.9903(D^2) - 1479(BA) - 12.02(D * BA) + 14.69(BA^2) - 16{,}720 * \ln(CBCP)}$$

Where:

[163] See 'ESLampCenterBeamTool.xls'.

[164] The ENERGY STAR Center Beam Candle Power tool does not accurately model baseline wattages for lamps with certain bulb characteristic combinations – specifically for lamps with very high CBCP.

D = Bulb diameter (e.g. for PAR20 D = 20)

BA = Beam angle

CBCP = Center beam candle power

The result of the equation above should be rounded DOWN to the nearest wattage established by ENERGY STAR:

Diameter	Permitted Wattages
16	20, 35, 40, 45, 50, 60, 75
20	50
30S	40, 45, 50, 60, 75
30L	50, 75
38	40, 45, 50, 55, 60, 65, 75, 85, 90, 100, 120, 150, 250

Additional EISA non-exempt bulb types:

Bulb Type	Minimum Lumens	Maximum Lumens	LED Wattage ($Watts_{EE}$)	Baseline ($Watts_{Base}$)	Baseline for New Construction ($Watts_{Base}$)		Delta Watts (WattsEE)	Delta Watts for New Construction (WattsEE)	
					IECC 2015	IECC 2018		IECC 2015	IECC 2018
Dimmable Twist, Globe (less than 5" in diameter and > 749 lumens), candle (shapes B, BA, CA > 749 lumens), Candelabra Base Lamps (>1049 lumens), Intermediate Base Lamps (>749 lumens)	120	399	4.0	25	9.3	6.1	21.0	5.3	2.1
	400	749	6.6	29	12.2	8.8	22.4	5.6	2.2
	750	899	9.6	43	18.0	12.9	33.4	8.4	3.3
	900	1,399	13.1	53	23.1	17.1	39.9	10.0	4.0
	1,400	1,999	16.0	72	30.0	21.6	56.0	14.0	5.6

ISR = In Service Rate or the percentage of lamps rebated that get installed

Program	Weighted Average 1st year In Service Rate (ISR)	2nd year Installations	3rd year Installations	Final Lifetime In Service Rate
Retail (Time of Sale)	81.5%[165]	8.9%	7.6%	98.0%[166]

[165] 1st year in service rate is based upon analysis of ComEd PY8, PY9 and CY2018 intercept data (see 'Res Lighting ISR_2019.xlsx' for more information).

[166] The 98% Lifetime ISR assumption is based upon the standard CFL measure in the absence of any better reference. This value is based upon review of two evaluations:
'Nexus Market Research, RLW Analytics and GDS Associates study; "New England Residential Lighting Markdown Impact Evaluation, January 20, 2009' and 'KEMA Inc, Feb 2010, Final Evaluation Report:, Upstream Lighting Program, Volume 1.' This implies that only 2% of bulbs purchased are never installed. The second and third year installations are based upon Ameren

Program		Weighted Average 1st year In Service Rate (ISR)	2nd year Installations	3rd year Installations	Final Lifetime In Service Rate
Direct Install		94.5%[167]			
Virtual Assessment followed by Unverified Self-Install		80.3%[168]	9.6%	8.1%	98%[169]
Efficiency Kits[170]	LED Distribution[171]	59%	13%	11%	83%
	School Kits[172]	60%	13%	11%	84%
	Direct Mail Kits[173]	66%	14%	12%	93%
	Direct Mail Kits, Income Qualified[174]	68%	15%	12%	95%
	Community Distributed Kits[175]	88%	4%	3%	95%

Leakage = Adjustment to account for the percentage of program bulbs that move out (and in if deemed appropriate)[176] of the Utility Jurisdiction.

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.

167 Consistent with assumption for standard LEDs (in the absence of evidence that it should be different for this bulb type). Based upon average of Navigant low income single family direct install field work LED ISR and 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.

168 An equal weighted average of Direct Install and Direct Mail Kit ISRs. Interest and applicability of measures confirmed through virtual assessment.

169 The 98% Lifetime ISR assumption is based upon the standard CFL measure in the absence of any better reference. This value is based upon review of two evaluations:
'Nexus Market Research, RLW Analytics and GDS Associates study; "New England Residential Lighting Markdown Impact Evaluation, January 20, 2009' and 'KEMA Inc, Feb 2010, Final Evaluation Report:, Upstream Lighting Program, Volume 1.' This implies that only 2% of bulbs purchased are never installed. The second and third year installations are based upon Ameren analysis of the Californian KEMA study showing that 54% of future installs occur in year 2 and 46% in year 3. The 2nd and 3rd year installations should be counted as part of those future program year savings.

170 In Service Rates provided are for the bulb within a kit only. Given the significant differences in program design and the level of education provided through Efficiency Kits programs, the evaluators should apply the ISR estimated through evaluations (either past evaluations or the current program year evaluation) of the specific Efficiency Kits program. In cases where program-specific evaluation results for an ISR are unavailable, the default ISR values for Efficiency Kits provide may be used.

171 Free bulbs provided without request, with little or no education. Consistent with Standard CFL assumptions.

172 1st year ISR for school kits based on ComEd PY9 data for the Elementary Energy Education program. Final ISR assumptions are based upon comparing with CFL Distribution First year ISR and multiplying by the CFL Distribution Final ISR value, and second and third year estimates based on same proportion of future installs.

173 Opt-in program to receive kits via mail, with little or no education. Consistent with Standard CFL assumptions.

174 Research from 2018 Ameren Illinois Income Qualified participant survey.

175 Kits distributed in a community setting, targeted to income qualified communities. Research from 2018 Ameren Illinois Income Qualified participant survey.

176 Leakage in is only appropriate to credit to IL utility program savings if it is reasonably expected that the IL utility program marketing efforts played an important role in influencing customer to purchase the light bulbs. Furthermore, consideration that such customers might be free riders should be addressed. If leakage in is assessed, efforts should be made to ensure no double counting of savings occurs if the evaluation is estimating both leakage in and spillover savings of light bulbs.

