

**MEMORANDUM**

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**TO:** TECHNICAL ADVISORY COMMITTEE

**FROM:** KEITH CRONIN, PROJECT LEAD and SAM DENT, TECHNICAL LEAD - VEIC

**SUBJECT:** V13.0 ERRATA MEASURES EFFECTIVE 01/01/2025

**DATE:** 09/19/2025

**Cc:** CELIA JOHNSON, SAG

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This memo documents errata changes to Version 13.0 of the Illinois Technical Reference Manual (TRM) that the Technical Advisory Committee (TAC) recommends be made effective 01/01/2025.

VEIC has provided a summary table below showing the errata measures and a brief summary of what was changed, followed by the v13.0 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 13.0 of the TRM).

**Summary of Errata Measures**

Section	Measure Name	Measure Code	Brief Summary of Change	TAC Reviewed and Approved As of
4.4.9	Air and Water Source Heat Pump Systems (Centrally Ducted and Ductless)	CI-HVC-HPSY-V13-250101	Error in ASHPSiteHeatingImpact algorithm for non-fuel switch measures >60kBtuh. A 3412 btu/kWh factor is provided since calculation uses COP for efficiency, however it was erroneously only applied to the baseline heatload. Edits to unit conversions when using COP efficiency ratings.	01/01/2025
4.4.15	Single-Package and Split System Unitary Air Conditioners	CI-HVC-SPUA-V12-250101	Corrected code baseline SEER2 value for split systems <65,000 Btu/h. Value was incorrectly transcribed from code. The compliance date for these baseline systems was also incorrect, updated that as well. Also made minor adjustments/updates, transitioning the SEER/EER metrics for systems <65,000 Btu/h to SEER2/EER2	01/01/2025
4.4.58	Steam Trap Monitoring System	CI-HVC-STMS-V2-250101	Correct deemed table values for process heating based on variable inputs provided.	07/07/2025
4.4.60	Variable Refrigerant Flow HVAC System	CI-HVC-VFFY-V4-250101	Energy saving algorithm for units >65 kBtu/hr should use IEER rather than EER.	01/01/2025
4.8.8	Commercial Secondary Windows	CI-SHL-CSW-V02-250101	Fixing Fossil Fuel algorithm to divide by heating efficiency, not multiply.	08/15/2025
5.5.12	Connected LED Lamps	RS-LTG-LEDC-V05-250101	Fixing heat penalty algorithms to reflect savings calculation. Updating Hour, WHF and CF assumptions to use either Omnidirectional or Specialty versions.	09/19/2025
5.6.3	Floor Insulation Above Crawlspace	RS-SHL-FINS-V17-250101	CDD and HDD fixed to reflect Conditioned spaces since measure will be between conditioned space and vented crawlspace.	08/15/2025



#### 4.4.9 Air and Water Source Heat Pump Systems (Centrally Ducted and Ductless)

##### DESCRIPTION

This measure applies to the installation of high-efficiency air cooled and water source heat pump systems with conditioned air delivered to the building via ductwork, ductless systems and “hybrid” systems that work in conjunction with fuel-fired heating systems. This measure could apply to replacing an existing unit at the end of its useful life, or installation of a new unit in a new or existing building.

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

##### DEFINITION OF EFFICIENT EQUIPMENT

In order for this characterization to apply, the efficient equipment is assumed to be a high-efficiency air cooled or water source, heat pump system that exceeds the baseline and meets program requirements.

##### DEFINITION OF BASELINE EQUIPMENT

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

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

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

In order for this characterization to apply, the baseline equipment is assumed to meet the efficiency requirements within the IECC code in effect on the date of the building permit. As code requirements and adoption can differ from municipality to municipality, the user should verify which version of code is applicable given these constraints.

Note, IECC 2021 is became effective statewide on 1/1/2024. IECC 2018 is the requisite code for any projects with permitting dates spanning July 1, 2019 to 12/31/2023. Prior to July 1, 2019, IECC 2015 is the applicable code. If evaluation determines the applicable version of code, given location and timing, isn't an appropriate baseline due to supply constraints, low compliance, or other issues, the previous iteration of code may be used through 2023.

IECC 2021 leverages new DOE testing methods and associated metrics. The following conversion factors are recommended for use if the efficient equipment is not rated under the new testing procedure but the stipulated baseline is:<sup>1</sup>

$$\text{SEER2} = X * \text{SEER}$$

$$\text{EER2} = X * \text{EER}$$

$$\text{HSPF2} = X * \text{HSPF}$$

Where:

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<sup>1</sup> Consortium for Energy Efficiency (CEE), Testing, Testing, M1, 2, 3, Transitioning to New Federal Minimum Standards, CEE Summer Program Meeting, August, 2022.

X	SEER2	EER2	HSPF2
Ducted	0.95	0.95	0.85
Ductless	1.00	1.00	0.90
Packaged	0.95	0.95	0.84

Note: new Federal Standards affecting heat pumps and air conditioning equipment became effective January 1, 2023.

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

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

**Deemed Early Replacement Rates For ASHP<sup>2</sup>**

Equipment Type	Full System Displacement	Partial System Displacement
Cooling	30%	30%
Heating	30%	100%

Note to apply these deemed early replacement rates, an assumption of the percentage of replacements that are full displacement v partial displacement is required. This should be determined through evaluation, or a deemed ratio of 100% Full Displacement for ducted ASHPs and 50% Full: 50% Partial for Ductless ASHPs can be used. Savings should be calculated following both the full and partial displacement methodology and then this ratio should be used to weight the savings accordingly.

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The expected measure life is assumed to be 16 years.<sup>3</sup>

Remaining life of existing equipment is assumed to be 6 years for ASHP and Central AC, 6 years for furnace, 8 years for boilers<sup>4</sup> and 16 years for electric resistance.<sup>5</sup>

**DEEMED MEASURE COST**

Ducted Air Source Heat Pumps:

New Construction and Time of Sale: For analysis purposes, the incremental capital cost for this measure is assumed as \$100 per ton for air-cooled units.<sup>6</sup> The incremental cost for all other equipment types should be determined on a

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<sup>2</sup> Consistent with Residential assumptions – should be updated with Commercial data when available. Program tracking data from ComEd and Ameren between 2018 and 2020 was used to develop these assumptions. During this period the air source heat pump programs operated downstream and projects were classified as Time of Sale or Early Replacement. Note that any fuel switch scenario at the time would have been classified as Time of Sale and therefore the rates provided likely represent a low estimate of the true early replacement rates. In the absence of alternative data, the TAC agreed to apply these rates and the deemed full v partial displacement assumptions listed, but these assumptions should be revisited through future evaluation.

<sup>3</sup> Consistent with Residential measure and based on 2016 DOE Rulemaking Technical Support document, as recommended in Guidehouse ‘ComEd Effective Useful Life Research Report’, May 2018.

<sup>4</sup> Assumed to be one third of effective useful life of replaced equipment.

<sup>5</sup> 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.

<sup>6</sup> Based on a review of TRM incremental cost assumptions from Vermont, Wisconsin, and California.

site-specific basis.

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

Ductless Minisplit Heat Pumps:

**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 (\$6,562 + \$600 per ton for ASHP,<sup>7</sup> or \$2,011 for a new baseline 80% AFUE furnace, or \$4,053 for a new 84% AFUE boiler,<sup>8</sup> and \$952 per ton for new baseline Central AC replacement<sup>9</sup>).

Default full cost of the DMSHP is provided below. Note, for smaller units a minimum cost of \$2,000 should be applied:<sup>10</sup>

Unit Size	Full Install Cost (\$/ton) <sup>11</sup>
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:<sup>12</sup>

Efficiency (HSPF2)	Incremental Cost (\$/ton) over an HSPF2 7.5 DHP
8.1-8.9	\$62
9-9.8	\$224
9.9-11.6	\$334
11.7+	\$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.<sup>13</sup> 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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<sup>7</sup> Full install ASHP costs are based upon data provided by Ameren. See 'ASHP Costs\_06242022'.

<sup>8</sup> 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.

<sup>9</sup> Based on 3 ton initial cost estimate for a conventional unit from ENERGY STAR Central AC calculator

<sup>10</sup> 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.

<sup>11</sup> 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.

