MEMORANDUM

TO:	**TECHNICAL ADVISORY COMMITTEE**
FROM:	KALEE WHITEHOUSE, PROJECT MANAGER, and SAM DENT, TECHNICAL LEAD - VEIC
SUBJECT:	V11.0 ERRATA MEASURES EFFECTIVE 01/01/2023
DATE:	09/22/2023
Cc:	CELIA JOHNSON, SAG

This memo documents errata changes to Version 11.0 of the Illinois Technical Reference Manual (TRM) that the Technical Advisory Committee (TAC) recommends be made effective 01/01/2023.

VEIC has provided a summary table below showing the errata measures and a brief summary of what was changed, followed by the v11.0 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 11.0 of the TRM).

Summary of Errata Measures

Section	Measure Name	Measure Code	Brief Summary of Change	TAC Reviewed and Approved As of
Volume 1: 3.9	Heating and Cooling Degree-Day Data	N/A	Fixing CDD55 values for Zone 2 – Chicago, Zone 4 – Belleville and Zone 5 – Marion, and State Average.	6/19/2023
4.2.1	Combination Oven	CI-FSE-CBOV-V04-230101	Added '* 1000' to ElecIDLE$_{SteamEE}$ algorithm for 3-4 Pan capacity in order to calculate watts rather than kW.	3/17/2023
4.2.5	ENERGY STAR Convection Oven	CI-FSE-ESCV-V04-230101	Added savings associated with pre heat which were inadvertently not included when electric and gas measures were combined. Applied a fix to 6/19 draft errata- preheat savings algorithm now include number of preheats per day and preheat time.	6/19/2023 8/21/2023
4.3.8	C&I Controls for Central Domestic Hot Water	CI-HWE-CDHW-V05-230101	Between version 10 and 11, assumptions for the reduction in operating hours for normal and low occupancy were incorrectly switched between multi family and dormitories.	5/12/2023
4.3.9	Heat Recovery Grease Trap Filter	CI-HWE-GRTF-V03-230101	Fixing conversion from BTU to kWh: 0.000293 kWh/BTU not 0.00293 kWh/BTU	6/19/2023
4.4.60	Variable Refrigerant Flow HVAC System	CI-HVC-VFFY-V2-230101	Fix error in HPSiteCoolingImpact algorithm to correctly convert to MMBtu	5/12/2023
4.5.4	LED Bulbs and Fixtures	CI-LTG-LEDB-V16-230101	Added column to lamp tables to indicate which are impacted by EISA backstop and which aren't. Also clarified that LED Downlight Fixture is also subject to EISA backstop. Added distinction in measure life section for common area lighting in Income Qualified multi family applications to align with the Residential IQ 8 year assumption.	11/1/2022 5/12/2023
4.8.23	Lithium Ion Forklift Batteries	CI-MSC-LION-V03-230101	Added clarity on fuel switch opportunity. Fix to the efficiency terms in the algorithm to reflect that battery capacity values represent output capacities.	5/12/2023

Section	Measure Name	Measure Code	Brief Summary of Change	TAC Reviewed and Approved As of
4.8.27	C&I Air Sealing	CI-MSC-CAIR-V02-230101	CDD55 assumptions for Chicago, Belleville and Marion were switched.	6/19/2023
4.8.30	Commercial Wall Insulation	CI-HVC-WINS-V02-230101	CDD55 assumptions for Chicago, Belleville and Marion were switched.	6/19/2023
5.3.1	Centrally Ducted Air Source Heat Pump	RS-HVC-ASHP-V13-230101	Addition of baselines for 'space constrained' units as per the Federal Standard.	3/17/2023
5.3.3	Central Air Conditioning	RS-HVC-CAC1-V11-230101	Addition of baselines for 'space constrained' units as per the Federal Standard.	3/17/2023
5.3.12	Ductless Heat Pumps	RS-HVC-DHP-V11-230101	Addition of baselines for 'space constrained' units as per the Federal Standard.	3/17/2023
5.5.6	LED Specialty Lamps	RS-LTG-LEDD-V16-230101	EISA exempt bulb types (<310 and >3300 lumens) removed from measure.	11/1/2022
5.5.8	LED Screw Based Omnidirectional Bulbs	RS-LTG-LEDA-V15-230101	EISA exempt bulb types (<310 and >3300 lumens) removed from measure.	11/1/2022
5.5.13	EISA Exempt LED Lighting	RS-LTG-LEDE-V2-230101	EISA exempt decorative and directional bulb types added to measure.	11/1/2022

Volume 1: 3.9 Heating and Cooling Degree-Day Data

Many measures are weather sensitive. Because there is a range of climactic conditions across the state, VEIC engaged the Utilities to provide their preferences for what airports and cities are the best proxies for the weather in their service territories. The result of this engagement is in the table below. All of the data represents 30-year normals from the National Climactic Data Center (NCDC).[1] Note that the base temperature for the calculation of heating degree-days in this document does not follow the historical 65F degree base temperature convention. Instead VEIC used several different temperatures in this TRM to more accurately reflect the outdoor temperature when a heating or cooling system turns on.

Residential heating is based on 60F, in accordance with regression analysis of heating fuel use and weather by state by the Pacific Northwest National Laboratory.[2] Residential cooling is based on 65F in agreement with a field study in Wisconsin.[3] These are lower than typical thermostat set points because internal gains, such as appliances, lighting, and people, provide some heating. In C&I settings, internal gains are often much higher; the base temperatures for both heating and cooling is 55F.[4] Custom degree-days with building-specific base temperatures are recommended for large C&I projects.

Table 3.5: Degree-Day Zones and Values by Market Sector

Zone	Residential		C&I		Weather Station / City
	HDD	CDD	HDD	CDD	
1	5,352	820	4,272	2,173	Rockford AP / Rockford
2	5,113	842	4,029	2,181	Chicago O'Hare AP / Chicago
3	4,379	1,108	3,406	2,666	Springfield #2 / Springfield
4	3,378	1,570	2,515	3,357	Belleville SIU RSCH / Belleville
5	3,438	1,370	2,546	3,090	Carbondale Southern IL AP / Marion
Average	4,860	947	3,812	2,362	Weighted by occupied housing units
Base Temp	60F	65F	55F	55F	30 year climate normals, 1981-2010

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[1] 30-year normals have been used instead of Typical Meteorological Year (TMY) data due to the fact that few of the measures in the TRM are significantly affected by solar insolation, which is one of the primary benefits of using the TMY approach.

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

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

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

4.2.1   Combination Oven

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

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

DEFINITION OF EFFICIENT EQUIPMENT
To qualify for this measure, the installed equipment must be a new natural gas or electric combination oven meeting the ENERGY STAR idle rate and cooking efficiency requirements as specified below.[5]

ENERGY STAR Requirements (Version 3.0, Effective January 12, 2023)

Fuel Type	Operation	Idle Rate (Btu/h for Gas, kW for Electric)	Cooking-Energy Efficiency, (%)
Natural Gas (5-40 Pan Capacity)	Steam Mode Convection Mode	≤ 200P+6,511 ≤ 140P+3,800	≥ 41 ≥ 57
Electric (5-40 Pan Capacity)	Steam Mode Convection Mode	≤ 0.133P+0.6400 ≤ 0.083P+0.35	≥ 55 ≥ 78
Electric (3-4 Pan Capacity)	Steam Mode Convection Mode	≤ 0.60P ≤ 0.05P+0.55	≥ 51 ≥ 70

Note: P = Pan capacity as defined in Section 1.Y, of the Commercial Ovens Program Requirements Version 3.0[6]

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

DEEMED LIFETIME OF EFFICIENT EQUIPMENT
The expected measure life is assumed to be 12 years.[7]

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

LOADSHAPE
Loadshape C01 - Commercial Electric Cooking

COINCIDENCE FACTOR
Summer Peak Coincidence Factor for measure is provided below for different building type:[8]

Location	CF
Fast Food Limited Menu	0.32

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[5] ENERGY STAR Commercial Ovens Key Product Criteria, version 3.0, effective January 12, 2023
[6] Ibid. Pan capacity is defined as the number of steam table pans the combination oven is able to accommodate as per the ASTM F-1495-05 standard specification.
[7] The measure life is sourced from the Food Service Technology Center's energy savings calculator for combination ovens.
[8] Values taken from Minnesota Technical Reference Manual (Version 2.2, effective May 2, 2018), 'Electric Oven and Range' measure and are based upon "Project on Restaurant Energy Performance-End-Use Monitoring and Analysis", Appendixes I and II, Claar, et. al., May 1985

Location	CF
Fast Food Expanded Menu	0.41
Pizza	0.46
Full Service Limited Menu	0.51
Full Service Expanded Menu	0.36
Cafeteria	0.39

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY AND FOSSIL FUEL SAVINGS [9]

Non Fuel Switch Measures

The algorithm below applies to electric combination ovens only.

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

The algorithm below applies to natural gas combination ovens only.

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

Fuel Switch/Electrification Measures

Fuel switch / electrification measures must produce positive total energy savings (i.e., reduction in Btus at the premises) in order to qualify. This is determined as follows:

SiteEnergySavings (MMBTUs) = [GasConsumptionReplaced] − [ElectricConsumptionAdded]

$= [(CookingEnergy_{ConvGasBase} + CookingEnergy_{SteamGasBase} + IdleEnergy_{ConvGasBase} + IdleEnergy_{SteamGasBase} + PreHeatEnergy_{BaseGas}) * Days / 1,000,000] −$

$[(CookingEnergy_{ConvElecEE} + CookingEnergy_{SteamElecEE} + IdleEnergy_{ConvElecEE} + IdleEnergy_{SteamElecEE} + PreHeatEnergy_{EEElec}) * Days * 3.412/ 1,000,000]$

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

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[9] Algorithms and assumptions derived from ENERGY STAR Commercial Kitchen Equipment Savings Calculator, updated March 2021.

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

Where:

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

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

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

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

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

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

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

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

$\Delta PreHeatEnergy_{Elec}$ = Change in total daily energy consumed by electric oven to preheat

= $Preheat_{BaseElec}$ - $Preheat_{EEElec}$

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

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

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

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

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

mode

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

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

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

$\Delta PreHeatEnergy_{Gas}$ = Change in total daily energy consumed by gas oven to preheat

$$= Preheat_{BaseGas} - Preheat_{EEGas}$$

$CookingEnergy_{ConvElecEE}$ = Total daily cooking energy consumed by new ENERGY STAR electric oven in convection mode (for fuel switch measure)

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

$CookingEnergy_{SteamElecEE}$ = Total daily cooking energy consumed by new ENERGY STAR electric oven in steam mode (for fuel switch measure)

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

$IdleEnergy_{ConvElecEE}$ = Total daily idle energy consumed by new ENERGY STAR electric oven in convection mode (for fuel switch measure)

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

$IdleEnergy_{SteamElecEE}$ = Total daily idle energy consumed by new ENERGY STAR electric oven in convection mode (for fuel switch measure)

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

$CookingEnergy_{ConvGasBase}$ = Total daily cooking energy consumed by baseline gas oven in convection mode (for fuel switch measure)

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

$CookingEnergy_{SteamGasBase}$ = Total daily cooking energy consumed by baseline gas oven in steam mode (for fuel switch measure)

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

$IdleEnergy_{ConvGasBase}$ = Total daily idle energy consumed by baseline gas oven in convection mode (for fuel switch measure)

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

$IdleEnergy_{SteamGasBase}$ = Total daily idle energy consumed by baseline gas oven in convection mode(for fuel switch measure)

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

Where:

LB_{Elec}	= Estimated mass of food cooked per day for electric oven (lbs/day)
	= Custom, or if unknown, use 200 lbs (If P <15) or 250 lbs (If P >= 15)
$EFOOD_{ConvElec}$	= Energy absorbed by food product for electric oven in convection mode
	= Custom or if unknown, use 73.2 Wh/lb
ElecEFF	= Cooking energy efficiency of electric oven
	= Custom or if unknown, use values from table below

	Base	EE
$ElecEFF_{Conv}$	72%	78%
$ElecEFF_{Steam}$	52%	55%

$\%_{Conv}$	= Percentage of time in convection mode
	= Custom or if unknown, use 50%
$EFOOD_{SteamElec}$	= Energy absorbed by food product for electric oven in steam mode
	= Custom or if unknown, use 30.8 Wh/lb
$\%_{steam}$	= Percentage of time in steam mode
	$= 1 - \%_{conv}$
$ElecIDLE_{Base}$	= Idle energy rate (W) of baseline electric oven
	= Custom or if unknown, use values from table below

Pan Capacity	Convection Mode ($ElecIDLE_{ConvBase}$)	Steam Mode ($ElecIDLE_{SteamBase}$)
< 15	1,754	5,260
> = 15 to <30	2,966	8,866
>= 30	4,418	11,875

HOURS	= Average daily hours of operation
	= Custom or if unknown, use 12 hours
$ElecPC_{Base}$	= Production capacity (lbs/hr) of baseline electric oven
	= Custom of if unknown, use values from table below

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

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

= $(0.083*P +0.350)*1000$ for 5-40 Pan Capacity

= $(0.05*P +0.55)*1000$ for 3-4 Pan Capacity

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

= Custom of if unknown, use values from table below

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

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

= $(0.133 * P+0.64)*1000$ for 5-40 Pan Capacity

= $(0.60 * P)*1000$ for 3-4 Pan Capacity

Preheat$_{BaseElec}$ = Total preheat energy consumption per day of baseline electric unit (Wh)

Pan Capacity	Preheat$_{BaseElec}$
< 15	1,635
> = 15	3,146

Preheat$_{BaseElec}$ = Total preheat energy consumption per day of ENERGY STAR electric unit (Wh)

Pan Capacity	Preheat$_{EEElec}$
< 15	997
> = 15	1,633

Days = Days of operation per year

= Custom or if unknown, use 365 days per year

1,000 = Wh to kWh conversion factor

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

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

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

= Custom or if unknown, use 250 Btu/lb

GasEFF = Cooking energy efficiency of gas oven

= Custom or if unknown, use values from table below

	Base	EE
GasEFF$_{Conv}$	49%	57%
GasEFF$_{Steam}$	37%	41%

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

= Custom or if unknown, use 105 Btu/lb

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

= Custom or if unknown, use values from table below

Pan Capacity	Convection Mode (GasIDLE$_{ConvBase}$)	Steam Mode (GasIDLE$_{SteamBase}$)
< 15	9,840	24,003
15-30	11,734	27,795
>30	15,376	27,957

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

= Custom of if unknown, use values from table below

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

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

= 140*P + 3,800

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

= Custom of if unknown, use values from table below

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

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

= 200 * P +6511

$Preheat_{BaseGas}$ = Total preheat energy consumption per day of baseline gas unit (BTU)

Pan Capacity	$Preheat_{BaseGas}$
< 15	10,964
> = 15	15,844

$Preheat_{BaseGas}$ = Total preheat energy consumption per day of ENERGY STAR gas unit (BTU)

Pan Capacity	$Preheat_{EEGas}$
< 15	4,467
> = 15	10,638

100,000 = Conversion factor from Btu to therms

3.412 = Conversion factor from Wh to Btu

1,000,000 = Conversion factor from Btu to MMBtu

For example, a 10-pan capacity ENERGY STAR electric combination oven in place of a baseline electric oven would save:

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

$\Delta CookingEnergy_{ConvElec}$ = 200 * (73.2 / 0.72 – 73.2 / 0.78) * 0.50

= 782 Wh

$\Delta CookingEnergy_{SteamElec}$ = 200 * (30.8 / 0.52 – 30.8 / 0.55) * (1 – 0.50)

= 323 Wh

$\Delta IdleEnergy_{ConvElec}$ = [(1,754 * ((12 – 200/79) * 0.50)) - (1,180 *((12 - 200/119) * 0.50))]

= 2215 Wh

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

= 16,678 Wh

$\Delta PreHeatEnergy_{Elec}$ = 1,635 – 997

= 638 Wh

ΔkWh = (782 + 323 + 2215 + 16,678 + 638) * 365 /1,000

= 7,532 kWh

For example, an ENERGY STAR 10-pan capacity electric combination oven in place of a baseline gas combination oven would save:

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

= [(CookingEnergy$_{ConvGasBase}$ + CookingEnergy$_{SteamGasBase}$ + IdleEnergy$_{ConvGasBase}$ + IdleEnergy$_{SteamGasBase}$ + PreHeatEnergy$_{BaseGas}$) * Days / 1,000,000] –

[(CookingEnergy$_{ConvElecEE}$ + CookingEnergy$_{SteamElecEE}$ + IdleEnergy$_{ConvElecEE}$ + IdleEnergy$_{SteamElecEE}$ + PreHeatEnergy$_{EEElec}$) * Days * 3.412/ 1,000,000]

CookingEnergy$_{ConvGasBase}$ = 200 * (250 / 0.49) * 0.50
= 51,020 Btu

CookingEnergy$_{SteamGasBase}$ = 200 * (105 / 0.37) * (1 – 0.50)
= 28,378 Btu

IdleEnergy$_{ConvGasBase}$ = 9,840 * ((12 – 200/125) * 0.50))
= 51,168 Btu

IdleEnergy$_{SteamGasBase}$ = 24,003 * ((12 – 200/195) * (1 – 0.50))
= 131,709 Btu

PreHeatEnergy$_{BaseGas}$ = 10,964 Btu

CookingEnergy$_{ConvElecEE}$ = 200 * (73.2 / 0.78) * 0.50
= 9,385 Wh

CookingEnergy$_{SteamElecEE}$ = 200 * (30.8 / 0.55) * (1 – 0.50)
= 5,600 Wh

IdleEnergy$_{ConvElecEE}$ = 1,180 * ((12 - 200/119) * 0.50)
= 6,088 Wh

IdleEnergy$_{SteamElecEE}$ = 1,970 * ((12 - 200/177) * (1 – 0.50)))
= 10,707 Wh

PreHeatEnergy$_{EEElec}$ = 997 Wh

SiteEnergySavings (MMBTUs) = [(51,020 + 28,378 + 51,168 + 131,709 + 10,964) * 365 /1,000,000]
– [(9,385 + 5,600 + 6,088 + 10,707 + 997) * 3.412/1,000,000]
= 99.6 MMBtu

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

= 99.6 * 1,000,000/3,412

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ΔkWh / (HOURS * DAYS) *CF

Where:

CF   = Summer peak coincidence factor is dependent on building type: [10]

Location	CF
Fast Food Limited Menu	0.32
Fast Food Expanded Menu	0.41
Pizza	0.46
Full Service Limited Menu	0.51
Full Service Expanded Menu	0.36
Cafeteria	0.39

All other variables as defined above.

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

ΔkW   = ΔkWh / (HOURS * DAYS) *CF

      = 7,532/ (12 * 365) * 0.51

      = 0.88 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 fossil fuel to electric.

For the purposes of forecasting load reductions due to fuel switch projects per Section 16-111.5B, changes in site energy use at the customer's meter (using ΔkWh algorithm below), 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, should therefore reflect the decrease in one fuel and increase in another, as opposed to the single savings value calculated in the "Electric and Fossil Fuel Energy Savings" section above. Therefore in addition to the calculation of savings claimed, the following values should be used to assess the cost effectiveness of the measure.

ΔTherms   = [Gas Cooking Consumption Replaced]

       = [(CookingEnergy$_{ConvGasBase}$ + CookingEnergy$_{SteamGasBase}$ + IdleEnergy$_{ConvGasBase}$ +

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[10]Values taken from Minnesota Technical Reference Manual (Version 2.2, effective May 2, 2018), 'Electric Oven and Range' measure and are based upon "Project on Restaurant Energy Performance-End-Use Monitoring and Analysis", Appendixes I and II, Claar, et. al., May 1985

$\qquad$ IdleEnergy$_{SteamGasBase}$ + PreHeatEnergy$_{BaseGas}$) * Days / 100,000]

ΔkWh $\qquad$ = [Electric Cooking Consumption Added]

$\qquad$ = - [(CookingEnergy$_{ConvElecEE}$ + CookingEnergy$_{SteamElecEE}$ + IdleEnergy$_{ConvElecEE}$ + IdleEnergy$_{SteamElecEE}$ + PreHeatEnergy$_{EEElec}$) * Days/1,000]

MEASURE CODE: CI-FSE-CBOV-V04-230101

REVIEW DEADLINE: 1/1/2026

4.2.5   ENERGY STAR Convection Oven

DESCRIPTION

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

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

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

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed equipment must meet ENERGY STAR requirements listed in ENERGY STAR Commercial Ovens Specifications Version 3.0.

DEFINITION OF BASELINE EQUIPMENT

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

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 12 years. [11]

DEEMED MEASURE COST

The incremental capital cost is assumed to be $1000 for all units [12].

LOADSHAPE

Loadshape C01 - Commercial Electric Cooking

COINCIDENCE FACTOR

Summer Peak Coincidence Factor for measure is provided below for different building type: [13]

Location	CF
Fast Food Limited Menu	0.32
Fast Food Expanded Menu	0.41
Pizza	0.46
Full Service Limited Menu	0.51
Full Service Expanded Menu	0.36
Cafeteria	0.39
Unknown	0.41

---

[11] Lifetime from ENERGY STAR Commercial Kitchen Equipment Savings Calculator, Oven Calculations, which cites reference as "FSTC research on available models, 2009".

[12] ENERGY STAR Commercial Kitchen Calculator, updated March 2021.

[13] Minnesota Technical Reference Manual, (version 3.2, effective January 7, 2021), Commercial Food Service - Electric Oven and Range, page 481. Unknown is an average of other location types.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY AND FOSSIL FUEL SAVINGS
Non Fuel Switch Measures

The algorithm below applies to ENERGY STAR compared to baseline electric convection ovens:

$$\Delta kWh = (\Delta DailyIdle\ Energy + \Delta DailyPreheat\ Energy + \Delta DailyCooking\ Energy) * Days$$

The algorithm below applies to ENERGY STAR compared to baseline gas convection ovens:

$$\Delta Therms = (\Delta DailyIdle\ Energy + \Delta DailyPreheat\ Energy + \Delta DailyCooking\ Energy) * Days /100{,}000$$

Fuel Switch/Electrification Measures

Fuel switch / electrification measures must produce positive total energy savings (i.e., reduction in Btus at the premises) in order to qualify. This is determined as follows:

$$SiteEnergySavings\ (MMBTUs) = [GasConsumptionReplaced] - [ElectricConsumptionAdded]$$

$$= [(DailyIdle\ Energy_{GasBase} + DailyPreheat\ Energy_{GasBase} + DailyCooking\ Energy_{GasBase}) * 1/1{,}000{,}000 * Days] -$$

$$[(DailyIdle\ Energy_{ElecEE} + DailyPreheat\ Energy_{ElecEE} + DailyCooking\ Energy_{ElecEE}) * 3412/1{,}000{,}000 * Days]$$

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

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

ΔDailyCookingEnergy $= (LB * EFOOD/ Eff_{Base}) - (LB * EFOOD/ Eff_{ENERGYSTAR})$

ΔDailyPreheatEnergy $= (PreHeatNumber*PreheatTimBase/60*PreHeatRateBase)-(PreHeatNumber * PreheatTimeENERGYSTAR/60 * PreHeatRateENERGYSTAR)$DailyIdle Energy$_{GasBase}$ $= (IdleBase_{Gas} * IdleBaseTime_{Gas})$

DailyCooking Energy$_{GasBase}= (LB * EFOOD/ Eff_{BaseGas})$

DailyIdle Energy$_{ElecEE}$ $=(IdleENERGYSTAR_{Elec} * IdleENERGYSTARTime)$

DailyCooking Energy$_{ElecEE}$ $= (LB * EFOOD/ Eff_{ENERGYSTARElec})$

Where [14]:

IdleENERGYSTAR = Idle energy rate

= Actual, if unknown assume:

Oven Type	IdleENERGYSTAR
Electric Half Size	0.8 kW/h
Electric Full-Size ≥ 5 pans	1.2 kW/h
Electric Full-Size < 5 pans	1.0 kW/h
Natural Gas	8,027 Btu/h

IdleBase = Idle energy rate

Oven Type	IdleBASE
Electric Half Size	1.51 kW/h
Electric Full-Size ≥ 5 pans	1.63 kW/h
Electric Full-Size < 5 pans	1.29 kW/h
Natural Gas	12,239 Btu/h

IdleENERGYSTARTime = ENERGY STAR Idle Time (hours)

$=HOURsday-LB/PC_{ENERGYSTAR} -PreHeatTime_{ENERGYSTAR}/60$

Using defaults:

Oven Type	Calculation	IdleENERGYSTARTime
Electric Half Size	= 12 − 61/42 − 8/60	10.4
Electric Full-Size ≥ 5 pans	= 12 − 122/98 − 9/60	10.6
Electric Full-Size < 5 pans	= 12 − 122/65 − 9/60	10.0
Natural Gas	= 12 − 100/90 − 11/60	10.7

HOURsday = Average Daily Operation

= custom or if unknown, use 12 hours

LB = Food cooked per day

---

[14] All assumptions except where noted are based upon data package provided alongside ENERGY STAR Commercial Ovens Specifications Version 3.0. See ENERGY STAR v3 Commercial Ovens Data Package.xlsx.

= custom or if unknown, use 100 pounds for gas oven, 61 lbs for half sized electric oven or 122 lbs for full-sized electric oven [15]

$PC_{ENERGYSTAR}$ = Production Capacity ENERGY STAR (lb/hr)

= Actual, if unknown use:

Oven Type	$PC_{ENERGYSTAR}$
Electric Half Size	42
Electric Full-Size ≥ 5 pans	98
Electric Full-Size < 5 pans	65
Natural Gas	90

$PreheatTime_{ENERGYSTAR}$ = preheat length of ENERGY STAR oven

= custom or if unknown use [16]:

Oven Type	PreheatTimeENERGYSTAR
Electric Half Size	8
Electric Full-Size	9
Natural Gas	11

IdleBaseTime = BASE Idle Time

= HOURSday-LB/PC_{base} −PreHeatTime$_{Base}$/60

Using defaults:

Oven Type	Calculation	IdleENERGYSTARTime
Electric Half Size	= 12 – 61/45 – 9/60	10.5
Electric Full-Size ≥ 5 pans	= 12 – 122/102 – 9/60	10.7
Electric Full-Size < 5 pans	= 12 – 122/76 – 9/60	10.2
Natural Gas	= 12 – 100/93 – 12/60	10.7

PC_{Base} = Production Capacity base

= Actual, if unknown use:

Oven Type	PC_{Base}
Electric Half Size	45
Electric Full-Size ≥ 5 pans	102
Electric Full-Size < 5 pans	76
Natural Gas	93

---

[15] Gas default is based upon the ENERGY STAR Commercial Kitchen Calculator. Electric defaults based on data from the Regional Technical Forum for the Northwest Council (Commercial Cooking Convection Oven Calculator, UES Measure Workbook), see "ComCookingConvectionOven_v4_0.xlsm".

[16] ENERGY STAR Commercial Kitchen Calculator, updated March 2021.

PreheatTimeBase   = preheat length of base oven

= custom or if unknown use[17]:

Oven Type	PreheatTimeBase
Electric Half Size	9
Electric Full-Size	9
Natural Gas	12

Days   = Annual days of operation

= custom or if unknown, use 365.25 days a year

EFOOD   = ASTM energy to food

= 0.0732 kWh/lb for electric ovens or 250 btu/pound for natural gas ovens[18]:

$Eff_{ENERGYSTAR}$ = Cooking Efficiency ENERGY STAR

= Actual, if unknown use:

Oven Type	$Eff_{ENERGYSTAR}$
Electric Half Size	75%
Electric Full-Size ≥ 5 pans	80%
Electric Full-Size < 5 pans	81%
Natural Gas	52%

Eff_{Base} = Cooking Efficiency Baseline

Oven Type	Eff_{Base}
Electric Half Size	64%
Electric Full-Size ≥ 5 pans	74%
Electric Full-Size < 5 pans	76.5%
Natural Gas	47%

$PreheatRate_{Base}$ =Preheat rate (kWh/day for electric units, btu/day for natural gas units) baseline.

=Actual, if unknown

Oven Type	$PreheatRate_{Base}$
Electric Half Size	0.89
Electric Full-Size ≥ 5 pans	1.56
Electric Full-Size < 5 pans	1.56
Natural Gas	76,000

---

[17] ENERGY STAR Commercial Kitchen Calculator, updated March 2021.
[18] ENERGY STAR Commercial Kitchen Calculator, updated March 2021.

PreheatRate$_{ENERGYSTAR}$ =Preheat rate (kWh/day for electric units, btu/day for natural gas units) ENERGY STAR.

=Actual, if unknown

Oven Type	PreheatRate$_{ENERGYSTAR}$
Electric Half Size	0.70
Electric Full-Size ≥ 5 pans	1.39
Electric Full-Size < 5 pans	1.39
Natural Gas	44,000

PreheatNumber   =Number of preheats per day

= Actual; or if unknown use 1

For example, an ENERGY STAR gas oven compared to baseline gas oven using default values from above would save.

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

Where:

ΔDailyIdleEnergy	=(12,239 *10.7)- (8,027*10.7)
	= 45,068 btu
ΔDailyPreheatEnergy	= (1 * 12/ 60 * 76,000) – (1 * 12/ 60 * 44,000)
	= 6,400 btu
ΔDailyCookingEnergy	= (100 * 250/ 0.47) - (100 * 250/ 0.52)
	= 5,115 btu
ΔTherms	= (45068 + 6400 + 5115) * 365.25 /100000
	= 207 therms

An ENERGY STAR half sized electric oven compared to baseline electric oven using default values from above would save.