KITS programs = Determined through evaluation

Upstream (TOS) Lighting programs = Use deemed assumptions below:[177]

ComEd: 1.1%

Ameren: 13.1%

All other programs = 0

Hours = Average hours of use per year

Installation Location	Annual hours of use (HOU)
Residential and In-Unit Multi Family	763[178]
Exterior	2,475[179]
Unknown	1,020[180]

WHFe = Waste heat factor for energy to account for cooling savings from efficient lighting

Bulb Location	WHFe
Interior single family	1.06 [181]
Multifamily in unit	1.04 [182]
Exterior or uncooled location	1.0
Unknown location	1.046[183]

Use Multifamily if: Building meets utility's definition for multifamily

For example, a 13W PAR20 LED is purchased through a ComEd upstream program and installed in place of a 750 lumen PAR20 incandescent screw-in lamp with medium screw base, diameter >2.5" in a single family interior

[177] Leakage rate is based upon review of PY8-CY2018 evaluations from ComEd and PY5,6 and 8 for Ameren.

[178] Based on the IL Statewide LED Lighting Logger study conducted as part of the PY8/PY9 evaluations of the Ameren Illinois and ComEd Residential Lighting programs.

[179] Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation. The IL Statewide LED Lighting Logger study conducted as part of the PY8/PY9 evaluations of the Ameren Illinois and ComEd Residential Lighting programs was unable to provide hours of use for specialty LEDs in exterior applications.

[180] Based on a weighted average of interior and exterior hours of use from the IL Statewide LED Lighting Logger study conducted as part of the PY8/PY9 evaluations of the Ameren Illinois and ComEd Residential Lighting programs, assuming 15% exterior specialty lighting. The distribution of LEDs is based on the on-site lighting inventory conducted as part of the IL Statewide LED Lighting Logger study.

[181] 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)

[182] As above but using estimate of 45% of multifamily buildings in Illinois having central cooling (based on data from "Table HC7.1 Air Conditioning in U.S. Homes, By Housing Unit Type, 2009" which is for the whole of the US, scaled to IL air conditioning prevalence compared to US average)

[183] Unknown is weighted average of interior v exterior (assuming 15% exterior specialty lighting based on distribution of LEDs from on-site lighting inventory conducted as part of the IL Statewide LED Lighting Logger study) and SF v MF interior based on statewide weighted average of 69% single family and 31% multifamily, based on IL data from 2009 RECS Table HC2.9 Structural and Geographic Characteristics of Homes in Midwest Region, Divisions and States, 2009.

location:

ΔkWh = ((75 - 13) / 1000) * 0.840 * (1 – 0.011) * 763 * 1.06

= 41.6 kWh

DEFERRED INSTALLS

For example: using the assumptions from above, for an 8W LED, 450 Lumens purchased for the interior of a residential homes through a ComEd upstream program.

$\Delta kWh_{2nd\ year\ installs}$ = ((29 - 8.0)/1000) * 0.106 * (1 – 0.008) * 1,089 * 1.06

= 2.5 kWh

$\Delta kWh_{3rd\ year\ installs}$ = ((29 – 8.0)/1000) * 0.09 * (1 – 0.008) * 1,089 * 1.06

= 2.2 kWh

Note: Here we assume no change in hours assumption. NTG value from Purchase year should be applied.

For v9 and v10 of this measure, deferred installs claimed in 2023 and 2024 should use all assumptions provided in v10 of the measure, with the exception of the year of midlife adjustment. This should be claimed as follows:

Install Year	Lamp Type	Population	2023		2024	
			Year from which adjustment is applied	Adjustment Factor applied to Annual kWh Savings	Year from which adjustment is applied	Adjustment Factor applied to Annual kWh Savings
2021 Installs (v9)	Decorative	Income Eligible	2030	67%	N/A	
		All others	2027	70%		
	Directional	Income Eligible	2030	73%		
		All others	2027	61%		
2022 Installs (v10)	Decorative	Income Eligible	2030	67%	2031	67%
		All others	2027	70%	2028	70%
	Directional	Income Eligible	2030	73%	2031	73%
		All others	2027	61%	2028	61%

~~As presented above, the characterization assumes that a percentage of bulbs purchased are not installed until Year 2 and Year 3 (see ISR assumption above). The Illinois Technical Advisory Committee has determined the following methodology for calculating the savings of these future installs.~~

~~Year 2 and 3 installs:~~ ~~Characterized using delta watts assumption and hours of use from the Install Year; i.e., the actual deemed assumptions active in Year 2 and 3 should be applied.~~

~~The NTG factor for the Purchase Year (Year 1) should be applied.~~

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HEATING PENALTY

If electric heated home (if heating fuel is unknown assume gas, see Natural Gas section):

ΔkWh[184] = - (((WattsBase - WattsEE) / 1000) * ISR * (1-Leakage) * Hours * HF) / ηHeat

Where:

HF = Heating Factor or percentage of light savings that must be heated

= 49% for interior location [185]

= 0% for exterior location

= 42% for unknown location [186]

ηHeat = Efficiency in COP of Heating equipment

= Actual. If not available use: [187]

System Type	Age of Equipment	HSPF Estimate	COP_{HEAT} (COP Estimate) = (HSPF/3.413)*0.85
Heat Pump	Before 2006	6.8	1.7
	After 2006 - 2014	7.7	1.92
	2015 on	8.2	2.04
Resistance	N/A	N/A	1.00
Unknown[188]	N/A	N/A	1.28

For example, a 13W PAR20 LED is purchased through a ComEd upstream program and installed in place of a 750 lumen PAR20 incandescent screw-in lamp with medium screw base, diameter >2.5" in a single family interior location with a 2016 heat pump:

ΔkWh = - (((75 - 13) / 1000) * 0.840 * (1 – 0.011) * 763 * 0.49) / 2.04

= - 9.4 kWh

[184] Negative value because this is an increase in heating consumption due to the efficient lighting.

[185] 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.

[186] Based on a weighted average of interior and exterior hours of use from the IL Statewide LED Lighting Logger study conducted as part of the PY8/PY9 evaluations of the Ameren Illinois and ComEd Residential Lighting programs, assuming 15% exterior specialty lighting. The distribution of LEDs is based on the on-site lighting inventory conducted as part of the IL Statewide LED Lighting Logger study.

[187] 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. Note efficiency should include duct losses. Defaults provided assume 15% duct loss for heat pumps.

[188] Calculation assumes 35% Heat Pump and 65% Resistance, which is based upon data from Energy Information Administration, 2009 Residential Energy Consumption Survey, see "HC6.9 Space Heating in Midwest Region.xls", using average for East North Central Region. Average efficiency of heat pump is based on assumption that 50% are units from before 2006 and 50% from 2006-2014. Program or evaluation data should be used to improve this assumption if available.