<sup>12</sup> Memo from Opinion Dynamics Evaluation Team, Ductless Mini-Split Heat Pumps: Incremental Cost Analysis, April 27, 2017

<sup>13</sup> 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 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.

$$\begin{aligned} CF_{SSP} &= \text{Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)} \\ &= 91.3\%^{14} \end{aligned}$$

$$\begin{aligned} CF_{PJM} &= \text{PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)} \\ &= 47.8\%^{15} \end{aligned}$$

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### Algorithm

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### CALCULATION OF SAVINGS

#### ELECTRIC AND FOSSIL FUEL ENERGY SAVINGS

Non fuel switch measures:

$$\Delta kWh_{\text{Non Fuel Switch}} = \text{ASHPSiteCoolingImpact} + \text{ASHPSiteHeatingImpact}$$

Where:

For units with cooling capacities less than 65 kBtu/hr (ASHP only):

$$\text{ASHPSiteCoolingImpact} = ((\text{CoolingLoad}/\text{DuctlessSave} * (1/(\text{SEER2\_base}))) - (\text{CoolingLoad} * 1/(\text{SEER2\_ee}))) / 1,000$$

$$\text{ASHPSiteHeatingImpact} = ((\text{HeatLoad\_Disp}/\text{DuctlessSave} * (1/(\text{HSPF2\_base} * \text{HSPF2\_ClimateAdj}))) - (\text{HeatLoad\_Disp} * 1/(\text{HSPF2\_ee} * \text{HSPF2\_ClimateAdj}))) / 1,000$$

For ASHP units with cooling capacities equal to or greater than 65 kBtu/hr and all WSHPs:

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<sup>14</sup> 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.

<sup>15</sup> 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.

$$\Delta kWh_{\text{Non Fuel Switch}} = \text{ASHPSiteCoolingImpact} + \text{ASHPSiteHeatingImpact}$$

Where:

$$\text{ASHPSiteCoolingImpact} = ((\text{CoolingLoad} * (1/(\text{IEER\_base}))) - (\text{CoolingLoad} * 1/(\text{IEER\_ee}))) / 1,000$$

$$\text{ASHPSiteHeatingImpact} = (\text{HeatLoad\_Disp} / 3,412 * (1/\text{COP\_base} - 1/\text{COP\_ee}))$$

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):

$$\text{SiteEnergySavings (MMBTUs)} = \text{FuelSwitchSavings} + \text{NonFuelSwitchSavings}$$

$$\text{FuelSwitchSavings} = \text{GasHeatReplaced} - \text{HPSiteHeatConsumed}$$

$$\text{NonFuelSwitchSavings} = \text{FurnaceFanSavings} + \text{HPSiteCoolingImpact}$$

For units with cooling capacities less than 65 kBtu/hr (ASHP only):

$$\text{ASHPSiteHeatConsumed} = ((\text{HeatLoad\_Disp} * (1/(\text{HSPF2\_ee} * \text{HSPF2\_ClimateAdj} * \text{PD\_Adj}))) / 1,000 * 3,412) / 1,000,000$$

$$\text{ASHPSiteCoolingImpact} = (((\text{CoolingLoad}/\text{DuctlessSave} * (1/(\text{SEER2\_base})) - ((\text{CoolingLoad} * 1/(\text{SEER2\_ee}))) / 1,000 * 3412) / 1,000,000$$

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

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

For ASHP units with cooling capacities greater than 65 kBtu/hr and all WSHPs:

$$\text{ASHPSiteHeatConsumed} = (\text{HeatLoad\_Disp} * (1/(\text{COP\_ee} * \text{PD\_Adj}))) / 1,000,000$$

$$\text{ASHPSiteCoolingImpact} = (((\text{CoolingLoad} * (1/(\text{IEER\_base})) - ((\text{CoolingLoad} * 1/(\text{IEER\_ee}))) / 1,000 * 3,412) / 1,000,000$$

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

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

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

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

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

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

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:

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

Plus

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

$$= \%FuelSwitch * SiteEnergySavings \text{ (MMBTUs)}$$

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

$$= EFLH_{\text{cool}} * Capacity_{\text{cool}}$$

Capacity<sub>cool</sub> = Output capacity of the cooling equipment in Btu per hour (1 ton of cooling capacity equals 12,000 Btu/hr).

= Actual installed

SEER<sub>2base</sub> = Seasonal Energy Efficiency Ratio of the baseline equipment

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

SEER<sub>2ee</sub> = Seasonal Energy Efficiency Ratio of the energy efficient equipment.

- = Actual installed
- EFLH<sub>cool</sub> = Equivalent Full Load Hours for cooling in Existing Buildings or New Construction are provided in section 4.4 HVAC End Use.
- DuctlessSave = Factor used to adjust ducted heating or cooling load displaced by ductless systems that are not subject to losses from existing ductwork.
  - = 1-0.15 = 0.85 for ducted system displaced by ductless system
  - = 1.00 for ducted system displaced by ducted system or ductless system displaced by ductless system
- HSPF2<sub>base</sub> = 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 a blended baseline value of 5.1 HSPF2<sup>16</sup>).
- HSPF2<sub>ee</sub> = Heating Seasonal Performance Factor of the energy efficient equipment.
  - = Actual installed. If rating is COP, HSPF = COP \* 3.413
- HSPF\_ClimateAdj = Adjustment factor to account for observed discrepancy 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)<sup>17</sup>:

City (county based upon)	HSPF_ClimateAdj When using HSPF2 rating
1 (Rockford)	77%
2 (Chicago)	77%
3 (Springfield)	91%
4 (Belleville)	91%
5 (Marion)	91%
Weighted Average <sup>18</sup>	
ComEd	77%
Ameren	89%
Statewide	80%

<sup>16</sup> Blended Baseline value came from percentage of accounts with heat pumps (40.17%) at 7.5 HSPF2 and electric furnaces (59.83%) at 3.41 HSPF as reported in the ComEd Baseline Study August 14, 2020.

<sup>17</sup> 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'.

<sup>18</sup> 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.

IEER<sub>base</sub> = Integrated Energy Efficiency Ratio of the baseline equipment  
 = IEER (or EER2) 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 SEER2 to EER2 for calculation of peak savings:<sup>19</sup>

$$EER2 = (-0.02 * SEER2^2) + (1.12 * SEER2)$$

IEER<sub>ee</sub> = Integrated Energy Efficiency Ratio (or EER2) of the energy efficient equipment. For air-cooled units < 65 kBtu/hr, if the actual EER2<sub>ee</sub> is unknown, assume the conversion from SEER2 to EER2 as provided above.

= Actual installed

HeatLoad\_Displacement = Annual heat load for the building displaced by the ASHP (Btus)

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

EFLH<sub>heat</sub> = heating mode equivalent full load hours in Existing Buildings or New Construction are provided in section 4.4 HVAC End Use.

Capacity<sub>heat</sub> = output capacity of the heat pump equipment in Btu per hour.

= Actual installed

HeatLoadFactor = Portion of HeatLoad displaced by ASHP in partial displacement applications. Varies by Switchover Temperature and Climate Region. If Switchover Temperature is unknown, use 32°F.

= 1.0 if full displacement (e.g. cold climate heat pumps and water source heat pumps) or if switchover temperature is lower than 17°F or if Partial Displacement with simultaneous operation

Climate Zone (City based upon)	HeatLoadFactor (by Switchover Temperature) <sup>20</sup>										
	47°F	44°F	41°F	38°F	35°F	32°F	29°F	26°F	23°F	20°F	17°F
1 (Rockford)	4%	8%	12%	16%	26%	36%	45%	58%	66%	71%	78%
2 (Chicago)	4%	9%	15%	21%	32%	43%	52%	66%	74%	77%	84%
3 (Springfield)	4%	9%	15%	21%	37%	52%	59%	69%	76%	79%	85%
4 (Belleville)	7%	14%	22%	30%	41%	55%	66%	77%	85%	90%	93%
5 (Marion)	7%	16%	25%	34%	53%	67%	76%	86%	90%	93%	97%
Weighted Average <sup>21</sup>	4%	9%	15%	20%	31%	43%	51%	66%	73%	77%	84%
ComEd	5%	11%	17%	24%	38%	52%	60%	71%	79%	82%	88%
Ameren	4%	9%	16%	21%	33%	45%	54%	67%	75%	79%	85%

<sup>19</sup> 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.

<sup>20</sup> Values based on Morehead Energy 2024 analysis of TMYx typical hourly weather data for 2007-2021. See 'ASHP Partial Displacement Analysis 20240611\_HDD55.xlsx'.

<sup>21</sup> 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)	HeatLoadFactor (by Switchover Temperature) <sup>20</sup>										
	47°F	44°F	41°F	38°F	35°F	32°F	29°F	26°F	23°F	20°F	17°F
Statewide											

PD\_Adj = Adjustment multiplier to account for increased heat pump efficiency in Partial Displacement applications when there is no electric resistance backup and switchover temperature is higher than 17F. Varies by Switchover Temperature and Climate Region. If Switchover Temperature is unknown, use 32F.

= 1.0 if full displacement (e.g. cold climate heat pumps or water source heat pumps) or if switchover temperature is lower than 17F or if Partial Displacement with simultaneous operation

Climate Zone (City based upon)	PD_Adj (by Switchover Temperature) <sup>22</sup>										
	47°F	44°F	41°F	38°F	35°F	32°F	29°F	26°F	23°F	20°F	17°F
1 (Rockford)	153%	149%	146%	143%	138%	134%	132%	128%	126%	124%	122%
2 (Chicago)	153%	148%	145%	142%	138%	134%	132%	128%	126%	125%	123%
3 (Springfield)	153%	148%	145%	142%	137%	133%	132%	129%	128%	127%	125%
4 (Belleville)	152%	149%	145%	143%	139%	135%	133%	131%	128%	127%	126%
5 (Marion)	153%	148%	145%	142%	138%	135%	134%	131%	130%	129%	128%
Weighted Average <sup>23</sup>											
ComEd	153%	148%	145%	142%	138%	134%	132%	128%	126%	125%	123%
Ameren	153%	148%	145%	142%	138%	134%	132%	130%	128%	127%	125%
Statewide	153%	148%	145%	142%	138%	134%	132%	129%	127%	126%	124%

3412 = Btu per kWh.