ΔkWh = (ΔIdle Energy + ΔDailyPreheat Energy + ΔCooking Energy) * Days /100000

Where:

ΔDailyIdleEnergy	=(1.51 * 10.5) - (0.8 * 10.4)
	= 7.5 kWh
ΔDailyPreheatEnergy	= (1 * 9/ 60 * 0.89) – (1 * 9/ 60 * 0.70)
= 0.03 kWhΔDailyCookingEnergy	= (61 * 0.0732/ 0.64) - (61 * 0.0732/ 0.75)
	= 1.02 kWh
ΔkWh	= (7.5 + 0.03 + 1.02) * 365.25
	= 3,123 kWh

An ENERGY STAR full sized electric oven ≥ 5 pans compared to baseline electric oven using default values from above would save.

ΔkWh = (ΔIdle Energy + ΔDailyPreheat Energy + ΔCooking Energy) * Days /100000

Where:

ΔDailyIdleEnergy	=(1.63 * 10.7)- (1.2 * 10.6)
	= 4.7 kWh
ΔDailyPreheatEnergy	= (1 * 9/ 60 * 1.56) – (1 * 9/ 60 * 1.39)
= 0.03 kWhΔDailyCookingEnergy	= (122 * 0.0732/ 0.74) - (122 * 0.0732/ 0.80)
	= 0.9 kWh
ΔkWh	= (4.7 + 0.03 + 0.9) * 365.25
	= 2056 kWh

An ENERGY STAR full sized electric oven < 5 pans compared to baseline electric oven using default values from above would save.

$$\Delta kWh = (\Delta Idle\ Energy + \Delta Cooking\ Energy) * Days /100000$$

Where:

$\Delta DailyIdleEnergy$	$=(1.29 * 10.2)- (1.0 * 10.0)$
	$= 3.2$ kWh
$\Delta DailyPreheatEnergy$	$= (1 * 9/ 60 * 1.56) – (1 * 9/ 60 * 1.39)$
	$= 0.03$ kWh $\Delta DailyCookingEnergy = (122 * 0.0732/ 0.765) - (122 * 0.0732/ 0.81)$
	$= 0.65$ kWh
ΔkWh	$= (3.2 + 0.03 + 0.65) * 365.25$
	$= 1,417$ kWh

An ENERGY STAR full sized >5 pan electric oven compared to baseline gas oven assuming 100 lbs food cooked per day and using other default values from above would save.

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

$= [(DailyIdle\ Energy_{GasBase} + DailyPreheat\ Energy_{GasBase} + DailyCooking\ Energy_{GasBase}) * 1/1,000,000 * Days]$ –

$[(DailyIdle\ Energy_{ElecEE} + DailyPreheat\ Energy_{ElecEE}\ DailyCooking\ Energy_{ElecEE}) * 3412/1,000,000 * Days]$

$DailyIdleEnergy_{GasBase}$	$=(12,239*10.7)$
	$= 130957$ btu
$DailyPreheatEnergy_{GasBase}$	$= (1*12/60*76,000)$
	$= 15200$ btu
$DailyCookingEnergy_{GasBase}$	$= (100 * 250/ 0.47)$
	$= 53191$ btu
$DailyIdleEnergy_{ElecEE}$	$= (1.2 * 10.6)$
	$= 12.7$ kWh
$DailyPreheatEnergy_{ElecEE}$	$= (1 * 9/ 60 * 1.39)$
	$= 0.21$ kWh
$DailyCookingEnergy_{ElecEE}$	$= (100 * 0.0732/ 0.80)$
	$= 9.2$ kWh

SiteEnergySavings (MMBTUs) $= ((130957 + 15200 + 53191) * 1/1,000,000 * 365.25) – ((12.7 + 0.21 + 9.2) * 3412/1,000,000 * 365.25)$

$= 45.3$ MMBtu

If supported by an electric utility: ΔkWh $= \Delta SiteEnergySavings * 1,000,000 / 3,412$

$= 45.3 * 1,000,000/3,412$

$= 13,277$ kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

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

Where:

ΔkWh   = Annual kWh savings from measure as calculated above. Note do not include the secondary savings in this calculation.

CF   =Summer Peak Coincidence Factor for measure is provided below for different locations:[19]

Location	CF
Fast Food Limited Menu	0.32
Fast Food Expanded Menu	0.41
Pizza	0.46
Full Service Limited Menu	0.51
Full Service Expanded Menu	0.36
Cafeteria	0.39

Other values as defined above

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 fossil fuel to electric.

For the purposes of forecasting load reductions due to fuel switch projects per Section 16-111.5B, changes in site energy use at the customer's meter (using ΔkWh algorithm below), 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, should therefore reflect the decrease in one fuel and increase in another, as opposed to the single savings value calculated in the "Electric and Fossil Fuel Energy Savings" section above. Therefore in addition to the calculation of savings claimed, the following values should be used to assess the

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[19]Values taken from Minnesota Technical Reference Manual (Version 2.2, effective May 2, 2018), 'Electric Oven and Range' measure and are based upon "Project on Restaurant Energy Performance-End-Use Monitoring and Analysis", Appendixes I and II, Claar, et. al., May 1985.

cost effectiveness of the measure.

ΔTherms = [Gas Cooking Consumption Replaced]

= [(DailyIdle Energy$_{GasBase}$ + DailyPreheat Energy$_{GasBase}$ + DailyCooking Energy$_{GasBase}$) * 1/100,000 * Days]

ΔkWh = [Electric Cooking Consumption Added]

= - [(DailyIdle Energy$_{ElecEE}$ + DailyPreheat Energy$_{ElecEE}$ + DailyCooking Energy$_{ElecEE}$) * Days]

MEASURE CODE: CI-FSE-ESCV-V04-230101

REVIEW DEADLINE: 1/1/2025

4.3.8   Controls for Central Domestic Hot Water

DESCRIPTION

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

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

DEFINITION OF EFFICIENT EQUIPMENT

There are three efficient technologies to be considered:
- Timer-based: allows the user to program a schedule to perform recirculation during specific windows throughout the day.
- Aquastat-controlled: calls for recirculation when the water temperature at one point in the system falls below a certain pre-programmed setpoint (e.g., 100°F).
- On-Demand: senses the demand as water flow through the CDHW system. These types of system are most adequate on small central water heating systems.

DEFINITION OF BASELINE EQUIPMENT

The baseline for this measure category is existing, uncontrolled recirculation pumps on gas-fired CDHW system.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The effective useful life is 15 years. [20]

DEEMED MEASURE COST

The average cost of the demand controller circulation kit is $1,442 with an installation cost of $768 for a total measure cost of $2,210. [21]

LOADSHAPE

Loadshape C02 - Non-Residential Electric DHW

COINCIDENCE FACTOR

N/A

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

[21] The incremental costs were averaged based on the following multi-family, dormitory and hospitality building studies-
Gas Technology Institute. (2014). *1003: Demand-based domestic hot water recirculation Public project report.* Des Plaines, IL: Prepared for Nicor Gas, January 7, 2014.
Studies performed in multiple dormitory buildings in the California region for Southern California Gas' PREPS Program, 2012.
Evaluation of New DHW System Controls in Hospitality and Commercial Buildings. Prepared for: Minnesota Department of Commerce, Division of Energy Resources, 2018.

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = \Delta kWh_{heater} + \Delta kWh_{pump}$$

ΔkWh_{heater} = %ElecDHW * Boiler Capacity * ($t_{normal\ occ}$ * $R_{normal\ occ}$ + $t_{low\ occ}$ * $R_{low\ occ}$) / 3,412

ΔkWh_{pump} = (HP_{recirc} * 0.746 * (8760 − $Pump_{hrs\ controlled}$)) / $Motor_{eff}$

ΔkWh_{pump} = 1,103[22] kWh as default value if values unknown.

Where:

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

= 1 if electric DHW; 0 if fuel DHW. If unknown, assume 27.6%.[23]

Boiler Capacity = Input Capacity of the Domestic Hot Water boiler in BTU/hr

= If the facility uses the same boiler for space heat and domestic hot water,

estimate the boiler input capacity for only domestic hot water loads. If this

cannot be estimated, use the table below:

Building Type	% of Boiler Input Capacity	Or Use the Following Formulas
Multifamily	22.75%[24]	= 12,493 BTU/hr * (#Apartments) [25]
Dormitories	16.48%[26]	= 4,938 BTU/hr * (#Rooms) [27]

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[22] This value is the average kWh saved per pump based on results from Multi-Family buildings studied in Nicor Gas Emerging Technology Program study, Southern California Gas' study in multiple dormitory buildings, and Minnesota's Evaluation of New DHW System Controls in Hospitality and Commercial Buildings. Note this value does not reflect savings from electric units but electrical savings from gas-fired units. See 'CDHW Controls Summary Calculations.xlsx' for more information.

[23] Based on Applied Energy Group, 2016 'Ameren Illinois Demand Side Management Market Potential Study: Volume 4 – APPENDICES'.

[24] This is an average number based on Residential Energy Consumption Survey (2009) data and Commercial Building Energy Consumption Survey (2012) data compiled by U.S. Energy Information Administration, for buildings with more than 5 apartments in Illinois and Nursing Home and Assisted Living facilties in Midwest.

[25] This is based on studies done in multiple university dormitory buildings in the California region, for Southern California Gas' PREPS Program, 2012. It closely matches the design guidelines outlined in 2007 ASHRAE Handbook, Chapter 49: Service Water Heating, Table 7, and assumes 1 to 2 students per dorm room based on typical dorm room layouts. This source provides the source for dormitory assumptions of Boiler Input Capacity, $t_{low\ occ}$, $R_{normal\ occ}$ and $R_{low\ occ}$.

[26] This is based on Commercial Building Energy Consumption Survey (2012) data compiled by U.S. Energy Information Administration, for Education facilities in East North Central.

[27] This is based on studies done at Multi-Family Buildings for the Nicor Gas Emerging Technology Program by Gas Technology Institute. It closely matches the design guidelines outlined in 2007 ASHRAE Handbook, Chapter 49: Service Water Heating, Table 9, and assumes 2.1 persons per apartment as per ComEd PY3 Multi-Family Home Energy Savings Program Evaluation Report Final, May 16, 2012, by Navigant. This source provides the source for dormitory assumptions of Boiler Input Capacity, $t_{low\ occ}$, $R_{normal\ occ}$ and $R_{low\ occ}$.

Hotels/Motels	12.33%[28]	= 3,696 BTU/hr * (#Rooms) [29]
Offices	Use Actual Size	Use Actual Size

$HP_{recirculating}$ = the size of the recirculating pump in HP

0.746 = Conversion factor kW/HP

8760 = Hours of operation of uncontrolled recirculating pump

$Pump_{hrs\ controlled}$ = The table below corresponds to the control types for commercial buildings

Hours of Operation[30]	
Timer	6,570
Aquastat-Controlled	1,095
On Demand	122

$Motor_{eff}$ = The efficiency of the pump motor. Use actual or, if unknown, use the table below:

Motor HP	Efficiency
0.25	66.7%
0.33	70.6%
0.5	75.3%
0.75	79.6%
1.0	81.2%
1.5	84.8%
2.0	85.8%
3.0	87.2%

SUMMER COINCIDENT PEAK DEMAND SAVINGS
N/A

FOSSIL FUEL SAVINGS
Gas savings for this measure can be calculated by using site specific boiler size and boiler usage information or deemed values are provided based on number of rooms for Dormitories and number of apartments for multifamily buildings. [32]

$$\Delta Therms = \%FossilDHW * Boiler\ Input\ Capacity * (t_{normal\ occ} * R_{normal\ occ} + t_{low\ occ} * R_{low\ occ}) / 100,000$$

Where:

---

[28] This value is ratioed upon the Btu per Dwelling per Hotel/Motel vs Dormitory building type assuming the same heating capacity requirements based upon the similarity between the building types.

[29] Calculated based upon ASHRAE 2015 ASHRAE HVAC Applications Table 6 and IL TRM assumptions. See 'CDHW Controls Summary Calculations.xlsx' for more information

[30] The Hours of operation of recirculating pump for commercial buildings in general from Research and Analysis of the Benefits of Appliance Standards for Domestic Hot Water Circulator Pumps. Energy Solutions (October 2021)

[31] Blended efficiencies for small motors IECC 2021, Table C405.8(2), Table C405.8(3) and Table C405.8(3)

[32] See 'CDHW Controls Summary Calculations.xlsx' for more information.

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

= 0 if electric DHW; 1 if fuel DHW. If unknown, assume 72.4%[33].

Boiler Input Capacity = Input capacity of the Domestic Hot Water boiler in BTU/hr.

= If the facility uses the same boiler for space heat and domestic hot water, estimate the boiler input capacity for only domestic hot water loads. If this cannot be estimated, use the following table:

Building Type	% of Boiler Input Capacity	Or Use the Following Formulas
Multifamily	22.75% [34]	= 12,493 BTU/hr * (#Apartments) [35]
Dormitories	16.48% [36]	= 4,938 BTU/hr * (#Rooms) [37]
Hotels/Motels	12.33% [38]	= 3,696 BTU/hr * (#Rooms) [39]
Offices	Use Actual Size	Use Actual Size

$t_{normal\ occ}$ = Total operating hours of domestic hot water burner when the facility has normal occupancy. If unknown, use the following table.

$t_{low\ occ}$ = Total operating hours of domestic hot water burner, when the facility has low occupancy.[40] If unknown, use the following table.

$R_{normal\ occ}$ = Reduction(%) in total operating hours of domestic hot water burner, due to installed central domestic hot water controls, during normal occupancy period. Values are set in the table below.

$R_{low\ occ}$ = Reduction(%) in total operating hours of domestic hot water burner, due to installed central domestic hot water controls, during low occupancy period. Values are set in the table below.

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

[34] This is an average number based on Residential Energy Consumption Survey (2009) data and Commercial Building Energy Consumption Survey (2012) data compiled by U.S. Energy Information Administration, for buildings with more than 5 apartments in Illinois and Nursing Home and Assisted Living facilties in Midwest.

[35] This is based on studies done in multiple university dormitory buildings in the California region, for Southern California Gas' PREPS Program, 2012. It closely matches the design guidelines outlined in 2007 ASHRAE Handbook, Chapter 49: Service Water Heating, Table 7, and assumes 1 to 2 students per dorm room based on typical dorm room layouts. This source provides the source for dormitory assumptions of Boiler Input Capacity, $t_{low\ occ}$, $R_{normal\ occ}$ and $R_{low\ occ}$.

[36] This is based on Commercial Building Energy Consumption Survey (2012) data compiled by U.S. Energy Information Administration, for Education facilities in East North Central.

[37] This is based on studies done at Multi-Family Buildings for the Nicor Gas Emerging Technology Program by Gas Technology Institute. It closely matches the design guidelines outlined in 2007 ASHRAE Handbook, Chapter 49: Service Water Heating, Table 9, and assumes 2.1 persons per apartment as per ComEd PY3 Multi-Family Home Energy Savings Program Evaluation Report Final, May 16, 2012 by Navigant. This source provides the source for dormitory assumptions of Boiler Input Capacity, $t_{low\ occ}$, $R_{normal\ occ}$ and $R_{low\ occ}$.

[38] This value is ratioed upon the Btu per Dwelling per Hotel/Motel vs Dormitory building type assuming the same heating capacity requirements based upon the similarity between the building types.

[39] Calculated based upon ASHRAE 2015 ASHRAE HVAC Applications Table 6 and IL TRM assumptions. See 'CDHW Controls Summary Calculations.xlsx' for more information

[40] Low occupancy periods for dormitory buildings can be assumed as vacation day or holiday occupancy.

Building Type	$t_{normal\ occ}$ (hours)	$t_{low\ occ}$ (hours)	$R_{normal\ occ}$ (%)	$R_{low\ occ}$ (%)
Multi-Family	2,089[41]	0	24.02%	0%
Dormitories	1,688[42]	520[43]	22.44%	44.57%[44]
Hotels/Motels	2,428[45]	0	13.44%[46]	0%
Offices	2,857[47]	1,231	22.90%	41.70%

Based on defaults above:

ΔTherms = 30.1 * number of rooms (for dormitories)

= 62.7 * number of apartments (for multifamily buildings)

= 12.06 * number of rooms (hotels/motels)

> **For example**, a dormitory building has a 400,000 BTU/hr boiler whose burner operates for an estimated 580 hours during vacation months and 1,300 hours during regular occupancy months. Savings from installing central domestic hot water controls in this building are:
>
> ΔTherms = 400,000 BTU/hr * (1,300 * 0.2244 + 580 * 0.4457) / 100,000
>
> = 2,201 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION
N/A

MEASURE CODE: CI-HWE-CDHW-V05-230101

REVIEW DEADLINE: 1/1/2027

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[41] Based on results of the studies done at Multi-Family Buildings for the Nicor Gas Emerging Technology Program: Gas Technology Institute. (2014). *1003: Demand-based domestic hot water recirculation Public project report.* Des Plaines, IL: Prepared for Nicor Gas, January 7, 2014.

[42] Based on results of studies performed in multiple university dormitory buildings in the California region, for Southern California Gas' PREPS Program, 2012.

[43] Low occupancy periods for dormitory buildings can be assumed as vacation day or holiday occupancy.

[44] Estimated from low occupancy hours

[45] Calculated from the Btu per dwelling unit and average annual therm consumption for DHW for all Hospitality Buildings noted in "Evaluation of New DHW System Controls in Hospitality and Commercial Buildings", MN Commerce Department Energy Resources, 06/30/2018.

[46] Average Hospitallity Savings, "Evaluation of New DHW System Controls in Hospitality and Commercial Buildings", MN Commerce Department Energy Resources, 06/30/2018.

[47] Based on the report, Energy Efficiency with Domestic Water Heating in Commercial Buildings, ACEEE Summer Study on Energy Efficiency in Buildings, 2010. Using the tables of results for Tuesday, Saturday and Sunday to estimate blended values for $t_{normal\ occ}$, $t_{low\ occ}$, $R_{normal\ occ}$ and $R_{low\ occ}$.

4.3.9 Heat Recovery Grease Trap Filter

DESCRIPTION

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

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

DEFINITION OF EFFICIENT EQUIPMENT

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

DEFINITION OF BASELINE EQUIPMENT

Kitchen exhaust air duct with constant air flow and no heat recovery.[48]

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 15 years.[49]

DEEMED MEASURE COST

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

LOADSHAPE

Loadshape C01 - Commercial Electric Cooking

COINCIDENCE FACTOR

Summer Peak Coincidence Factor for measure is provided below for different building type:[50]

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

---

[48] Savings methodology factors are for a constant speed fan.
[49] Professional judgement, consistent with expected lifetime of kitchen demand ventilation controls and other kitchen equipment.
[50] Minnesota 2012 Technical Reference Manual, Electric Food Service_v03.2.xls

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS

For electric hot water heaters:

$$\Delta kWh = [(\text{Meal/Day} * \text{HW/Meal} * \text{Days/Year}) * \text{lbs/gal} * \text{BTU/lb.°F} * (\Delta T\text{/filter} * \text{Qty\_Filter}) * 0.000293] / (\eta_{HeaterElec})$$

Where:

Meal/Day	= Average number of meals served per day. If not directly available, see Table 1.
HW/Meal	= Hot water required per meal
	= 3 gal/meal[51]
Days/Year	= Number of days kitchen operates per year. If not directly available, see Table 1.
Lbs/gal	= weight of water
	= 8.3 lbs/gal
BTU/lb.°F	= Specific heat of water
	= 1.0
ΔT/filter	= Temperature difference of domestic water across each filter
	= 5.8°F/filter[52]
Qty_Filter	= Number of heat recovery grease trap filters installed. If not directly available, see Table 1.

Commercial Kitchen Load based on Building Type

Building Type	Meals/Day[53]	Assumed days/Year	Number of Filters[54]
Primary School	400	312	2
Secondary School	600	312	3
Quick Service Restaurant	800	312	5
Full Service Restaurant	780	312	4
Large Hotel	780	356	4

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[51] Average dishwashing and faucet water usage taken from Chapter 8, Table 8.3.3 Normalized Annual End Uses of Water in Select Restaurants in Western United States.

[52] Average value based on case studies. Northwinds Sailing, Inc. and North Shore Sustainable Energy, LLC. *Angry Trout Café Kitchen Exhaust Heat Recovery.* Minnesota Department of Commerce, Division of Energy Resources, 2012.

[53] Commercial Kitchen Loads for listed buildings in U.S. Department of Energy Commercial Reference Building Models of the National Building Stock, NREL

[54] Each filter is 20 X 20 inches.

Hospital	800	356	4

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

= Actual. If unknown, for retrofit use the table C404.2 in IECC 2012. For new construction use the active code at time the permit was issued.

SUMMER COINCIDENT PEAK DEMAND SAVINGS

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

Where:

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

Building Type	Kitchen Exhaust Fan Annual Operating Hours[55]
Primary School	4,056
Secondary School	4,056
Quick Service Restaurant	5,616
Full Service Restaurant	5,616
Large Hotel	5,340
Hospital	3,916

CF = Summer Peak Coincidence Factor for measure:[56]

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

FOSSIL FUEL SAVINGS

For natural gas hot water heaters:

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

Where:

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[55] Exhaust Fan Schedules for listed buildings in U.S. Department of Energy Commercial Reference Building Models of the National Building Stock, NREL.
[56] Minnesota 2012 Technical Reference Manual, Electric Food Service_v03.2.xls.

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

= Actual. If unknown, for retrofit use the table C404.2 in IECC 2012. For new construction use the active code at time the permit was issued.

Other variables as above.

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

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

MEASURE CODE: CI-HWE-GRTF-V03-230101

REVIEW DEADLINE: 1/1/2024

4.4.60 Variable Refrigerant Flow HVAC System – Provisional Measure

DESCRIPTION

This measure applies to the installation of air source Variable Refrigerant Flow (VRF) HVAC systems. VRF systems are heat pumps that have one outdoor condensing unit with refrigerant piped to multiple indoor evaporator units to deliver cooling and/or heating to individual interior zones as needed. This measure could apply to replacing an existing unit at the end of its useful life or the installation of a new unit in a new or existing building.

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

DEFINITION OF EFFICIENT EQUIPMENT

This measure applies to both retrofit and new construction installations of VRF systems. Savings are based in the inherent efficiency of VRF systems as compared to traditional HVAC systems. VRF systems should meet or exceed ASHRAE 90.1 minimum efficiency requirements for air source VRF systems.

DEFINITION OF BASELINE EQUIPMENT
Time of Sale / New Construction

Non-fuel switch measures:

To calculate savings with an electric baseline, the baseline equipment is assumed to be a standard-efficiency air cooled heat pump roof top unit (RTU) system. For building types which utilize individual in-unit HVAC systems (lodging, multifamily, etc.), the baseline equipment is assumed to be a residential style, standard efficiency, ducted heat pump split system.

Fuel switch measures:

To calculate savings with a fossil fuel-fired baseline, the baseline equipment is assumed to be a standard efficiency gas-fired RTU with DX cooling. For building types which utilize individual in-unit HVAC systems (lodging, multifamily, etc.), the baseline equipment is assumed to be a residential style standard efficiency ducted furnace/split AC system.

Standard efficiency implies equipment that complies with 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. 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.

Baseline selection:

The following table can be used to determine the appropriate baseline HVAC system type. This measure is only applicable to retrofit projects or new construction projects which have an alternative HVAC option of packaged RTUs[57] or residential style ducted split systems[58].

Scenario	Alternate or Existing System	Measure Baseline System
New Construction	RTU	Heat Pump RTU
New Construction	Ducted split system	Ducted split system (heat pump)
Retrofit	Gas-fired RTU	Gas-fired RTU
Retrofit	Ducted split system (Furnace + AC)	Ducted split system (Furnace + AC)

---

[57] For example, large facilities like hospitals or laboratories which could not feasibly utilize RTUs would not be eligible for this standard measure.
[58] Commonly found in multifamily, lodging, etc.

Scenario	Alternate or Existing System	Measure Baseline System
Retrofit	Heat Pump RTU	Heat Pump RTU
Retrofit	Ducted split system (heat pump)	Ducted split system (heat pump)

DEEMED LIFETIME OF EFFICIENT EQUIPMENT
The expected measure life for VRF is 16 years[59].

DEEMED MEASURE COST
Time of Sale / New Construction: For analysis, the incremental capital costs are summarized in the following table. Site specific cost data should be used where available.

Baseline System	Incremental Cost ($/ton)[60]
Heat Pump RTU	100
Gas-fired RTU	500
Ducted Split System (Heat Pump)	100
Ducted Split System (Furnace/AC)	500

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. 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%[61]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)
= 47.8%[62]

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS
Non-fuel switch measures:

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

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[59] Consistent with Residential air source heat pump measure and based on a 2016 DOE Rulemaking Technical Support document, as recommended in Guidehouse 'ComEd Effective Useful Life Research Report', May 2018.
[60] Insert reference for costs.
[61] 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.
[62] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.

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

$$\text{Annual kWh Savings}_{cool} = (\text{Capacity}_{cool} * \text{EFLH}_{cool} * (1/\text{SEERbase} - 1/\text{SEERee}))/1000$$

$$\text{Annual kWh Savings}_{heat} = (\text{HeatLoad} * (1/\text{HSPFbase} - 1/\text{HSPFee}))/1000$$

$$\text{FanSavings} = (\text{Flag} * \text{HeatLoad} * 1/\text{AFUE}_{base} * F_e) / 3412$$

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

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

$$\text{Annual kWh Savings}_{cool} = (\text{Capacity}_{cool} * \text{EFLH}_{cool} * (1/\text{EERbase} - 1/(\text{EERee} * \text{Cool}_{adj})))/1000$$

$$\text{Annual kWh Savings}_{heat} = (\text{HeatLoad}/3412 * (1/\text{COPbase} - 1/(\text{COPee} * \text{Heat}_{adj})))$$

$$\text{FanSavings} = (\text{Flag} * \text{HeatLoad} * 1/\text{AFUE}_{base} * F_e) / 3412$$

Fuel switch measures:

Fuel switch measures must produce positive total lifecycle site energy savings 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):

$$\text{SiteEnergySavings (MMBTU)} = \text{GasHeatReplaced} + \text{FanSavings} - \text{HPSiteHeatConsumed} + \text{HPSiteCoolingImpact}$$

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

$$\text{FanSavings (MMBTU)} = (\text{Flag} * \text{HeatLoad} * 1/\text{AFUE}_{base} * F_e) / 1{,}000{,}000$$

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

$$\text{HPSiteHeatConsumed (MMBTU)} = (\text{HeatLoad} * (1/(\text{HSPFee} * \text{Heat}_{adj}))) * 3412 / 1{,}000 / 1{,}000{,}000$$

$$\text{HPSiteCoolingImpact (MMBTU)} = (\text{EFLHcool} * \text{Capacity}_{cool} * (1/\text{SEERbase} - 1/\text{SEERee})) /1000 * 3412/ 1{,}000{,}000$$

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

$$\text{HPSiteHeatConsumed (MMBTU)} = (\text{HeatLoad} * (1/(\text{COPee} * \text{Heat}_{adj}))) / 1{,}000{,}000$$

$$\text{HPSiteCoolingImpact (MMBTU)} = (\text{FLHcool} * \text{Capacity}_{cool} * (1/\text{EER\_base} - 1/(\text{EER\_ee} * \text{Cool}_{adj}))) /1000 * 3412 / 1{,}000{,}000$$

Savings are adjusted by heating (Heat$_{adj}$) and cooling (Cool$_{adj}$) factors presented in the following table. These values bring the expected savings in line with energy model estimated savings.

Baseline System	Cool$_{adj}$	Heat$_{adj}$
RTU	1.5	1.2
Ducted Split System	1.1	1.3

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

Where:

Cool$_{adj}$ = This cooling adjustment factor is derived from energy modeling results to calibrate TRM calculation savings to energy modeling savings estimates.[63] Adjustment factor values are presented in a table above.

Heat$_{adj}$ = This heating adjustment factor is derived from energy modeling results to calibrate TRM calculation savings to energy modeling savings estimates.[64] Adjustment factor values are presented in a table above.

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

= Actual installed

SEERbase = 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).

SEERee = Seasonal Energy Efficiency Ratio of the energy efficient equipment.
= Actual installed

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

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[63] Based on Variable Refrigerant Flow Study. See 'Variable Refrigerant Flow Study 2022'.
[64] Based on Variable Refrigerant Flow Study. See 'Variable Refrigerant Flow Study 2022'.

HSPFbase = 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).

HSPFee = Heating Seasonal Performance Factor of the energy efficient equipment.
= Actual installed. If rating is COP, HSPF = COP * 3.413

EERbase = 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[65]:

EER = (-0.02 * SEER$_2$) + (1.12 * SEER)

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

= Actual installed

HeatLoad = Calculated heat load for the building

= EFLH$_{heat}$ * Capacity$_{heat}$

Where:

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

Capacity$_{heat}$ = Actual installed input capacity of the heat pump equipment in Btu per hour.

3412 = Btu per kWh.

COPbase = 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

COPee = coefficient of performance of the energy efficient equipment.

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

AFUEbase = **Baseline Annual Fuel Utilization Efficiency Rating. Use appropriate code level efficiency.**

Flag = **1 if system replaced is an RTU or ducted system with furnace fan, 0 if not.**

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[65] 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.