Mid-Life Baseline Adjustment

During the lifetime of an LED, the baseline incandescent/halogen bulb would need to be replaced multiple times. Natural growth of LED market share has, and will continue to grow over the lifetime of the measure, and so a single mid-life adjustment is calculated that results in an equivalent net present value of lifetime savings as the forecast decline in annual savings. See 'Lamp Forecast Workbook_2021.xls' for details.

The calculated mid-life adjustments for 2021 are provided below for each population:

Population	Lamp Type	Year from which adjustment is applied	Adjustment Factor applied to Annual kWh Savings
Income Eligible	Decorative	2029	67%
	Directional	2029	73%
All others	Decorative	2026	70%
	Directional	2026	61%

For example, a 13W PAR20 LED is purchased through a ComEd upstream program and installed in place of a 750 lumen PAR20 incandescent screw-in lamp with medium screw base, diameter >2.5" in a single family interior location:

ΔkWh (2021-2024) = ((75 - 13) / 1000) * 0.840 * (1 – 0.011) * 763 * 1.06

= 41.7 kWh

ΔkWh (2025 on) = 41.7 * 0.61

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ((WattsBase - WattsEE) / 1000) * ISR * (1-Leakage) * WHFd * CF

Where:

WHFd = Waste heat factor for demand to account for cooling savings from efficient lighting.

Bulb Location	WHFd
Interior single family	1.11[189]
Multifamily in unit	1.07[190]
Exterior or uncooled location	1.0
Unknown location	1.083[191]

189 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.

190 As above but using estimate of 45% of multifamily buildings in Illinois having central cooling (based on data from "Table HC7.1 Air Conditioning in U.S. Homes, By Housing Unit Type, 2009" which is for the whole of the US, scaled to IL air conditioning prevalence compared to US average)

191 Unknown is weighted average of interior v exterior (assuming 15% exterior specialty lighting based on distribution of LEDs from on-site lighting inventory conducted as part of the IL Statewide LED Lighting Logger study) and SF v MF interior based on statewide weighted average of 69% single family and 31% multifamily, based on IL data from 2009 RECS Table HC2.9 Structural

Use Multifamily if: Building meets utility's definition for multifamily

CF = Summer Peak Coincidence Factor for measure

= 0.109 for residential and in-unit multifamily bulbs[192], 0.273 for exterior bulbs,[193] and 0.117 for unknown.[194]

Use Multifamily if: Building meets utility's definition for multifamily

Other factors as defined above

> **For example**, a 13W PAR20 LED is purchased through a ComEd upstream program and installed in place of a 750 lumen PAR20 incandescent screw-in lamp with medium screw base, diameter >2.5" in a single family interior location:
>
> ΔkW = (((75 - 13) / 1000) * 0.840 * (1 – 0.011) * 1.11* 0.109
>
> = 0.0062 kW

NATURAL GAS SAVINGS

Heating penalty if Natural Gas heated home, or if heating fuel is unknown.

Δtherms = - (((WattsBase - WattsEE) / 1000) * ISR * (1-Leakage) * Hours * HF * 0.03412) / ηHeat

Where:

HF = Heating factor, or percentage of lighting savings that must be replaced by heating system.

= 49% for interior[195]

= 0% for exterior location

= 42% for unknown location[196]

0.03412 = Converts kWh to Therms

ηHeat = Average heating system efficiency.

and Geographic Characteristics of Homes in Midwest Region, Divisions and States, 2009.

192 Based on the IL Statewide LED Lighting Logger study conducted as part of the PY8/PY9 evaluations of the Ameren Illinois and ComEd Residential Lighting programs.

193 Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation. the IL Statewide LED Lighting Logger study conducted as part of the PY8/PY9 evaluations of the Ameren Illinois and ComEd Residential Lighting programs was unable to provide coincidence factors for specialty LEDs in exterior applications.

194 Based on a weighted average of coincidence factors in interior and exterior applications, assuming 5% exterior lighting. The distribution of LEDs is based on the on-site lighting inventory conducted as part of the IL Statewide LED Lighting Logger study.

195 Average result from REMRate modeling of several different configurations and IL locations of homes

196 Based on a weighted average of interior and exterior hours of use from the IL Statewide LED Lighting Logger study conducted as part of the PY8/PY9 evaluations of the Ameren Illinois and ComEd Residential Lighting programs, assuming 15% exterior specialty lighting. The distribution of LEDs is based on the on-site lighting inventory conducted as part of the IL Statewide LED Lighting Logger study.

= 0.70 [197]

Other factors as defined above

> **For example**, a 13W PAR20 LED is purchased through a ComEd upstream program and installed in place of a 750 lumen PAR20 incandescent screw-in lamp with medium screw base, diameter >2.5" in single family interior location with gas heating at 70% total efficiency:
>
> Δtherms = - (((75 - 13) / 1000) * 0.840 * (1 – 0.011) * 763 * 0.49* 0.03412) / 0.70
>
> = - 0.94 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

Bulb replacement costs assumed in the O&M calculations are provided below:[198]

Lamp Type	Standard Incandescent	EISA Compliant Halogen	CFL	LED
Decorative	$1.74	$1.74	$2.50	$3.40
Directional	$3.53	$3.53	$4.50	$5.18

For non-exempt EISA bulb types defined above, in order to account for natural growth of LED over the lifetime of the measure, an equivalent annual levelized baseline replacement cost is calculated and applied over the life of the measure life.

The NPV for replacement lamps and annual levelized replacement costs using the societal real discount rate of 0.42% are presented below:[199]

[197] 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) 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

[198] Baseline costs are based on field data collected by CLEAResult and provided by ComEd. See ComEd Pricing Projections 06302016.xlsx for analysis.

[199] See "Lamp Forecast Workbook_2020.xlsx" for calculation.

Lamp Type	Population	Location	NPV of replacement costs for period	Levelized annual replacement cost savings
			2021	2021
Decorative	Income eligible	Residential and in-unit Multi Family, and Unknown	$14.14	$1.45
		Exterior	$20.85	$3.09
	All others	Residential and in-unit Multi Family, and Unknown	$13.15	$1.35
		Exterior	$19.59	$2.90
Directional	Income eligible	Residential and in-unit Multi Family, and Unknown	$28.94	$2.96
		Exterior	$60.71	$6.21
	All others	Residential and in-unit Multi Family, and Unknown	$24.84	$2.54
		Exterior	$51.25	$5.19

It is important to note that for cost-effectiveness screening purposes, the O&M cost adjustments should only be applied in cases where the light bulbs area actually in service and so should be multiplied by the appropriate ISR.