COP<sub>base</sub> = 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 HSPF2, COP = HSPF2 / 3.413

COP<sub>ee</sub> = coefficient of performance of the energy efficient equipment.

= Actual installed. If rating is HSPF2, COP = HSPF2 / 3.413

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

<sup>22</sup> Values based on Morehead Energy 2024 analysis of TMYx typical hourly weather data for 2007-2021. See 'ASHF Partial Displacement Analysis 20240611\_HDD55.xlsx'.

<sup>23</sup> 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.

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

F<sub>e</sub> = Furnace Fan energy consumption as a percentage of annual fuel consumption  
= 7.7%<sup>24</sup>

%IncentiveElectric = % of total incentive paid by electric utility  
= Actual

%IncentiveGas = % of total incentive paid by gas utility  
= Actual

**Code of Federal Regulations (baseline effective 1/1/2019):<sup>25</sup>**

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<sup>24</sup> F<sub>e</sub> 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<sub>e</sub> of the three building types. See “Fan Energy Factor Example Calculation 2021-06-23.xlsx” for reference.

<sup>25</sup> Code of Federal Regulations: Table 3 to §431.97—Updates to the Minimum Cooling Efficiency Standards for Air Conditioning and Heating Equipment and Table 4 to §431.97—Updates to the Minimum Heating Efficiency Standards for Air-Cooled Air Conditioning and Heating Equipment [Heat Pumps]. For 1/1/2024 compliance dates, note these manufacturing and import federal standards go into effect on 1/1/2023. The measure characterization is recommending delaying adopting these standards until 1/1/2024.

Equipment type	Cooling capacity	Heating type	Cooling Efficiency level	Heating Efficiency level	Compliance date
Small Commercial Packaged Air Conditioning and Heating Equipment (Air-Cooled)	≥65,000 Btu/h and <135,000 Btu/h	Electric Resistance Heating or No Heating	IEER = 12.2 IEER = 14.1	N/A	1/1/2018 1/1/2024
		All Other Types of Heating	IEER = 12.0 IEER = 13.9	COP = 3.3 COP = 3.4	1/1/2018 1/1/2024
Large Commercial Packaged Air Conditioning and Heating Equipment (Air-Cooled)	≥135,000 Btu/h and <240,000 Btu/h	Electric Resistance Heating or No Heating	IEER = 11.6 IEER = 13.5	N/A	1/1/2018 1/1/2024
		All Other Types of Heating	IEER = 11.4 IEER = 13.3	COP = 3.2 COP = 3.3	1/1/2018 1/1/2024
Very Large Commercial Packaged Air Conditioning and Heating Equipment (Air-Cooled)	≥240,000 Btu/h and <760,000 Btu/h	Electric Resistance Heating or No Heating	IEER = 10.6 IEER = 12.5	N/A	1/1/2018 1/1/2024
		All Other Types of Heating	IEER = 10.4 IEER = 12.3	COP = 3.2	1/1/2018 1/1/2024
Small Commercial Package Air-Conditioning and Heating Equipment (Air-Cooled, Single-Phase, Split-System)	<65,000 Btu/h	All	SEER2 = 14.3 EER2 = 9.4	HSPF2 = 7.5	1/1/2023
Small Commercial Package Air-Conditioning and Heating Equipment (Air-Cooled, Single-Phase, Single-Package)	<65,000Btu/h	All	SEER2 = 13.4 EER2 = 8.8	HSPF2 = 6.7	1/1/2023
Small Commercial Package Air-Conditioning and Heating Equipment (Air-Cooled, 3-Phase, Split-System)	<65,000 Btu/h	All	SEER2 = 14.3 EER2 = 9.4	HSPF2 = 7.5	1/1/2025
Small Commercial Package Air-Conditioning and Heating Equipment (Air-Cooled, 3-Phase, Single-Package)	<65,000Btu/h	All	SEER2 = 13.4 EER2 = 8.8	HSPF2 = 6.7	1/1/2025
Small Commercial Packaged Air-Conditioning and Heating Equipment (Water Source: Water-to-Air, Water-Loop)	<17,000 Btu/h	All	EER = 12.2	COP = 4.3	10/9/2015
	≥17,000 Btu/h and <65,000 Btu/h	All	EER = 13.0	COP = 4.3	10/9/2015
	≥65,000 Btu/h and <135,000Btu/h	All	EER = 13.0	COP = 4.3	10/9/2015

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

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

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

(continued)

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

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

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

- a. Chapter 6 contains a complete specification of the referenced test procedure, including the reference year version of the test procedure.
- b. Single-phase, air-cooled air conditioners less than 65,000 Btu/h are regulated by NAECA. SEER values are those set by NAECA.
- c. Minimum efficiency as of January 1, 2015.

Minimum Efficiency Requirements: 2018 IECC (baseline effective 7/1/2019 to 9/30/2022)

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

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

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

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

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

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

Minimum Efficiency Requirements: 2021 IECC (baseline effective 10/1/2022 for New Construction measures)

TABLE C403.3.2(2)  
ELECTRICALLY OPERATED AIR-COOLED UNITARY HEAT PUMPS—MINIMUM EFFICIENCY REQUIREMENTS<sup>a, d</sup>

EQUIPMENT TYPE	SIZE CATEGORY	HEADING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE <sup>a</sup>			
Air cooled (cooling mode)	< 66,000 Btu/h	All	Split system, three phase and applications outside US single phase <sup>b</sup>	14.0 SEER before 1/1/2023 14.3 SEER2 after 1/1/2023	AHRI 210/240—2017 before 1/1/2023 AHRI 210/240—2023 after 1/1/2023			
			Single package, three phase and applications outside US single phase <sup>b</sup>	14.0 SEER before 1/1/2023 13.4 SEER2 after 1/1/2023				
Space constrained, air cooled (cooling mode)	≤ 30,000 Btu/h	All	Split system, three phase and applications outside US single phase <sup>b</sup>	12.0 SEER before 1/1/2023 11.7 SEER2 after 1/1/2023	AHRI 210/240—2017 before 1/1/2023 AHRI 210/240—2023 after 1/1/2023			
			Single package, three phase and applications outside US single phase <sup>b</sup>	12.0 SEER before 1/1/2023 11.7 SEER2 after 1/1/2023				
Single duct, high velocity, air cooled (cooling mode)	< 65,000	All	Split system, three phase and applications outside US single phase <sup>b</sup>	12.0 SEER before 1/1/2023 12.0 SEER2 after 1/1/2023	AHRI 210/240—2017 before 1/1/2023 AHRI 210/240—2023 after 1/1/2023			
Air cooled (cooling mode)	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric resistance (or none)	Split system and single package	11.0 EER 12.2 IEER before 1/1/2023 14.1 IEER after 1/1/2023	AHRI 340/360			
		All other		10.8 EER 12.0 IEER before 1/1/2023 13.9 IEER after 1/1/2023				
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric resistance (or none)		10.6 EER 11.6 IEER before 1/1/2023 13.5 IEER after 1/1/2023				
		All other		10.4 EER 11.4 IEER before 1/1/2023 13.3 IEER after 1/1/2023				
	≥ 240,000 Btu/h	Electric resistance (or none)		9.5 EER 10.6 IEER before 1/1/2023 12.5 IEER after 1/1/2023				
		All other		9.3 EER 10.4 IEER before 1/1/2023 12.3 IEER after 1/1/2023				
	Air cooled (heating mode)	< 65,000 Btu/h		All		Split system, three phase and applications outside US single phase <sup>b</sup>	8.2 HSPF before 1/1/2023 7.5 HSPF2 after 1/1/2023	AHRI 210/240—2017 before 1/1/2023 AHRI 210/240—2023 after 1/1/2023
						Single package, three phase and applications outside US single phase <sup>b</sup>	8.0 HSPF before 1/1/2023 6.7 HSPF2 after 1/1/2023	

**IECC2021 Table C403.3.2(2) continued from previous page**

**TABLE C403.3.2(2)—continued  
ELECTRICALLY OPERATED AIR-COOLED UNITARY HEAT PUMPS—MINIMUM EFFICIENCY REQUIREMENTS<sup>a, d</sup>**