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

= **7.7% for RTU replacement, 3% for multifamily (residential style) furnace replacement** [66]

%IncentiveElectric = % of total incentive paid by electric utility

= Actual

%IncentiveGas = % of total incentive paid by gas utility

= Actual

Equipment Type	Size Category	Heating Section Type	Subcategory or Rating Condition	Minimum Efficiency	Test Procedure
VRF air cooled (cooling mode)	<65,000 Btu/h	All	VRF multisplit system	13.0 SEER	AHRI 1230
	≥65,000 Btu/h and <135,000 Btu/h	Electric resistance (or none)		11.0 EER 12.9 IEER14.6 IEER	
			VRF multisplit system with heat recovery	10.8 EER 12.7 IEER 14.4 IEER	
	≥135,000 Btu/h and <240,000 Btu/h		VRF multisplit system	10.6 EER 12.3 IEER 13.9 IEER	
			VRF multisplit system with heat recovery	10.4 EER 12.1 IEER 13.7 IEER	
	≥240,000 Btu/h		VRF multisplit system	9.5 EER 11.0 IEER 12.7 IEER	
			VRF multisplit system with heat recovery	9.3 EER 10.8 IEER 12.5 IEER	
VRF air cooled (heating mode)	<65,000 Btu/h (cooling capacity)		VRF multisplit system	7.7 HSPF	AHRI 1230
	≥65,000 Btu/h and <135,000 Btu/h (cooling capacity)		VRF multisplit system 47°F db/43°F wb outdoor air	3.3 COP_H	
			17°F db/15°F wb outdoor air	2.25 COP_H	
	≥135,000 Btu/h (cooling capacity)		VRF multisplit system 47°F db/43°F wb outdoor air	3.2 COP_H	
			17°F db/15°F wb outdoor air	2.05 COP_H	

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[66] Fe is estimated using TRM models for the three building types: low-rise office, sit-down restaurant and retail-strip mall. 7.7% represents the average Fe of the three building types. See "Fan Energy Factory Example Calculation 2021-06-23.xlsx" for reference. Mutlifamily is 3%, lower than commercial, due to typically lower fan static pressure in residential style applications.

Non Fuel Switch example, a heat recovery VRF system with 8 ton cooling capacity and 96 kbtu heating capacity, an efficient EER of 12.5 and COP of 3.75, at a new construction low-rise office in Chicago saves:

ΔkWh = Annual kWh Savings$_{cool}$ + Annual kWh Savings$_{heat}$ + FanSavings

Annual kWh Savings$_{cool}$ = (Capacity$_{cool}$ * EFLH$_{cool}$ * (1/EERbase – 1/(EERee * Cool$_{adj}$)))/1000

Annual kWh Savings$_{heat}$ = (HeatLoad/3412 * (1/COPbase – 1/(COPee* Heat$_{adj}$)))

FanSavings = (Flag * HeatLoad * 1/AFUE$_{base}$ * F$_e$) / 3412

ΔkWh = 96000 * 989 * (1/10.8 – 1/(12.5*1.5))/1000 + (916 * 60000 / 3412 * (1/3.3 – 1/(3.75 * 1.2))) + (1

Fuel Switch example, a heat recovery VRF system with 8-ton cooling capacity and 96 kbtu heating capacity, an efficient EER of 12.5 and COP of 3.75, at a new construction low-rise office in Chicago, assuming a gas-fired RTU baseline. Assuming 50%-50% Incentive agreement is used for joint programs, savings:

SiteEnergySavings (MMBTUs) = GasHeatReplaced + FanSavings – HPSiteHeatConsumed + HPSiteCoolingImpact

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

= (96000 * 916 * 1/0.8) / 1000000

= 109.9 MMBtu

FanSavings = (Flag * HeatLoad * $1/AFUE_{base}$ * F_e) / 1,000,000

= (1 * 96000 * 916 * 1/0.8 * 0.077) / 1000000

= 8.46 MMBtu

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

HPSiteHeatConsumed = (HeatLoad * $(1/(COP_{ee} * Heat_{adj})))$ / 1,000,000

= (96000 * 916 * (1/(3.75*1.2)))/1000000

= 19.5 MMBtu

HPSiteCoolingImpact = (FLH_{cool} * $Capacity_{cool}$ * (1/EER_base - 1/(EER_{ee} * $Cool_{adj}$)))/1000 * 3412/ 1,000,000

= (989 * 96000 * (1/10.8-1/(12.5*1.5)))/1000 *3412/1000000

= 12.7 MMBtu

SiteEnergySavings (MMBTUs) = 109.9 + 8.5 – 19.5 + 12.7 = 111.6 [Measure is eligible]

Savings would be claimed as follows, assuming a 50%-50% incentive agreement:

Measure supported by:	Electric Utility claims (kWh):	Gas Utility claims (therms):
Electric utility only	111.6 * 1,000,000/3,412	N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

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

Where CF value is chosen between:

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

= 91.3%

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

= 47.8%

For example, a heat recovery VRF system with 8-ton cooling capacity and 96 kbtu heating capacity, an efficient EER of 12.5, saves:

$$\Delta kW = (96 * (1/10.8 - 1/12.5)) * 0.913$$
$$= 1.1 \text{ kW}$$

Fosil fuel

SAVINGS
Calculation provided together with Electric Energy Savings above.

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 ASHP projects per Section 16-111.5B, changes in site energy use at the customer's meter (using ΔkWh algorithm below), 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, should therefore reflect the decrease in one fuel and increase in another, as opposed to the single savings value calculated in the "Electric and Fossil Fuel Energy Savings" section above. Therefore in addition to the calculation of savings claimed, the following values should be used to assess the cost effectiveness of the measure.

ΔTherms   = [Heating Consumption Replaced]
               = [(HeatLoad * 1/AFUE$_{base}$) / 100,000]
ΔkWh   = [FurnaceFanSavings] - [HP heating consumption] + [Cooling savings]

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

ΔkWh = [FurnaceFlag * HeatLoad * $1/AFUE_{base}$ * F_e * 0.000293] - [(HeatLoad/3412 * (1/((COPee * $Heat_{adj}$)))/1000] + [($Capacity_{cool}$ * $EFLH_{cool}$ * (1/EERbase - 1/(EER_ee * $Cool_{adj}$)))/1000]

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

ΔkWh = [FurnaceFlag * HeatLoad * $1/AFUE_{base}$ * F_e * 0.000293] - [HeatLoad/3412 * (1/(COPee * $Heat_{adj}$))] + [($Capacity_{cool}$ * $EFLH_{cool}$ * (1/EERbase - 1/(EER_ee * $Cool_{adj}$)))/1000]

MEASURE CODE: CI-HVC-VFFY-V2-230101

REVIEW DEADLINE: 1/1/2024

4.5.4   LED Bulbs and Fixtures

DESCRIPTION

Please note that this measure characterization contains assumptions that were negotiated as a compromise between the utilities and stakeholders. The Parties agree that TRM version 11 does not allow utilities to claim General Service Lamp measure savings for business customers with longer than a 2 year measure life; though the Parties recognize that small businesses, disadvantaged businesses and non-profit entities often face challenges similar to Income Qualified customers. The Parties commit to future discussions on how best to serve small businesses, disadvantaged businesses and non-profit entities with this measure, specifically those located in communities identified as disadvantaged and to offer an errata to the TRM version 11 if appropriate.

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 not in a store 'easily accessed by income qualified communities' (see discussion in Residential LED measures – 100% of sales in stores easily accessed by income qualified communities are assumed to be income qualified (IQ) residential)), a deemed split of 97% Residential and 3% Commercial assumptions should be used,[67] 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.[68]

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 equivalent to the most recent version of ENERGY STAR specifications or be listed on the Design Lights Consortium Qualifying Product List.[69]

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

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[67] 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.

[68] 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.

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

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), finding that this more stringent standard was not economically justified. However, in May 2022 DOE reversed this decision by issuing a Final rule for both the broadened General Service Lamp definition as well as the implementation of the 45 lumen per watt backstop. DOE stated that it will use its enforcement discretion to minimize impacts on the supply chain and effectively allow companies to continue the manufacture and import of noncompliant bulbs through the remainder of 2022, and allow retailers to continue selling them with limited enforcement until July 2023.

This TRM assumes that commercial participants would continue to have access to baseline / noncompliant bulbs through retail until 6/30/2023 after which the baseline for new purchases becomes an LED (since only CFL and LED are able to meet the 45 lu/watt standard and CFLs now make up <1% of the market). For purchases made before this date it is assumed that stockpiles would remain through the remainder of 2023 such that the measure life for 2023 purchases is reduced to 2 years.

Direct Install programs where it can be shown that the LED is replacing working inefficient lighting should continue to use the existing inefficient lighting as baseline and also assume a measure life of 2 years.

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 impacted by the EISA backstop as indicated in tables below and LED Downlight Fixtures the measure life is assumed to be two years, unless installed in income qualified locations such as IQ common area lighting where a lifetime of 8 years should be used consistent with the residential measure assumption.

For lamps not impacted by the EISA backstop, the 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. [70]

DEEMED MEASURE COST
Wherever possible, actual incremental costs should be used. Refer to reference table "LED component Cost & Lifetime" for defaults.

LOADSHAPE
Loadshape C06 - Commercial Indoor Lighting
Loadshape C07 - Grocery/Conv. Store Indoor Lighting

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

Loadshape C08 - Hospital Indoor Lighting
Loadshape C09 - Office Indoor Lighting
Loadshape C10 - Restaurant Indoor Lighting
Loadshape C11 - Retail Indoor Lighting
Loadshape C12 - Warehouse Indoor Lighting
Loadshape C13 - K-12 School Indoor Lighting
Loadshape C14 - Indust. 1-shift (8/5) (e.g., comp. air, lights)
Loadshape C15 - Indust. 2-shift (16/5) (e.g., comp. air, lights)
Loadshape C16 - Indust. 3-shift (24/5) (e.g., comp. air, lights)
Loadshape C17 - Indust. 4-shift (24/7) (e.g., comp. air, lights)
Loadshape C18 - Industrial Indoor Lighting
Loadshape C19 - Industrial Outdoor Lighting
Loadshape C20 - Commercial Outdoor Lighting
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:[71]

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

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[71] 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)	Impacted by EISA Backstop
120	309	4.0	25	21.0	No
310	399	4.0	25	21.0	Yes
400	749	6.6	29	22.4	Yes
750	899	9.6	43	33.4	Yes
900	1,399	13.1	53	39.9	Yes
1,400	1,999	16.0	72	56.0	Yes
2,000	2,999	21.8	150	128.2	Yes
3,000	3,299	28.9	200	171.1	Yes
3,300	3,999	28.9	200	171.1	No
4,000	5,000	35.7	300	264.3	No

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)	Impacted by EISA Backstop
Omni-Directional 3-Way	1,100	1,999	14.7	100	85.3	Yes
	2,000	2,700	22.6	150	127.4	Yes
Globe (medium and intermediate bases less than 750 lumens)	150	309	3.0	25	22	No
	310	349	3.0	25	22	Yes
	350	499	4.7	40	35.3	Yes
	500	574	5.7	60	54.3	Yes
	575	649	6.5	75	68.5	Yes
	650	1,000	8.2	100	91.8	Yes
Globe (candelabra bases less than 1050 lumens)	150	309	3.5	25	21.5	No
	310	349	3.5	25	21.5	Yes
	350	499	4.4	40	35.6	Yes
	500	574	5.5	60	54.5	Yes
Decorative (Shapes B, BA, C, CA, DC, F, G, medium and intermediate bases less than 750 lumens)	160	299	2.6	25	22.4	No
	300	309	4.3	40	35.7	No
	310	499	4.3	40	35.7	Yes
	500	800	5.8	60	54.2	Yes
Decorative (Shapes B, BA, C, CA, DC, F, G, T candelabra bases	120	159	1.5	15	13.5	No
	160	299	2.7	25	22.3	No
	300	309	4.2	40	35.8	No
	310	499	4.2	40	35.8	Yes

Bulb Type	Minimum Lumens	Maximum Lumens	LED Wattage (Watts$_{EE}$)	Baseline (Watts$_{Base}$)	Delta Watts (WattsEE)	Impacted by EISA Backstop
less than 1050 lumens)	500	650	5.5	60	54.5	Yes
Decorative (Shape ST)	250	309	6.5	40	33.5	No
	310	499	6.5	40	33.5	Yes
	500	999	8.8	60	51.2	Yes
	1000	1500	10.0	100	90.0	Yes
Decorative (Shape S)	50	75	1.0	11	10.0	No
	100	120	1.2	15	13.8	No
	120	309	2.25	25	22.8	No
	310	340	2.25	25	22.8	Yes

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

For Directional R, BR, 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)	Impacted by EISA Backstop
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	Yes
	650	899	10.7	75	64.3	Yes
	900	1,049	13.9	90	76.1	Yes
	1,050	1,199	13.8	100	86.2	Yes
	1,200	1,499	15.9	120	104.1	Yes
	1,500	1,999	18.9	150	131.1	Yes
	2,000	3,299	27.3	250	222.7	Yes
	3,300	4,200	27.3	250	222.7	No
Reflector lamp types with medium screw bases (PAR16, R14, R16, etc.) w/ diameter <2.25" (*see exceptions below)	280	309	4.6	35	30.4	No
	310	374	4.6	35	30.4	Yes
	375	600	6.4	50	43.6	Yes
*BR30, BR40, or ER40	650	949	9.3	65	55.7	Yes
	950	1,099	12.7	75	62.3	Yes
	1,100	1,399	14.4	85	70.6	Yes
	1,400	1,600	16.6	100	83.4	Yes
	1,601	1,800	22.2	120	97.8	Yes
*R20	450	524	6.0	40	34.0	Yes
	525	750	7.1	45	37.9	Yes

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Bulb Type	Minimum Lumens	Maximum Lumens	LED Wattage (Watts$_{EE}$)	Baseline (Watts$_{Base}$)	Delta Watts (WattsEE)	Impacted by EISA Backstop
*MR16	250	309	3.8	20.0	16.2	No
	310	324	3.8	20.0	16.2	Yes
	325	369	4.8	25.0	20.2	Yes
	370	400	4.9	25.0	20.1	Yes

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.[72] 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.[73]

Wattsbase =

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

Where:

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

BA = Beam angle

CBCP = Center beam candle power

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

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

Additional bulb types:

Bulb Type	Minimum Lumens	Maximum Lumens	LED Wattage (Watts$_{EE}$)	Baseline (Watts$_{Base}$)	Delta Watts (WattsEE)	Impacted by EISA Backstop
Dimmable Twist,	120	309	4.0	25	21.0	No

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[72] ENERGY STAR Lamps Center Beam Intensity Benchmark Tool and Calculator
[73] 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.

Globe (less than 5" in diameter and > 749 lumens), candle (shapes B, BA, CA > 749 lumens), Candelabra Base Lamps (>1049 lumens), Intermediate Base Lamps (>749 lumens)	310	399	4.0	25	21.0	Yes
	400	749	6.6	29	22.4	Yes
	750	899	9.6	43	33.4	Yes
	900	1,399	13.1	53	39.9	Yes
	1,400	1,999	16.0	72	56.0	Yes

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.[74] If sign off form not completed, assume the following ISR assumptions, if program survey data is not available:

Type	1st year In Service Rate (ISR)[75]
LED Bulbs	97.9%[76]
LED Fixtures (Energy Star Fixtures)	98.0%[77]
Efficiency Kits	92.9%[78]

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[74] 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.

[75] In Service Rates now represent the lifetime In Service Rates with the second and third year installations discounted by the Real Discount Rate of 0.46%. Lifetime ISR assumptions for efficiency kits are based upon Residenital direct mailed kits. For all other programs Tthe 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.

[76] 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

[77] 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

[78] 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"

Type	Weighted Average 1st year In Service Rate (ISR)	2nd year Installations	3rd year Installations	Final Lifetime In Service Rate
TLEDs	83.1%[79]	8.1%	6.8%	98.0%

Mid Life Baseline Adjustment

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%.[80]

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:

$$\Delta kWh_{heatpenalty}[81] = (((WattsBase-WattsEE)/1000) * ISR * Hours * -IFkWh$$

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:
> $$\Delta kWh_{heatpenalty} = ((29-6.7)/1000)*1.0*3088* -0.151$$
> $$= - 10.4 \text{ kWh}$$

DEFERRED INSTALLS
As presented above, if a sign off form is not completed the characterization assumes that a percentage of T-LED

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[79] 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

[80] 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.

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

bulbs purchased are not installed until Year 2 and Year 3 (see ISR assumption above). The Illinois Technical Advisory Committee has determined the following methodology for calculating the savings of these future installs.

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

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

The NTG factor for the Purchase Year should be applied.

SUMMER COINCIDENT 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:

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

FOSSIL FUEL 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:

$$\Delta Therms = ((29-6.7)/1000) * 1.0 * 3088 * -0.016$$
$$= - 1.10 \text{ therms}$$

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. [82]

For lamps no O&M costs should be applied.

REFERENCE TABLES
LED Bulb Assumptions

Wherever possible, actual incremental costs should be used. If unavailable assume the following incremental costs: [83]

Bulb Type	Year	LED	Incandescent	Incremental Cost
Omnidirectional	2017	$3.21		$1.96
	2018	$3.21	$1.25	$1.96
	2019	$3.11		$1.86
	2020	$2.70		$1.45
Directional	2017	$6.24		$2.71
	2018+	$5.18	$3.53	$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 [84]

LED Category	EE Measure Description	Watts$_{EE}$	Baseline Description	Watts$_{BASE}$	Incremental Cost
LED Downlight Fixtures * Impacted by EISA Backstop – apply 2 year measure life	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 [85]	LED Display Case Light Fixture	4 per ft	Baseline Display Case Light Fixture	36.2 per ft	$11/ft

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

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

[84] 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.

[85] 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 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
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 Category	EE Measure Description	Watts$_{EE}$	Baseline Description	Watts$_{BASE}$	Incremental Cost
	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 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 Category	EE Measure Description	Watts$_{EE}$	Baseline Description	Watts$_{BASE}$	Incremental Cost
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[86]

LED Category	EE Measure Description	EE Measure				Baseline			
		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	50,000	$8.57	70,000	$13.67	24,000	$6.17	40,000	$11.96

[86] 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				Baseline			
		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
	Replacement Lamp (TLED), 1200-2400 lumens								
	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, 3000-4500 lumens	50,000	$96.10	70,000	$40.00	24,000	$12.33	40,000	$35.00
	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-	50,000	$93.22	70,000	$40.00	24,000	$12.33	40,000	$35.00

LED Category	EE Measure Description	EE Measure				Baseline			
		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
	4500 lumens								
	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, 10,001-15,000 lumens	50,000	$122.59	70,000	$62.50	18,000	$86.00	40,000	$92.50
	LED High-Bay Fixtures, 15,001-20,000 lumens	50,000	$157.22	70,000	$62.50	18,000	$129.00	40,000	$117.50
	LED High-Bay Fixtures, 20,001 – 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	50,000	$179.81	70,000	$62.50	15,000	$63.00	40,000	$112.50

LED Category	EE Measure Description	EE Measure				Baseline			
		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, 8,001-12,000 lumens								
	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 Fixtures, 10,001-15,000 lumens	50,000	$214.95	70,000	$62.50	15,000	$68.00	40,000	$122.50
	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-V16-230101

REVIEW DEADLINE: 1/1/2024

4.8.23 Lithium Ion Forklift Batteries

DESCRIPTION

This measure applies to electric forklifts used in commercial, industrial, and warehouse environments. Electric forklifts with lithium ion battery systems are more efficient than electric forklfits with traditional lead acid battery systems because the lithium ion batteries have lower internal resistance. This allows the batteries to transfer power faster, reduces waste heat, and reduces standby losses.

Electric forklifts can be purchased with lithium ion battery systems or an existing electric forklift can be retrofitted to use a lithium ion battery system. An electric forklift can be converted to a lithium ion battery system by removing the lead acid battery and installing a battery case that includes a series of lithium ion batteries and the appropriate ballast to meet weight and balance specifications for the forklift. The lithium ion battery case is a one-for-one equivalent replacement of the lead acid battery in respect to capacity, shape, and weight. The forklift may require a new charger to work with the new lithium ion battery system. Electric fork trucks can also replace propane or diesel powered fork truck in a one to one scenario. Where a facility normally operates a fleet of fossil-fueled fork trucks a fossil-fuel baseline should be considered for any additional fork trucks that might be purchased beyond the current quantity of trucks operating at the facility.

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

DEFINITION OF EFFICIENT EQUIPMENT
Class I, Class II, or Class III forklifts that are powered by lithium ion batteries with minimum 8-hour shift operation five days per week.

DEFINITION OF BASELINE EQUIPMENT
Class I, Class II, or Class III forklifts that are powered by lead acid batteries or fossil-fuels such as propane or diesel with minimum 8-hour shift operation five days per week.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT
15 years. [87]

DEEMED MEASURE COST
Costs will vary significantly based on the capacity and class of the forklift. Costs for this measure should be determined by actual quotes obtained from manufacturers and estimated labor. If not available, it is estimated that a new lithium ion forklift would cost $34,400 compared with $17,200 for a new lead-acid battery forklift, $24,200 for a propane and $25,100 for a diesel forklift. [88]

Converting a lead acid battery forklift to a lithium ion battery system would cost $17,000. [89]

LOADSHAPE
Loadshape C14 - Indust. 1-shift (8/5) (e.g., comp. air, lights)

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[87] Lifetime of measure assumed to be limited by the lifetime of the lithium ion charger. See reference file Suzanne Foster Porter et al., "Analysis of Standards Options for Battery Charger Systems", (PG&E, 2010), 45.
[88] Estimates for new lithium ion, propane and diesel from Dennis, Allen and Vairamohan, Bashkar. "EPRI Forklift (Lift Truck) Comparison with Capital Costs." Electric Power Research Institute. Accessed April 19, 2022. https://et.epri.com/ForkliftCalculator.html. A new lead-acid battery is estimated to be approximately half the cost of a lithium ion, as suggested in Thomas, Pete. "Is a Lithium Ion Forklift Battery Worth the Extra Expense?" Toyota Material Handling Northern California. https://www.tmhnc.com/blog/lithium-ion-forklift-battery-cost-and-runtime.
[89] Thomas, Pete. "Is a Lithium Ion Forklift Battery Worth the Extra Expense?" Toyota Material Handling Northern California. Accessed May 5, 2021. https://www.tmhnc.com/blog/lithium-ion-forklift-battery-cost-and-runtime.

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)

COINCIDENCE FACTOR

It is assumed that lead acid battery forklifts are charged overnight. Therefore, the coincidence factor is assumed to be 0.0 for 1-shift and 2-shift operations and 1.0 for 3-shift and 4-shift operations.[90]

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS AND FOSSIL FUEL SAVINGS

Non-fuel switch (baseline of lead-acid forklift):

$$\Delta kWh = CAP * DOD * CHG * (1/ EE_{LAB} - 1/EE_{LIB})$$

Where:

CAP = Capacity of Battery

= Use actual battery output capacity, otherwise use a default value of 35 kWh[91]

DOD = Depth of Discharge

= Use actual depth of discharge, otherwise use a default value of 80%.[92]

CHG = Number of Charges per year

= Use actual number of annual charges, if unknown use values below based on the type of operation

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[90] Matley, Ryan. May 29, 2009. "Industrial Battery Charger Energy Savings Opportunities." Emerging Technologies Program Application Assessment Report #0808. Pacific Gas & Electric.

[91] Renquist, Jacob V., Brian Dickman, and Thomas H. Bradley. June 19, 2012. "Economic comparison of fuel cell powered forklifts to battery powered forklifts." International Journal of Hydrogen Energy, Volume 37, Issue 17.

[92] Matley, Ryan. May 2009. "Measuring Energy Efficiency Improvements in Industrial Battery Chargers." Energy Systems Laboratory.

Standard Operations	Number of Charges per year
1-shift (8 hrs/day – 5 days/week)	520
2-shift (16 hrs/day – 5 days/week)	1,040
3-shift (24 hrs/day – 5 days/week)	1,560
4-shift (24 hrs/day – 7 days/week)	2,184

EE_{LAB} = Energy Efficiency of Lead Acid Battery

             = Use actual efficiency of battery for retrofit, for new or unknown use 46%[93]

EE_{LIB} = Energy Efficiency of Lithium Ion Battery

             = Use actual efficiency of battery, if unknown use 73%**Error! Bookmark not defined.**

Fuel switch measures (baseline of propane or diesel forklift):

Fuel switch measures must produce positive total lifecycle energy 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):

       $\Delta SiteEnergySavings$ (MMBtu) = (CAP* DOD * CHG * (1/ EE_{BASE} - 1/EE_{LIB})) * 3,412/1,000,000

Where:

EE_{BASE} = Energy efficiency of baseline forklift. If unknown, assume the efficiency values below based on the type of forklift. [94]

                   = 20.4% for Propane

                   = 20.5% for Diesel

3,412   = Btu per kWh

1,000,000   = Btu per MMBtu

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

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[93] Abdulhameed, Alshaebi, Husam Dauod, and Sang Won Yoon. May 2017. "Evaluation of Different Forklift Battery Systems Using Statistical Analysis and Discrete Event Simulation." Industrial and Systems Engineering Conference. Pittsburg, PA.

[94] Dennis, Allen and Vairamohan, Bashkar. "EPRI Forklift (Lift Truck) Comparison with Capital Costs." Electric Power Research Institute. Accessed April 19, 2022. https://et.epri.com/ForkliftCalculator.html. Tank-to-wheel efficiency is based on dividing output electricity by input propane energy, assuming HHV of 91,333 BTU/gallon for propane and 138,500 BTU/gallon for diesel.

Calculate savings as follows:

$$\Delta kWh = \Delta SiteEnergySavings * 1{,}000{,}000 / 3{,}412$$

Savings for each shift operation and baseline technology type using defaults provided above are provided below:

Standard Operations	Lead Acid	Diesel		Propane	
	Δ Elec (kWh)	ΔSiteEnergy Savings (MMBtu)	ΔSiteEnergy Savings (ΔkWh)	ΔSiteEnergy Savings (MMBtu)	ΔSiteEnergy Savings (ΔkWh)
1-shift (8 hrs/day – 5 days/week)	11,707	175	51,427	174	51,079
2-shift (16 hrs/day – 5 days/week)	23,414	351	102,855	349	102,158
3-shift (24 hrs/day – 5 days/week)	35,121	526	154,282	523	153,238
4-shift (24 hrs/day – 7 days/week)	49,169	737	215,995	732	214,533

SUMMER COINCIDENT PEAK DEMAND SAVINGS
It is assumed there is zero peak demand savings.

FOSSIL FUEL SAVINGS
Calculation provided together with Electric Energy Savings above.

Water and Other Non-Energy Impact Descriptions and Calculation

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION
Lithium ion batteries offer several O&M advantages over lead acid batteries. These benefits include, but are not limited to:

- Lithium ion batteries charge must faster, which results in less downtime.[95]
- There is no requirement for changing out batteries at the end of a shift or having multiple spare batteries in stock.[Error! Bookmark not defined.] A 3-shift operation would require a facility to have three separate lead acid batteries for each forklift, so they could swap out batteries at the end of each shift. A lithium ion battery is charged while still in the forklift and can use opportunity charging during employee breaktime.
- Fewer maintenance issues and no requirement for battery watering[Error! Bookmark not defined.]
- Longer operating life.[96] Lithium ion batteries can last nearly four times as long as lead acid batteries.

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[95] Abdulhameed, Alshaebi, Husam Dauod, and Sang Won Yoon. May 2017. "Evaluation of Different Forklift Battery Systems Using Statistical Analysis and Discrete Event Simulation." Industrial and Systems Engineering Conference. Pittsburg, PA.
[96] Mongird, Kendall, Viswanathan, Vilayanur V., Balducci, Patrick J., Alam, Md Jan E., Fotedar, Vanshika, Koritarov, V S., and

These benefits should be considered and evaluated on a project-by-project basis. It is estimated that lithium ion forklift adoption saves a facility 65 labor hours per truck on an annual basis. [97]

COST EFFECTIVENESS SCREENING AND LOAD REDUCTION FORECASTING WHEN FUEL SWITCHING

This measure can involve fuel switching from fossil fuel to electric.

For the purposes of forecasting load reductions due to fuel switch 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 "Fuel Switch Measures" section above. Therefore in addition to the calculation of savings claimed, the following values should be used to assess the cost effectiveness of the measure.

ΔTherms = [Fossil Fuel Consumption Saved]

= [CAP * DOD * CHG * EE_{LIB}/EE_{BASE} * 3412/100,000]

ΔkWh = [Electric Consumption Added]

= - [CAP * DOD * CHG]

MEASURE CODE: CI-MSC-LION-V03-230101

REVIEW DEADLINE: 1/1/2025

Hadjerioua, Boualem. July 2019. "Energy Storage Technology and Cost Characterization Report". U.S. Department of Energy – HydroWires. https://doi.org/10.2172/1573487.

[97] Abdulhameed, Alshaebi, Husam Dauod, and Sang Won Yoon. May 2017. "Evaluation of Different Forklift Battery Systems Using Statistical Analysis and Discrete Event Simulation." Industrial and Systems Engineering Conference. Pittsburg, PA.

4.8.27 C&I Air Sealing

DESCRIPTION

Note- this measure provides a comprehensive approach for various commercial air sealing opportunities. A prescriptive approach for door sweeps only is provided in measure 4.8.16 C&I Weather Stripping.

This Air Sealing Measure incorporates a wide variety of products and procedures that reduce unwanted uncontrolled outdoor air infiltration into commercial or industrial buildings. Unwanted outdoor air causes significant increases in both heating and cooling costs throughout most of the year, and causes unwanted introduction of dust and odors into the building. This outdoor air infiltration is caused by both wind blowing against one or more sides of the building, and also through thermal stack effects in tall buildings that cause infiltration on lower floors and exfiltration on upper floors.

This measure applies to all existing commercial and industrial buildings that utilize mechanical heating and/or cooling to maintain occupant comfort. Identifying the exact length and width of cracks and holes in a building is difficult to do accurately. Similarly, conducting a building pressurization test using multiple blower doors or programming the air handling equipment to pressurize a building is also impractical in most situations. Therefore, this measure's savings calculations are instead based primarily on deemed values of air leakage reduction per unit length or unit area of air sealing retrofits installed.[98] If a blower door or air handler pressurization and measurement test can be done both before and after air sealing, the amount of air cfm reduction, adjusted to 50 pascals of pressure differential, may be directly inserted into the 'Annual Avg infiltration CFM Saved' value to determine annual energy savings.