MEASURE CODE: RS-LTG-LEDD-V14~~3~~-220101

REVIEW DEADLINE: 1/1/2023

5.5.8 LED Screw Based Omnidirectional Bulbs

DESCRIPTION

This characterization provides savings assumptions for LED Screw Based Omnidirectional (e.g., A-Type lamps) lamps within the residential and multifamily sectors. This characterization assumes that the LED lamp is installed in a residential location. Where the implementation strategy does not allow for the installation location to be known (e.g., an upstream retail program) a deemed split of 97% Residential and 3% Commercial assumptions should be used.[200]

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

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

DEFINITION OF EFFICIENT EQUIPMENT

In order for this characterization to apply, new lamps must be ENERGY STAR labeled. Note a new ENERGY STAR specification v2.1 became effective on 1/2/2017.

DEFINITION OF BASELINE EQUIPMENT

In 2012, Federal legislation stemming from the Energy Independence and Security Act of 2007 (EISA) will require all general-purpose light bulbs between 40 watts and 100 watts to have ~30% increased efficiency, essentially phasing out standard incandescent technology. In 2012, the 100 w lamp standards apply; in 2013 the 75 w lamp standards will apply, followed by restrictions on the 60 w and 40 w lamps in 2014. Since measures installed under this TRM all occur after 2014, baseline equipment are the values after EISA. These are shown in the baseline table below.

Additionally, an EISA backstop provision was included that would require replacement baseline lamps to meet an efficacy requirement of 45 lumens/watt or higher beginning on 1/1/2020. However, in December 2019, DOE issued a final determination for General Service Incandescent Lamps (GSILs), finding that this more stringent standard was not economically justified.

The natural growth of LED market share however, has and will continue to grow over the lifetime of the LED measures installed. The TAC convened a Lamp Forecast Working Group to develop a forecast of the baseline growth of LED, based upon historical growth rates provided via CREED LightTracker data, comparisons of with and no-program states and review of projections provided by the Department of Energy.[201]

This baseline forecast was then used to estimate how replacement lamps would change over the lifetime of an LED. A single mid-life adjustment is calculated that results in an equivalent net present value of lifetime savings as the forecast decline in annual savings.

Income Eligible Program Adjustments

The Lamp Forecast Working Group also developed forecasts for estimated Income Eligible market growth in LEDs. These forecasts are used to provide a separate mid-life adjustment for programs supporting income eligible populations. Note that upstream lighting programs in DIY, Warehouse, and Big Box stores located in income eligible neighborhoods should not assume that all customers are from income eligible populations, as data has indicated that the product selection and low prices found in these stores attract customers from beyond.[202] A weighted blend of the two measure types (Income eligible and non-income eligible) can be used for DIY, Warehouse, and Big Box stores located in income eligible neighborhoods based upon primary evaluation research at these store types, or

---

[200] RES v C&I split is based on a weighted (by sales volume) average of ComEd PY8, PY9 and CY2018 and Ameren PY8 in store intercept survey results. See 'RESvCI Split_2019.xlsx'.

[201] US Department of Energy, "Energy Savings Forecast of Solid State Lighting in General Illumination Applications", December 2019. The resultant forecast is provided on the SharePoint site "Lamp Forecast Workbook.xls".

[202] Navigant and Itron, "CY2018 ComEd Income Eligible Product Discounts – Lighting NTG Recommendations".

using a default of 30% income eligible customers.[203]

New Construction Programs

Since IECC 2015 energy code, there has been mandatory requirements for lighting in New Construction: *"Not less than 75 percent (90 percent in IECC 2018) of the lamps in permanently installed lighting fixtures shall be high-efficacy lamps or not less than 75 percent (90 percent in IECC 2018) of the permanently installed lighting fixtures shall contain only high-efficacy lamps"*. To meet the 'high efficacy' requirements, lamps need to be CFL or LED, however since CFLs are no longer commonly purchased (only 1% baseline forecast) it is assumed that 75% (IECC 2015) or 90% (IECC 2018) of the New Construction baseline is an LED and therefore savings are reduced by that percentage for bulbs provided in New Construction projects.

Early Replacement

The baseline for the early replacement measure is the existing bulb being replaced.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The average rated life for Omnidirectional lamps on the ENERGY STAR Qualified Products list (accessed 6/16/2020) is approximately 20,000 hours.

The deemed measure life is 8 years for exterior application and lifetimes are capped at 10 years for other applications.[204]

For early replacement measures, if replacing a halogen or incandescent bulb, the remaining life is assumed to be 333 hours. For CFL's, the remaining life is 3,333 hours.[205]

DEEMED MEASURE COST

The price of LED lamps is falling quickly. Where possible, the actual LED lamp cost should be used and compared to the baseline cost provided below. If the incremental cost is unknown, assume the following:[206]

Year	EISA Compliant Halogen	LED A-Lamp	Incremental Cost	Incremental Cost for New Construction	
				(IECC 2015)	(IECC 2018)
2020 and on	$1.25	$2.70	$1.45	$0.36	$0.15

LOADSHAPE

Loadshape R06 – Residential Indoor Lighting

Loadshape R07 – Residential Outdoor Lighting

COINCIDENCE FACTOR

The summer peak coincidence factor is assumed to be 0.128 for Residential and in-unit Multi Family bulbs,[207] 0.273

203 30% of the respondents at the three Income Eligible Program stores where in-store intercepts were conducted met ComEd's income eligible definition; Navigant and Itron, "CY2018 ComEd Income Eligible Product Discounts – Lighting NTG Recommendations".

204 Based on recommendation in the Dunsky Energy Consulting, Livingston Energy Innovations and Opinion Dynamics Corporation; NEEP Emerging Technology Research Report, p 6-18.

205 Representing a third of the expected lamp lifetime.

206 Baseline and LED lamp costs are based on field data collected by CLEAResult and provided by ComEd. See ComEd Pricing Projections 06302016.xlsx for analysis.