EQUIPMENT TYPE	SIZE CATEGORY	HEADING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE <sup>e</sup>
Space constrained, air cooled (heating mode)	≤ 30,000 Btu/h	All	Split system, three phase and applications outside US single phase <sup>b</sup>	7.4 HSPF before 1/1/2023 6.3 HSPF2 after 1/1/2023	AHRI 210/240—2017 before 1/1/2023 AHRI 210/240—2023 after 1/1/2023
			Single package, three phase and applications outside US single phase <sup>b</sup>	7.4 HSPF before 1/1/2023 6.3 HSPF2 after 1/1/2023	
Small duct, high velocity, air cooled (heating mode)	< 65,000 Btu/h	All	Split system, three phase and applications outside US single phase <sup>b</sup>	7.2 HSPF before 1/1/2023 6.1 HSPF2 after 1/1/2023	AHRI 210/240—2017 before 1/1/2023 AHRI 210/240—2023 after 1/1/2023
Air cooled (heating mode)	≥ 65,000 Btu/h and < 135,000 Btu/h (cooling capacity)	All	47°F db/43°F wb outdoor air	3.30 COP <sub>H</sub> before 1/1/2023 3.40 COP <sub>H</sub> after 1/1/2023	AHRI 340/360
			17°F db/15°F wb outdoor air	2.25 COP <sub>H</sub>	
	47°F db/43°F wb outdoor air		3.20 COP <sub>H</sub> before 1/1/2023 3.30 SOP <sub>H</sub> after 1/1/2023		
	17°F db/15°F wb outdoor air		2.05 COP <sub>H</sub>		
	47°F db/43°F wb outdoor air		3.20 COP <sub>H</sub>		
	17°F db/15°F wb outdoor air		2.05 COP <sub>H</sub>		
≥ 135,000 Btu/h and < 240,000 Btu/h (cooling capacity)					
≥ 240,000 Btu/h (cooling capacity)					

**Non Fuel Switch example**, a 5-ton single phase split system 60,000 Btuh capacity heat pump, with an efficiency SEER2 of 16, and an efficient HSPF2 of 9.5, at a new restaurant in Chicago with a building permit dated after 1/1/2023 saves:

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

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

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

$$\begin{aligned} \Delta kWh &= (60,000 * 761 * (1/14.3 - 1/16))/1000 + (60,000 * 797 * (1/(7.5 * 0.7) - 1/(9.5 * 0.7)))/1000 \\ &= 2257 \text{ kWh} \end{aligned}$$

### Fuel Switch Illustrative Examples

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

New construction using gas furnace and central AC baseline:

For example, a 60,000 Btu, 16 SEER2, 9.5 HSPF2 single phase split system Air Site Heat Pump installed in a new Chicago restaurant, in place of a 120,000 Btuh natural gas furnace and 5 ton Central AC unit:

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

$$\begin{aligned} \text{GasHeatReplaced} &= (\text{HeatLoad} * 1/\text{AFUE}_{\text{base}}) / 1,000,000 \\ &= (60,000 * 797 * 1/0.8) / 1000000 \\ &= 59.8 \text{ MMBtu} \end{aligned}$$

$$\begin{aligned} \text{FurnaceFanSavings} &= (\text{FurnaceFlag} * \text{HeatLoad} * 1/\text{AFUE}_{\text{base}} * F_e) / 1,000,000 \\ &= (1 * 60,000 * 797 * 1/0.8 * 0.077) / 1,000,000 \\ &= 4.6 \text{ MMBtu} \end{aligned}$$

$$\begin{aligned} \text{HPSiteHeatConsumed} &= ((\text{HeatLoad} * (1/(\text{HSPF}_{\text{ee}} * \text{HSPF}_{\text{ClimateAdj}}))) / 1000 * 3412) / 1,000,000 \\ &= ((60,000 * 797 * (1/(9.5 * 0.77))) / 1000 * 3412) / 1,000,000 \\ &= 22.3 \text{ MMBtu} \end{aligned}$$

$$\begin{aligned} \text{HPSiteCoolingImpact} &= ((\text{FLH}_{\text{cool}} * \text{Capacity}_{\text{cool}} * (1/\text{SEER}_{\text{base}} - 1/\text{SEER}_{\text{ee}}))/1000 * 3412) / 1,000,000 \\ &= ((761 * 60,000 * (1/14.3 - 1/16)) / 1000 * 3412) / 1,000,000 \end{aligned}$$

**Fuel Switch Illustrative Example continued**

Savings would be claimed as follows:

Measure supported by:	Electric Utility claims:	Gas Utility claims:
Electric utility only	43.3 * 1,000,000/3412 = 12,691 kWh	N/A
Electric and gas utility	0.5 * 43.3 * 1,000,000/3412 = 6,345 kWh	0.5 * 43.3 * 10 = 217 Therms
Gas utility only	N/A	43.3 * 10 = 433 Therms

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

$$\Delta kW = ((\text{Capacity}_{\text{cool}}/\text{DuctlessSave} * 1/\text{EER2}_{\text{base}}) - (\text{Capacity}_{\text{cool}} * 1/\text{EER2}_{\text{ee}})) / 1000 * \text{CF}$$

Where CF value is chosen between:

$$\begin{aligned} \text{CF}_{\text{SSP}} &= \text{Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)} \\ &= 91.3\%^{26} \end{aligned}$$

$$\begin{aligned} \text{CF}_{\text{PJM}} &= \text{PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)} \\ &= 47.8\%^{27} \end{aligned}$$

**For example**, a 5 ton single phase split system air source heat pump, with an efficient EER2 of 12.5 with a building permit dated after 1/1/2023 saves:

$$\begin{aligned} \Delta kW &= ((60,000/1 * 1/9.4) - (60,000 * 1/12.5))/1000 * 0.913 \\ &= 1.44 \text{ kW} \end{aligned}$$

**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 ASHP projects per Section 16-111.5B, changes in

<sup>26</sup> 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.

<sup>27</sup> 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.

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, 7 years for furnace, 8 years for boilers or GSHP, 15 years for electric resistance), and the efficiency terms for a new baseline unit should be used for the remaining years of the measure.

$$\begin{aligned} \Delta\text{Therms} &= [\text{Heating Consumption Replaced}] \\ &= [(\% \text{FuelSwitch} * \text{HeatLoad\_Disp/DuctlessSave} * 1/\text{AFUE}_{\text{base}}) / 100,000] \\ \Delta\text{kWh} &= [\text{FurnaceFanSavings}] - [\text{HP heating consumption}] + [\text{Cooling savings}] \end{aligned}$$

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

$$= \% \text{FuelSwitch} * [\text{FurnaceFlag} * \text{HeatLoad\_Disp/DuctlessSave} * 1/\text{AFUE}_{\text{base}} * F_e * 0.000293] - [(\text{HeatLoad\_Disp} * (1/(\text{HSPF2}_{\text{ee}} * \text{HSPF2\_ClimateAdj} * \text{PD\_Adj}))/1000] + [((\text{CoolingLoad/DuctlessSave} * 1/\text{SEER2}_{\text{base}}) - (\text{CoolingLoad} * 1/\text{SEER2}_{\text{ee}}))/1000]$$

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

$$= \% \text{FuelSwitch} * [\text{FurnaceFlag} * \text{HeatLoad\_Disp} * 1/\text{AFUE}_{\text{base}} * F_e * 0.000293] - [\text{HeatLoad\_Disp}/3412 * 1/(\text{COP}_{\text{ee}} * \text{PD\_Adj})] + [(\text{CoolingLoad} * (1/\text{IEER}_{\text{base}} - 1/\text{IEER}_{\text{ee}}))/1000]$$

**MEASURE CODE: CI-HVC-HPSY-V13-250101**

**REVIEW DEADLINE: 1/1/2028**

#### 4.4.15 Single-Package and Split System Unitary Air Conditioners

##### **DESCRIPTION**

This measure promotes the installation of high-efficiency unitary air-, water-, and evaporatively-cooled air conditioning equipment, both single-package and split systems. Air conditioning (AC) systems are a major consumer of electricity and systems that exceed baseline efficiency requirements can significantly reduce energy consumption. This measure could apply to the replacing of an existing unit at the end of its useful life or the installation of a new unit in a new or existing building.

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

##### **DEFINITION OF EFFICIENT EQUIPMENT**

The efficient equipment is assumed to be a high-efficiency air-, water-, or evaporatively-cooled air conditioner that exceeds the energy efficiency requirements as prescribed by the program.

##### **DEFINITION OF BASELINE EQUIPMENT**

In order for this characterization to apply, the baseline equipment is assumed to be a standard-efficiency air-, water, or evaporatively-cooled air conditioner that meets the Code energy efficiency requirements (IECC or Code of Federal Regulations whichever is higher) in effect on the date of equipment purchase (if date is unknown, assume current Code minimum).

For Early Replacement programs, use the actual efficiency of the existing unit or assume IECC code base in place at the original time of existing unit installation. To qualify under the early replacement characterization, baseline equipment must meet these additional qualifications:

- The existing unit is operational when replaced or the existing unit would be operational with minor repairs.<sup>28</sup>

In order for this characterization to apply, the baseline equipment is assumed to meet the efficiency requirements within the IECC code in effect on the date of the building permit. As code requirements and adoption can differ from municipality to municipality, the user should verify which version of code is applicable given these constraints.