This measure was developed to be applicable to the following program types: RF

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

DEFINITION OF EFFICIENT EQUIPMENT

Air sealing materials and diagnostic testing should meet all eligibility program qualification criteria. If applicable, the initial and final tested leakage rates should be performed in such a manner that the identified reductions can be properly discerned, particularly in situations wherein multiple building envelope measures may be implemented simultaneously.

DEFINITION OF BASELINE EQUIPMENT

The baseline condition of a building upon first inspection significantly impacts the opportunity for cost-effective energy savings through air-sealing.

If applicable and feasible, the existing air leakage rate for an existing building may be determined through approved and appropriate test methods using either blower doors or air handling units programmed to pressurize the building. Outdoor air flow quantities and simultaneous measurements of building differential pressure (inside vs outside) must be measured using approved methods and adjusted to values at 50 pascals differential.

Alternatively, if actual leakage rates cannot be measured, air leakage savings may be deemed using quantities of air leakage lengths or quantities based on inspection of the building. Lengths of cracks to be filled, quantities of leaky doors or windows to be sealed, etc. are documented and prescriptive, deemed savings rates are used to estimate savings.

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[98] ASHRAE, 2001 AHSRAE Handbook – Fundamentals, Chapter 26, Table 1. Effective Air Leakage Areas (Low-Rise Residential Applications Only).

DEEMED LIFETIME OF EFFICIENT EQUIPMENT
The expected measure life is assumed to be 20 years.[99]

MEASURE COST
Use actual cost of air sealing measures installed, if available. If actual costs are unknown, use estimated costs from table below multiplied by the number of units of each application installed:

Technology	Application	Unit Definition	Unit Cost Estimate[100]
Weather Stripping	Single Door - Weather Stripping, Sweep	Enter Number of Doors Retrofitted	$37
	Double Doors - Weather Stripping	Enter Number of Double Door Sets Retrofitted	$166
	Casement Window - Weather Stripping	Enter Lin. Ft. of Crack Retrofitted	$5
	Double Horizontal Slider, Wood - Weather Stripping	Enter Lin. Ft. of Crack Retrofitted	$5
	Double-Hung - Weather Stripping	Enter Lin. Ft. of Crack Retrofitted	$5
	Double-Hung, with Storm Window - Weather Stripping	Enter Lin. Ft. of Crack Retrofitted	$5
	Roof-Wall Intersection, Block Seal	Enter Lin. Ft. of Crack Retrofitted	$10
	Roof-Wall Intersection, Seal Paint	Enter Lin. Ft. of Crack Retrofitted	$23
	Roof-Wall Intersection, Seal	Enter Lin. Ft. of Crack Retrofitted	$6
	Piping/Plumbing/Wiring Penetrations - Sealing	Enter Number of Penetrations Retrofitted	$50
Caulking	Caulking, External Block	Enter Lin. Ft. of Crack Retrofitted	$12
	Caulking, Internal Seal	Enter Lin. Ft. of Crack Retrofitted	$6
Attic Sealing	Attic Bypass Air Sealing, Block, Seal	Each	$386
	Attic Bypass Air Sealing, Seal	Each	$249
	Retrofit Existing Attic Hatch	Each	$223
Gasket	Exterior Wall Outlet Penetrations - Gasket	Enter Number of Outlets Retrofitted	$5
Avg Caulking / Weather Stripping	Average Window/Door Caulking / Weather Stripping	Enter Lin. Ft. of Crack Retrofitted	$10

LOADSHAPE

      Loadshape C01 – Commercial Electric Cooling

      Loadshape C03 – Commercial Cooling

      Loadshape C04 – Commercial Electric Heating

      Loadshape C05 – Commercial Electric Heating and Cooling

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[99] As recommended in Navigant 'ComEd Effective Useful Life Research Report', May 2018.
[100] Typical project costs from quotation for large commercial air sealing project in Northeast (site: Concord, NH). All unit prices taken from BE Retrofit quote, October 2021.

Loadshape C23 – Commercial Ventilation

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% [101]

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

= 47.8% [102]

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS

ΔkWh = $\Delta kWh\_cooling$ + $\Delta kWh\_heatingElectric$ + $\Delta kWh\_heatingFurnace$

$\Delta kWh\_cooling$ = If building is cooled, reduction in annual cooling requirement due to air sealing

= 1.08 * Infiltration_CFM_Saved * CDD55/yr * 24 / 1000 / ηCool * %Cool

$\Delta kWh\_heatingElectric$ = if building is electrically heated, reduction in annual heating requirement due to air sealing

= 1.08 * Infiltration_CFM_Saved * HDD55/yr * 24 / ηHeat / 3,412 * %ElectricHeat

$\Delta kWh\_heatingGas$ = If gas furnace or gas boiler heat, kWh savings for reduction in combustion fan run time

= $\Delta Therms$ * F_e * 29.3

Where:

1.08 = Specific heat of air x density of inlet air @ 70F x 60 min/hr in BTU/hr-F-CFM

Infiltration_CFM_Saved = Annual average CFM of outdoor air infiltration reduced due to air sealing measures implemented

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[101] 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.
[102] 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.

= Calculated EITHER by sum of applicable values from table below multiplied by the quantities of each item implemented [103]

Technology	Application	Delta CFM50 per Unit	Unit Definition
Weather Stripping	Single Door - Weather Stripping	25.500	Enter Number of Doors Retrofitted
	Double Doors - Weather Stripping	0.730	Enter Sq. Ft. of Both Doors Retrofitted
	Casement Window - Weather Stripping	0.360	Enter Lin. Ft. of Crack Retrofitted
	Double Horizontal Slider, Wood - Weather Stripping	0.473	Enter Lin. Ft. of Crack Retrofitted
	Double-Hung - Weather Stripping	1.618	Enter Lin. Ft. of Crack Retrofitted
	Double-Hung, with Storm Window - Weather Stripping	0.164	Enter Lin. Ft. of Crack Retrofitted
	Average Caulking Weatherstripping	0.639	Enter Lin. Ft. of Crack Retrofitted
	Piping/Plumbing/Wiring Penetrations - Sealing	10.900	Enter Number of Penetrations Retrofitted
Caulking	Window Framing, Masonry - Caulking	1.364	Enter Sq. Ft. of Windows Retrofitted
	Window Framing, Wood - Caulking	0.382	Enter Sq. Ft. of Windows Retrofitted
	Door Frame, Masonry - Caulking	1.018	Enter Sq. Ft. of Doors Retrofitted
	Door Frame, Wood - Caulking	0.364	Enter Sq. Ft. of Doors Retrofitted
	Average Window/Door - Caulking	0.689	Enter Lin. Ft. of Crack Retrofitted
Avg Caulking / Weather Stripping	Average Window/Door Caulking / Weather Stripping	0.664	Enter Lin. Ft. of Crack Retrofitted
Gasket	Electrical Outlets - Gasket	6.491	Enter Number of Outlets Retrofitted

OR if blower door or total building pressurization measurements have been conducted, by determining the CFM infiltration differential between the existing and efficient building air infiltration rates:

$$= CFM50\_existing - CFM50\_efficient$$

Where:

CFM50_existing = CFM of Infiltration measured by blower door or by total building pressurization test before air sealing, adjusting measured CFM to equivalent CFM at 50 pascals indoor/outdoor pressure differential [104]

CFM50_efficient = Infiltration as measured by blower door or total building pressurization text after air sealing, adjusted to equivalent CFM at 50 pascals pressure differential

CDD55/yr = Annual cooling degree days at 55F base for the climate zone of the location of the building as deemed in the table below [105]

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[103] ASHRAE, 2001 AHSRAE Handbook – Fundamentals, Chapter 26, Table 1. Effective Air Leakage Areas (Low-Rise Residential Applications Only).

[104] 50 Pascals has been established in TRM XXX as the standard building pressure differential for determining average annual infiltration rates; 50 Pascals differential is equivalent to a wind pressure from approximately 10 mph.

[105] 30-year normals from the National Climactic Data Center (NCDC) consistent with Volume 1 Section 3.8.

Climate Zone	Cooling Degree Days: CDD55/yr
1 - Rockford	2,173
2 - Chicago	2,182
3 - Springfield	2,666
4 - Belleville	3,357
5 - Marion	3,090

24 = 24 hours per day

1000 = Conversion of watts to kW

ηCool = Efficiency of cooling system. Actual, if possible. Alternatively, use IECC 2012 if equipment type is known, or as deemed from table below[106]

Space Cooling / Heating Source	Deemed Cooling EER	Deemed Cooling SEER
No Cooling	N/A	N/A
Unknown Cooling Source	11	13

%Cool = Percentage of the building that is cooled

HDD55/yr = Annual heating degree days at 60F base for the climate zone of the building, as deemed in the table below [107]

Climate Zone	Heating Degree Days: HDD55/yr
1 - Rockford	4,272
2 - Chicago	4,029
3 - Springfield	3,406
4 - Belleville	2,515
5 - Marion	2,546

ηHeat = Efficiency of heating system. Actual, if possible. Alternatively, as deemed from table below:

System Type	Cooling Capacity of Equipment	Age of Equipment	HSPF Estimate	η (Effective COP Estimate) (HSPF/3.413)
Heat Pump [108]	All	Before 2009	6.8	2.0
	< 65,000 Btu/h	2009 - 2017	7.7	2.3
		2017 on	8.2	2.40

---

[106] Simplified version of IECC 2012 as a conservative estimate of what is existing.

[107] 30-year normals from the National Climactic Data Center (NCDC) consistent with Volume 1 Section 3.8.

[108] Minimum heating efficiency standards for heat pumps are sourced from the Code of Federal Standards for Small and Large Commercial Package Air Conditioning and Heating Equipment (Air Cooled), 10 CFR 431.97 with compliance dates of June 16, 2008; January 1, 2010; January 1, 2017; and January 1, 2018. As the first federal appliance standards for heating efficiency for commercial heat pumps went into effect in June 2008, assuming efficiency standards equivalent to residential heat pumps prior to that date.

System Type	Cooling Capacity of Equipment	Age of Equipment	HSPF Estimate	η (Effective COP Estimate) (HSPF/3.413)
	≥ 65,000 Btu/h and < 135,000 Btu/h	2010 on	11.3	3.3
	≥ 135,000 Btu/h and < 240,000 Btu/h	2010 on	10.9	3.2
	≥ 240,000 Btu/h and < 760,000 Btu/h	2010 on	10.9	3.2
Resistance	N/A	N/A	N/A	1
Fossil Fuel Furnace or Boiler	N/A	N/A	N/A	0.8 Thermal Efficiency

3,412 = Number of BTUs per kWh

%ElectricHeat = % of building heated by electricity

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

= 7.7%[109]

29.3 = kWh per therm (= 100,000 BTU/Therm / 3,412 BTU/kWh)

For example, assuming air conditioned and electric resistance heated building with 10 IEER equipment in Rockford: Infiltration_CFM_Saved = 272.8; CDD55/yr = 1,273; ηCool = 10.0; %Cool = 100%, HDD55/yr = 4,272; ηHeat = 1.0; %ElectricHeat = 100%, then

$$\Delta kWh\_Cooling = 1.08 * 272.8 * 1273 * 24 / 1000 / 10 * 100\%$$

$$= 900 \text{ kWh of cooling energy saved}$$

$$\Delta kWh\_Heating = 1.08 * 272.8 * 4272 * 24 / 1.0 / 3,412 * 100\%$$

$$= 8853 \text{ kWh of cooling energy saved}$$

$$\Delta kWh = \Delta kWh\_cooling + \Delta kWh\_heatingElectric + \Delta kWh\_heatingFurnace$$
$$= 900 + 8853 + 0$$
$$= 9753 \text{ kWh}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = \Delta kWh\_cooling / EFLH_{cooling} * CF$$

---

[109] 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 F_e of the three building types. See "Fan Energy Factor Example Calculation 2021-06-23.xlsx" for reference.

Where:

  ΔkWh_cooling = Sum of kWh saved from cooling from above calculations

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

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

    = 91.3% [110]

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

    = 47.8% [111]

> For example, for an Elementary School in Rockford with air conditioning as defined earlier in this section; assuming: = ΔkWh_cooling = 900; EFLH = 834; CF_{SSP} = 0.913, then
>
>   ΔkW = 900 / 834 * 0.913
>
>   = 0.98 kW

FOSSIL FUEL SAVINGS

If Fossil Fuel heating:

  ΔTherms = 1.08 * Infiltration_CFM_Saved * HDD55/yr * 24 / ηHeat / 100,000 * %FossilHeat

Where:

  ηHeat = as defined previously

  100,000 = BTUs per therm

  %FossilHeat = % of building heated by fossil fuel

> **For Example**, assuming for Rockford with unknown natural gas heat: Infiltration_CFM_Saved =272.8; HDD55/yr = 2173; ηHeat = 0.80; %GasHeat = 100%, then
>
>   Δ Therms = 1.08 * 272.8 * 2173 * 24 / 0.80 / 100000 * 100%
>
>   = 192 Therms

---

[110] 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.
[111] 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

MEASURE CODE: CI-MSC-CAIR-V02-230101

REVIEW DEADLINE: 1/1/2026

4.8.30 Commercial Wall Insulation

DESCRIPTION

Wall insulation is added to building wall cavities or to building internal/external wall surfaces; foundation insulation is added to building internal/external foundation surfaces, both above grade and below grade. This measure requires pre- and post-implementation R-values and measurements surface areas.

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

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

DEFINITION OF EFFICIENT EQUIPMENT
The efficient scenario is the installation of added insulation. This measure requires a member of the implementation staff or a participating contractor to evaluate the pre- and post-implementation R-values and to measure surface areas. The requirements for participation in the program will be defined by the utilities.

DEFINITION OF BASELINE EQUIPMENT
The existing condition will be evaluated by implementation staff or a participating contractor and is likely to be empty or minimally insulated wall cavities, and uninsulated above and below grade foundation walls.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT
The expected measure life is assumed to be 25 years.[112]

DEEMED MEASURE COST
The actual installed cost for this measure should be used in screening.

LOADSHAPE
Loadshape C01 – Commercial Electric Cooling

Loadshape C03 – Commercial Cooling

Loadshape C04 – Commercial Electric Heating

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)

---

[112] Navigant 'ComEd Effective Useful Life Research Report', May 2018.

= 91.3% [113]

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

= 47.8% [114]

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

Where available, savings from wall and foundation insulation measures should be determined through a custom analysis. When that is not feasible for the program the following engineering algorithms can be used.

$$\Delta kWh = \Delta kWh\_cooling + \Delta kWh\_heatingElectric + \Delta kWh\_heatingGas$$

Where:

$\Delta kWh\_cooling$ = If building is cooled, reduction in annual cooling requirement due to wall insulation

= [(1 / R_ExistWall - 1 / R_NewWall) * A_wall + (1 / R_ExistAG - 1 / R_ NewAG) * A_AG + (1 / R_ExistBG - 1 / R_NewBG) * A_BG] * CDD55 * 24 / 1000 / ηCool * %Cool

Where:

R_NewWall   = R-value of proposed new wall assembly (including all layers between inside air and outside air).

= Actual

R_ExistWall   = R-value value of existing assembly and any existing insulation.

= Minimum of R-5 for uninsulated assemblies [115]

A_wall   = Net area of insulated wall (ft^2)

= Actual

R_NewAG   = Effective R-value of proposed new Above-Ground Foundation assembly (including all layers between inside air and outside air).

= Actual

R_ExistAG   = Effective R-value value of existing Above-Ground Foundation assembly and any existing insulation.

---

[113] 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.

[114] 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.

[115] An estimate based on review of Madison Gas and Electric, Exterior Wall Insulation, R-value for no insulation in walls, and NREL's Building Energy Simulation Test for Existing Homes (BESTEST-EX).

	= Minimum of R-5 for uninsulated assemblies [116]
A_AG	= Net area of Above-Ground Foundation being insulated (ft^2)
	= Actual
R_NewBG	= Effective R-value of proposed new Foundation Below Grade assembly (including all layers between inside air and outside ground).
	= Actual
R_ExistBG	= Effective R-value value of existing Foundation Below Grade assembly and any existing insulation.

NOTE: Added to the above R-values of Below Grade assemblies shall be the following deemed Average Earth R-values, which account for transmission of heat through direct contact with the earth outside the foundation. The Effective Ground Contact R-value varies as a function of the average depth below grade of the bottom of the foundation: [117]

Depth Below Grade of Bottom of Foundation	Earth R-value	Average Earth R-value
0 feet	2.44 F-Ft^2-Hr/Btu	2.44 F-Ft^2-Hr/Btu
1 feet	4.50 F-Ft^2-Hr/Btu	3.47 F-Ft^2-Hr/Btu
2 feet	6.30 F-Ft^2-Hr/Btu	4.41 F-Ft^2-Hr/Btu
3 feet	8.40 F-Ft^2-Hr/Btu	5.41 F-Ft^2-Hr/Btu
4 feet	10.44 F-Ft^2-Hr/Btu	6.42 F-Ft^2-Hr/Btu
5 feet	12.66 F-Ft^2-Hr/Btu	7.46 F-Ft^2-Hr/Btu
6 feet	14.49 F-Ft^2-Hr/Btu	8.46 F-Ft^2-Hr/Btu
7 feet	17.00 F-Ft^2-Hr/Btu	9.53 F-Ft^2-Hr/Btu
8 feet	20.00 F-Ft^2-Hr/Btu	10.69 F-Ft^2-Hr/Btu

A_BG	= Net area of Foundation Below Grade being insulated (ft^2)
	= Actual
CDD55/yr	= Annual cooling degree days at 55 °F base for the climate zone of the location of the building as deemed in the table below [118]

Climate Zone	Cooling Degree Days: CDD55
1 - Rockford	2,173
2 - Chicago	2,182

[116] An estimate based on review of Madison Gas and Electric, Exterior Wall Insulation, R-value for no insulation in walls, and NREL's Building Energy Simulation Test for Existing Homes (BESTEST-EX).

[117] Source: Illinois Statewide Technical Reference Manual V10.0, Volume 3 - Section 5.6.2 Basement Sidewall Insulation, Table on page 338 of 401.

[118] Source: TRM V11.0 Volume 1 Section 3.8

Climate Zone	Cooling Degree Days: CDD55
3 - Springfield	2,666
4 - Belleville	3,357
5 - Marion	3,090

24 = Converts days to hours

1000 = Converts Btu to kBtu

ηCool = Efficiency of cooling system. Actual, if known. Alternatively, use IECC 2012 as a default source if equipment type is known, or as deemed from table below[119]

Space Cooling / Heating Source	Deemed Cooling EER	Deemed Cooling SEER
No Cooling	N/A	N/A
Unknown Cooling Source	11	13

%Cool = Percent of building **_where wall or foundation insulation is to be installed_** that is cooled

= Actual %, if known, or, If actual % unknown, use following deemed values:

Is Space Being Insulated Cooled?	Deemed %Cool, if actual % is unknown
Yes	100%
No	0%

For example, for a commercial building with unknown cooling equipment in Rockford with increase in wall insulation: R_ExistWall = 5.0; R_NewWall = 16.0; A_wall = 1500; CDD55 = 2173; ηCool = 13.0; %Cool = 100%

ΔkWh_cooling = (1 / 5.0 - 1 / 16.0) * 1500 * 2173 * 24 / 1000 / 11.0 * 100%

= 827 kWh

ΔkWh_heatingElectric = If electric heat (resistance or heat pump), reduction in annual electric heating due to wall and/or foundation insulation

= [(1 / R_ExistWall - 1 / R_NewWall) * A_wall + (1 / R_ExistAG - 1 / R_NewAG) * A_AG + (1 / R_ExistBG - 1 / R_NewBG) * A_BG] * HDD55 * 24 / ηHeat / 3412 * %ElectricHeat

Where:

---

[119] Simplified version of IECC 2012 as a conservative estimate of what is existing

HDD55 = Annual heating degree days at 55 °F base for the climate zone of the building, as deemed in the table below [120]

Climate Zone	Heating Degree Days: HDD55
1 - Rockford	4,272
2 - Chicago	4,029
3 - Springfield	3,406
4 - Belleville	2,515
5 - Marion	2,546

ηHeat = Efficiency of heating system. Actual, or as deemed from table below

System Type	Cooling Capacity of Equipment	Age of Equipment	HSPF Estimate	η (Effective COP Estimate) (HSPF/3.413)
Heat Pump [121]	All	Before 2009	6.8	2.0
	< 65,000 Btu/h	2009 - 2017	7.7	2.3
		2017 on	8.2	2.40
	≥ 65,000 Btu/h and < 135,000 Btu/h	2010 on	11.3	3.3
	≥ 135,000 Btu/h and < 240,000 Btu/h	2010 on	10.9	3.2
	≥ 240,000 Btu/h and < 760,000 Btu/h	2010 on	10.9	3.2
Resistance	N/A	N/A	N/A	1
Natural Gas Furnace or Boiler	N/A	N/A	N/A	0.8 E_T

3412 = Converts Btu to kWh

%ElectricHeat = Percent of building ***where wall or foundation insulation is to be installed*** that is electrically heated

= Actual %, if known, or, If actual % unknown, use following deemed values:

Is Space Being Insulated Electrically Heated?	Deemed %ElectricHeat, if actual % is unknown
Yes	100%
No	0%

---

[121] Minimum heating efficiency standards for heat pumps are sourced from the Code of Federal Standards for Small and Large Commercial Package Air Conditioning and Heating Equipment (Air Cooled), 10 CFR 431.97 with compliance dates of June 16, 2008; January 1, 2010; January 1, 2017; and January 1, 2018. As the first federal appliance standards for heating efficiency for commercial heat pumps went into effect in June 2008, assuming efficiency standards equivalent to residential heat pumps prior to that date.

> **For example**, for a commercial building with resistance heating in Rockford: R_ExistWall = 5.0; R_NewWall = 16.0; A_wall = 1500; HDD55 = 4272; ηHeat = 1.0; %ElectricHeat = 100%
>
> ΔkWh_heatingElec = (1 / 5.0 - 1 / 16.0) * 1500 * 4272 * 24 / 3412 / 1.0 * 100%
>
> = 6198 kWh

ΔkWh_heatingGas = If gas *furnace* heat, kWh savings for reduction in combustion fan run time

= $\Delta Therms * F_e * 29.3$

Where:

ΔTherms = Annual therms of gas space heating saved, as determined below

F_e = Furnace or boiler combustion fan energy consumption as a percentage of annual fuel consumption

= 7.7%[122]

29.3 = conversion of therms to kWh (= 100000 / 3412)

> **For example**, if: ΔTherms = 264; F_e = 7.7%, then:
>   ΔkWh_heatingGas = 264 * 7.7% * 29.3
>
>   = 596 kWh

> **For example**, based on the above calculations for electric resistance , total annual kWh savings =
>   Total Annual kWh Savings = 827 + 6198 + 0
>   = 7025 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ΔkWh_cooling / EFLH_Cooling * CF

Where:

ΔkWh_cooling = Annual kWh saving in cooling energy use, as determined above

EFLH_cooling = Equivalent Full Load Hours for cooling in Existing Buildings are provided in section 4.4 HVAC End Use

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[122] F_e is not one of the AHRI certified ratings provided for residential furnaces, but can be reasonably estimated from a calculation based on the certified values for fuel energy (Ef in MMBtu/yr) and Eae (kWh/yr). An average of a 300 record sample (non-random) out of 1495 was 3.14%. This is, appropriately, ~50% greater than the ENERGY STAR version 3 criteria for 2% F_e. See "Programmable Thermostats Furnace Fan Analysis.xlsx" for reference.

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

= 91.3% [123]

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

= 47.8% [124]

For example, for a Grocery store in Rockford with unknown cooling per above example: ΔkWh_cooling = 827; EFLH_Cooling = 826; CF = 0.478; then:

Summer Coindicent Peak savings = 827 / 826 * 0.478

= 0.48 kW

NATURAL GAS SAVINGS
If Natural Gas heating:

ΔTherms = [(1 / R_ExistWall - 1 / R_NewWall) * A_wall + (1 / R_ExistAG - 1 / R_ NewAG) * A_AG + (1 / R_ExistBG - 1 / R_NewBG) * A_BG] * HDD55 * 24 / ηHeat / 100,000 * %GasHeat

Where:

%GasHeat = Percent of space being retrofitted with insulation that is heated using gas

= Actual %, if known, or, If actual % unknown, use following deemed values:

Is Space Being Insulated Heated with Gas?	Deemed %GasHeat, if actual % is unknown
Yes	100%
No	0%

Other variables as defined above.

For example, for a commercial building in Rockford with unknown gas heat: R_ExistWall = 5.0; R_NewWall = 16.0; A_wall = 1500; HDD55 = 4272; ηHeat = 0.8; %GasHeat = 100%; then
Annual Therm Savings = (1 / 5.0 - 1 / 16.0) * 1500 * 4272 * 24 / 0.8 / 100000 * 100%
= 264 therms

---

[123] 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.
[124] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.

WATER IMPACT DESCRIPTIONS AND CALCULATION
N/A

DEEMED O&M COST ADJUSTMENT CALCULATION
N/A

MEASURE CODE: CI-HVC-WINS-V02-230101

REVIEW DEADLINE: 1/1/2026

5.3.1 Centrally Ducted Air Source Heat Pump

DESCRIPTION

A heat pump provides heating or cooling by moving heat between indoor and outdoor air. This measure relates to a unitary central heat pump (split or packaged) with conditioned air delivered to the home via ductwork. This prescriptive measure does not apply to known installations where existing fuel-fired heating systems remain in place to provide back up heat at low temperatures ("hybrid systems"). Savings from such installations should be calculated on a custom basis if done outside of midstream type offerings where installation details are tracked.

This measure characterizes:

New Construction:

The installation of a new residential sized (<= 65,000 Btu/hr) Air Source Heat Pump system meeting ENERGY STAR efficiency standards presented below in a new home.

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.

Time of Sale:

The installation of a new residential sized (<= 65,000 Btu/hr) Air Source Heat Pump that is more efficient than required by federal standards. This relates to the replacement of an existing unit at the end of its useful life.

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 allocation 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.

Early Replacement:

The early removal of functioning electric or gas heating and/or cooling (SEER 10 or under if present) systems from service, prior to its natural end of life, and replacement with a new high efficiency air source heat pump unit.

Note the baseline in this case is the existing equipment being replaced. The allocation 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.

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

- The existing unit is operational when replaced, or
- The existing unit requires minor repairs (<$276 per ton). [125]
- All other conditions will be considered Time of Sale.

The Baseline SEER of the existing unit replaced:

- If the SEER of the existing unit is known and <=10, the Baseline SEER is the actual SEER value of the unit replaced. If the SEER is >10, the Baseline SEER = 14 for standard sized units, or 12 for space constrained units.
- If the SEER of the existing unit is unknown use assumptions in variable list below (SEER_exist and HSPF_exist).
- If the operational status or repair cost of the existing unit is unknown, use time of sale assumptions.

---

[125] The Technical Advisory Committee agreed that if the cost of repair is less than 20% of the new baseline replacement cost it can be considered early replacement. Note the non-inflated cost is used as this would be a cost consideration in the program year.

A weighted average early replacement rate is provided for use in downstream programs when the actual baseline early replacement rates are unknown.

Deemed Early Replacement Rates For ASHP

	Deemed Early Replacement Rate
Early Replacement Rate for downstream ASHP participants	36% [126]

Quality Installation:

Additional savings are attributed to the Quality Installation (QI) of the system. QI programs should follow industry standards such as those described in ENERGY STAR Verified HVAC Installation Program (ESVI), ANSI ACCA QI5 and QI9vp. This must include considerations of system design (including sizing, matching, ventilation calculations) and equipment installation (including static pressure, airflow, refrigerant charge) and may also consider distribution.

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

DEFINITION OF EFFICIENT EQUIPMENT
A new residential sized (<= 65,000 Btu/hr) air source heat pump with specifications to be determined by program.

The following conversion factors are recommended for use if the efficient equipment is not rated under the new testing procedure: [127]

$$SEER = SEER2 / X$$

$$EER = EER2 / X$$

$$HSPF = HSPF2 / X$$

Where:

X	SEER	EER	HSPF
Ducted	0.95	0.95	0.91

DEFINITION OF BASELINE EQUIPMENT
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 EER for standard sized units, or 12SEER, 7.4 HSPF, 10.5EER for space constrained product. [128] Note, the space constrained product baseline should only be used when the efficient unit is classified as space constrained.

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 for standard sized units, or

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[126] Based on ComEd program data from 2018-2020 (444 ASHP installs).
[127] Consortium for Energy Efficiency (CEE), Testing, Testing, M1, 2, 3, Transitioning to New Federal Minimum Standards, CEE Summer Program Meeting, June 10, 2022.
[128] 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'.

12SEER, 10.5EER for space constrained product.[129]

Note: New Federal Standards affecting heat pumps become effective January 1, 2023. The new standards effective in 2023, require any residential heat pump manufactured in, or imported into, the United States to have a minimum efficiency rating meeting the following:[130]

- Split system heat pump standard sized units – 14.3 SEER2 and 7.5 HSPF2

- Single-package heat pump standard sized units – 13.4 SEER2 and 6.7 HSPF2

- Space constrained heat pump units - 11.9 SEER2 and 6.3 HSPF2

These new federal standards will be adopted by the program, beginning 1/1/2024. For the 2023 program year, the baseline equipment efficiencies are detailed in this section by replacement scenario.

Time of Sale: The baseline for this measure is a new replacement unit of the same system type as the existing unit, meeting the baselines provided below[131].

Unit Type	Efficiency Standard
Standard sized ASHP	14 SEER, 11 EER, 8.2 HSPF
Space constrained ASHP	12 SEER, 10.5 EER, 7.4 HSPF
Electric Resistance	3.412 HSPF
Natural Gas or LP Furnace	80% AFUE
Natural Gas or LP Boiler	84% AFUE
Oil Furnace	83% AFUE
Oil Boiler	86% AFUE
Standard sized Central AC	13 SEER, 10.5 EER
Space constrained Central AC	12 SEER, 10.5 EER
Unknown [132]	13.52 SEER, 10.75EER, 6.25 HSPF, 80.1% AFUE

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 for the remainder of the measure life (as provided in table above).