207 Based on the IL Statewide LED Lighting Logger study conducted as part of the PY8/PY9 evaluations of the Ameren Illinois and

for exterior bulbs,[208] and 0.135 for unknown,[209]

Use Multifamily if: Building meets utility's definition for multifamily.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = ((Watts_{base} - Watts_{EE})/1000) * ISR * (1-Leakage) * Hours * WHF_e$$

Where:

$Watts_{base}$ = Input wattage of the existing or baseline system. Reference the "LED New and Baseline Assumptions" table for default values.

$Watts_{EE}$ = Actual wattage of LED purchased / installed. If unknown, use default provided below:[210]

LED New and Baseline Assumptions Table

Minimum Lumens	Maximum Lumens	LED Wattage (WattsEE)	Baseline (WattsBase)	Baseline for New Construction (WattsBase)		Delta Watts (WattsEE)	Delta Watts for New Construction (WattsEE)	
				(IECC 2015)	(IECC 2018)		(IECC 2015)	(IECC 2018)
120	399	4.0	25	9.3	6.1	21.0	5.3	2.1
400	749	6.6	29	12.2	8.8	22.4	5.6	2.2
750	899	9.6	43	18.0	12.9	33.4	8.4	3.3
900	1,399	13.1	53	23.1	17.1	39.9	10.0	4.0
1,400	1,999	16.0	72	30.0	21.6	56.0	14.0	5.6
2,000	2,999	21.8	150	53.9	34.6	128.2	32.1	12.8
3,000	3,999	28.9	200	71.7	46.0	171.1	42.8	17.1
4,000	5,000	35.7	300	101.8	62.1	264.3	66.1	26.4

ISR = In Service Rate, the percentage of lamps rebated that are actually in service.

ComEd Residential Lighting programs.

[208] Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation. the IL Statewide LED Lighting Logger study conducted as part of the PY8/PY9 evaluations of the Ameren Illinois and ComEd Residential Lighting programs was unable to provide coincidence factors for screw-based omnidirectional LEDs in exterior applications.

[209] Based on a weighted average of coincidence factors in interior and exterior applications, assuming 5% exterior lighting. The distribution of LEDs is based on the on-site lighting inventory conducted as part of the IL Statewide LED Lighting Logger study.

[210] See file "LED Lamp Updates 2021-06-09" for details on Guidehouse lamp wattage calculations based on equivalent baseline wattage and LED wattage of available ENERGY STAR product.

Program		Weighted Average 1st year In Service Rate (ISR)	2nd year Installations	3rd year Installations	Final Lifetime In Service Rate[211]
Retail (Time of Sale)		76.0%[212]	11.9%	10.1%	98.0%[213]
Direct Install		94.5%[214]			
Virtual Assessment followed by Unverified Self-Install		80.3%[215]	9.6%	8.1%	98.0%[216]
Efficiency Kits[217]	LED Distribution[218]	59%	13%	11%	83%
	School Kits[219]	60%	13%	11%	84%
	Direct Mail Kits[220]	66%	14%	12%	93%
	Direct Mail Kits, Income Qualified[221]	68%	15%	12%	95%
	Community Distributed Kits[222]	88%	4%	3%	95%
Food Bank / Pantry Distribution[223]		80.3%[224]	9.6%	8.1%	98%[225]

[211] Final ISR assumptions for efficiency kits are based upon comparing with CFL Distribution First year ISR and multiplying by the CFL Distribution Final ISR value, capped at 95%, and second and third year estimates based on same proportion of future installs. 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.

[212] 1st year in service rate is based upon analysis of ComEd PY8, PY9 and CY2018 and Ameren PY8 intercept data (see 'RES Lighting ISR_2019.xlsx' for more information).

[213] The 98% Lifetime ISR assumption is based upon the standard CFL measure in the absence of any better reference. This value is based upon review of two evaluations:
'Nexus Market Research, RLW Analytics and GDS Associates study; "New England Residential Lighting Markdown Impact Evaluation, January 20, 2009' and 'KEMA Inc, Feb 2010, Final Evaluation Report:, Upstream Lighting Program, Volume 1.' This implies that only 2% of bulbs purchased are never installed.

[214] Based upon average of Navigant low income single family direct install field work LED ISR and Standard CFL assumption in the absence of better data, and is based upon review of the PY2 and PY3 ComEd Direct Install program surveys. This value includes bulb failures in the 1st year to be consistent with the Commission approval of annualization of savings for first year savings claims. ComEd PY2 All Electric Single Family Home Energy Performance Tune-Up Program Evaluation, Navigant Consulting, December 21, 2010.

[215] An equal weighted average of Direct Install and Direct Mail Kit ISRs. Interest and applicability of measures confirmed through virtual assessment.

[216] The 98% Lifetime ISR assumption is based upon the standard CFL measure in the absence of any better reference. This value is based upon review of two evaluations:
'Nexus Market Research, RLW Analytics and GDS Associates study; "New England Residential Lighting Markdown Impact Evaluation, January 20, 2009' and 'KEMA Inc, Feb 2010, Final Evaluation Report:, Upstream Lighting Program, Volume 1.' This implies that only 2% of bulbs purchased are never installed.

[217] In Service Rates provided are for the bulb within a kit only. Given the significant differences in program design and the level of education provided through Efficiency Kits programs, the evaluators should apply the ISR estimated through evaluations (either past evaluations or the current program year evaluation) of the specific Efficiency Kits program. In cases where program-specific evaluation results for an ISR are unavailable, the default ISR values for Efficiency Kits provide may be used.

[218] Free bulbs provided without request, with little or no education. Consistent with Standard CFL assumptions.

[219] 1st year ISR for school kits based on ComEd PY9 data for the Elementary Energy Education program. Final ISR assumptions are based upon comparing with CFL Distribution First year ISR and multiplying by the CFL Distribution Final ISR value, and second and third year estimates based on same proportion of future installs.

[220] Opt-in program to receive kits via mail, with little or no education. Consistent with Standard CFL assumptions.

[221] Research from 2018 Ameren Illinois Income Qualified participant survey.

[222] Kits distributed in a community setting, targeted to income qualified communities. Research from 2018 Ameren Illinois Income Qualified participant survey.

[223] Free bulbs provided through local food banks and food pantries.

[224] 1st year ISR is determined based on online surveys conduted for ComEd CY2018 Food Bank LED Distribution program. See 'CY2018 ComEd Foodbank LED Dist Survey Results_Navigant'.