Note, IECC 2021 became effective statewide on 1/1/2024. IECC 2018 is the requisite code for any projects with permitting dates spanning July 1, 2019 to 12/31/2023. Prior to July 1, 2019, IECC 2015 is the applicable code. If evaluation determines the applicable version of code, given location and timing, isn't an appropriate baseline due to supply constraints, low compliance, or other issues, the previous iteration of code may be used through 2023.

IECC 2021 leverages new DOE testing methods and associated metrics. The following conversion factors are recommended for use if the efficient equipment is not rated under the new testing procedure but the stipulated baseline is:<sup>29</sup>

$$\text{SEER2} = X * \text{SEER}$$

$$\text{EER2} = X * \text{EER}$$

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<sup>28</sup> Based on ComEd Small Business Trade Ally feedback. For units rated at less than 20 ton units, the cost of common repairs is under \$2,000, significantly less than the cost of purchasing new equipment. Therefore, if the cost of repair is less than \$2,000, it can be considered early replacement because customers would repair instead of replace a failed unit. Repair cost data was not available for units larger than 20 tons.

<sup>29</sup> Consortium for Energy Efficiency (CEE), Testing, Testing, M1, 2, 3, Transitioning to New Federal Minimum Standards, CEE Summer Program Meeting, August, 2022.

$$\text{HSPF2} = X * \text{HSPF}$$

Where:

X	SEER2	EER2	HSPF2
Ducted	0.95	0.95	0.85
Ductless	1.00	1.00	0.90
Packaged	0.95	0.95	0.84

Note: new Federal Standards affecting heat pumps and air conditioning equipment became effective January 1, 2025.

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The expected measure life is assumed to be 15 years.<sup>30</sup>

For early replacement, the remaining life of existing equipment is assumed to be 5 years.<sup>31</sup>

**DEEMED MEASURE COST**

The incremental capital cost for this measure is based upon capacity and efficiency level (defined by CEE specifications),<sup>32</sup> as outlined in the following table:<sup>33</sup>

Capacity	Incremental cost (\$/ton)	
	Up to and including CEE Tier 1 units	CEE Tier 2 and above
< 135,000 Btu/hr	\$63	\$127
135,000 Btu/hr to > 250,000 Btu/hr	\$63	\$127
250,000 Btu/hr and greater	\$19	\$38

For early replacement, the full cost of the installed unit should be used. If unknown use defaults below. The assumed deferred cost (after 5 years) of replacing existing equipment with a new baseline unit is also provided. This future cost should be discounted to present value using the real discount rate:

Capacity	Full Install Cost (\$/ton)		
	Base Units	Up to and including CEE Tier 1 units	CEE Tier 2 and above
< 135,000 Btu/hr	\$895	\$958	\$1,021
135,000 Btu/hr to > 250,000 Btu/hr	\$762	\$825	\$889
250,000 Btu/hr and greater	\$673	\$691	\$710

**LOADSHAPE**

Loadshape C03 - Commercial Cooling

<sup>30</sup> Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, Inc., June 2007.

<sup>31</sup> Assumed to be one third of effective useful life.

<sup>32</sup> CEE Commercial Unitary Air-conditioning and Heat Pumps Specification, which provides high efficiency performance specifications for single-package and split system unitary air conditioners.

<sup>33</sup> NEEP Incremental Cost Study (ICS) Final Report – Phase 3, May 2014.

**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<sub>SSP</sub> = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)  
 = 91.3%<sup>34</sup>

CF<sub>PJM</sub> = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)  
 = 47.8%<sup>35</sup>

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**Algorithm**

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**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

Time of Sale:

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

$$\Delta kWh = (kBtu/hr) * \left[ \frac{1}{SEER2base} - \frac{1}{SEER2ee} (1/SEERee) \right] * EFLH$$

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

$$\Delta kWh = (kBtu/hr) * \left[ \frac{1}{IEERbase} - \frac{1}{IEERee} \right] * EFLH$$

Early replacement:<sup>36</sup>

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

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

$$\Delta kWh = (kBtu/hr) * \left[ \frac{1}{SEER2exist} - \frac{1}{SEER2ee} \right] * EFLH$$

For remaining measure life (next 10 years):

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<sup>34</sup> 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.

<sup>35</sup> 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.

<sup>36</sup> 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).

$$\Delta kWh = (kBtu/hr) * \left[ \frac{1}{SEER2_{base}} - \frac{1}{SEER2_{ee}} \right] * EFLH$$

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

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

$$\Delta kWh = (kBtu/hr) * \left[ \frac{1}{IEER_{exist}} - \frac{1}{IEER_{ee}} \right] * EFLH$$

NOTE: If the existing equipment age is such that IEER ratings are not available, EER may be substituted when necessary. In such instances both existing and efficient unit efficiencies should be specified in EER.

For remaining measure life (next 10 years):

$$\Delta kWh = (kBtu/hr) * \left[ \frac{1}{IEER_{base}} - \frac{1}{IEER_{ee}} \right] * EFLH$$

Where:

kBtu/hr	= capacity of the cooling equipment actually installed in kBtu per hour (1 ton of cooling capacity equals 12 kBtu/hr)
SEER2 <sub>base</sub>	= Seasonal Energy Efficiency Ratio of the baseline equipment  = SEER2 values from tables below, based on applicable Code on date of equipment purchase (if unknown assume current Code).
SEER2 <sub>ee</sub>	= Seasonal Energy Efficiency Ratio of the energy efficient equipment (actually installed)
SEER2 <sub>exist</sub>	= Seasonal Energy Efficiency Ratio of the existing equipment  = Actual, or assume Code base in place at the original time of existing unit installation
IEER <sub>base</sub>	= Integrated Energy Efficiency Ratio of the baseline equipment. See table below based on applicable Code on date of equipment purchase (if unknown assume current Code).
IEER <sub>ee</sub>	= Integrated Energy Efficiency Ratio of the energy efficient equipment (actually installed)
IEER <sub>exist</sub>	= Integrated Energy Efficiency Ratio of the existing equipment  = Actual, or assume Code base in place at the original time of existing unit installation
EFLH	= Equivalent Full Load Hours for cooling in Existing Buildings or New Construction are provided in section 4.4 HVAC End Use

The rating conditions for the baseline and efficient equipment efficiencies must be equivalent.

**Code of Federal Redulations (baseline effective 1/1/2025):<sup>37</sup>**

Equipment type	Cooling capacity	Heating type	Efficiency level	Compliance date
Small Commercial Packaged Air Conditioning and Heating Equipment (Air-Cooled)	≥65,000 Btu/h and <135,000 Btu/h	Electric Resistance Heating or No Heating	IEER = 12.9 IEER = 14.8	1/1/2018 1/1/2023
		All Other Types of Heating	IEER = 12.7 IEER = 14.6	1/1/2018 1/1/2023
Large Commercial Packaged Air Conditioning and Heating Equipment (Air-Cooled)	≥135,000 Btu/h and <240,000 Btu/h	Electric Resistance Heating or No Heating	IEER = 12.4 IEER = 14.2	1/1/2018 1/1/2023
		All Other Types of Heating	IEER = 12.2 IEER = 14.0	1/1/2018 1/1/2023
Very Large Commercial Packaged Air Conditioning and Heating Equipment (Air-Cooled)	≥240,000 Btu/h and <760,000 Btu/h	Electric Resistance Heating or No Heating	IEER = 11.6 IEER = 13.2	1/1/2018 1/1/2023
		All Other Types of Heating	IEER = 11.4 IEER = 13.0	1/1/2018 1/1/2023
Small Commercial Package Air-Conditioning and Heating Equipment (Air-Cooled, 3-Phase, Split-System)	<65,000 Btu/h	All	SEER2 = 13.4	1/1/2025
Small Commercial Package Air-Conditioning and Heating Equipment (Air-Cooled, 3-Phase, Single-Package)	<65,000Btu/h	All	SEER2 = 13.4	1/1/2025

<sup>37</sup> Code of Federal Regulations: Table 3 to §431.97 – Updates to Minimum Cooling Efficiency Standards for Air Conditioning and Heating Equipment

2015 IECC Minimum Efficiency Requirements (baseline effective 1/1/2016 to 6/30/2019)

TABLE C403.2.3(1)  
 MINIMUM EFFICIENCY REQUIREMENTS:  
 ELECTRICALLY OPERATED UNITARY AIR CONDITIONERS AND CONDENSING UNITS