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[129] 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'.

[130] The 2023 federal standards (10 CFR 430.32(c)(5)) are in terms of an updated metric, depicted as SEER2, EER2, and HSPF2 and manufacturers must certify their products meet the standard according to the new test procedure and new metrics. The updated test method as well as the updated energy conservation standards were negotiated under the appliance standards and rulemaking federal advisory committee (ASRAC) in accordance with the Federal Advisory Committee Act (FACA) and the negotiated rulemaking act. An equivalent stringency of these new standards for split system heat pumps are 15 SEER and 8.8 HSPF and for single-package heat pumps are 14 SEER and 8 HSPF, as detailed in: Federal Code of Regulations, Energy Conservation Program: Energy Conservations Standards for residential Central Air Conditioners and Heat Pumps; Confirmation of effective date and compliance date for direct final rule, May 26, 2017, Docket: EERE-2014-BT-STD-0048 (https://www.regulations.gov/document/EERE-2014-BT-STD-0048-0200)

[131] Federal Standard as provided in DOE 10 CFR 430.32.

[132] Values represent the weighted average [SEER/EER/HSPF/AFUE] baseline values reflecting the assumed shares of installed ASHP replacing given baseline technologies (e.g. ASHP/electric resistance or furnace/boiler) by fuel type. Assumed shares are based on Opinion Dynamics and Guidehouse analysis of 2018-2021 Ameren and ComEd HVAC (downstream) program tracking data. For further details, see '2018-2021 AIC Res HVAC Data ASHP Baseline TRM Update 2022-07-11.xls'.

When unknown, default early replacement efficiency assumptions are 9.70 SEER, 7.83 EER, 5.24 HSPF and 80% AFUE. Consistent with TRM Volume 1 Section 2.3.1 for midstream programs or other cases where the existing condition is unknown, it may be appropriate to apply a deemed percent split of Time of Sale and Early Replacement assumptions based on evaluation results

DEEMED LIFETIME OF EFFICIENT EQUIPMENT
The expected measure life is assumed to be 16 years. [133]

Remaining life of existing equipment is assumed to be 6 years for ASHP and Central AC, 7 years for furnace, 8 years for boilers [134] and 16 years for electric resistance. [135]

DEEMED MEASURE COST
New Construction and Time of Sale: The actual installed cost of the Air Source Heat Pump (including any necessary electrical or distribution upgrades required) should be used minus the assumed installation cost of the baseline equipment ($6562 + $600 per ton for a new baseline ASHP [136], $2,011 for a new baseline 80% AFUE furnace or $4,053 for a new 84% AFUE boiler [137] and $952 per ton for new baseline Central AC replacement [138]).

Early Replacement: The actual full installation cost of the Air Source Heat Pump (including any necessary electrical or distribution upgrades required) should be used. The assumed deferred cost (after the appropriate number of years described above in the 'Deemed Lifetime of Efficient Equipment' section) of replacing existing equipment with a new baseline unit is assumed to be $7,527 + $688 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 $1,092 per ton for new baseline Central AC replacement. [139] This future cost should be discounted to present value using the nominal societal discount rate.

If the install cost of the efficient Air Source Heat Pump is unknown, assume the following (note these costs are per ton of unit capacity); [140]

Efficiency (SEER)	Full Efficient ASHP Cost (including labor)
14.5	$6,685 + $600/ ton
15	$6,865 + $600/ ton
16	$7,000 + $600/ ton
17	$7,286 + $600/ ton
18	$7,495 + $600/ ton
19	$7,720 + $600/ ton
20	$7,946 + $600/ ton

Fuel switch scenarios are likely to require additional installation work which may include adding new electrical

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[133] Based on 2016 DOE Rulemaking Technical Support document, as recommended in Guidehouse 'ComEd Effective Useful Life Research Report', May 2018.
[134] Assumed to be one third of effective useful life of replaced equipment.
[135] 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.
[136] Full install ASHP costs are based upon data provided by Ameren. See 'ASHP Costs_06242022'. Efficiency cost increment consistent with Cadmus "HVAC Program: Incremental Cost Analysis Update", December 19, 2016 study results.
[137] 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.
[138] Based on 3 ton initial cost estimate for a conventional unit from ENERGY STAR Central AC calculator.
[139] All baseline replacement costs are consistent with their respective measures and include inflation rate of 1.98%.
[140] Full install ASHP costs are based upon data provided by Ameren. See 'ASHP Costs_06242022'. Efficiency cost increment consistent with Cadmus "HVAC Program: Incremental Cost Analysis Update", December 19, 2016 study results.

circuits, capping existing gas lines and upgrading electrical panels. These costs are likely to range significantly and actual values should be used wherever possible. If unknown, assume an additional $2,000 for fuel switch installations.

Quality Installation: The additional design and installation work associated with quality installation has been estimated to cost an additional $150. [141]

LOADSHAPE
Loadshape R10 - Residential Electric Heating and Cooling

COINCIDENCE FACTOR
The summer peak coincidence factor for cooling is provided in two different ways below. The first is used to estimate peak savings during the utility peak hour and is most indicative of actual peak benefits, and the second represents the *average* savings over the defined summer peak period and is presented so that savings can be bid into PJM's Forward Capacity Market.

$CF_{SSP\ SF}$ = Summer System Peak Coincidence Factor for Heat Pumps in single-family homes (during utility peak hour)

= 72% [142]

$CF_{PJM\ SF}$ = PJM Summer Peak Coincidence Factor for Heat Pumps in single-family homes (average during PJM peak period)

= 46.6% [143]

$CF_{SSP,\ MF}$ = Summer System Peak Coincidence Factor for Heat Pumps in multi-family homes (during system peak hour)

= 67% [144]

$CF_{PJM,\ MF}$ = PJM Summer Peak Coincidence Factor for Heat Pumps in multi-family homes (average during peak period)

= 28.5%

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS AND FOSSIL FUEL SAVINGS
Non fuel switch measures:

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[141] Based on data provided by MidAmerican in April 2018 summarizing survey results from 11 HVAC suppliers in Iowa.
[142] 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)'.
[143] 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.
[144] Multifamily coincidence factors both from; *All-Electric Homes PY6 Metering Results: Multifamily HVAC Systems*, Cadmus, October 2015

$\Delta kWh_{Non\ Fuel\ Switch}$ = ((CoolingLoad * (1/(SEER_base * (1 − DeratingCool$_{Base}$)) - 1/(SEER_ee * SEERadj * (1 − DeratingCool$_{Eff}$)))) / 1000) + ((HeatLoad * (1/(HSPF_base * HSPF_ClimateAdj * (1 − DeratingHeat$_{Base}$)) - 1/(HSPF_ee * HSPF_ClimateAdj * HSPFadj * (1 − DeratingHeat$_{Eff}$)))) / 1000)

Fuel switch measures:

Fuel switch measures must produce positive total lifecycle energy savings (i.e., reduction in Btus at the premises) in order to qualify. This is determined as follows:

SiteEnergySavings (MMBTUs) = FuelSwitchSavings + NonFuelSwitchSavings

FuelSwitchSavings = GasHeatReplaced – ASHPSiteHeatConsumed

NonFuelSwitchSavings = FurnaceFanSavings + ASHPSiteCoolingImpact

Where:

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

FurnaceFanSavings = (FurnaceFlag * HeatLoad * 1/AFUE$_{base}$ * F$_e$) / 1,000,000

ASHPSiteHeatConsumed = ((HeatLoad * (1/(HSPF_ee * HSPF_ClimateAdj * HSPFadj * (1 − DeratingHeat$_{Eff}$)))) /1000 * 3412)/ 1,000,000

ASHPSiteCoolingImpact = ((CoolingLoad * (1/(SEER_base * (1 – DeratingCool$_{Base}$)) - 1/(SEER_ee * SEERadj * (1 – DeratingCool$_{Eff}$))))/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 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, 7 years for furnace, 8 years for

boilers, 16 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.

Programs where existing system unknown

In programs where the existing fuel or system type is unknown, savings should be apportioned between the Fuel Switch and Non- Fuel Switch scenarios, as follows:

Savings from Non-Fuel Switch (kWh)   = (1 – %FuelSwitch) * $\Delta kWh_{\text{Non Fuel Switch}}$

Plus

Savings from Fuel Switch (MMBtu converted to appropriate fuel as table above)

= %FuelSwitch * SiteEnergySavings (MMBTUs)

Where:

%FuelSwitch   = The percentage of replacements resulting in fuel-switching.

= 1 when fuel switching is known, 0 if non fuel switch

= when unknown, e.g. midstream program, determine via evaluation

CoolingLoad   = Annual cooling load for the building

= FLH_cooling * Capacity_ASHPcool

FLH_cooling   = Full load hours of air conditioning

= dependent on location:

Climate Zone (City based upon)	FLH_cooling (single family) [145]	FLH_cooling (multifamily) [146]
1 (Rockford)	512	467
2 (Chicago)	570	506
3 (Springfield)	730	663
4 (Belleville)	1,035	940
5 (Marion)	903	820
Weighted Average [147]	567	

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[145] Full load hours for Chicago, Moline and Rockford are provided in "Final Evaluation Report: Central Air Conditioning Efficiency Services (CACES), 2010, Navigant Consulting", p.33. An average FLH/Cooling Degree Day (from NCDC) ratio was calculated for these locations and applied to the CDD of the other locations in order to estimate FLH. There is a county mapping table in Volume 1, Section 3.7 providing the appropriate city to use for each county of Illinois.
[146] Ibid.
[147] Weighting for Ameren is based on electric accounts in each of the cooling zones. Weighting for ComEd and Statewide average

Climate Zone (City based upon)	FLH_cooling (single family) [145]	FLH_cooling (multifamily) [146]
ComEd	810	504
Ameren	632	734
Statewide		565

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

Capacity_ASHPcool = Cooling Output Capacity of Air Source Heat Pump (Btu/hr)

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

SEER_base = Seasonal Energy Efficiency Ratio of baseline unit (kBtu/kWh). 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). If using rated efficiencies, derate efficiency value by 1% per year (maximum of 30 years) to account for degradation over time, [148] or if unknown assume default provided below:

Baseline/Existing Cooling System	SEER_base		
	Early Replacement (Remaining useful life of existing equipment)	Early Replacement (Remaining measure life)	Time of Sale or New Construction
Air Source Heat Pump – Standard sized	9.7 [149]	14 [150]	
Air Source Heat Pump – Space constrained	9.7	12	
Central AC – Standard sized	9.7 [151]	13 [152]	
Central AC – Space constrained	9.7	12	
No central cooling	Make '1/SEER_exist' = 0 [153]	13 [154]	
Unknown [155]	9.7	13.52	

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is based on number of occupied residential housing units in each zone. ComEd is weighted average of Zones 1-2. Alternative program-weighted assumptions can be used if appropriate.

[148] 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).

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

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

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

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

[153] If there is no central cooling in place but the incentive encourages installation of a new ASHP with cooling, the added cooling load should be subtracted from any heating benefit.

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

[155] Values represent the weighted average SEER baseline values reflecting the assumed shares of installed ASHP replacing given baseline technologies (e.g. ASHP/electric resistance or furnace/boiler) by fuel type. Assumed shares are based on Opinion Dynamics and Guidehouse analysis of 2018-2021 Ameren and ComEd HVAC (downstream) program tracking data. For further details, see '2018-2021 AIC Res HVAC Data ASHP Baseline TRM Update 2022-07-11.xls'.

SEER_ee   = Rated Seasonal Energy Efficiency Ratio of ENERGY STAR unit (kBtu/kWh)

                         = Actual.

SEERadj   = Adjustment percentage to account for in-situ performance of variable speed units[156]

                         = $[(0.805 \times (\frac{EER_{ee}}{SEER_{ee}}) + 0.367]$ if variable speed or unknown

                         = 1 if single speed

DeratingCool$_{Eff}$ = Efficent ASHP Cooling derating

                         = 0% if Quality Installation is performed

                         = 10% if Quality Installation is not performed or unknown[157]

DeratingCool$_{Base}$ = Baseline Cooling derating

                         = 10%

HeatLoad   = Annual heat load for the building (Btus)

                         = FLH_ASHPheat * Capacity_ASHPheat

FLH_ASHPheat   = Full load hours of heat pump heating

                         = Dependent on location and home type:

Climate Zone (City based upon)	FLH_heat (single family and multifamily)[158]
1 (Rockford)	1,969
2 (Chicago)	1,840
3 (Springfield)	1,754
4 (Belleville)	1,266
5 (Marion)	1,288
Weighted Average[159]	

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[156] 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'.

[157] Based on Cadmus assumption provided in preparation of the 2014 Interstate Power and Light TRM based upon proper refrigerant charge, evaporator airflow, and unit sizing. Appears conservative in comparison to ENERGY STAR statements (see 'Sponsoring an ENERGY STAR Verified HVAC Installation (ESVI) Program') and so could be considered for future evaluation.

[158] Full load heating hours for heat pumps are provided for Rockford, Chicago and Springfield in the ENERGY STAR Calculator. Estimates for the other locations were calculated based on the FLH to Heating Degree Day (from NCDC) ratio. VEIC consider ENERGY STAR estimates to be high due to oversizing not being adequately addressed. Using average Illinois billing data (from ICC commerce Commission) VEIC estimated the average gas heating load and used this to estimate the average home heating output (using 83% average gas heat efficiency). Dividing this by a typical 36,000 Btu/hr ASHP gives an estimate of average ASHP FLH_heat of 1821 hours. We used the ratio of this value to the average of the locations using the ENERGY STAR data (1994 hours) to scale down the ENERGY STAR estimates. There is a county mapping table in Volume 1, Section 3.7 providing the appropriate city to use for each county of Illinois.

[159] Weighting for Ameren is based on electric heat accounts in each of the heating zones. Weighting for ComEd and Statewide average is based on number of occupied residential housing units in each zone. ComEd is weighted average of Zones 1-2. Alternative program-weighted assumptions can be used if appropriate.

Climate Zone (City based upon)	FLH_heat (single family and multifamily) [158]
ComEd	1,846
Ameren	1,612
Statewide	1,821

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

Capacity_ASHPheat = Heating Output Capacity of Air Source Heat Pump (Btu/hr)

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

HSPF_base = Heating Seasonal 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, 16 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, [160] 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 – standard sized	5.78 [161]	8.2 [162]	
Air Source Heat Pump – space constrained	5.78	7.4	
Electric Resistance	3.41 [163]		
Unknown [164]	5.24	6.25	

HSPF_ee = Heating Seasonal Performance Factor of efficient Air Source Heat Pump

(kBtu/kWh)

= Actual or 8.5 if unknown [165]

HSPFadj = Adjustment percentage to account for the heating capacity ratio of the efficient variable

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[160] 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).

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

[162] Based on Minimum Federal Standard effective 1/1/2015.

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

[164] Values represent the weighted average HSPF baseline values reflecting the assumed shares of installed ASHP replacing given baseline technologies (e.g. ASHP/electric resistance or furnace/boiler) by fuel type. Assumed shares are based on Opinion Dynamics and Guidehouse analysis of 2018-2021 Ameren and ComEd HVAC (downstream) program tracking data. For further details, see '2018-2021 AIC Res HVAC Data ASHP Baseline TRM Update 2022-07-11.xls'.

[165] ENERGY STAR minimum.

speed unit[166]

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

= Actual using AHRI lookup values for efficient unit heating capacities rated at 17°F and 47°F. If not available or if single speed, assume 1.[167]

DeratingHeat$_{Eff}$ = Efficent ASHP Heating derating

= 0% if Quality Installation is performed

= 10% if Quality Installation is not performed[168]

DeratingHeat$_{Base}$ = Baseline Heating derating

= 10%

HSPF_ClimateAdj = Adjustment factor to account for observed discrepency between seasonal heating performance relative to rated HSPF as provided by standard AHRI 210/240 rating conditions. Note, the adjustment is dependent on the test method use for the rating (i.e. HSPF or HSPF2 rating) [169]:

City (county based upon)	HSPF_ClimateAdj When using HSPF rating	HSPF_ClimateAdj When using HSPF2 rating
1 (Rockford)	70%	77%
2 (Chicago)	70%	77%
3 (Springfield)	83%	91%
4 (Belleville)	83%	91%
5 (Marion)	83%	91%
Weighted Average[170]		
ComEd	70%	77%
Ameren	81%	89%
Statewide	73%	80%

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[166] 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'.

[167] 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.

[168] Based on Cadmus assumption provided in preparation of the 2014 Interstate Power and Light TRM based upon proper refrigerant charge, evaporator airflow, and unit sizing, Assumed consistent for heating and cooling. Appears conservative in comparison to ENERGY STAR statements (see 'Sponsoring an ENERGY STAR Verified HVAC Installation (ESVI) Program') and so could be considered for future evaluation.

[169] Adjustment factors are based on findings from NEEA, July 2020 'EXP07:19 Load-based and Climate-Specific Testing and Rating Procedures for Heat Pumps and Air Conditioners'. See 'NEEA HP data' for calculation. Findings were consistent with other reviewed sources including ASHRAE, 2020 'Right-Sizing Electric Heat Pump and Auxiliary Heating for Residential Heating Systems Based on Actual Performance Associated with Climate Zone' and Cadmus, 2022 'Residential ccASHP Building Electrification Study'. The difference between HSPF and HSPF2 ratings is based on the change in testing procedure that will correct for some of this effect where ducted systems will have an approximately 9% lower HSPF2 rating as compared to HSPF, based on CEE presentation, July 2022, 'Testing Testing, M1, 2, 3: Transitioning to New Federal Minimum Standards'.

[170] Weighting for Ameren is based on electric heat accounts in each of the heating zones. Weighting for ComEd and Statewide average is based on number of occupied residential housing units in each zone. ComEd is weighted average of Zones 1-2. Alternative program-weighted assumptions can be used if appropriate.

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, [171] or if unknown assume default:

Baseline/ Existing Heating System	AFUEbase		
	Early Replacement (Remaining useful life of existing equipment) [172]	Early Replacement (Remaining measure life)	Time of Sale or New Construction
Furnace	64.4%	80%	80%
Boiler	61.6%	84%	84%
Unknown [173]	80%	80.1%	80.1%

FurnaceFlag = 1 if system replaced is a fossil fuel 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% [174]

For New Construction, Time of Sale and early replacement (remaining 10 years)
F_e_New = 1.88% [175]

3412 = Btu per kWh

%IncentiveElectric = % of total incentive paid by electric utility

= Actual

%IncentiveGas = % of total incentive paid by gas utility

= Actual

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[171] 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).

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

[173] Values represent the weighted average AFUE baseline values reflecting the assumed shares of installed ASHP replacing given baseline technologies (e.g. ASHP/electric resistance or furnace/boiler) by fuel type. Assumed shares are based on Opinion Dynamics and Guidehouse analysis of 2018-2021 Ameren and ComEd HVAC (downstream) program tracking data. For further details, see '2018-2021 AIC Res HVAC Data ASHP Baseline TRM Update 2022-07-11.xls'.

[174] F_e is not one of the AHRI certified ratings provided for residential furnaces, but can be reasonably estimated from a calculation based on the certified values for fuel energy (Ef in MMBtu/yr) and Eae (kWh/yr). An average of a 300 record sample (non-random) out of 1495 was 3.14%. This is, appropriately, ~50% greater than the ENERGY STAR version 3 criteria for 2% F_e. See "Programmable Thermostats Furnace Fan Analysis.xlsx" for reference.

[175] 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%.

Non Fuel Switch Illustrative Examples

Time of Sale using ASHP baseline:

For example, an ASHP is installed in a single-family home in Marion with the following nameplate information: 15 SEER, 12EER, 9 HSPF; Cooling capacity: 34,800 Btuh; Heating capacity at 47°F: 33,000 Btuh; Heating capacity at 17°F: 21,200 Btuh with Quality Installation;

$$\% \, SEER_{adj} = 0.805 \times \left(\frac{EER_{ee}}{SEER_{ee}}\right) + 0.367 = 1.011$$

$$\% \, HSPF_{adj} = \left(\frac{17 \,°F \, Capacity}{47 \,°F \, Capacity}\right) \times 0.158 + 0.899 = 1.001$$

ΔkWh = ((903 * 34,800 * (1/(14 * (1 - 0.1)) - 1/(15 * 1.011 * $(1-0)$))) / 1000) + ((1,288 * 33,000 * (1/(8.2 * 0.83 * $(1-0.1)$)) - 1/(9 * 0.83 * 1.001 * (1-0)))) / 1000)

= 1,677 kWh

Early Replacement:

For example, a 15 SEER, 12EER, 9 HSPF Air Source Heat Pump with nameplate information as above replaces an existing working Air Source Heat Pump with unknown efficiency ratings in a single family home in Marion:

ΔkWH for remaining life of existing unit (1st 6 years):

= ((903 * 34,800 * (1/(9.3 * (1-0.1)) - 1/(15 * 1.011 * (1-0)))) / 1000) + ((1,288 * 33,000 * (1/(5.54 * 0.83 * (1-0.1)) - 1/(9 * 0.83 * 1.001 * (1-0)))) / 1000)

= 6,269 kWh

ΔkWH for remaining measure life (next 12 years):

= ((903 * 34,800 * (1/(14 * (1 - 0.1)) - 1/(15 * 1.011 * $(1-0)$))) / 1000) + ((1,288 * 33,000 * (1/(8.2 * 0.83 * $(1-0.1)$)) - 1/(9 * 0.83 *1.001 * (1-0)))) / 1000)

= 1,677 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 three ton (Cooling capacity of 34,800Btuh and Heating capacity of 33,000 Btuh), 15 SEER, 12EER, 9 HSPF Air Source Heat Pump installed in single-family home in Marion with Quality Installation, in place of a 81,000 Btuh natural gas furnace and 3 ton Central AC unit:

SiteEnergySavings (MMBTUs) = GasHeatReplaced + FurnaceFanSavings − ASHPSiteHeatConsumed + ASHPSiteCoolingImpact

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

= ((1288 * 33,000 * 1/0.8) / 1000000)

= 53.1 MMBtu

FurnaceFanSavings = (FurnaceFlag * HeatLoad * 1/AFUE$_{base}$ * F$_{e}$_New) / 1,000,000

= (1 * 1288 * 33,000 * 1/0.8 * 0.0188) / 1,000,000

= 1.0 MMBtu

ASHPSiteHeatConsumed = ((HeatLoad * (1/(HSPF_ee * HSPF_ClimateAdj * HSPFadj * $(1 - DeratingHeat_{Eff})$))) /1000 * 3412)/ 1,000,000

Fuel Switch Illustrative Example continued

$$\text{ASHPSiteCoolingImpact} = ((\text{CoolingLoad} * (1/(\text{SEER\_base} * (1 - \text{DeratingCool}_{Base})) - 1/(\text{SEER\_ee} * \text{SEERadj} * (1 - \text{DeratingCool}_{Eff}))))/1000) * 3412) / 1,000,000$$

$$= ((903 * 34,800 * (1/(13 * (1-0.1)) - 1/(15 * 1.011 * (1-0)))) / 1000 * 3412)/1,000,000$$

$$= 2.1 \text{ MMBtu}$$

SiteEnergySavings (MMBTUs) = 53.1 + 1.0 – 19.4 + 2.1 = 36.8 MMBtu [Measure is eligible]

Savings would be claimed as follows:

Measure supported by:	Electric Utility claims:	Gas Utility claims:
Electric utility only	36.8 * 1,000,000/3412 = 10,785 kWh	N/A
Electric and gas utility	0.5 * 36.8 * 1,000,000/3412 = 5,393 kWh	0.5 * 36.8 * 10 = 184 Therms
Gas utility only	N/A	36.8 * 10 = 368 Therms

Early Replacement fuel switch:

For example a three ton (Cooling capacity of 34,800Btuh and Heating capacity of 33,000 Btuh), 15 SEER, 12EER, 9 HSPF Air Source Heat Pump installed in single-family home in Marion with Quality Installation, replaces an existing working natural gas furnace and 3 ton Central AC unit with unknown efficiency ratings:

LifetimeSiteEnergySavings (MMBTUs) = LifetimeGasHeatReplaced + LifetimeFurnaceFanSavings – LifetimeASHPSiteHeatConsumed + LifetimeASHPSiteCoolingImpact

$$\text{LifetimeGasHeatReplaced} = [(\text{HeatLoad} * 1/\text{AFUE}_{exist}) / 1,000,000] * 6 \text{ years} + [(\text{HeatLoad} * 1/\text{AFUE}_{base}) / 1,000,000] * 10 \text{ years}$$

$$= (((1288 * 33000 * 1/0.644) / 1000000) * 6) + (((1288 * 33000 * 1/0.8) / 1000000) * 10)$$

$$= 927.3 \text{ MMBtu}$$

$$\text{LifetimeFurnaceFanSavings} = ((\text{FurnaceFlag} * \text{HeatLoad} * 1/\text{AFUE}_{exist} * F_{e}\_\text{Exist}) / 1,000,000) * 6 \text{ years} + ((\text{FurnaceFlag} * \text{HeatLoad} * 1/\text{AFUE}_{base} * F_{e}\_\text{New}) / 1,000,000) * 10 \text{ years}$$

$$= ((1 * 1288 * 33,000 * 1/0.644 * 0.0314) / 1,000,000) * 6 + ((1 * 1288 * 33,000 * 1/0.8 * 0.0188)/ 1,000,000) * 10$$

$$= 22.4 \text{ MMBtu}$$

$$\text{LifetimeASHPSiteHeatConsumed} = ((\text{HeatLoad} * (1/(\text{HSPF\_ee} * \text{HSPF\_ClimateAdj} * \text{HSPFadj} * (1 - \text{DeratingHeat}_{Eff}))))/1000 * 3412)/ 1,000,000 * 16 \text{ years}$$

$$= ((1,288 * 33,000 * (1/(9 * 0.83 * 1.001 * (1-0)))) / 1000 * 3412)/1,000,000 * 16$$

$$= 310.3 \text{ MMBtu}$$

Fuel Switch Illustrative Example continued

LifetimeASHPSiteCoolingImpact = $(((CoolingLoad * (1/(SEER\_exist * (1 – DeratingCool_{Base})) - 1/(SEER\_ee * SEERadj * (1 – DeratingCool_{Eff}))))/1000 * 3412)/1{,}000{,}000 * 6 \text{ years}) + (((CoolingLoad * (1/(SEER\_base * (1 – DeratingCool_{Base})) - 1/(SEER\_ee * SEERadj * (1 – DeratingCool_{Eff}))))/1000 * 3412)/1{,}000{,}000 * 10 \text{ years})$

= $(((903 * 34{,}800 * (1/(9.3 * (1{-}0.1)) - 1/(15 * 1.011 * (1{-}0)))) / 1000 * 3412)/1{,}000{,}000 * 6) + (((903 * 34{,}800 * (1/(13 * (1{-}0.1)) - 1/(15 * 1.011 * (1{-}0)))) / 1000 * 3412)/1{,}000{,}000 * 10)$

= 55.4 MMBtu

LifetimeSiteEnergySavings (MMBTUs) = 927.3 + 22.4 – 310.3 + 55.4 = 695 MMBtu [Measure is eligible]

First 6 years:

SiteEnergySavings_FirstYear (MMBTUs) = GasHeatReplaced + FurnaceFanSavings – ASHPSiteHeatConsumed + ASHPSiteCoolingImpact

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

= $((1288 * 33{,}000 * 1/0.644) / 1000000)$

= 66.0 MMBtu

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

= $(1 * 1288 * 33{,}000 * 1/0.644 * 0.0314) / 1{,}000{,}000$

= 2.1 MMBtu

ASHPSiteHeatConsumed = $((HeatLoad * (1/(HSPF\_ee * HSPF\_ClimateAdj * HSPFadj * (1 – DeratingHeat_{Eff})))) /1000 * 3412)/ 1{,}000{,}000$

= $((1{,}288 * 33{,}000 * (1/(9 * 0.83 * 1.001 * (1{-}0)))) / 1000 * 3412) / 1{,}000{,}000$

= 19.4 MMBtu

ASHPSiteCoolingImpact = $((CoolingLoad * (1/(SEER\_exist * (1 – DeratingCool_{Base})) - 1/(SEER\_ee * SEERadj * (1 – DeratingCool_{Eff}))))/1000 * (FirstYearH_{grid} * (1 + ElectricT\&D)) / 1{,}000{,}000$

= $((903 * 34{,}800 * (1/(9.3 * (1{-}0.1)) - 1/(15 * 1.011 * (1{-}0)))) / 1000 * 3412)/1{,}000{,}000$

= 5.7 MMBtu

SiteEnergySavings_FirstYear (MMBTUs) = 66.0 + 2.1 – 19.4 + 5.7 = 54.4 MMBtu

Remaining 10 years:

SiteEnergySavings_PostAdj (MMBTUs) = GasHeatReplaced + FurnaceFanSavings – ASHPSiteHeatConsumed + ASHPSiteCoolingImpact

GasHeatReplaced = $((1288 * 33{,}000 * 1/0.8) / 1000000)$

= 53.1 MMBtu

Fuel Switch Illustrative Example continued

ASHPSiteHeatConsumed = ((1,288 * 33,000 * (1/(9 * 0.83 * 1.001 * (1-0)))) / 1000 * 3412) / 1,000,000

= 19.4 MMBtu

ASHPSiteCoolingImpact = ((903 * 34,800 * (1/(13 * (1-0.1)) - 1/(15 * 1.011 * (1-0)))) / 1000 *3412)/1,000,000

= 2.1 MMBtu

SiteEnergySavings_ PostAdj (MMBTUs) = 53.1 + 1.2 – 19.4 + 2.1 = 37.0 MMBtu

Savings would be claimed as follows:

Measure supported by:	Electric Utility claims:	Gas Utility claims:
Electric utility only	First 6 years: 54.4 * 1,000,000/3412 = 15,944 kWh Remaining 10 years: 37.0 * 1,000,000/3412 = 10,844kWh	N/A
Electric and gas utility	First 6 years: 0.5 * 54.4 * 1,000,000/3412 = 7,972 kWh Remaining 10 years: 0.5 * 37.0 * 1,000,000/3412 = 5,422 kWh	First 6 years: 0.5 * 54.4 * 10 = 272 Therms Remaining 10 years: 0.5 * 37.0 * 10 = 185 Therms
Gas utility only	N/A	First 6 years: 54.4 * 10 = 544 Therms Remaining 10 years:

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = (Capacity_cooling * (1/(EER_base * (1 – DeratingCool_{Base})) - 1/(EER_ee * (1 – DeratingCool_{Eff})))) / 1000 * CF

Where:

EER_base = 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.[176] If unknown, assume default provided below:

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[176] 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).