[225] In the absence of any program specific data, 98% lifetime ISR assumption is made based on similarity between 1st year ISR

Leakage = Adjustment to account for the percentage of program bulbs that move out (and in if deemed appropriate)[226] of the Utility Jurisdiction.

KITS programs = Determined through evaluation

Upstream (TOS) Lighting programs = Use deemed assumptions below:[227]

ComEd: 0.8%

Ameren: 13.1%

All other programs = 0

Hours = Average hours of use per year

Installation Location	Hours
Residential and in-unit Multi Family	1,089[228]
Exterior	2,475[229]
Unknown	1,159[230]

WHFe = Waste heat factor for energy to account for cooling energy savings from efficient lighting

Bulb Location	WHFe
Interior single family	1.06 [231]
Multifamily in unit	1.04 [232]
Exterior or uncooled location	1.0
Unknown location	1.051[233]

values with the Retail (Time of Sale) program and the 2nd and 3rd year installations are scaled accordingly.

226 Leakage in is only appropriate to credit to IL utility program savings if it is reasonably expected that the IL utility program marketing efforts played an important role in influencing customer to purchase the light bulbs. Furthermore, consideration that such customers might be free riders should be addressed. If leakage in is assessed, efforts should be made to ensure no double counting of savings occurs if the evaluation is estimating both leakage in and spillover savings of light bulbs.

227 Leakage rate is based upon review of PY8-CY2018 evaluations from ComEd and PY8 for Ameren.

228 Based on the IL Statewide LED Lighting Logger study conducted as part of the PY8/PY9 evaluations of the Ameren Illinois and ComEd Residential Lighting programs.

229 Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation. The IL Statewide LED Lighting Logger study conducted as part of the PY8/PY9 evaluations of the Ameren Illinois and ComEd Residential Lighting programs was unable to provide hours of use for screw-based omnidirectional LEDs in exterior applications.

230 Based on a weighted average of hours of use in interior and exterior applications, assuming 5% exterior lighting. The distribution of LEDs is based on the on-site lighting inventory conducted as part of the IL Statewide LED Lighting Logger study.

231 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)

232 As above but using estimate of 45% of multifamily buildings in Illinois having central cooling (based on data from "Table HC7.1 Air Conditioning in U.S. Homes, By Housing Unit Type, 2009" which is for the whole of the US, scaled to IL air conditioning prevalence compared to US average)

233 Unknown is weighted average of interior v exterior (assuming 5% exterior lighting based on distribution of LEDs from on-site

For example, an 8W LED lamp, 450 lumens, is installed in the interior of a home. The customer purchased the lamp through a ComEd upstream program:

ΔkWh = ((29.0 - 8) /1000) * 0.784 * (1 - 0.008) * 1,089 * 1.06

= 18.9 kWh

DEFERRED INSTALLS

For example: using the assumptions from above, for an 8W LED, 450 Lumens purchased for the interior of a residential homes through a ComEd upstream program.

$\Delta kWh_{2nd\ year\ installs}$ = ((29 - 8.0)/1000) * 0.106 * (1 – 0.008) * 1,089 * 1.06

= 2.5 kWh

$\Delta kWh_{3rd\ year\ installs}$ = ((29 – 8.0)/1000) * 0.09 * (1 – 0.008) * 1,089 * 1.06

= 2.2 kWh

Note: Here we assume no change in hours assumption. NTG value from Purchase year should be applied.

For v9 and v10 of this measure, deferred installs claimed in 2023 and 2024 should use all assumptions provided in v10 of the measure, with the exception of the year of midlife adjustment. This should be claimed as follows:

Install Year	Population	2023		2024	
		Year from which adjustment is applied	Adjustment Factor applied to Annual kWh Savings	Year from which adjustment is applied	Adjustment Factor applied to Annual kWh Savings
2021 Installs (v9)	Income Eligible	2030	81%	N/A	
	All others	2027	34%		
2022 Installs (v10)	Income Eligible	2030	81%	2031	81%
	All others	2027	34%	2028	34%

~~As presented above, the characterization assumes that a percentage of bulbs purchased are not installed until Year 2 and Year 3 (see ISR assumption above). The Illinois Technical Advisory Committee has determined the following methodology for calculating the savings of these future installs.~~

~~Year 2 and 3 installs:~~ ~~Characterized using delta watts assumption and hours of use from the Install Year; i.e., the actual deemed assumptions active in Year 2 and 3 should be applied.~~

lighting inventory conducted as part of the IL Statewide LED Lighting Logger study) and SF v MF interior based on statewide weighted average of 69% single family and 31% multifamily, based on IL data from 2009 RECS Table HC2.9 Structural and Geographic Characteristics of Homes in Midwest Region, Divisions and States, 2009.

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~~The NTG factor for the Purchase Year should be applied.~~

For example: using the assumptions from above, for an 8W LED, 450 Lumens purchased for the interior of a residential homes through a ComEd upstream program.

$\Delta kWh_{2nd\ year\ installs}$ = ((29 - 8.0)/1000) * 0.106 * (1 – 0.008) * 1,089 * 1.06

= 2.5 kWh

$\Delta kWh_{3rd\ year\ installs}$ = ((29 – 8.0)/1000) * 0.09 * (1 – 0.008) * 1,089 * 1.06

= 2.2 kWh

Note: Here we assume no change in hours assumption. NTG value from Purchase year should be applied.

HEATING PENALTY

If electric heated home (if heating fuel is unknown assume gas, see Natural Gas section):

ΔkWh[234] = - (((WattsBase - WattsEE) / 1000) * ISR * (1-Leakage) * Hours * HF) / ηHeat

Where:

HF = Heating Factor or percentage of light savings that must be heated

= 49% for interior[235]

= 0% for exterior or unheated location

= 42% for unknown location[236]

ηHeat = Efficiency in COP of Heating equipment

= actual. If not available use:[237]

System Type	Age of Equipment	HSPF Estimate	COP_{HEAT} (COP Estimate) = (HSPF/3.413)*0.85
Heat Pump	Before 2006	6.8	1.7
	After 2006 - 2014	7.7	1.92
	2015 on	8.2	2.04
Resistance	N/A	N/A	1.00
Unknown[238]	N/A	N/A	1.28

[234] Negative value because this is an increase in heating consumption due to the efficient lighting.
[235] 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.
[236] Based on a weighted average of interior and exterior hours of use from the IL Statewide LED Lighting Logger study conducted as part of the PY8/PY9 evaluations of the Ameren Illinois and ComEd Residential Lighting programs, assuming 15% exterior or specialty lighting. The distribution of LEDs is based on the on-site lighting inventory conducted as part of the IL Statewide LED Lighting Logger study.
[237] 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. Note efficiency should include duct losses. Defaults provided assume 15% duct loss for heat pumps.
[238] Calculation assumes 35% Heat Pump and 65% Resistance, which is based upon data from Energy Information Administration,

For example: using the same 8 W LED that is installed in home with 2.0 COP Heat Pump (including duct loss) through a ComEd upstream program:

$\Delta kWh_{1st\ year}$ = - (((29 - 8) / 1000) * 0.784 * (1-0.008) * 1,089 * 0.42) / 2.0

= - 3.7 kWh

Second and third year install savings should be calculated using the appropriate ISR and the delta watts and hours from the install year.