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY		TEST PROCEDURE <sup>2</sup>		
				Before 1/1/2016	As of 1/1/2016			
Air conditioners, air cooled	< 65,000 Btu/h <sup>3</sup>	All	Split System	13.0 SEER	13.0 SEER	AHRI 210/240		
			Single Package	13.0 SEER	14.0 SEER <sup>4</sup>			
Through-the-wall (air cooled)	≤ 30,000 Btu/h <sup>3</sup>	All	Split system	12.0 SEER	12.0 SEER			
			Single Package	12.0 SEER	12.0 SEER			
Small-duct high-velocity (air cooled)	< 65,000 Btu/h <sup>3</sup>	All	Split System	11.0 SEER	11.0 SEER			
Air conditioners, air cooled	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.2 EER 11.4 IEER	11.2 EER 12.8 IEER		AHRI 340/360	
			All other	Split System and Single Package	11.0 EER 11.2 IEER	11.0 EER 12.6 IEER		
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER 11.2 IEER	11.0 EER 12.4 IEER			
			All other	Split System and Single Package	10.8 EER 11.0 IEER	10.8 EER 12.2 IEER		
	≥ 240,000 Btu/h and < 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	10.0 EER 10.1 IEER	10.0 EER 11.6 IEER			
			All other	Split System and Single Package	9.8 EER 9.9 IEER	9.8 EER 11.4 IEER		
	≥ 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	9.7 EER 9.8 IEER	9.7 EER 11.2 IEER			
			All other	Split System and Single Package	9.5 EER 9.6 IEER	9.5 EER 11.0 IEER		
	Air conditioners, water cooled	< 65,000 Btu/h <sup>3</sup>	All	Split System and Single Package	12.1 EER 12.3 IEER	12.1 EER 12.3 IEER		AHRI 210/240
				Split System and Single Package	12.1 EER 12.3 IEER	12.1 EER 13.9 IEER		
		≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.9 EER 12.1 IEER	11.9 EER 13.7 IEER		AHRI 340/360
				All other	Split System and Single Package	12.5 EER 12.5 IEER		
≥ 135,000 Btu/h and < 240,000 Btu/h		Electric Resistance (or None)	Split System and Single Package	12.3 EER 12.5 IEER	12.3 EER 13.7 IEER			
			All other	Split System and Single Package	12.4 EER 12.6 IEER	12.4 EER 13.6 IEER		
≥ 240,000 Btu/h and < 760,000 Btu/h		Electric Resistance (or None)	Split System and Single Package	12.2 EER 12.4 IEER	12.2 EER 13.4 IEER			
			All other	Split System and Single Package	12.2 EER 12.4 IEER	12.2 EER 13.5 IEER		
≥ 760,000 Btu/h		Electric Resistance (or None)	Split System and Single Package	12.0 EER 12.2 IEER	12.0 EER 13.3 IEER			
			All other	Split System and Single Package	12.0 EER 12.2 IEER	12.0 EER 13.3 IEER		

(continued)

2018 IECC Minimum Efficiency Requirements (baseline effective 7/1/2019 to 9/30/2022)

TABLE C403.3.2(1)  
MINIMUM EFFICIENCY REQUIREMENTS: ELECTRICALLY OPERATED UNITARY AIR CONDITIONERS AND CONDENSING UNITS

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE <sup>a</sup>		
Air conditioners, air cooled	< 65,000 Btu/h <sup>b</sup>	All	Split System	13.0 SEER	AHRI 210/240		
			Single Package	14.0 SEER			
Through-the-wall (air cooled)	≤ 30,000 Btu/h <sup>b</sup>	All	Split system	12.0 SEER			
			Single Package	12.0 SEER			
Small-duct high-velocity (air cooled)	< 65,000 Btu/h <sup>b</sup>	All	Split System	11.0 SEER			
Air conditioners, air cooled	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.2 EER 12.8 IEER		AHRI 340/360	
		All other	Split System and Single Package	11.0 EER 12.6 IEER			
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER 12.4 IEER			
		All other	Split System and Single Package	10.8 EER 12.2 IEER			
	≥ 240,000 Btu/h and < 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	10.0 EER 11.6 IEER			
		All other	Split System and Single Package	9.8 EER 11.4 IEER			
	≥ 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	9.7 EER 11.2 IEER			
		All other	Split System and Single Package	9.5 EER 11.0 IEER			
	Air conditioners, water cooled	< 65,000 Btu/h <sup>b</sup>	All	Split System and Single Package	12.1 EER 12.3 IEER		AHRI 210/240
		≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	12.1 EER 13.9 IEER		AHRI 340/360
All other			Split System and Single Package	11.9 EER 13.7 IEER			
≥ 135,000 Btu/h and < 240,000 Btu/h		Electric Resistance (or None)	Split System and Single Package	12.5 EER 13.9 IEER			
		All other	Split System and Single Package	12.3 EER 13.7 IEER			
≥ 240,000 Btu/h and < 760,000 Btu/h		Electric Resistance (or None)	Split System and Single Package	12.4 EER 13.6 IEER			
		All other	Split System and Single Package	12.2 EER 13.4 IEER			
≥ 760,000 Btu/h		Electric Resistance (or None)	Split System and Single Package	12.2 EER 13.5 IEER			
		All other	Split System and Single Package	12.0 EER 13.3 IEER			

Air conditioners, evaporatively cooled	< 65,000 Btu/h <sup>b</sup>	All	Split System and Single Package	12.1 EER 12.3 IEER	AHRI 210/240
	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	12.1 EER 12.3 IEER	AHRI 340/360
		All other	Split System and Single Package	11.9 EER 12.1 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	12.0 EER 12.2 IEER	
		All other	Split System and Single Package	11.8 EER 12.0 IEER	
	≥ 240,000 Btu/h and < 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.9 EER 12.1 IEER	
		All other	Split System and Single Package	11.7 EER 11.9 IEER	
	≥ 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.7 EER 11.9 IEER	
All other		Split System and Single Package	11.5 EER 11.7 IEER		
Condensing units, air cooled	≥ 135,000 Btu/h	—	—	10.5 EER 11.8 IEER	AHRI 365
Condensing units, water cooled	≥ 135,000 Btu/h	—	—	13.5 EER 14.0 IEER	
Condensing units, evaporatively cooled	≥ 135,000 Btu/h	—	—	13.5 EER 14.0 IEER	

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

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

2021 IECC Minimum Efficiency Requirements (baseline effective 10/1/2022)

**TABLE C403.3.2(1)**  
**ELECTRICALLY OPERATED UNITARY AIR CONDITIONERS AND CONDENSING UNITS—MINIMUM EFFICIENCY REQUIREMENTS<sup>c, d</sup>**

EQUIPMENT TYPE	SIZE CATEGORY	HEADING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE <sup>a</sup>
Air conditioners, air cooled	< 65,000 Btu/h <sup>b</sup>	All	Split system, three phase and applications outside US single phase <sup>b</sup>	13.0 SEER before 1/1/2023 13.4 SEER2 after 1/1/2023	AHRI 210/240—2017 before 1/1/2023
			Single-package, three phase and applications outside US single phase <sup>b</sup>	14.0 SEER before 1/1/2023 13.4 SEER2 after 1/1/2023	AHRI 210/240—2023 after 1/1/2023
Space constrained, air cooled	≤ 30,000 Btu/h <sup>b</sup>	All	Split system, three phase and applications outside US single phase <sup>b</sup>	12.0 SEER before 1/1/2023 11.7 SEER2 after 1/1/2023	AHRI 210/240—2017 before 1/1/2023
			Single package, three phase and applications outside US single phase <sup>b</sup>	12.0 SEER before 1/1/2023 11.7 SEER2 after 1/1/2023	AHRI 210/240—2023 after 1/1/2023
Small duct, high velocity, air cooled	< 65,000 Btu/h <sup>b</sup>	All	Split system, three phase and applications outside US single phase <sup>b</sup>	12.0 SEER before 1/1/2023 12.1 SEER2 after 1/1/2023	AHRI 210/240—2017 before 1/1/2023 AHRI 210/240—2023 after 1/1/2023
Air conditioners, air cooled	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric resistance (or none)	Split system and single package	11.2 EER 12.9 IEER before 1/1/2023 14.8 IEER after 1/1/2023	AHRI 340/360
		All other		11.0 EER 12.7 IEER before 1/1/2023 14.6 IEER after 1/1/2023	
	Electric resistance (or none)	11.0 EER 12.4 IEER before 1/1/2023 14.2 IEER after 1/1/2023			
	All other	10.8 EER 12.2 IEER before 1/1/2023 14.0 IEER after 1/1/2023			
	≥ 135,000 Btu/h and < 240,000 Btu/h				

**TABLE C403.3.2(1)—continued  
ELECTRICALLY OPERATED UNITARY AIR CONDITIONERS AND CONDENSING UNITS—MINIMUM EFFICIENCY REQUIREMENTS<sup>c, d</sup>**