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 – standard sized	7.83 [177]	11.0 [178]	
Air Source Heat Pump – space constrained	7.83	10.5	
Central AC – standard sized	7.83 [179]	10.5 [180]	
Central AC – space constrained	7.83	10.5	
No central cooling	Make '1/EER_exist' = 0 [181]	10.5 [182]	
Unknown [183]	7.83	10.75	

EER_{ee} = Energy Efficiency Ratio of efficient Air Source Heat Pump (kBtu/hr / kW)

= Actual. If unknown, assume 12.5 EER. [184]

$CF_{SSP\ SF}$ = Summer System Peak Coincidence Factor for Heat Pumps in single-family homes (during system peak hour)

= 72% [185]

$CF_{PJM\ SF}$ = PJM Summer Peak Coincidence Factor for Heat Pumps in single-family homes (average during peak period)

= 46.6% [186]

$CF_{SSP,\ MF}$ = Summer System Peak Coincidence Factor for Heat Pumps in multi-family homes (during system peak hour)

= 67% [187]

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

[178] 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'.

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

[180] 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'.

[181] If there is no central cooling in place but the incentive encourages installation of a new ASHP with cooling, the added cooling load should be subtracted from any heating benefit.

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

[183] Program tracking data does not provide an EER value. These are estimated based on the other values in the table.

[184] ENERGY STAR minimum.

[185] 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)'.

[186] 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.

[187] *All-Electric Homes PY6 Metering Results: Multifamily HVAC Systems*, Cadmus, October 2015

$CF_{PJM, MF}$ = PJM Summer Peak Coincidence Factor for Heat Pumps in multi-family homes (average during peak period)

= 28.5%

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

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Time of Sale:

For example, a three ton, 15 SEER, 12EER, 9 HSPF Air Source Heat Pump installed in single-family home in Marion with Quality Installation:

ΔkW_{SSP} = (36,000 * (1/(11 * (1-0.1)) – 1/(12 * (1-0)))) / 1000 * 0.72

= 0.458 kW

ΔkW_{PJM} = (36,000 * (1/(11 * (1-0.1)) – 1/(12 * (1-0)))) / 1000 * 0.466

= 0.297 kW

Early Replacement:

For example, a three ton, 15 SEER, 12EER, 9 HSPF Air Source Heat Pump replaces an existing working Air Source Heat Pump with unknown efficiency ratings in single-family home in Marion with Quality Installation:

ΔkW_{SSP} for remaining life of existing unit (1st 6 years):

= (36,000 * (1/(7.5 * (1-0.1)) - 1/(12 * (1-0)))) / 1000 * 0.72

= 1.68 kW

ΔkW_{SSP} for remaining measure life (next 10 years):

= (36,000 * (1/(11 * (1-0.1)) – 1/(12 * (1-0)))) / 1000 * 0.72

= 0.458 kW

ΔkW_{PJM} for remaining life of existing unit (1st 6 years):

= (36,000 * (1/(7.5 * (1-0.1)) - 1/(12 * (1-0)))) / 1000 * 0.466

= 1.087 kW

ΔkW_{PJM} for remaining measure life (next 10 years):

= (36,000 * (1/(11 * (1-0.1)) – 1/(12 * (1-0)))) / 1000 * 0.466

= 0.297 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 fossil fuel to electric.

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), 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, should therefore reflect the decrease in one fuel and increase in another, as opposed to the single savings value calculated in the "Electric and Fossil Fuel Energy Savings" section 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 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, 7 years for furnace, 8 years for boilers or GSHP, 16 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.

ΔTherms = [Heating Consumption Replaced]

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

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

= %FuelSwitch * [[FurnaceFlag * HeatLoad * $1/AFUE_{base}$ * F_e * 0.000293] - [(HeatLoad * (1/(HSPF_ee * HSPF_ClimateAdj * HSPFadj * (1 − $DeratingHeat_{Eff}$))))/1000] + [(CoolingLoad * (1/(SEER_base * (1 − $DeratingCool_{Base}$)) - 1/(SEER_ee * SEERadj * (1 − $DeratingCool_{Eff}$))))/1000]]

MEASURE CODE: RS-HVC-ASHP-V13-230101

REVIEW DEADLINE: 1/1/2025

5.3.3   Central Air Conditioning

DESCRIPTION

This measure characterizes:

> Time of Sale:
>
>> The installation of a new residential sized (<= 65,000 Btu/hr) Central Air Conditioning ducted split system meeting ENERGY STAR SEER efficiency standards presented below. This could relate to the replacement of an existing unit at the end of its useful life, or the installation of a new system in a new home.
>
> Early Replacement:
>
>> Early Replacement determination will be based on meeting the following conditions:
>>
>> - The existing unit is operational when replaced, or
>> - The existing unit requires minor repairs (<$190 per ton).[188]
>> - All other conditions will be considered Time of Sale.
>>
>> The Baseline SEER of the existing Central Air Conditioning unit replaced:
>>
>>> If the SEER of the existing unit is known and <=10, the Baseline SEER is the actual SEER value of the unit replaced. If the SEER is >10, the Baseline SEER = 13 for standard sized units or SEER = 12 for space constrained units.
>>>
>>> If the SEER of the existing unit is unknown, use assumptions in variable list below (SEER_exist).
>>>
>>> If the operational status or repair cost of the existing unit is unknown, use time of sale assumptions.
>>
>> A weighted average early replacement rate is provided for use in downstream programs when the actual baseline early replacement rate is unknown.[189]

Deemed Early Replacement Rates for CAC Units in Combined System Replacement (CSR) Projects

Replacement Scenario for the CAC Unit	Deemed Early Replacement Rate
Early Replacement Rate for downstream participants when a CAC unit when the CAC unit is the Primary unit in a CSR project	14%
Early Replacement Rate for downstream participants when a CAC unit when the CAC unit is the Secondary unit in a CSR project	40%

Note: it is not appropriate to claim additional ECM fan savings (from 5.3.5 Furnace Blower Motor) due to installing new CAC units with an ECM, since the SEER/EER ratings already account for this electrical load.

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[188] The Technical Advisory Committee agreed that if the cost of repair is less than 20% of the new baseline replacement cost it can be considered early replacement. Note the non-inflated cost is used as this would be a cost consideration in the program year.

[189] Based upon research from "Home Energy Efficiency Rebate Program GPY2 Evaluation Report" which outlines early replacement rates for both primary and secondary central air cooling (CAC) and residential furnaces. The unit (furnace or CAC unit) that initially caused the customer to contact a trade ally is defined as the "primary unit". The furnace or CAC unit that was also replaced but did not initially prompt the customer to contact a trade ally is defined as the "secondary unit". This evaluation used different criteria for early replacement due to the availability of data after the fact; cost of any repairs < $550 and age of unit < 20 years. Report presented to Nicor Gas Company February 27, 2014.

Quality Installation:

Additional savings are attributed to the Quality Installation (QI) of the system. QI programs should follow industry standards such as those described in ENERGY STAR Verified HVAC Installation Program (ESVI), ANSI ACCA QI5 and QI9vp. This must include considerations of system design (including sizing, matching, ventilation calculations) and equipment installation (including static pressure, airflow, refrigerant charge) and may also consider distribution.

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

DEFINITION OF EFFICIENT EQUIPMENT

In order for this characterization to apply, the efficient equipment is assumed to be a ducted split central air conditioning unit meeting at least the minimum ENERGY STAR version 5.0 efficiency level standards; 15 SEER and 12.5 EER.

Note: New ENERGY STAR specifications affecting heat pump and central air conditioners, v6.1, becomes effective January 1, 2023. The new specifications require central air conditioners to meet the following minimum efficiency requirements:[190]

- Split system central air conditioners – 15.2 SEER2 and 12.0 EER2

- Single package central air conditioners – 15.2 SEER2 and 11.5 EER2

The measure characterization recommends sourcing the efficiency specifications from the actually installed equipment. If those values are not known, the default equipment efficiency recommendations are conservatively based on ENERGY STAR version 5.0 specifications.

The following conversion factors are recommended for use if the efficient equipment is not rated under the new testing procedure:[191]

$$SEER = SEER2 / X$$

$$EER = EER2 / X$$

Where:

X	SEER	EER
Ducted	0.95	0.95
Packaged	0.95	0.95

DEFINITION OF BASELINE EQUIPMENT

The baseline for the Time of Sale measure is based on the current Federal Standard efficiency level; 13 SEER and an estimate of expected peak rated efficiency of 10.5 EER for standard sized units or 12 SEER and 10.5EER for space constrained units. Note, the space constrained product baseline should only be used when the efficient unit is

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[190] ENERGY STAR Program Requirements Product Specification for Central Air Conditioner and Heat Pump Equipment, v6.1, effective January 1, 2023, are in terms of an updated metric, depicted as SEER2 and EER2. The updated test method as well as the updated ENERGY STAR specifications mimic the updated federal appliance standards. An equivalent stringency of these new standards for split system air conditioners are 16 SEER and 13 EER and for single-package air conditioners are 16 SEER and EER 12, as detailed in: Consortium for Energy Efficiency (CEE) Residential HVAC Specifications, Estimated Appendix M1 Equivalents, January 15 2021

[191] Consortium for Energy Efficiency (CEE), Testing, Testing, M1, 2, 3, Transitioning to New Federal Minimum Standards, CEE Summer Program Meeting, June 10, 2022.

classified as space constrained. It is assumed that 'Quality Installation' did not occur.

The baseline for the early replacement measure is the efficiency of the existing equipment for the assumed remaining useful life of the unit and the new baseline as defined above for the remainder of the measure life.[192] Consistent with TRM Volume 1 Section 2.3.1 for midstream programs or other cases where the existing condition is unknown, it may be appropriate to apply a deemed percent split of Time of Sale and Early Replacement assumptions based on evaluation results

Note: New Federal Standards affecting central air conditioners become effective January 1, 2023. The new standards effective in 2023, require any residential central air conditioner manufactured in, or imported into, the United States to have a minimum efficiency rating meeting the following:[193]

- Standard sized Split system air conditioners – 13.4 SEER2

- Standard sized Single-package air conditioners – 13.4 SEER2

- Space constrained air conditioners – 11.7 SEER2

These new federal standards will be adopted by the program, beginning 1/1/2024. For the 2023 program year, the baseline equipment efficiencies are detailed in this section by replacement scenario.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT
The expected measure life is assumed to be 18 years.[194]

Remaining life of existing equipment is assumed to be 6 years.[195]

DEEMED MEASURE COST
Time of sale: The incremental capital cost for this measure is dependent on efficiency. Assumed incremental costs are provided below:[196]

Efficiency Level (SEER)	Incremental Cost
14	$104
15	$108
16	$221
17	$620
18	$620

Early replacement: The full install cost for this measure is the actual cost of removing the existing unit and

---

[192] Baseline SEER and EER should be updated when new minimum federal standards become effective.

[193] The 2023 federal standards (10 CFR 430.32(c)(5)) are in terms of an updated metric, depicted as SEER2 and manufacturers must certify their products meet the standard according to the new test procedure and new metrics. The updated test method as well as the updated energy conservation standards were negotiated under the appliance standards and rulemaking federal advisory committee (ASRAC) in accordance with the Federal Advisory Committee Act (FACA) and the negotiated rulemaking act. An equivalent stringency of these new standards for split system air conditioners are 14 SEER and for single-package air conditioners are 14 SEER, as detailed in: Federal Code of Regulations, Energy Conservation Program: Energy Conservations Standards for residential Central Air Conditioners and Heat Pumps; Confirmation of effective date and compliance date for direct final rule, May 26, 2017, Docket: EERE-2014-BT-STD-0048 (https://www.regulations.gov/document/EERE-2014-BT-STD-0048-0200)

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

[195] Assumed to be one third of effective useful life

[196] Based on incremental cost results from Cadmus "HVAC Program: Incremental Cost Analysis Update", December 19, 2016.

installing the new one. If this is unknown, assume defaults below.[197]

Efficiency Level (SEER)	Full Retrofit Cost (including labor)
14	$952 / ton + $104
15	$952 / ton + $108
16	$952 / ton + $221
17	$952 / ton + $620
18	$952 / ton + $620

Assumed deferred cost (after 6 years) of replacing existing equipment with new baseline unit is assumed to be $3,140.[198] This cost should be discounted to present value using the nominal societal discount rate.

Quality Installation: The additional design and installation work associated with quality installation has been estimated to cost an additional $150.[199]

LOADSHAPE
Loadshape R08 – Residential Cooling

COINCIDENCE FACTOR
The summer peak coincidence factor for cooling is provided in two different ways below. The first is used to estimate peak savings during the utility peak hour and is most indicative of actual peak benefits, and the second represents the *average* savings over the defined summer peak period and is presented so that savings can be bid into PJM's capacity market.

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)
            = 68%[200]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)
            = 46.6%[201]

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS
Time of sale:

ΔkWH = (FLHcool * Capacity * (1/(SEERbase * (1 − DeratingCool$_{Base}$)) − 1/(SEERee * SEERadj * (1 − DeratingCool$_{Eff}$))))/1000

---

[197] Based on 3 ton initial cost estimate for a conventional unit from ENERGY STAR Central AC calculator, $2,857. Efficiency cost increment consistent with Cadmus study results.
[198] Based on 3 ton initial cost estimate for a conventional unit from ENERGY STAR Central AC calculator, $2,857, and applying inflation rate of 1.91%. While baselines are likely to shift in the future, there is currently no good indication of what the cost of a new baseline unit will be in 6 years. In the absence of this information, assuming a constant federal baseline cost is within the range of error for this prescriptive measure.
[199] Based on data provided by MidAmerican in April 2018 summarizing survey results from 11 HVAC suppliers in Iowa.
[200] Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.
[201] 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.

Early replacement:[202]

ΔkWH for remaining life of existing unit (1st 6 years):

$$=(FLHcool * Capacity * (1/(SEERexist * (1 − DeratingCool_{Base})) − 1/(SEERee * SEERadj * (1 − DeratingCool_{Eff}))))/1000$$

ΔkWH for remaining measure life (next 12 years):

$$= (FLHcool * Capacity * (1/(SEERbase * (1 − DeratingCool_{Base})) − 1/(SEERee * SEERadj * (1 − DeratingCool_{Eff}))))/1000$$

Where:

FLHcool   = Full load cooling hours

= dependent on location and building type:[203]

Climate Zone (City based upon)	FLHcool (single family)	FLHcool (multifamily)	FLH_cooling (weatherized multifamily) [204]
1 (Rockford)	512	467	299
2 (Chicago)	570	506	324
3 (Springfield)	730	663	425
4 (Belleville)	1035	940	603
5 (Marion)	903	820	526
Weighted Average[205]			
ComEd	567	504	323
Ameren	810	734	470
Statewide	632	565	362

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

Capacity   = Size of new equipment in Btu/hr (note 1 ton = 12,000Btu/hr)

---

[202] The two equations are provided to show how savings are determined during the initial phase of the measure (existing to efficient) and the remaining phase (new baseline to efficient). In practice, the screening tools used may either require a First Year savings (using the first equation) and then a "number of years to adjustment" and "savings adjustment" input which would be the (new base to efficient savings)/(existing to efficient savings).

[203] Full load hours for Chicago, Moline and Rockford are provided in "Final Evaluation Report: Central Air Conditioning Efficiency Services (CACES), 2010, Navigant Consulting", p.33. An average FLH/Cooling Degree Day (from NCDC) ratio was calculated for these locations and applied to the CDD of the other locations in order to estimate FLH. There is a county mapping table in Volume 1, Section 3.7 providing the appropriate city to use for each county of Illinois.

[204] *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.

[205] Weighting for Ameren is based on electric accounts in each of the cooling zones. Weighting for ComEd and Statewide average is based on number of occupied residential housing units in each zone. ComEd is weighted average of Zones 1-2. Alternative program-weighted assumptions can be used if appropriate.

                               = Use actual when program delivery allows size of AC unit to be known. If unknown, assume 33,600 Btu/hr for single family homes, 28,000 Btu/hr for multifamily, or 24,000 Btu/hr for mobile homes.[206] If building type is unknown, assume 31,864Btu/hr.[207]

SEERbase   = Seasonal Energy Efficiency Ratio of baseline unit (kBtu/kWh)

                               = 13 for standard sized units or 12 for space constrained units [208]

SEERexist   = Seasonal Energy Efficiency Ratio f existing unit (kBtu/kWh)

                               = Use actual SEER rating where it is possible to measure or reasonably estimate. If using rated efficiencies, derate efficiency value by 1% per year (maximum of 30 years) to account for degradation over time,[209] or, if unknown, assume 9.3.[210]

SEERee   = Rated Seasonal Energy Efficiency Ratio of ENERGY STAR unit (kBtu/kWh)

                               = Actual, or 15 if unknown.

SEERadj   = Adjustment percentage to account for in-situ performance of the unit**[211]**

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

DeratingCool$_{Eff}$ = Efficent Central Air Conditioner Cooling derating

                               = 0% if Quality Installation is performed

                               = 10% if Quality Installation is not performed or unknown[212]

DeratingCool$_{Base}$ = Baseline Central Air Conditioner Cooling derating

                               = 10%

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[206] Single family cooling capacity based on Final Evaluation Report: Central Air Conditioning Efficiency Services (CACES), October 19, 2010, ComEd, Navigant Consulting. Multifamily capacity based on weighted average of PY9 Ameren and ComEd MF cooling capacities. Mobile home capacity based on ENERGY STAR's Manufactured Home Cooling Equipment Sizing Guidelines which vary by climate zone and home size. The average size of a mobile home in the East North Central region (1,120 square feet) from the 2015 RECS data is used to calculated appropriate size.

[207] Unknown is 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.

[208] Based on Minimum Federal Standard.

[209] 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).

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

[211] 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'.

[212] Based on Cadmus assumption provided in preparation of the 2014 Interstate Power and Light TRM based upon proper refrigerant charge, evaporator airflow, and unit sizing, Appears conservative in comparison to ENERGY STAR statements (see 'Sponsoring an ENERGY STAR Verified HVAC Installation (ESVI) Program'). Note pending ComEd evaluation will provide an update to these assumptions.

Time of sale example: a 3 ton unit with SEER rating of 17, EER rating of 12.5 in unknown location without Quality Install:

SEERadj   = (0.805 * (12.5/17) + 0.367)

= 0.959

ΔkWH   = (629 * 36,000 * (1/(13 * (1-0.1)) – 1 / (17 * 0.959 * (1-0.1)))) / 1000

= 392 kWh

Time of sale example: a 3 ton unit with SEER rating of 17, EER rating of 12.5 in unknown location with Quality Install:

ΔkWH   = (629 * 36,000 * (1/(13 * (1-0.1)) – 1 / (17 * 0.959 * (1-0)))) / 1000

= 546 kWh

Early replacement example: a 3 ton unit, with SEER rating of 17, EER rating of 12.5 replaces an existing unit in unknown location with quality installation:

ΔkWH(for first 6 years)   = (629 * 36,000 * (1/(9.3 * (1-0.1)) - 1/(17* 0.959 * (1-0))))/1000

= 1,316 kWh

ΔkWH(for next 12 years)   = (629 * 36,000 * (1/(13 * (1-0.1)) - 1/(17* 0.959 * (1-0))))/1000

= 546 kWh

Therefore savings adjustment of 41% (546/1316) after 6 years.

SUMMER COINCIDENT PEAK DEMAND SAVINGS

Time of sale:

$$\Delta kW = (Capacity * (1/(EERbase * (1 – DeratingCool_{Base})) - 1/(EERee * (1 – DeratingCool_{Eff}))))/1000 * CF$$

Early replacement:[213]

ΔkW for remaining life of existing unit (1st 6 years):

$$= (Capacity * (1/(EERexist * (1 – DeratingCool_{Base})) - 1/(EERee* (1 – DeratingCool_{Eff}))))/1000 * CF$$

ΔkW for remaining measure life (next 12 years):

$$= (Capacity * (1/(EERbase * (1 – DeratingCool_{Base})) - 1/(EERee* (1 – DeratingCool_{Eff}))))/1000 * CF$$

Where:

EERbase   = EER Efficiency of baseline unit

= 10.5 [214]

EERexist   = EER Efficiency of existing unit

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[213] The two equations are provided to show how savings are determined during the initial phase of the measure (existing to efficient) and the remaining phase (new baseline to efficient). In practice, the screening tools used may either require a First Year savings (using the first equation) and then a "number of years to adjustment" and "savings adjustment" input which would be the (new base to efficient savings)/(existing to efficient savings).

[214] 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'.

	= Use actual EER rating where it is possible to measure or reasonably estimate. If using rated efficiencies, derate efficiency value by 1% per year (maximum of 30 years) to account for degradation over time.[215] If unknown, assume 7.5.[216]
EERee	= EER Efficiency of ENERGY STAR unit
	= Actual installed or 12 if unknown
CF_{SSP}	= Summer System Peak Coincidence Factor for Central A/C (during system peak hour)
	= 68%[217]
CF_{PJM}	= PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)
	= 46.6%[218]

Time of sale example: a 3 ton unit with EER rating of 12 with Quality Install:

ΔkW_{SSP} = (36,000 * (1/(10.5 * (1-0.1)) − 1/(12 * (1-0)))) / 1000 * 0.68
= 0.550 kW

ΔkW_{PJM} = (36,000 * (1/(10.5 * (1-0.1)) − 1/(12 * (1-0)))) / 1000 * 0.466
= 0.377 kW

Early replacement example: a 3 ton unit with EER rating of 12 replaces an existing unit with Quality Install:

ΔkW_{SSP} (for first 6 years) = (36,000 * (1/(7.5 * (1-0.1)) − 1/(12 * (1-0)))) / 1000 * 0.68
= 1.587 kW

ΔkW_{SSP} (for next 12 years) = (36,000 * (1/(10.5 * (1-0.1)) − 1/(12 * (1-0)))) / 1000 * 0.68
= 0.550 kW

ΔkW_{PJM} (for first 6 years) = (36,000 * (1/(7.5 * (1-0.1)) − 1/(12 * (1-0)))) / 1000 * 0.466
= 1.087 kW

ΔkW_{PJM} (for next 12 years) = (36,000 * (1/(10.5 * (1-0.1)) − 1/(12 * (1-0)))) / 1000 * 0.466
= 0.377 kW

FOSSIL FUEL SAVINGS
N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION
N/A

DEEMED O&M COST ADJUSTMENT CALCULATION
N/A

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[215] 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).
[216] Based on Opinion Dynamics and Cadmus metering study of Ameren HVAC program participants; See 'AIC HVAC Metering Study Memo FINAL 2_28_2018'.
[217] Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.
[218] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.

MEASURE CODE: RS-HVC-CAC1-V11-230101

REVIEW DEADLINE: 1/1/2024
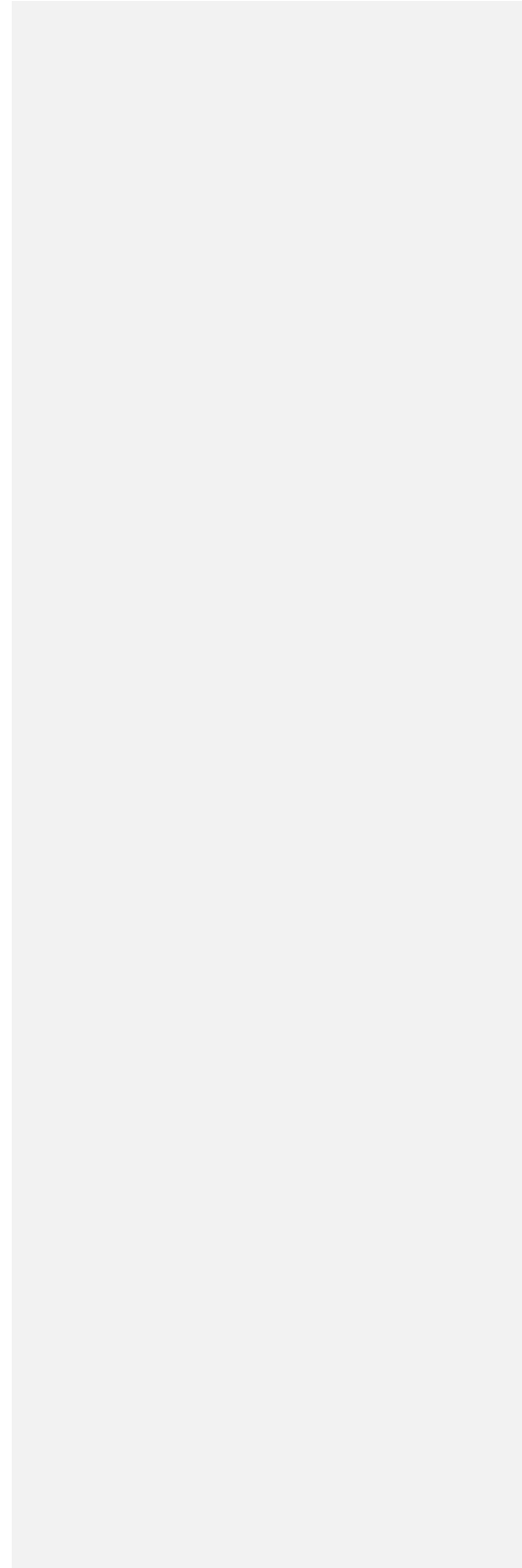
5.3.12 Ductless Heat Pumps

DESCRIPTION

A heat pump provides heating or cooling by moving heat between indoor and outdoor air. This measure relates to a split heat pump with an outdoor unit and single or multi indoor units providing conditioned air.

This measure is designed to calculate electric savings for the installation of a ductless mini-split heat pump (DMSHP). DMSHPs save energy in heating mode because they provide heat more efficiently than electric resistance heat and central ASHP systems. Additionally, DMSHPs use less fan energy to move heat and don't incur heat loss through a duct distribution system.

For cooling, the proposed savings calculations are aligned with those of typical replacement systems. DMSHPs save energy in cooling mode because they provide cooling capacity more efficiently than other types of unitary cooling equipment. A DMSHP installed in a home with a central ASHP system will save energy by offsetting some of the cooling energy of the ASHP. In order for this measure to apply, the control strategy for the heat pump is assumed to be chosen to maximize savings per installer recommendation.[219]

This measure characterizes the following scenarios:

New Construction:

The installation of a new DMSHP meeting efficiency standards required by the program in a new home.

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.

Time of Sale:

The planned installation of a new DMSHP meeting efficiency standards required by the program to replace an existing system(s) that does not meet the criteria for early replacement described in section c below.

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.

Early Replacement/Retrofit:

The early removal or displacement 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 DMSHP.

Note the baseline in this case is the existing equipment being replaced/displaced. 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.

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

- The existing unit is operational when replaced/displaced, or

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[219] The whole purpose of installing ductless heat pumps is to conserve energy, so the installer can be assumed to be capable of recommending an appropriate controls strategy. For most applications, the heating setpoint for the ductless heat pump should be at least 2F higher than any remaining existing system and the cooling setpoint for the ductless heat pump should be at least 2F cooler than the existing system (this should apply to all periods of a programmable schedule, if applicable). This helps ensure that the ductless heat pump will be used to meet as much of the load as possible before the existing system operates to meet the remaining load. Ideally, the new ductless heat pump controls should be set to the current comfort settings, while the existing system setpoints should be adjusted down (heating) and up (cooling) to capture savings.

- The existing unit requires minor repairs, defined as costing less than:[220]

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

- All other conditions will be considered Time of Sale.

The Baseline efficiency of the existing unit replaced:

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

Existing System	Maximum efficiency for Actual	New Baseline[221]
Air Source Heat Pump	10 SEER	14 SEER, 11 EER, 8.2 HSPF if standard sized 12 SEER, 10.5 EER, 7.4 HSPF if space constrained
Central Air Conditioner	10 SEER	13 SEER, 10.5 EER if standard sized 12 SEER, 10.5 EER if space constrained
Natural Gas or LP Boiler	75% AFUE	84% AFUE
Natural Gas or LP Furnace	75% AFUE	80% AFUE
Oil Furnace	75% AFUE	83% AFUE
Oil Boiler	75% AFUE	86% AFUE
Ground Source Heat Pump	10 SEER	14 SEER, 11 EER, 8.2 HSPF

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.

A weighted average early replacement rate is provided for use in downstream programs when the actual baseline early replacement rates are unknown.

Deemed Early Replacement Rates For DMSHP

	Deemed Early Replacement Rate
Early Replacement Rate for DMSHP participants	27%[222]

This measure was developed to be applicable to the following program types: RF, 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 new equipment must be a high-efficiency, variable-capacity (typically "inverter-driven" DC motor) ductless heat pump system that exceeds the program minimum efficiency requirements.