Mid-Life Baseline Adjustment

During the lifetime of a standard Omnidirectional LED, the baseline incandescent/halogen bulb would need to be replaced multiple times. In December 2019, DOE issued a final determination for General Service Incandescent Lamps (GSILs), finding that the more stringent standards (45 lumen per watt) prescribed in the 2007 EISA regulation to become effective in 2020 (known as the 'Backstop' provision), was not economically justified. However, natural growth of LED market share has, and will continue to grow over the lifetime of the measure, and so a single mid-life adjustment is calculated that results in an equivalent net present value of lifetime savings as the forecast decline in annual savings. See 'Lamp Forecast Workbook_2021.xls' for details.

The calculated mid-life adjustments for 2021 are provided below for each population:

Population	Year from which adjustment is applied	Adjustment Factor applied to Annual kWh Savings
Income Eligible	2029	81%
All others	2026	34%

For example, an 8W LED lamp, 450 lumens, is installed in the interior of a home. The customer purchased the lamp through a ComEd upstream program:

ΔkWh (2021-2024) = ((29.0 – 8.0) /1000) * 0.784 * (1 - 0.008) * 1,089 * 1.06

= 18.9 kWh

ΔkWh (2025 on) = 18.9 * 0.34

= 6.4 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ((WattsBase - WattsEE) / 1000) * ISR * (1-Leakage) * WHFd * CF

Where:

WHFd = Waste heat factor for demand to account for cooling savings from efficient lighting.

2009 Residential Energy Consumption Survey, see "HC6.9 Space Heating in Midwest Region.xls", using average for East North Central Region. Average efficiency of heat pump is based on assumption that 50% are units from before 2006 and 50% from 2006-2014. Program or evaluation data should be used to improve this assumption if available.

Bulb Location	WHFd
Interior single family	1.11[239]
Multifamily in unit	1.07[240]
Exterior or uncooled location	1.0
Unknown location	1.093[241]

CF = Summer Peak Coincidence Factor for measure.

Bulb Location	CF
Interior	0.128[242]
Exterior	0.273[243]
Unknown	0.135[244]

Other factors as defined above

For example: for the same 8 W LED that is installed in a single family interior location through a ComEd upstream program:

ΔkW = ((29 - 8) / 1000) * 0.784 * (1-0.008) * 1.11 * 0.128

= 0.0023 kW

Second and third year install savings should be calculated using the appropriate ISR and the delta watts and hours from the install year.

NATURAL GAS SAVINGS

Heating penalty if Natural Gas heated home, or if heating fuel is unknown.

ΔTherms = - (((WattsBase - WattsEE) / 1000) * ISR * (1-Leakage) * Hours * HF * 0.03412) / ηHeat

Where:

HF = Heating factor, or percentage of lighting savings that must be replaced by heating

[239] 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.

[240] As above but using estimate of 45% of multifamily buildings in Illinois having central cooling (based on data from "Table HC7.1 Air Conditioning in U.S. Homes, By Housing Unit Type, 2009" which is for the whole of the US, scaled to IL air conditioning prevalence compared to US average)

[241] Unknown is weighted average of interior v exterior (assuming 5% exterior lighting based on distribution of LEDs from on-site lighting inventory conducted as part of the IL Statewide LED Lighting Logger study) and SF v MF interior based on statewide weighted average of 69% single family and 31% multifamily, based on IL data from 2009 RECS Table HC2.9 Structural and Geographic Characteristics of Homes in Midwest Region, Divisions and States, 2009.

[242] Based on the IL Statewide LED Lighting Logger study conducted as part of the PY8/PY9 evaluations of the Ameren Illinois and ComEd Residential Lighting programs.

[243] Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation. the IL Statewide LED Lighting Logger study conducted as part of the PY8/PY9 evaluations of the Ameren Illinois and ComEd Residential Lighting programs was unable to provide coincidence factors for screw-based omnidirectional LEDs in exterior applications.

[244] Based on a weighted average of coincidence factors in interior and exterior applications, assuming 5% exterior lighting. The distribution of LEDs is based on the on-site lighting inventory conducted as part of the IL Statewide LED Lighting Logger study.

system.

= 49% for interior[245]

= 0% for exterior location

= 42% for unknown location[246]

0.03412 = Converts kWh to Therms

ηHeat = Average heating system efficiency.

= 0.70 [247]

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

In order to account for the natural growth of LED over the lifetime of the measure, an equivalent annual levelized baseline replacement cost is calculated and applied over the life of the measure as described above.

The NPV for replacement lamps and annual levelized replacement costs using the societal real discount rate of 0.42% are presented below.[248] It is important to note that for cost-effectiveness screening purposes, the O&M cost adjustments should only be applied in cases where the light bulbs area actually in service and so should be multiplied by the appropriate ISR:

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[245] Average result from REMRate modeling of several different configurations and IL locations of homes

[246] Based on a weighted average of interior and exterior hours of use from the IL Statewide LED Lighting Logger study conducted as part of the PY8/PY9 evaluations of the Ameren Illinois and ComEd Residential Lighting programs, assuming 15% exterior specialty lighting. The distribution of LEDs is based on the on-site lighting inventory conducted as part of the IL Statewide LED Lighting Logger study.

[247] 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) 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

[248] See “Lamp Forecast Workbook_2020.xlsx” for calculation.