EQUIPMENT TYPE	SIZE CATEGORY	HEADING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE <sup>e</sup>			
Air conditioners, air cooled <i>(continued)</i>	≥ 240,000 Btu/h and < 760,000 Btu/h	Electric resistance (or none)	Split system and single package	10.0 EER 11.6 IEER before 1/1/2023 13.2 IEER after 1/1/2023	AHRI 340/360			
		All other		9.8 EER 11.4 IEER before 1/1/2023 13.0 IEER after 1/1/2023				
	≥ 760,000 Btu/h	Electric resistance (or none)		9.7 EER 11.2 IEER before 1/1/2023 12.5 IEER after 1/1/2023				
		All other		9.5 EER 11.0 IEER before 1/1/2023 12.3 IEER after 1/1/2023				
		Air conditioners, water cooled		< 65,000 Btu/h		All	12.1 EER 12.3 IEER	AHRI 210/240
						≥ 65,000 Btu/h and < 135,000 Btu/h	Electric resistance (or none)	12.1 EER 13.9 IEER
All other	11.9 EER 13.7 IEER							
≥ 135,000 Btu/h and < 240,000 Btu/h	Electric resistance (or none)		12.5 EER 13.9 IEER					
	All other		12.3 EER 13.7 IEER					
≥ 240,000 Btu/h and < 760,000 Btu/h	Electric resistance (or none)		12.4 EER 13.6 IEER					
	All other	12.2 EER 13.4 IEER						
≥ 760,000 Btu/h	Electric resistance (or none)	12.2 EER 13.5 IEER						
	All other	12.0 EER 13.3 IEER						

**TABLE C403.3.2(1)—continued**  
**ELECTRICALLY OPERATED UNITARY AIR CONDITIONERS AND CONDENSING UNITS—MINIMUM EFFICIENCY REQUIREMENTS<sup>c, d</sup>**

EQUIPMENT TYPE	SIZE CATEGORY	HEADING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE <sup>a</sup>
Air conditioners, evaporatively cooled	< 65,000 Btu/h <sup>b</sup>	All	Split system and single package	12.1 EER 12.3 IEER	AHRI 210/240
	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric resistance (or none)		12.1 EER 12.3 IEER	AHRI 340/360
		All other		11.9 EER 12.1 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric resistance (or none)		12.0 EER 12.2 IEER	
		All other		11.8 EER 12.0 IEER	
	≥ 240,000 Btu/h and < 760,000 Btu/h	Electric resistance (or none)		11.9 EER 12.1 IEER	
		All other		11.7 EER 11.9 IEER	
	≥ 760,000 Btu/h	Electric resistance (or none)		11.7 EER 11.9 IEER	
All other		11.5 EER 11.7 IEER			
Condensing units, air cooled	≥ 135,000 Btu/h	—	—	10.5 EER 11.8 IEER	AHRI 365
Condensing units, water cooled	≥ 135,000 Btu/h	—	—	13.5 EER 14.0 IEER	AHRI 365
Condensing units, evaporatively cooled	≥ 135,000 Btu/h	—	—	13.5 EER 14.0 IEER	AHRI 365

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

- a. Chapter 6 contains a complete specification of the referenced standards, which include test procedures, including the reference year version of the test procedure.
- b. Single-phase, US air-cooled air conditioners less than 65,000 Btu/h are regulated as consumer products by the US Department of Energy Code of Federal Regulations DOE 10 CFR 430. SEER and SEER2 values for single-phase products are set by the US Department of Energy.
- c. DOE 10 CFR 430 Subpart B Appendix M1 includes the test procedure updates effective 1/1/2023 that will be incorporated in AHRI 210/240—2023.
- d. This table is a replica of ASHRAE 90.1 Table 6.8.1-1 Electrically Operated Unitary Air Conditioners and Condensing Units—Minimum Efficiency Requirements.

**For example**, a 5 ton air cooled split system with a SEER2 of 15 at an existing retail strip mall in Rockford would save:

$$\begin{aligned} \Delta kWh &= (60) * [(1/13.4) - (1/15)] * 697 \\ &= 290 kWh \end{aligned}$$

### SUMMER COINCIDENT PEAK DEMAND SAVINGS

Time of Sale:

$$\begin{aligned} \Delta kW &= (kBtu/hr * (\frac{1}{EER2_{base}} - \frac{1}{EER2_{ee}})) * CF \Delta kW \\ &= (kBtu/hr) * (\frac{1}{EER2_{base}} - \frac{1}{EER2_{ee}}) * CF \end{aligned}$$

Early Replacement:

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

$$\Delta kW = (kBtu/hr) * [\frac{1}{EER2_{exist}} - \frac{1}{EER2_{ee}}] * CF$$

For remaining measure life (next 10 years):

$$\Delta kW = (kBtu/hr) * [\frac{1}{EER2_{base}} - \frac{1}{EER2_{ee}}] * CF$$

Where:

EER2 <sub>base</sub>	= Energy Efficiency Ratio of the baseline equipment  = EER values from tables above, based on applicable Code on 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: <sup>38</sup> EER = (-0.02 * SEER <sup>2</sup> ) + (1.12 * SEER))
EER2 <sub>ee</sub>	= Energy Efficiency Ratio of the energy efficient equipment. If the actual EER <sub>ee</sub> is unknown, assume the conversion from SEER to EER for calculation of peak savings as above).  = Actual installed
EER2 <sub>exist</sub>	= Energy Efficiency Ratio of the existing equipment  = Actual, or assume Code base in place at the original time of existing unit installation
CF <sub>SSP</sub>	= Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)

<sup>38</sup> 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.

$$= 91.3\%^{39}$$

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

$$= 47.8\%^{40}$$

**For example**, a 5 ton air cooled split system with a SEER of 15 in Rockford would save:

$$\begin{aligned}\Delta kW_{SSP} &= (60) * [(1/11.4) - (1/12.3)] * 0.913 \\ &= 0.352 \text{ kW}\end{aligned}$$

**FOSSIL FUEL SAVINGS**

N/A

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**MEASURE CODE: CI-HVC-SPUA-V12-250101**

**REVIEW DEADLINE: 1/1/2026**

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<sup>39</sup> 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.

<sup>40</sup> Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.

#### 4.4.58 Steam Trap Monitoring System

##### DESCRIPTION

The measure applies to the installation of a steam trap monitoring system. The measure is applicable to commercial applications, commercial HVAC including multifamily buildings, and industrial applications. An existing measure, 4.4.16 Steam Trap Replacement or Repair, covers the replacement of a faulty steam trap in the failed open or leaking state. In addition to the steam trap replacement savings, the proposed measure allows to account for savings due to faster repair of the steam traps. Once a failed steam trap is detected, it can be immediately repaired/replaced. Continuous steam trap monitoring leaves behind manual inspections (audits) by using sensors to transmit real-time conditions of the steam system.

Energy savings for each steam trap occurs only when failed open, and steam trap failure rates vary based on trap size, type, and pressure. Energy savings are calculated on a per trap basis with the assumed annual failure rate for each application. Separate savings methodologies are recommended for space heating and process heating applications.

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

##### DEFINITION OF EFFICIENT EQUIPMENT

Customers must install a steam trap monitoring system on properly functioning steam traps serving either space heating or process heating load. The monitoring system must be capable of tracking the following, but not limited to, number of steam traps, trap type, operating pressure, operating temperature, ambient temperature, trap condition, date/time, application, and trap location. Applicants must provide characteristics for the steam system such as heating efficiency, steam trap orifice size(s), and system pressure(s). Customer must commit to repairing/replacing steam traps identified as failed by the steam trap monitoring system.

##### DEFINITION OF BASELINE EQUIPMENT

The baseline criterion are functioning steam traps serving either space heating or process heating load with no pre-existing monitoring system. No minimum leak rate is required.

##### DEEMED LIFETIME OF EFFICIENT EQUIPMENT

10 years based on vendor estimates.<sup>41</sup>

##### DEEMED MEASURE COST

The costs are subject to the subscription period chosen by the customer as shown in table below. The approximate installed cost is per trap per year and includes sensors, gateway, cellular service, cloud hosting, User license, data, and reports.

Number of Traps	Term <sup>42</sup>				
	1 Year	2 Years	3 Years	4 Years	5 Years
100 – 250	\$300	\$282	\$265	\$249	\$234
250 – 499	\$291	\$274	\$257	\$242	\$227
500 – 999	\$282	\$265	\$249	\$234	\$220
1000 – 1999	\$274	\$257	\$242	\$227	\$214
2000 – 2999	\$266	\$250	\$235	\$221	\$207

<sup>41</sup> Measure life as referenced in Michigan CI Technologies & Franklin Energy “Work paper FES-H8a – Steam Trap Monitoring System” dated September 2016.

<sup>42</sup> The Everactive Steam Trap Monitoring Service Price

Number of Traps	Term <sup>42</sup>				
	1 Year	2 Years	3 Years	4 Years	5 Years
3000 – 4999	\$262	\$246	\$232	\$218	\$204
5000 – 5999	\$258	\$242	\$228	\$214	\$201
6000 – 6999	\$254	\$238	\$224	\$210	\$198
7000+	\$251	\$235	\$221	\$207	\$196

Additional costs exist for the repair or replacement of steam traps once identifying a fault.