The following conversion factors are recommended for use if the efficient equipment is not rated under the new

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[220] 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.
[221] Based on relevant Federal Standards.
[222] Based on ComEd program data from 2018-2020 (1057 DMSHP installs).

testing procedure:[223]

SEER = SEER2 / X

EER = EER2 / X

HSPF = HSPF2 / X

Where:

X	SEER	EER	HSPF
Ductless	1.00	1.00	0.95

DEFINITION OF BASELINE EQUIPMENT

For these products, baseline equipment includes Air Conditioning and Space 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 EER for standard sized units, or 12SEER, 7.4 HSPF, 10.5EER for space constrained product.[224] Note, the space constrained product baseline should only be used when it is demonstrated that the alternative ducted system would need to be a space constrained unit.

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 for standard sized units, or 12SEER, 10.5EER for space constrained product. [225]

Time of Sale: The baseline for this measure is a new replacement unit of the same system type as the existing unit, meeting the baselines provided below. Note, the space constrained product baseline should only be used when the existing unit being replaced is classified as space constrained.

Unit Type	Efficiency Standard
Standard sized ASHP	14 SEER, 11 EER, 8.2 HSPF
Space constrained ASHP	12 SEER, 10.5 EER, 7.4 HSPF
Electric Resistance	3.412 HSPF
Natural Gas or LP Furnace	80% AFUE
Natural Gas or LP Boiler	84% AFUE
Oil Furnace	83% AFUE
Oil Boiler	86% AFUE
Standard sized Central AC	13 SEER, 10.5 EER
Space constrained Central AC	12 SEER, 10.5 EER

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[223] Consortium for Energy Efficiency (CEE), Testing, Testing, M1, 2, 3, Transitioning to New Federal Minimum Standards, CEE Summer Program Meeting, June 10, 2022.

[224] 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'.

[225] 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'.

Unit Type	Efficiency Standard
Unknown [226]	13.28 SEER, 11.35EER, 5.53 HSPF, 81.1% AFUE

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 for the remainder of the measure life (as provided in table above). Note that in order to claim cooling savings, there must be an existing air conditioning system.

Where unknown, early replacement efficiency assumptions are 9.95 SEER, 9.01 EER, 5.07 HSPF and 63% AFUE. Consistent with TRM Volume 1 Section 2.3.1 for midstream programs or other cases where the existing condition is unknown, it may be appropriate to apply a deemed percent split of Time of Sale and Early Replacement assumptions based on evaluation results

For multifamily buildings, each residence must have existing individual heating equipment. Multifamily residences with central heating do not qualify for this characterization.

Note: New Federal Standards affecting heat pumps become effective January 1, 2023. The new standards effective in 2023, require any residential heat pump manufactured in, or imported into, the United States to have a minimum efficiency rating meeting the following:[227]

- Split system heat pump standard sized units – 14.3 SEER2 and 7.5 HSPF2

- Single-package heat pump standard sized units – 13.4 SEER2 and 6.7 HSPF2

- Space constrained heat pump units - 11.9 SEER2 and 6.3 HSPF2

These new federal standards will be adopted by the program, beginning 1/1/2024. For the 2023 program year, the baseline equipment efficiencies are detailed in this section by replacement scenario.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT
The expected measure life is assumed to be 15 years.[228]

For early replacement, the remaining life of existing equipment is assumed to be 6 years for ASHP and Central AC, 7

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[226] Values represent the weighted average [SEER/EER/HSPF/AFUE] baseline values reflecting the assumed shares of installed DMSHP replacing given baseline technologies (e.g. ASHP/electric resistance or furnace/boiler) by fuel type. Assumed shares are based on Opinion Dynamics and Guidehouse analysis of 2018-2021 Ameren and ComEd HVAC (downstream) program tracking data. For further details, see '2018-2021 AIC Res HVAC Data ASHP Baseline TRM Update 2022-07-11.xls'.

[227] The 2023 federal standards (10 CFR 430.32(c)(5)) are in terms of an updated metric, depicted as SEER2 and HSPF2 and manufacturers must certify their products meet the standard according to the new test procedure and new metrics. The updated test method as well as the updated energy conservation standards were negotiated under the appliance standards and rulemaking federal advisory committee (ASRAC) in accordance with the Federal Advisory Committee Act (FACA) and the negotiated rulemaking act. An equivalent stringency of these new standards for split system heat pumps are 15 SEER and 8.8 HSPF and for single-package heat pumps are 14 SEER and 8 HSPF, as detailed in: Federal Code of Regulations, Energy Conservation Program: Energy Conservations Standards for residential Central Air Conditioners and Heat Pumps; Confirmation of effective date and compliance date for direct final rule, May 26, 2017, Docket: EERE-2014-BT-STD-0048 (https://www.regulations.gov/document/EERE-2014-BT-STD-0048-0200)

[228] Based on 2016 DOE Rulemaking Technical Support Document, as recommended in Navigant 'ComEd Effective Useful Life Research Report', May 2018.

years for furnace and unknown, 8 years for boilers[229] and 15 years for electric resistance.[230]

DEEMED MEASURE COST

New Construction and Time of Sale: The actual installed cost of the DMSHP (including any necessary electrical or distribution upgrades required) should be used (defaults are provided below), minus the assumed installation cost of the baseline equipment ($6562 + $600 per ton for ASHP,[231] or $2,011 for a new baseline 80% AFUE furnace, or $4,053 for a new 84% AFUE boiler,[232] and $952 per ton for new baseline Central AC replacement [233]).

Default full cost of the DMSHP is provided below. Note, for smaller units a minimum cost of $2,000 should be applied:[234]

Unit HSPF	Full Install Cost ($/ton)[235]
9-9.9	$1,443
10-10.9	$1,605
11-12.9	$1,715
13+	$2,041

The incremental cost of the DSMHP compared to a baseline minimum efficiency DSMHP is provided in the table below:[236]

Efficiency (HSPF)	Incremental Cost ($/ton) over an HSPF 8.0 DHP
9-9.9	$62
10-10.9	$224
11-12.9	$334
13+	$660

Early Replacement/retrofit (replacing existing equipment): The actual full installation cost of the DMSHP (including any necessary electrical or distribution upgrades required) should be used. The assumed deferred cost (after 8 years) of replacing existing equipment with a new baseline unit is assumed to be $7,527 + $688 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.[237] If replacing electric resistance heat, there is no deferred replacement cost. This future cost should be discounted to present value using the nominal societal discount rate.

Where the DMSHP is a supplemental HVAC system, the full installation cost of the DMSHP (including any necessary

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[229] Assumed to be one third of effective useful life of replaced equipment.
[230] 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.
[231] Full install ASHP costs are based upon data provided by Ameren. See 'ASHP Costs_06242022'.
[232] 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. Where efficiency ratings are not provided, the values are interpolated from those that are.
[233] Based on 3 ton initial cost estimate for a conventional unit from ENERGY STAR Central AC calculator
[234] The cost per ton table provides reasonable estimates for installation costs of DMSHP, which can vary significantly due to requirements of the home. It is estimated that all units, even those 1 ton or less will be at least $2000 to install.
[235] Full costs based upon full install cost of an ASHP plus incremental costs provided in Memo from Opinion Dynamics Evaluation Team, Ductless Mini-Split Heat Pumps: Incremental Cost Analysis, April 27, 2017.
[236] Memo from Opinion Dynamics Evaluation Team, Ductless Mini-Split Heat Pumps: Incremental Cost Analysis, April 27, 2017
[237] All baseline replacement costs are consistent with their respective measures and include inflation rate of 1.91%.

electrical or distribution upgrades required) should be used without a deferred replacement cost.

If the install cost is unknown a default is provided above. Fuel switch scenarios are likely to require additional installation work which may include adding new electrical circuits, capping existing gas lines and upgrading electrical panels. These costs are likely to range significantly and actual values should be used wherever possible. If unknown, assume an additional $300 for fuel switch installations.

LOADSHAPE

Loadshape R10 - Residential Electric Heating and Cooling   (if replacing gas heat and central AC)[238]

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 four different ways below. The first two relate to the use of DMSHP to supplement existing cooling or provide limited zonal cooling, the second two relate to use of the DMSHP to provide whole house cooling. In each pair, 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 metering data for 40 DMSHPs in Ameren Illinois service territory.[239]

For Single Zone DMSHPs providing supplemental or limited zonal cooling:

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

     = 43.1%[240]

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

     = 28.0%[241]

For Multi-Zone DMSHPs providing whole house cooling:

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

          = 72%[242]

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[238] The baseline for calculating electric savings is an Air Source Heat Pump.

[239] All-Electric Homes PY6 Metering Results: Multifamily HVAC Systems, Cadmus, October 2015

[240] 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)'.

[241] 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.

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

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

= 46.6%[243]

Algorithms

CALCULATION OF SAVINGS

ELECTRIC ENERGY AND FOSSIL FUEL SAVINGS
Non fuel switch measures:

$\Delta kWh_{NonFuelSwitch}$ = [Cooling Savings] + [Heating Savings]

= [(CoolingLoad * (1/$SEER_{Base}$ - 1/$SEER_{ee}$))/1000] + [(HeatLoad * $HeatLoadFactor_{elec}$ * (1/($HSPF_{Base}$ * HSPF_ClimateAdj) - 1/($HSPF_{ee}$ * HSPF_ClimateAdj)) / 1000]

Fuel switch measures:

Fuel switch measures must produce positive total lifecycle energy 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) = FuelSwitchSavings + NonFuelSwitchSavings

FuelSwitchSavings = GasHeatReplaced – DMSHPSiteHeatConsumed

NonFuelSwitchSavings = FurnaceFanSavings + DMSHPSiteCoolingImpact

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

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

DMSHPSiteHeatConsumed = ((HeatLoad * $HeatLoadFactor_{elec}$ * (1/$HSPF_{ee}$ * HSPF_ClimateAdj))/1000 * 3412) / 1,000,000

DMSHPSiteCoolingImpact = ((CoolingLoad * (1/$SEER_{Base}$ - 1/$SEER_{ee}$))/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:

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

Measure 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, 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.

Programs where existing system unknown

In programs where the existing fuel or system type is unknown, savings should be apportioned between the Fuel Switch and Non- Fuel Switch scenarios, as follows:

Savings from Non-Fuel Switch (kWh) $= (1 - \%FuelSwitch) * \Delta kWh_{Non\ Fuel\ Switch}$

Plus

Savings from Fuel Switch (MMBtu converted to appropriate fuel as table above)

$$= \%FuelSwitch * SiteEnergySavings\ (MMBTUs)$$

Where:

%FuelSwitch = The percentage of replacements resulting in fuel-switching.

= 1 when fuel switching is known

= where unknown, such as in a midstream program, determine through evaluation.

CoolingLoad = Annual cooling load being displaced

$= Capacity_{cool} * EFLH_{cool}$

$Capacity_{cool}$ = the total cooling output capacity of all the ductless heat pump units installed in Btu/hr[244]

= Actual installed

$EFLH_{cool}$ = Equivalent Full Load Hours for cooling. Depends on location. See table

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[244] 1 Ton = 12 kBtu/hr

below:[245]

Climate Zone (City based upon)	EFLH$_{cool}$
1 (Rockford)	323
2 (Chicago)	308
3 (Springfield)	468
4 (Belleville)	629
5 (Marion)	549
Weighted Average[246] ComEd Ameren Statewide	309 496 359

SEER$_{base}$ = Seasonal Energy Efficiency Ratio of baseline unit (kBtu/kWh). 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). If using rated efficiencies, derate efficiency value by 1% per year (maximum of 30 years) to account for degradation over time,[247] 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 – Standard sized	9.7[248]	14[249]	
Air Source Heat Pump – Space constrained	9.7	12	
Central AC – Standard sized	9.7[250]	13[251]	
Central AC – Space constrained	9.7	12	
Room AC	8.0[252]	13	

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[245] *All-Electric Homes PY6 Metering Results: Multifamily HVAC Systems*, Cadmus, October 2015. FLH values are based on metering of Multifamily units, and in buildings that had received weatherization improvements. Additional evaluation is recommended to refine the EFLH assumptions for the general population.

[246] Weighting for Ameren is based on electric accounts in each of the cooling zones. Weighting for ComEd and Statewide average is based on number of occupied residential housing units in each zone. ComEd is weighted average of Zones 1-2. Alternative program-weighted assumptions can be used if appropriate.

[247] 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).

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

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

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

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

[252] Estimated by converting the EER assumption for Room AC using the conversion equation; EER_base = (-0.02 * SEER_base^2) + (1.12 * SEER). From Wassmer, M. (2003). 'A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations', Masters Thesis, University of Colorado at Boulder.

Baseline/Existing Cooling System	SEERbase		
	Early Replacement (Remaining useful life of existing equipment)	Early Replacement (Remaining measure life)	Time of Sale or New Construction
No central cooling	Make '1/SEER_exist' = 0 [253]	13[254]	
Unknown [255]	9.95	13.28	

SEER$_{ee}$ = SEER rating of new equipment (kbtu/kwh)

= Actual installed[256]

HeatLoad = Calculated heat load being displaced

= EFLH$_{heat\_}$DMSHP * Capacity_DMSHPheat

EFLH$_{heat\_}$DMSHP = Ductless heat pump equivalent Full Load Hours for heating. Depends on location. See table below:

Climate Zone (City based upon)	EFLH$_{heat}$[257]
1 (Rockford)	1,520
2 (Chicago)	1,421
3 (Springfield)	1,347
4 (Belleville)	977
5 (Marion)	994
Weighted Average[258]	
ComEd	1,425
Ameren	1,243
Statewide	1,374

Capacity_DMSHPheat = the total rated 47°F heating output capacity of all the ductless heat pump units installed in Btu/hr

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[253] If there is no central cooling in place but the incentive encourages installation of a new ASHP with cooling, the added cooling load should be subtracted from any heating benefit.

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

[255] Values represent the weighted average SEER baseline values reflecting the assumed shares of installed DMSHP replacing given baseline technologies (e.g. ASHP/electric resistance or furnace/boiler) by fuel type. Assumed shares are based on Opinion Dynamics and Guidehouse analysis of 2018-2021 Ameren and ComEd HVAC (downstream) program tracking data. For further details, see '2018-2021 AIC Res HVAC Data ASHP Baseline TRM Update 2022-07-11.xls'.

[256] Note that if only an EER rating is available, use the following conversion equation; EER_base = (-0.02 * SEER_base^2) + (1.12 * SEER). From Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder.

[257] *All-Electric Homes PY6 Metering Results: Multifamily HVAC Systems*, Cadmus, October 2015. FLH values are based on metering of Multifamily units that were used as the primary heating source to the whole home, and in buildings that had received weatherization improvements. A DMSHP installed in a single-family home may be used more sporadically, especially if the DMSHP serves only a room, and buildings that have not been weatherized may require longer hours. Additional evaluation is recommended to refine the EFLH assumptions for the general population.

[258] Weighting for Ameren is based on electric heat accounts in each of the heating zones. Weighting for ComEd and Statewide average is based on number of occupied residential housing units in each zone. ComEd is weighted average of Zones 1-2. Alternative program-weighted assumptions can be used if appropriate.

= Actual

HeatLoadFactor = adjustment to reflect the heat load carried by the DMSHP in each use case, considering assumed operational strategy and switchover temperature, as well as DMSHP rated capacity.[259] If new DMSHP displaces all existing heating systems, assume 1. "Partial Displacement" application refers to the condition where an existing heating system remains in place to meet heating load not provided by the heat pump.

Use factor from table below. For programs where displacement scenario and switchover temperature is unknown, evaluation should determine appropriate weightings of the various scenarios including full displacement, partial displacement and cooling/heating only.

If Partial Displacement and Simultaneous Operation[260] with existing heat type, HeatLoadFactor:

Climate Zone	≤15 kBtu	>15 and ≤21 kBtu	>21 and ≤27 kBtu	>27 and ≤33 kBtu	>33 and ≤39 kBtu	>39 and ≤45 kBtu	>45 kBtu
1 (Rockford)	2.12	1.80	1.52	1.30	1.12	0.98	0.87
2 (Chicago)	2.25	1.89	1.58	1.33	1.14	0.99	0.87
3 (Springfield)	2.01	1.68	1.40	1.18	1.00	0.87	0.77
4 (Belleville)	2.89	2.34	1.90	1.58	1.34	1.16	1.02
5 (Marion)	2.50	1.93	1.53	1.25	1.05	0.90	0.79
ComEd Weighted Average	2.03	1.72	1.46	1.24	1.07	0.94	0.83
Ameren Weighted Average	2.15	1.81	1.51	1.27	1.09	0.95	0.84
Statewide Weighted Average	2.06	1.74	1.47	1.25	1.07	0.94	0.83

If Partial Displacement and Switchover[261] at >24°F, HeatLoadFactor:

Climate Zone	≤15 kBtu	>15 and ≤21 kBtu	>21 and ≤27 kBtu	>27 and ≤33 kBtu	>33 and ≤39 kBtu	>39 and ≤45 kBtu	>45 kBtu

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[259] Values for HeatLoadFactor were developed by applying DMSHP capacity curves of various sizes to a modeled full home load for each of the five IL TRM climate zones. The modeled home load was developed using eQuest simulation modeling with a home size of 2,500 square feet, single-story with attic construction, and utilizing default values for shell properties, occupancy levels, etc. Thermostat setpoints were fixed to 68F without daytime or nighttime setback. To determine the home load for each climate zone, the model home was simulated using TMY3 weather files specific to the five IL TRM climate zones. The resulting hourly heating loads, 8,760 values for each climate zone, were extracted from eQuest for further analysis.

[260] The heating setpoint for the ductless heat pump is assumed to be at least 2°F higher than any remaining existing system and the cooling setpoint for the ductless heat pump is assumed be at least 2°F cooler than the existing system (this should apply to all periods of a programmable schedule, if applicable). This is necessary such that the ductless heat pump is serving as the primary unit for heating and cooling.

[261] Temperature for switching from heat pump (used for the higher temperatures) to the supplemental system (used for lower temperatures).

1 (Rockford)	0.93	0.67	0.50	0.40	0.34	0.29	0.25
2 (Chicago)	1.06	0.77	0.58	0.46	0.39	0.33	0.29
3 (Springfield)	0.92	0.66	0.49	0.39	0.33	0.28	0.25
4 (Belleville)	1.71	1.24	0.93	0.74	0.62	0.53	0.46
5 (Marion)	1.54	1.07	0.80	0.64	0.53	0.46	0.40
ComEd Weighted Average	0.89	0.64	0.48	0.39	0.32	0.28	0.24
Ameren Weighted Average	0.99	0.72	0.54	0.43	0.36	0.31	0.27
Statewide Weighted Average	0.92	0.66	0.50	0.40	0.33	0.28	0.25

If Partial Displacement and Switchover at ≤24°F, HeatLoadFactor

Climate Zone	≤15 kBtu	>15 and ≤21 kBtu	>21 and ≤27 kBtu	>27 and ≤33 kBtu	>33 and ≤39 kBtu	>39 and ≤45 kBtu	>45 kBtu
1 (Rockford)	1.99	1.67	1.39	1.17	0.99	0.86	0.75
2 (Chicago)	2.14	1.78	1.47	1.22	1.03	0.89	0.78
3 (Springfield)	1.91	1.58	1.31	1.08	0.91	0.79	0.69
4 (Belleville)	2.79	2.24	1.80	1.48	1.25	1.07	0.94
5 (Marion)	2.47	1.90	1.50	1.22	1.02	0.88	0.77
ComEd Weighted Average	1.90	1.60	1.33	1.12	0.95	0.82	0.72
Ameren Weighted Average	2.04	1.70	1.40	1.17	0.99	0.85	0.74
Statewide Weighted Average	1.94	1.62	1.35	1.13	0.96	0.83	0.72

$HSPF_{base}$ =Heating Seasonal 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, 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,[262] or if unknown assume default:

	$HSPF_{Base}$		
Baseline/ Existing Heating System	Early Replacement (Remaining useful life of existing equipment)	Early Replacement (Remaining measure life)	Time of Sale or New Construction
Air Source Heat Pump	5.78[263]	8.2[264]	

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[262] 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).
[263] Based on Opinion Dynamics and Cadmus metering study of Ameren HVAC program participants; See 'AIC HVAC Metering Study Memo FINAL 2_28_2018'
[264] Based on Minimum Federal Standard effective 1/1/2015.

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
Electric Resistance	3.41[265]		
Unknown [266]	5.07	5.53	

HSPF_ClimateAdj = Adjustment factor to account for observed discrepency between seasonal heating performance relative to rated HSPF as provided by standard AHRI 210/240 rating conditions. Note, the adjustment is dependent on the displacement scenario and test method use for the rating (i.e. HSPF or HSPF2 rating) [267]:

Displacement Scenario	City (county based upon)	HSPF_ClimateAdj When using HSPF rating	HSPF_ClimateAdj When using HSPF2 rating
Partial Displacement	All	100%	
Whole Heat Load Displacement	1 (Rockford)	70%	74%
	2 (Chicago)	70%	74%
	3 (Springfield)	83%	87%
	4 (Belleville)	83%	87%
	5 (Marion)	83%	87%
	Weighted Average[268] ComEd Ameren Statewide	70% 81% 73%	74% 85% 77%

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,[269] or if unknown assume default:

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

[266] Values represent the weighted average HSPF baseline values reflecting the assumed shares of installed DMSHP replacing given baseline technologies (e.g. ASHP/electric resistance or furnace/boiler) by fuel type. Assumed shares are based on Opinion Dynamics and Guidehouse analysis of 2018-2021 Ameren and ComEd HVAC (downstream) program tracking data. For further details, see '2018-2021 AIC Res HVAC Data ASHP Baseline TRM Update 2022-07-11.xls'.

[267] Adjustment factors are based on findings from NEEA, July 2020 'EXP07:19 Load-based and Climate-Specific Testing and Rating Procedures for Heat Pumps and Air Conditioners'. See 'NEEA HP data' for calculation. Findings were consistent with other reviewed sources including ASHRAE, 2020 'Right-Sizing Electric Heat Pump and Auxiliary Heating for Residential Heating Systems Based on Actual Performance Associated with Climate Zone' and Cadmus, 2022 'Residential ccASHP Building Electrification Study'. The difference between HSPF and HSPF2 ratings is based on the change in testing procedure that will correct for some of this effect where ducted systems will have an approximately 5% lower HSPF2 rating as compared to HSPF, based on CEE presentation, July 2022, 'Testing Testing, M1, 2, 3: Trainsitioning to New Federal Minimum Standards'.

[268] Weighting for Ameren is based on electric heat accounts in each of the heating zones. Weighting for ComEd and Statewide average is based on number of occupied residential housing units in each zone. ComEd is weighted average of Zones 1-2. Alternative program-weighted assumptions can be used if appropriate.

[269] 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).

Baseline/ Existing Heating System	AFUEbase		
	Early Replacement (Remaining useful life of existing equipment)[270]	Early Replacement (Remaining measure life)	Time of Sale or New Construction
Furnace	64.4%	80%	80%
Boiler	61.6%	84%	84%
Unknown [271]	63%	81.1%	81.1%

$HSPF_{ee}$ = HSPF rating of new equipment (kbtu/kwh)

= Actual installed

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

= 0.44 for unknown baseline/existing heating systems[272]

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

For Early Replacement (1st 6 years) $F_e\_Exist = 3.14\%$[273]

For New Construction, Time of Sale and early replacement (remaining 10 years) $F_e\_New = 1.88\%$[274]

3412 = Btu per kWh

%IncentiveElectric = % of total incentive paid by electric utility

= Actual

%IncentiveGas = % of total incentive paid by gas utility

= Actual

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

[271] Values represent the weighted average AFUE baseline values reflecting the assumed shares of installed DMSHP replacing given baseline technologies (e.g. ASHP/electric resistance or furnace/boiler) by fuel type. Assumed shares are based on Opinion Dynamics and Guidehouse analysis of 2018-2021 Ameren and ComEd HVAC (downstream) program tracking data. For further details, see '2018-2021 AIC Res HVAC Data ASHP Baseline TRM Update 2022-07-11.xls'.

[272] Unknown value derived from Guidehouse DMSHP participant survey, 2022.

[273] F_e is not one of the AHRI certified ratings provided for residential furnaces, but can be reasonably estimated from a calculation based on the certified values for fuel energy (Ef in MMBtu/yr) and Eae (kWh/yr). An average of a 300 record sample (non-random) out of 1495 was 3.14%. This is, appropriately, ~50% greater than the ENERGY STAR version 3 criteria for 2% F_e. See "Programmable Thermostats Furnace Fan Analysis.xlsx" for reference.

[274] 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%.

Non Fuel Switch Illustrative Examples

Installing a 1.5-ton (heating and cooling capacity) ductless heat pump unit rated at 8 HSPF and 14 SEER in a single-family home in Chicago to partially displace electric baseboard heat with switchover at 20°F and replace a window air conditioner of unknown efficiency, savings are:

ΔkWh_{heat} = (18000 * 1421 * 1.78 * (1/3.412 – 1/8))/1000 = 7,653 kWh

ΔkWh_{cool} = (18000 * 308 *(1/8.0 – 1/14)) /1000 = 297 kWh

ΔkWh = 7,653 + 297 = 7,950 kWh

Fuel Switch Illustrative Examples

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

Installing a 1.5-ton (heating and cooling capacity) ductless heat pump unit rated at 9 HSPF and 16 SEER in a single-family home in Chicago to partially displace gas furnace heat with switchover at 28°F and replace a central air conditioner of unknown efficiency, savings are:

LifetimeSiteEnergySavings (MMBTUs) = LifetimeGasHeatReplaced + LifetimeFurnaceFanSavings – LifetimeDMSHPSiteHeatConsumed + LifetimeDMSHPSiteCoolingImpact

LifetimeGasHeatReplaced = ((HeatLoad * 1/AFUE$_{exist}$) / 1,000,000 * 6 years) + ((HeatLoad * 1/AFUE$_{base}$) / 1,000,000 * 9 years)

= ((1421 * 18,000 * 0.77 * 1/0.644) / 1,000,000 * 6) + ((1421 * 18,000 * 0.77 * 1/0.8) / 1,000,000 * 9)

= 405.1 MMBtu

LifetimeFurnaceFanSavings = ((FurnaceFlag * HeatLoad * 1/AFUE$_{exist}$ * F$_e$_Exist) / 1,000,000 * 6 years) + ((FurnaceFlag * HeatLoad * 1/AFUE$_{base}$ * F$_e$_New) / 1,000,000 * 9 years)

= ((1 * 1421 * 18,000 * 0.77 * 1/0.644 * 0.0314) / 1,000,000 * 6) + ((1 * 1421 * 18,000 * 0.77 * 1/0.8 * 0.0188) / 1,000,000 * 9)

= 9.9 MMBtu

LifetimeDMSHPSiteHeatConsumed = ((HeatLoad * (1/HSPF$_{ee}$))/1000 * 3412) / 1,000,000 * 15 years

= ((1421 * 18,000 * 0.77 * (1/9)) / 1000 * 3412)/1,000,000 * 15

= 112.0 MMBtu

LifetimeDMSHPSiteCoolingImpact = (((Capacity$_{cool}$* EFLH$_{cool}$ * (1/SEER$_{Exist}$ - 1/SEER$_{ee}$))/1000 * 3412) / 1,000,000 * 6 years) + (((Capacity$_{cool}$* EFLH$_{cool}$ * (1/SEER$_{Base}$ - 1/SEER$_{ee}$))/1000 * 3412) / 1,000,000 * 9 years)

= ((((308 * 18,000 * (1/9.3 – 1/16))/1000 * 3412)/1,000,000 * 6) + (((308 * 18,000 * (1/13 –1/16))/1000 * 3412) /1,000,000 * 9)

= 7.6 MMBtu

Fuel Switch Illustrative Examples continued

First 6 years:

$$\text{SiteEnergySavings\_FirstYear (MMBTUs)} = \text{GasHeatReplaced} + \text{FurnaceFanSavings} - \text{DMSHPSiteHeatConsumed} + \text{DMSHPSiteCoolingImpact}$$

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

$= (1421 * 18{,}000 * 0.77 * 1/0.644) / 1{,}000{,}000$

$= 30.6 \text{ MMBtu}$

$\text{FurnaceFanSavings} = (\text{FurnaceFlag} * \text{HeatLoad} * 1/\text{AFUE}_{Exist} * F_{e\_Exist}) / 1{,}000{,}000$

$= (1 * 1421 * 18{,}000 * 0.77 * 1/0.644 * 0.0314) / 1{,}000{,}000$

$= 0.9 \text{ MMBtu}$

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

$= ((1421 * 18{,}000 * 0.77 * (1/9)) / 1000 * 3412)/1{,}000{,}000$

$= 7.5 \text{ MMBtu}$

$\text{DMSHPSiteCoolingImpact} = ((\text{Capacity}_{cool} * \text{EFLH}_{cool} * (1/\text{SEER}_{Exist} - 1/\text{SEER}_{ee}))/1000 * 3412) / 1{,}000{,}000$

$= ((308 * 18{,}000 * (1/9.3 - 1/16))/1000 * 3412)/1{,}000{,}000$

$= 0.9 \text{ MMBtu}$

$$\text{SiteEnergySavings\_FirstYear (MMBTUs)} = 30.6 + 0.9 - 7.5 + 0.9 = 24.9 \text{ MMBtu}$$

Remaining 9 years:

$$\text{SiteEnergySavings\_PostAdj (MMBTUs)} = \text{GasHeatReplaced} + \text{FurnaceFanSavings} - \text{DMSHPSiteHeatConsumed} + \text{DMSHPSiteCoolingImpact}$$

$\text{GasHeatReplaced} = (1421 * 18{,}000 * 0.77 * 1/0.8) / 1{,}000{,}000$

$= 24.6 \text{ MMBtu}$

$\text{FurnaceFanSavings} = (1 * 1421 * 18{,}000 * 0.77 * 1/0.8 * 0.0188) / 1{,}000{,}000$

$= 0.5 \text{ MMBtu}$

$\text{DMSHPSiteHeatConsumed} = ((1421 * 18{,}000 * 0.77 * (1/9)) / 1000 * 3412)/1{,}000{,}000$

Fuel Switch Illustrative Example continued

Savings would be claimed as follows:

Measure supported by:	Electric Utility claims:	Gas Utility claims:
Electric utility only	First 6 years: 24.9 * 1,000,000/3412 = 7298 kWh Remaining 10 years: 17.9 * 1,000,000/3412 = 5246 kWh	N/A
Electric and gas utility	First 6 years: 24.9 * 0.5 * 1,000,000/3412 = 3649 kWh Remaining 10 years: 17.9 * 0.5 * 1,000,000/3412 = 2623 kWh	First 6 years: 24.9 * 0.5 * 10 = 124.5 Therms Remaining 10 years: 17.9 * 0.5 * 10 = 89.5 Therms
Gas utility only	N/A	First 6 years: 24.9 * 10 = 249 Therms Remaining 10 years: 17.9 * 10 = 179 Therms

SUMMER COINCIDENT PEAK DEMAND SAVINGS

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

Where:

EER_base = 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.[275] 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 – Standard sized	7.83[276]	11[277]	
Air Source Heat Pump – space constrained	7.83	10.5	

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[275] 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).