Population	Location	NPV of replacement costs for period	Levelized annual replacement cost savings
		2022	2022
Income eligible	Residential and in-unit Multi Family, and Unknown	$10.01	$1.02
	Exterior	$16.81	$2.14
All others	Residential and in-unit Multi Family, and Unknown	$7.47	$0.76
	Exterior	$12.86	$1.64

MEASURE CODE: RS-LTG-LEDA-V132-220101

REVIEW DEADLINE: 1/1/2023

5.7.3 Level 2 Electric Vehicle Charger

DESCRIPTION

The measure is for the purchase of a Level 2 electric vehicle charger consistent with the ENERGY STAR specification for Electric Vehicle Supply Equipment (EVSE) installed for residential household use. Networked chargers enable access to online energy management tools through an EVSE network. Non-networked chargers are standalone units that are not connected to other units through an EVSE network.

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

An ENERGY STAR qualified networked or non-networked level 2 electric vehicle charger.

DEFINITION OF BASELINE EQUIPMENT

A non-ENERGY STAR networked or non-networked level 2 electric vehicle charger.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life for the EV charger is assumed to be 10 years.[249]

DEEMED MEASURE COST

The incremental cost for the EV charger is assumed to be $57.[250]

LOADSHAPE

Loadshape R19 - Residential Electric Vehicle Charger

COINCIDENCE FACTOR

Coincidence factor is embedded in deemed demand reduction savings estimate, so the coincidence factor is assumed to be 1.

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS

ΔkWh = (((Hours_PS + Hours_US) * SP_base) - (Hours_PS * SP_EEp + Hours_US * SP_EEu))/ 1000)

Where:

Hours_C = Annual Active Charging Hours

= EV_kWh / Steady State Charger Output Capacity (kW)

[249] Based on Northwest Power and Conservation Council, Regional Technical Forum workbook for Level 2 Electric Vehicle Charger version 1.1. approved May 2019. https://rtf.nwcouncil.org/measure/level-2-electric-vehicle-charger

[250] Weighted average incremental cost based on limited data provided in Northwest Power and Conservation Council, Regional Technical Forum workbook for Level 2 Electric Vehicle Charger version 1.1. approved May 2019. https://rtf.nwcouncil.org/measure/level-2-electric-vehicle-charger. Recommend this assumption be reviewed in future versions.

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= EV_kWh / 8.2[251]

= 336 hours

EV_kWh = Annual Driving Energy Consumed at Home (kWh)

= VMT * EV_ee / 100 * %Home_Charging

VMT = Annual vehicle miles traveled of the vehicle measure.

= 10,690 [252]

EV_ee = Actual nameplate operation efficiency for electric vehicle expressed in kWh per 100 miles.

= 30 kWh per 100 miles[253]

%Home_Charging = Percent of charging that is done at home

= 86%[254]

= 2,758 kWh

Hours_P = Total Annual Hours Plugged In

= Annual # of Charging Sessions * Average EV Plug in Time per Charging Session (Hrs)

= (EV_kWh / 7.4 [255]) * 14.7 [256]

= 5,479 hours

Hours_PS = Annual Standby Hours Plugged In

= Hours_P - Hours_C

= 5,143 hours

Hours_US = Annual Standby Hours Unplugged

= 8760 - Hours_P

= 3,281 hours

[251] Analysis of WA and OR Cumulative EV Registrations through 2018 paired with Vehicle Maximum Power Acceptance (kW) data from Chargehub https://chargehub.com/en/find-the-right-charging-station-power.html

[252] Average annual vehicle miles traveled estimated based on Stateside average of data from the 2017 National Household Transportation survey, accessed 07/2020.

[253] Average electric vehicle efficiency based on light-duty vehicle miles per gallon from Annual Energy Outlook 2019. U.S. Energy Information Administration.

[254] Assumption consistent with RTF characterization based on 2014 Idaho National Laboratory study.

[255] Avista Docket No. UE-160082 – Avista Utilities Semi-Annual Report on Electric Vehicle Supply Equipment Pilot Program (November 2018) Table 13 Avg. kWh Consumed per Session

[256] Based on data provided by Avista. Total hours EV is plugged into charging station including both charge and standby time.

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SP_base = Baseline Average Standby Power (W)

= 3.7 for non-networked, 9.9 for networked[257]

SP_EEp = Efficient Average Standby Power (W) with vehicle plugged in

= 4.3 for non-networked, 6.4 for networked[258]

SP_EEu = Efficient Average Standby Power (W) in no vehicle mode

= 2.1 for non-networked, 3.2 for networked[259]

ΔkWh per non-networked charger = (((5,143 + 3,281) * 3.7) - (5,143 * 4.3 + 3,281 * 2.1))/ 1000)

= 2.2 kWh

ΔkWh per networked charger = (((5,143 + 3,281) * 9.9) - (5,143 * 6.4 + 3,281 * 3.2))/ 1000)

= 40.0 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = –AveragekW_vehicle * CF

Where:

AveragekW = Average electric demand during standby.

kW_vehicle = Summer peak electric demand of the electric vehicle.

Non-networked = (((3.7-4.3) * 3233/8482) + ((3.7-2.1) * 5249/8482))/1000

= 0.000761 kW

Networked = (((9.9-6.4) * 3233/8482) + ((9.9-3.2) * 5249/8482))/1000

= 0.00548 kW

= 0.28 kW[260]

[257] INL charger testing https://avt.inl.gov/evse-type/ac-level-2 and ENERGY STAR Market and Industry Scoping Report Electric Vehicle Supply Equipment (EVSE) September 2013 (source data is from INL).

[258] 2019 ENERGY STAR QPL of Residential EVSE. No Residential units, used commercial as a proxy. Averaged Partial On Mode Input Power (W) and Idle Mode Input Power (W)

[259] 2019 ENERGY STAR QPL of Residential EVSE. No Residential units, used commercial as a proxy. Averaged Partial On Mode Input Power (W) and Idle Mode Input Power (W).

[260] Summer peak demand impacts are a deemed value based on EV Charging Station Pilot Evaluation Report. Xcel CO. May 2015. Page 5.

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CF = Summer peak coincidence factor

= 1[261]

NATURAL GAS SAVINGS

N/A

WATER AND OTHER NON-ENERGY IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-MSC-L2CH-V0~~1~~2-2~~1~~20101

REVIEW DEADLINE: 1/1/2023

[261] kW_Vehicle accounts for the estimated average kW draw during the system peak.

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