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

[277] 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'.

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 – Standard sized	7.83[278]	10.5[279]	
Central AC – space constrained	7.83	10.5	
Room AC	7.7[280]	10.5	
No central cooling	Make '1/EER_exist' = 0 [281]	10.5[282]	
Unknown [283]	7.77	10.5	

EER_ee = Energy Efficiency Ratio of new ductless Air Source Heat Pump (kBtu/hr / kW)

= Actual, If not provided convert SEER to EER using this formula: [284]

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

For Single Zone DMSHPs providing supplemental or limited zonal cooling:

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

= 43.1%[285]

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

= 28.0%[286]

For Multi Zone DMSHPs providing whole house cooling:

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

= 72%[287]

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

[279] 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'.

[280] Same EER as Window AC recycling. Based on Nexus Market Research Inc, RLW Analytics, December 2005; "Impact, Process, and Market Study of the Connecticut Appliance Retirement Program: Overall Report."

[281] If there is no central cooling in place but the incentive encourages installation of a new ASHP with cooling, the added cooling load should be subtracted from any heating benefit.

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

[283] Program tracking data does not provide an EER value. These are estimated based on the other values in the table.

[284] 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.

[285] 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)'.

[286] 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.

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

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

= 46.6%[288]

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 DMSHP projects per Section 16-111.5B, changes in site energy use at the customer's meter (using ΔkWh algorithm below), 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, should therefore reflect the decrease in one fuel and increase in another, as opposed to the single savings value calculated in the "Electric and Fossil Fuel Energy Savings" section 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]

= [(HeatLoad * HeatLoadFactor$_{gas}$ * 1/AFUE$_{base}$) / 100,000]

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

= [FurnaceFlag * HeatLoad * HeatLoadFactor$_{gas}$ * 1/AFUE$_{base}$ * F$_e$ * 0.000293] - [(HeatLoad * HeatLoadFactor$_{elec}$ * 1/(HSPFee * HSPF_ClimateAd))/1000] + [(Capacity$_{cool}$* EFLH$_{cool}$ * (1/SEER$_{Base}$- 1/SEER$_{ee}$)) / 1000]

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REVIEW DEADLINE: 1/1/2025

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

5.5.6 LED Specialty Lamps

DESCRIPTION

Please note that this measure characterization contains specific assumptions that were negotiated as a compromise between the utilities and stakeholders and also reflects input from community-based organizations. The compromise is designed to allow for a gradual change in lncome Qualified programming and to address the unique challenges that an abrupt change makes within the context of the Illinois CPAS savings goal structure. Such compromise shall not be taken as precedent for future non-consensus discussions.

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 not in a store 'easily accessed by income qualified communities' (see discussion below)) a deemed split of 96% Residential and 4% Commercial assumptions should be used.[289] For stores easily accessed by income qualified communities, 100% of sales are assumed to be Income Qualified (IQ) residential.

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 or equivalent to the most recent version of ENERGY STAR specifications. 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. In September 2019 this decision was revoked in a new DOE Final Rule. However, in May 2022 DOE reversed this decision by issuing a Final rule for both the broadened General Service Lamp definition as well as the implementation of the 45 lumen per watt backstop. DOE stated that it will use its enforcement discretion to minimize impacts on the supply chain and effectively allow companies to continue the manufacture and import of noncompliant bulbs through the remainder of 2022, and allow retailers to continue selling them with limited enforcement until July 2023.

Non-Income Qualified Programs

This TRM assumes that non-income qualified participants would continue to have access to baseline / noncompliant bulbs through retail until 6/30/2023 after which the baseline for new purchases becomes an LED (since only CFL and LED are able to meet the 45 lu/watt standard and CFLs now make up <1% of the market). For purchases made before this date it is assumed that stockpiles would remain through the remainder of 2023 such that the measure life for 2023 purchases is reduced to 2 years.

Direct Install programs where it can be shown that the LED is replacing working inefficient lighting should continue to use the existing inefficient lighting as baseline and also assume a measure life of 2 years.

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[289] 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'.

Income Qualified Programs

Through 2025, Retail programs in stores 'easily accessed by income qualified communities' (as defined below), and Kit, School and Foodbank programs, will continue to assume a halogen baseline and apply a measure life of 8 years.

A store is considered easily accessed by income qualified communities[290]:

- a. For Ameren:
  - i. if it is a retail store that is closest to a community with a zip code that has 65% of family households with an income less than or equal to 299% of the Federal poverty level for their household size (Applies to big box (e.g., Walmart), club (e.g., Costco), DIY (e.g., Home Depot), hardware and grocery stores); or
  - ii. If it is a "dollar store" in the AIC service area; or
  - iii. If it is a "thrift store" in the AIC service area.
- b. For ComEd:
  - i. if it is a retail store is within a zip code where at least 60% or more of the households are at or below 80% Area Median Income (AMI); or
  - ii. If it is a "dollar store" in the ComEd service area; or
  - iii. If it is a "thrift store" in the ComEd service area.

100% of sales from such stores as defined above will count as IQ lighting.

Direct Install programs where it can be shown that the LED is replacing working inefficient lighting should continue to use the existing inefficient lighting as baseline and also assume a measure life of 8 years.

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 and 100 percent in IECC 2021) of the lamps in permanently installed lighting fixtures shall be high-efficacy lamps or not less than 75 percent (90 percent in IECC 2018 and 100 percent in IECC 2021) 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) or 100% (IECC 2021) of the New Construction baseline is an LED and therefore savings are reduced by that percentage for bulbs provided in New Construction projects. Any New Construction project utilitizing IECC 2021 code should therefore not include savings from this measure.

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.

However, for all purchases through 2025 the measure life is assumed to be two years for non-income eligible populations and eight years for income eligible populations.

DEEMED MEASURE COST
The price of LED lamps is falling quickly. Where possible, the actual cost should be used and compared to the baseline

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[290] Utilities to provide list of all stores that are easily accessed by income qualified communities, as defined above, by December 31, 2022, with one of the utility's quarterly reports and to the utility's independent evaluator. The Utilities will update the list of stores annually, by December 31 of each year of the current portfolio cycle in a similar fashion.

cost provided below. If the incremental cost is unknown, assume the following:[291]

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,[292] 0.273 for exterior bulbs[293] and 0.117 for unknown[294]. 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.[295]

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

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[291] 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.
[292] 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.
[293] 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.
[294] 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.
[295] 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)	310	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)	310	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)	310	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)	310	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
Decorative (Shape ST)	310	499	6.5	40	14.9	9.9	33.5	8.4	3.4
	500	999	8.8	60	21.6	13.9	51.2	12.8	5.1
	1000	1500	10.0	100	32.5	19.0	90.0	22.5	9.0
Decorative (Shape S)	310	340	2.25	25	7.9	4.5	22.8	5.7	2.3

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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:[296]

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[296] 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 (Watts$_{EE}$)	Delta Watts for New Construction (Watts$_{EE}$)	
					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	3,299	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)	310	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	310	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.[297] 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.[298]

Wattsbase =

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

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[297] See 'ESLampCenterBeamTool.xls'.

[298] 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.

Where:

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

        BA   = Beam angle

        CBCP   = Center beam candle power

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

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

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 (Watts$_{EE}$)	Delta Watts for New Construction (Watts$_{EE}$)	
					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)	310	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		In Service Rate (ISR) [299]
Retail (Time of Sale)		97.9%[300]
Direct Install		94.5%[301]
Virtual Assessment followed by Unverified Self-Install		97.9%[302]
Efficiency Kits[303]	LED Distribution[304]	82.8%
	School Kits[305]	83.8%
	Direct Mail Kits[306]	91.8%
	Direct Mail Kits, Income Qualified[307]	64.8%
	Community Distributed Kits[308]	95.0%

Leakage   = Adjustment to account for the percentage of program bulbs that move out (and in if deemed appropriate)[309] of the Utility Jurisdiction.

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[299] In Service Rates now represent the lifetime In Service Rates with the second and third year installations discounted by the Real Discount Rate of 0.46%. Lifetime 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. For all other programs 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.

[300] 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).

[301] 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.

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

[303] 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.

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

[305] 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.

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

[307] Research from 2021 Ameren Illinois Income Qualified participant survey (customer self-report), available on IL SAG website: https://ilsag.s3.amazonaws.com/AIC-Income-Qualified-Initiative-Participant-Survey-Results-Memo-FINAL-2022-02-01.pdf

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

[309] 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:[310]

        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[311]
Exterior	2,475[312]
Unknown	1,020[313]

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

Bulb Location	WHFe
Interior single family	1.06 [314]
Multifamily in unit	1.04 [315]
Exterior or uncooled location	1.0
Unknown location	1.046[316]

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

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

[311] 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.

[312] 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.

[313] 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.

[314] 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)

[315] 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)

[316] 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:

$\Delta kWh = ((75 - 13) / 1000) * 0.840 * (1 - 0.011) * 763 * 1.06$

$= 41.6 \text{ kWh}$

HEATING PENALTY

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

$\Delta kWh[317] = - (((WattsBase - WattsEE) / 1000) * ISR * (1-Leakage) * Hours * HF) / \eta Heat$

Where:

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

= 49% for interior location [318]

= 0% for exterior location

= 42% for unknown location [319]

$\eta Heat$ = Efficiency in COP of Heating equipment

= Actual. If not available use: [320]

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[321]	N/A	N/A	1.28

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

[318] 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.

[319] 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.

[320] 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.

[321] 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.

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:

$$\Delta kWh = - (((75 - 13) / 1000) * 0.840 * (1 - 0.011) * 763 * 0.49) / 2.04$$
$$= - 9.4 \text{ kWh}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = ((WattsBase - WattsEE) / 1000) * ISR * (1-Leakage) * WHFd * CF$$

Where:

WHFd = Waste heat factor for demand to account for cooling savings from efficient lighting.

Bulb Location	WHFd
Interior single family	1.11[322]
Multifamily in unit	1.07[323]
Exterior or uncooled location	1.0
Unknown location	1.083[324]

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[325], 0.273 for exterior bulbs,[326] and 0.117 for unknown.[327]

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

Other factors as defined above

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[322] 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.

[323] 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)

[324] 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.

[325] 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.

[326] 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.

[327] 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.

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:

$$\Delta kW = (((75 - 13) / 1000) * 0.840 * (1 – 0.011) * 1.11 * 0.109$$
$$= 0.0062 \text{ kW}$$

FOSSIL FUEL SAVINGS

Heating penalty if Natural Gas heated home, or if heating fuel is unknown.

$$\Delta therms = - (((WattsBase - WattsEE) / 1000) * ISR * (1-Leakage) * Hours * HF * 0.03412) / \eta Heat$$

Where:

HF	= Heating factor, or percentage of lighting savings that must be replaced by heating system.
	= 49% for interior[328]
	= 0% for exterior location
	= 42% for unknown location[329]
0.03412	= Converts kWh to Therms
$\eta Heat$	= Average heating system efficiency.
	= 0.70 [330]
	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:

$$\Delta therms = - (((75 - 13) / 1000) * 0.840 * (1 – 0.011) * 763 * 0.49 * 0.03412) / 0.70$$
$$= - 0.94 \text{ therms}$$

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[328] Average result from REMRate modeling of several different configurations and IL locations of homes

[329] 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.

[330] 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

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

For non-income eligible populations, no O&M costs should be applied.

For income eligible populations, an annual baseline cost of $1.74 for decorative and $3.53 for directional should be applied.

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-V16-230101

REVIEW DEADLINE: 1/1/2024

5.5.8   LED Screw Based Omnidirectional Bulbs

DESCRIPTION

Please note that this measure characterization contains specific assumptions that were negotiated as a compromise between the utilities and stakeholders and also reflects input from community-based organizations. The compromise is designed to allow for a gradual change in Income Qualified programming and to address the unique challenges that an abrupt change makes within the context of the Illinois CPAS savings goal structure. Such compromise shall not be taken as precedent for future non-consensus discussions.

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 not in a store 'easily accessed by income qualified communities' (see discussion below)) a deemed split of 97% Residential and 3% Commercial assumptions should be used.[331] For stores easily accessed by income qualified communities, 100% of sales are assumed to be Income Qualified (IQ) residential.

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 or equivalent to the most recent version of ENERGY STAR specifications. 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. In December 2019, DOE issued a final determination for General Service Incandescent Lamps (GSILs), finding that this more stringent standard was not economically justified. However, in May 2022 DOE reversed this decision by issuing a Final rule for both the broadened General Service Lamp definition as well as the implementation of the 45 lumen per watt backstop. DOE stated that it will use its enforcement discretion to minimize impacts on the supply chain and effectively allow companies to continue the manufacture and import of noncompliant bulbs through the remainder of 2022, and allow retailers to continue selling them with limited enforcement until July 2023.

Non-Income Qualified Programs

This TRM assumes that non-income qualified participants would continue to have access to baseline / noncompliant bulbs through retail until 6/30/2023 after which the baseline for new purchases becomes an LED (since only CFL and LED are able to meet the 45 lu/watt standard and CFLs now make up <1% of the market). For purchases made before this date it is assumed that stockpiles would remain through the remainder of 2023 such that the measure life for 2023 purchases is reduced to 2 years.

Direct Install programs where it can be shown that the LED is replacing working inefficient lighting should continue

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[331] 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'.

to use the existing inefficient lighting as baseline and also assume a measure life of 2 years.

Income Qualified Programs

Through 2025, Retail programs in stores 'easily accessed by income qualified communities' (as defined below), and Kit, School and Foodbank programs, will continue to assume a halogen baseline and apply a measure life of 8 years.

A store is considered easily accessed by income qualified communities[332]:

    c.   For Ameren:
         i.   if it is a retail store that is closest to a community with a zip code that has 65% of family households with an income less than or equal to 299% of the Federal poverty level for their household size (Applies to big box (e.g., Walmart), club (e.g., Costco), DIY (e.g., Home Depot), hardware and grocery stores); or
        ii.   If it is a "dollar store" in the AIC service area; or
       iii.   If it is a "thrift store" in the AIC service area.
    d.   For ComEd:
         i.   if it is a retail store is within a zip code where at least 60% or more of the households are at or below 80% Area Median Income (AMI); or
        ii.   If it is a "dollar store" in the ComEd service area; or
       iii.   If it is a "thrift store" in the ComEd service area.

100% of sales from such stores as defined above will count as IQ lighting.

Direct Install programs where it can be shown that the LED is replacing working inefficient lighting should continue to use the existing inefficient lighting as baseline and also assume a measure life of 8 years.

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 and 100 percent in IECC 2021) of the lamps in permanently installed lighting fixtures shall be high-efficacy lamps or not less than 75 percent (90 percent in IECC 2018 and 100 percent in IECC 2021) 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) or 100% (IECC 2021) of the New Construction baseline is an LED and therefore savings are reduced by that percentage for bulbs provided in New Construction projects. Any New Construction project utilizing IECC 2021 code should therefore not include savings from this measure.

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.

However, for all purchases through 2025 the measure life is assumed to be two years for non-income eligible populations and eight years for income eligible populations.

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[332] Utilities to provide list of all stores that are easily accessed by income qualified communities, as defined above, by December 31, 2022, with one of the utility's quarterly reports and to the utility's independent evaluator. The Utilities will update the list of stores annually, by December 31 of each year of the current portfolio cycle in a similar fashion.

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:[333]

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,[334] 0.273 for exterior bulbs,[335] and 0.135 for unknown,[336]

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:[337]

LED New and Baseline Assumptions Table

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[333] 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.

[334] 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.

[335] 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.

[336] 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.

[337] 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)	Baseline for New Construction (WattsBase)		Delta Watts (WattsEE)	Delta Watts for New Construction (WattsEE)	
				(IECC 2015)	(IECC 2018)		(IECC 2015)	(IECC 2018)
310	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	3,299	28.9	200	71.7	46.0	171.1	42.8	17.1

ISR = In Service Rate, the percentage of lamps rebated that are actually in service.

Program		In Service Rate (ISR)[338]s
Retail (Time of Sale)		97.9%[339]
Direct Install		94.5%[340]
Virtual Assessment followed by Unverified Self-Install		97.9%[341]
Efficiency Kits[342]	LED Distribution[343]	82.8%
	School Kits[344]	83.8%
	Direct Mail Kits[345]	91.8%
	Direct Mail Kits, Income	60%

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[338] In Service Rates now represent the lifetime In Service Rates with the second and third year installations discounted by the Real Discount Rate of 0.46%. Lifetime 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. For all other programs Tthe 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.
[339] 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).
[340] 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.
[341] An equal weighted average of Direct Install and Direct Mail Kit ISRs. Interest and applicability of measures confirmed through virtual assessment.
[342] 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.
[343] Free bulbs provided without request, with little or no education. Consistent with Standard CFL assumptions.
[344] 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.
[345] Opt-in program to receive kits via mail, with little or no education. Consistent with Standard CFL assumptions.

Program		In Service Rate (ISR)[338]s
	Qualified[346]	
	Community Distributed Kits[347]	95.0%
Food Bank / Pantry Distribution[348]		97.9%[349]

Leakage = Adjustment to account for the percentage of program bulbs that move out (and in if deemed appropriate)[350] of the Utility Jurisdiction.

KITS programs = Determined through evaluation

Upstream (TOS) Lighting programs = Use deemed assumptions below:[351]

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[352]
Exterior	2,475[353]
Unknown	1,159[354]

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

Bulb Location	WHFe
Interior single family	1.06 [355]

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[346] Research from 2021 Ameren Illinois Income Qualified participant survey (customer self-report), available on IL SAG website: https://ilsag.s3.amazonaws.com/AIC-Income-Qualified-Initiative-Participant-Survey-Results-Memo-FINAL-2022-02-01.pdf

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

[348] Free bulbs provided through local food banks and food pantries.

[349] 1st year ISR is determined based on online surveys conducted for ComEd CY2018 Food Bank LED Distribution program. See 'CY2018 ComEd Foodbank LED Dist Survey Results_Navigant'.

[350] 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.

[351] Leakage rate is based upon review of PY8-CY2018 evaluations from ComEd and PY8 for Ameren.

[352] 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.

[353] 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.

[354] 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.

[355] 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

Bulb Location	WHFe
Multifamily in unit	1.04 [356]
Exterior or uncooled location	1.0
Unknown location	1.051[357]

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:

$$\Delta kWh = ((29.0 - 8) /1000) * 0.784 * (1 - 0.008) * 1,089 * 1.06$$

$$= 18.9 \text{ kWh}$$

HEATING PENALTY

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

$$\Delta kWh^{[358]} = - (((WattsBase - WattsEE) / 1000) * ISR * (1-Leakage) * Hours * HF) / \eta Heat$$

Where:

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

= 49% for interior[359]

= 0% for exterior or unheated location

= 42% for unknown location[360]

ηHeat = Efficiency in COP of Heating equipment

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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)

[356] 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)

[357] 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.

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

[359] 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.

[360] 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.

= actual. If not available use:[361]

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[362]	N/A	N/A	1.28

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.

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[363]
Multifamily in unit	1.07[364]
Exterior or uncooled location	1.0
Unknown location	1.093[365]

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[361] 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.

[362] 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.

[363] 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.

[364] 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)

[365] 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.

CF = Summer Peak Coincidence Factor for measure.

Bulb Location	CF
Interior	0.128[366]
Exterior	0.273[367]
Unknown	0.135[368]

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.

FOSSIL FUEL 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[369]

= 0% for exterior location

= 42% for unknown location[370]

0.03412 = Converts kWh to Therms

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[366] 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.

[367] 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.

[368] 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.

[369] Average result from REMRate modeling of several different configurations and IL locations of homes

[370] 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.

ηHeat = Average heating system efficiency.

= 0.70 [371]

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

For non-income eligible populations, no O&M costs should be applied.

For income eligible populations, an annual baseline cost of $1 should be applied.

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-LEDA-V15-230101

REVIEW DEADLINE: 1/1/2024

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[371] 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:
$(0.24*0.92) + (0.76*0.8) * (1-0.15) = 0.70$

5.5.13 EISA Exempt LED Lighting

DESCRIPTION

This characterization provides savings assumptions for LED lamps and fixture types that are exempt from the EISA legislation. 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.[372]

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 or equivalent to the most recent version of ENERGY STAR specifications or be listed on the Design Lights Consortium Qualifying Product List. Note a new ENERGY STAR specification v2.1 became effective on 1/2/2017.

DEFINITION OF BASELINE EQUIPMENT

This measure is only for lamp and fixture types that are exempt from EISA, including lamps with an initial lumen output of less than 310 lumens, with initial lumen output greater than 3,300 lumens, and Task/Undercabinet Fixtures with a linear fluorescent baseline.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The average rated life for lamps on the ENERGY STAR Qualified Products list (accessed 6/16/2020) is approximately 20,000 hours for omnidirectional lamps, 17,000 hours for decorative lamps and 25,000 for directional lamps. The deemed measure life is 8 years for exterior omnidirectional lamps and 6.9 years for exterior decorative lamps and lifetimes are capped at 10 years for other applications.[373] 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.[374]

The rated life of linear task and under cabinet fixtures is 45,000 hours[375] and for T-LEDS is 50,000 hours. However, all fixture lifetimes are capped at 15 years.[376]

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:

Type	Incremental Cost
Omni-directional A-Lamps	$1.45[377]

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[372] 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'.

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

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

[375] Average rated lives are based on the average rated lives of fixtures available on the ENERGY STAR qualifying list as of 2/26/2018.

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

[377] 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.

Type	Incremental Cost
Decorative	$1.66
Directional	$1.65
Linear Task/Under Cabinet	$18[378]
T-LEDs	$13[379]

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,[380] 0.273 for exterior bulbs,[381] and 0.135 for unknown,[382]

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:[383]

LED New and Baseline Assumptions Table

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[378] Incremental costs for task/under cabinet and downlight fixtures are from the 2018 Michigan Energy Measures Database.
[379] Consistent with measure 4.5.4 LED Bulbs and Fixtures in Volume 2.
[380] 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.
[381] 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.
[382] 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.
[383] 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.

Type		Minimum Lumens	Maximum Lumens	LED Wattage (WattsEE)	Baseline (WattsBase)	Delta Watts
A-Lamps		120	309	4.0	25	21.0
		3,300	3,999	28.9	200	171.1
		4,000	5,000	35.7	300	264.3
Decorative	Globe (medium and intermediate bases less than 750 lumens)	150	309	3.0	25	22
	Globe (candelabra bases less than 1050 lumens)	150	309	3.5	25	21.5
	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	309	4.3	40	35.7
	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	309	4.2	40	35.8
	Decorative (Shape ST)	250	309	6.5	40	33.5
	Decorative (Shape S)	50	75	1.0	11	10.0
		100	120	1.2	15	13.8
		120	309	2.25	25	22.8
Directional	Reflector lamp types with medium screw bases (PAR20, PAR30(S,L), PAR38, R40, etc.) w/ diameter >2.25"	3,300	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	309	4.6	35	30.4
	*MR16	250	309	3.8	20.0	16.2
Linear Task/Under Cabinet		All		11.6	45.2	33.6
T-LEDs		0	1,199	8.9	15	6.1
		1,200	2,399	15.8	28.2	12.4
		2,400		22.9	41.8	18.9

ISR   = In Service Rate, the percentage of lamps rebated that are actually in service.

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Program		In Service Rate (ISR)[384]
Retail (Time of Sale)		97.9%[385]
Direct Install		94.5%[386]
Virtual Assessment followed by Unverified Self-Install		97.9%[387]
Efficiency Kits[388]	LED Distribution[389]	82.8%
	School Kits[390]	83.8%
	Direct Mail Kits[391]	91.8%
	Direct Mail Kits, Income Qualified[392]	60%
	Community Distributed Kits[393]	95.0%
Food Bank / Pantry Distribution[394]		97.9%[395]

Leakage = Adjustment to account for the percentage of program bulbs that move out (and in if deemed appropriate)[396] of the Utility Jurisdiction.

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[384] In Service Rates now represent the lifetime In Service Rates with the second and third year installations discounted by the Real Discount Rate of 0.46%. Lifetime 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. For all other programs Tthe 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.

[385] 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).

[386] 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.

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

[388] 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.

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

[390] 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.

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

[392] Research from 2021 Ameren Illinois Income Qualified participant survey (customer self-report), available on IL SAG website: https://ilsag.s3.amazonaws.com/AIC-Income-Qualified-Initiative-Participant-Survey-Results-Memo-FINAL-2022-02-01.pdf

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

[394] Free bulbs provided through local food banks and food pantries.

[395] 1st year ISR is determined based on online surveys conducted for ComEd CY2018 Food Bank LED Distribution program. See 'CY2018 ComEd Foodbank LED Dist Survey Results_Navigant'.

[396] 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

KITS programs = Determined through evaluation

Upstream (TOS) Lighting programs = Use deemed assumptions below:[397]

        ComEd: 0.8%

        Ameren: 13.1%

    All other programs   = 0

Hours   = Average hours of use per year

Type	Installation Location	Hours
Omnidirectional A-Lamps	Residential and in-unit Multi Family	1,089[398]
	Exterior	2,475[399]
	Unknown	1,159[400]
Decorative and Directional Lamps	Residential and In-Unit Multi Family	763[401]
	Exterior	2,475[402]
	Unknown	1,020[403]
Linear Task/Under Cabinet	All	730[404]
T-LEDs	All	730[405]

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

Bulb Location	WHFe
Interior single family	1.06 [406]

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.

[397] Leakage rate is based upon review of PY8-CY2018 evaluations from ComEd and PY8 for Ameren.

[398] 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.

[399] 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.

[400] 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.

[401] 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.

[402] 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.

[403] 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.

[404] Task/under cabinet hours of use are estimated at 2 hours per day.

[405] Consistent with Linear Task/Under Cabinet assumption.

[406] 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

Bulb Location	WHFe
Multifamily in unit	1.04 [407]
Exterior or uncooled location	1.0
Unknown location	1.051[408]

For example, an 4W LED lamp, 300 lumens, is installed in the interior of a home. The customer purchased the lamp through a ComEd upstream program:

ΔkWh = ((25.0 - 4) /1000) * 0.784 * (1 - 0.008) * 1,089 * 1.06

= 18.9 kWh

HEATING PENALTY

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

$$\Delta kWh^{409} = - (((WattsBase - WattsEE) / 1000) * ISR * (1-Leakage) * Hours * HF) / \eta Heat$$

Where:

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

= 49% for interior[410]

= 0% for exterior or unheated location

= 42% for unknown location[411]

ηHeat = Efficiency in COP of Heating equipment

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)

[407] 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)

[408] 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.

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

[410] 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.

[411] 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.

= actual. If not available use:[412]

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[413]	N/A	N/A	1.28

For example: using the same 4W LED that is installed in home with 2.0 COP Heat Pump (including duct loss) through a ComEd upstream program:

$\Delta kWh_{1st\ year}$ = - (((25 - 4) / 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.

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[414]
Multifamily in unit	1.07[415]
Exterior or uncooled location	1.0
Unknown location	1.093[416]

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[412] 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.

[413] 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.

[414] 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.

[415] 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)

[416] 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.

CF   = Summer Peak Coincidence Factor for measure.

Bulb Location	CF
Interior	0.128[417]
Exterior	0.273[418]
Unknown	0.135[419]

Other factors as defined above

For example: for the same 4W LED that is installed in a single family interior location through a ComEd upstream program:

ΔkW   = ((25 - 4) / 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.

FOSSIL FUEL 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[420]

                 = 0% for exterior location

                 = 42% for unknown location[421]

0.03412   = Converts kWh to Therms

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[417] 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.

[418] 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.

[419] 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.

[420] Average result from REMRate modeling of several different configurations and IL locations of homes

[421] 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.

ηHeat   = Average heating system efficiency.

                   = 0.70 [422]

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

For Omni-directional A-lamps, the baseline lamp is assumed to need replacing after 1000 hours. Therefore a baseline cost of $1.25 should be applied every 0.92 years for interior applications, 0.40 years for exterior applications and 0.86 years for unknown.

For Decorative a baseline cost of $1.74 should be applied every 0.92 years for interior applications, 0.40 years for exterior applications and 0.86 years for unknown.

For Directional a baseline cost of $3.53 should be applied every 0.92 years for interior applications, 0.40 years for exterior applications and 0.86 years for unknown.

For Linear Task/Under Cabinet and T-LEDs, with a linear fluorescent baseline, there is assumed no O&M impact since the baseline lamp life is 18,000 – 30,000 hours and which is longer than the assumed measure life.

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-LEDE-V2-230101

REVIEW DEADLINE: 1/1/2024

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[422] 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:
$(0.24*0.92) + (0.76*0.8) * (1-0.15) = 0.70$