**LOADSHAPE**

N/A

**COINCIDENCE FACTOR**

N/A

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**Algorithm**

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**CALCULATION OF ENERGY SAVINGS**

**ELECTRIC ENERGY SAVINGS**

Secondary kWh Savings for Water Supply and Wastewater Treatment

The following savings should be included in the total savings for this measure but should not be included in TRC tests to avoid double counting the economic benefit of water savings. These savings only apply to situations in which steam is lost from the steam system.

$$\Delta kWh_{water} = \Delta Water \text{ (gallons)} / 1,000,000 \times E_{water \text{ supply}}$$

Where

$$E_{water \text{ supply}} = \text{Water Supply Energy Factor (kWh/Million Gallons)}$$

$$= 2571^{43}$$

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

N/A

**FOSSIL FUEL SAVINGS**

$$\Delta Therm = N \times P_{malfunctioning} \times F_o \times S_a \times \left( \frac{(Hv + Hs \times (T_1 - T_{source})) \times Hours}{(100,000 \times \eta_B)} \right)$$

Where:

$$N = \text{Total number of steam traps monitored through the steam trap monitoring system}$$

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<sup>43</sup> This factor includes 2571 kWh/MG for water supply based on Illinois energy intensity data from a 2012 ISAWWA study. For more information please review Elevate Energy’s ‘IL TRM: Energy per Gallon Factor, May 2018 paper’. Note since the water loss associated with this measure is due to evaporation and does not discharge into the wastewater system, only the water supply factor is used here.

$P_{malfunctioning}$  = Annual Percentage of malfunctioning traps

$$P_{malfunctioning} = L \times T_{audit} \times T_u$$

Where:

L = Leaking & Blow-thru  
 = custom, if unknown:

Steam System	L (%) <sup>44</sup>
Commercial Dry Cleaners	27%
Commercial Heating (including Multifamily) LPS	27%
Industrial and Process Low Pressure ≤ 15 psig	16%
Medium Pressure > 15 psig < 30 psig	16%
Medium Pressure ≥ 30 < 75 psig	16%
High Pressure ≥ 75 < 125 psig	16%
High Pressure ≥ 125 < 175 psig	16%
High Pressure ≥ 175 < 250 psig	16%
High Pressure ≥ 300 psig	16%

$T_{audit}$  = Average time between audits  
 Custom, if unknown use 1 year

$T_u$  = Average percentage of year trap malfunctions are undetected for steam systems without a steam trap monitoring system  
 Custom, if unknown use 50%<sup>45</sup>

$F_o$  = Failed open to total failed ratio  
 = Custom, if unknown:  
 96%, Space heating applications<sup>46</sup>  
 98%, Dry cleaners<sup>3</sup>  
 94%, All other steam systems and applications<sup>3</sup>

$S_a$  = Steam loss per leaking trap, (lbs/hr)

$H_v$  = Heat of vaporization of steam, (Btu/lbm)

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<sup>44</sup> Dry cleaners survey data as referenced in CLEAResult "Work Paper Steam Traps Revision #2" Revision 3 dated March 2, 2012.  
<sup>45</sup> The energy savings estimates of this measure assume that without an automatic steam trap monitoring system, manual audits would be performed once per year, so a leaking steam trap would, on average, leak for 6 months before being detected and repaired/replaced when the trap fails  
<sup>46</sup> Results from Steam Trap Audit/Replacement efficiency improvement research through the C&I and public Sector Prescriptive Rebate Program, Small Business Program and the Multi-family program. The evaluation included project and population data from years 2019 through 2022

Steam System	Average Inlet Pressure psig	Heat of Vaporization (Btu/lbm) <sup>47</sup>
Commercial Dry Cleaners	--	890
Commercial Space Heating (including Multifamily) LPS	11.2 <sup>48</sup>	951
Industrial/Process Low Pressure: psig < 15	11.2 <sup>9</sup>	951
Medium Pressure: 15 ≤ psig < 30	16	944
Medium Pressure: 30 ≤ psig < 75	47	915
High Pressure: 75 ≤ psig < 125	101	880
High Pressure: 125 ≤ psig < 175	146	859
High Pressure: 175 ≤ psig < 250	202	837
High Pressure: 250 ≤ psig < 300	263	816
High Pressure: 300 ≤ psig	--	Custom

Hs = Specific heat of water, (Btu/(lbm \* °R))  
 = 1.001

T<sub>1</sub> = Temperature of Saturated Steam, (°R)  
 = 507.89 × P<sub>1</sub><sup>0.0962</sup>

Where:

$$= 507.89 = \text{Constant, } ^\circ R \times (in^2 / lb_f)^{0.0962}$$

T<sub>source</sub> = 513.67 °R<sup>49</sup>

Hours = Annual hours when steam system is pressurized  
 = custom, if unknown:

Steam System	Zone (Where applicable)	Hours/Yr <sup>50</sup>
Commercial Dry Cleaners	All Climate Zones	2,425
Industrial/Process Low Pressure: psig < 15		8,282
Medium Pressure: 15 ≤ psig < 30		8,282
Medium Pressure: 30 ≤ psig < 75		8,282
High Pressure: 75 ≤ psig < 125		8,282
High Pressure: 125 ≤ psig < 175		8,282
High Pressure: 175 ≤ psig < 250		8,282
High Pressure: 250 ≤ psig < 300		8,282

<sup>47</sup> Heat of vaporization of steam at the inlet pressure to the steam trap. Implicit assumption that the average boiler nominal pressure where the vaporization occurs, is essentially that same pressure. Referenced in CLEARresult "Work Paper Steam Traps Revision #2" Revision 3 dated March 2, 2012.

<sup>48</sup> Results from Armstrong International research through the steam trap management platform SAGE. The research population data included Commercial Heating LPS as well as Industrial or Process Low Pressure, < 15 psi applications. The search of the database yield 120,853 steam traps meeting these parameters: Average orifice size 0.21" and average pressure 11.2 psi.

<sup>49</sup> US DOE Building America Program. Building America Analysis Spreadsheet. For Chicago, IL.

<sup>50</sup> Medium and high-pressure steam trap annual operating hours based on Navigant analysis of source collected during program implementation by Nicor Gas for GPY1 through GPY4. For each steam trap project, the data provided measure savings description, operating pressure, installation Zip code, business building type, program year, and annual operating hours.

Steam System	Zone (Where applicable)	Hours/Yr <sup>50</sup>
High Pressure: 300 ≤ psig		8,282
Commercial Space Heating LPS	Rockford	4,272
	Chicago	4,029
	Springfield	3,406
	Belleville	2,515
	Marion	2,546
Multifamily Space Heating LPS	<p>For steam traps that are part of steam systems where the boiler cycles on/off to maintain space setpoint temperature or for steam traps located downstream of a steam control valve that opens/closes to maintain setpoint temperature, use Heating EFLH values in Section 4.4 for High Rise or Mid-Rise MF buildings.</p> <p>For steam traps that are exposed to steam continuously throughout the heating season, use the values listed above for Commercial Space Heating LPS for your appropriate climate zone.</p>	

100,000 = Conversion factor (Btu/Therms)

$\eta_B$  = Boiler efficiency

= custom, if unknown:

80.7% for steam boilers, except multifamily low-pressure<sup>51</sup>

64.8% for multifamily low-pressure steam boilers<sup>52</sup>

**Space Heating Savings Estimates**

For systems used in space heating applications that operate at 5 psig or lower, use the following equation to calculate  $S_a$ <sup>53</sup>. The condensate return system pressure,  $P_2$ , will typically be atmospheric pressure, 14.696 psia.

$$S_a = 1,519.3 \times P_1 \times D^2 \times \left[ \left( \frac{1}{T_1} \right) \times \left( \frac{\gamma}{\gamma - 1} \right) \times \left( \left( \frac{P_2}{P_1} \right)^{(2/\gamma)} - \left( \frac{P_2}{P_1} \right)^{((\gamma+1)/\gamma)} \right) \right]^{0.5} \times A \times FF$$

Where:

1,519.3 = Constant,  $(s^2 \times \text{°R}^{0.5}) / (ft \times hr)$

$P_1$  = Average steam trap inlet pressure (absolute, psia). If not available, use defaults provided in table below (note that defaults are provided in psig, not psia)

<sup>51</sup> US DOE Building America Program. Building America Analysis Spreadsheet. For Chicago, IL.

<sup>52</sup> Katrakis, J. and T.S. Zawacki. "Field-Measured Seasonal Efficiency of Intermediate-sized Low-Pressure Steam Boilers". ASHRAE V99, pt. 2, 1993.

<sup>53</sup> See "Derivation of Equation for Subsonic Compressible Flow through an Orifice and Supporting Calculations for Illinois TRM Steam Trap Measure" paper for more information

- D = Diameter of orifice, inches. Actual value should be used wherever possible as this value has a significant impact on steam flowrate value.
- $\gamma$  = Heat Capacity Ratio (*unitless*)  
 $= 5.071 \times 10^{-4} \times P_1 + 1.332$
- $P_2$  = Average steam trap outlet pressure (*absolute, psia*). If unknown, assume atmospheric pressure, 14.696 *psia*
- A = Adjustment factor  
 = 50%,<sup>54</sup> all steam systems. This factor accounts for reduction in the maximum theoretical steam flow to the average steam flow (the Enbridge factor).
- FF = Flow factor. In addition to the Adjustment factor (A), and additional 50% flow factor adjustment is recommended for medium and high-pressure steam systems to address industrial float and thermostatic style traps where additional blockage is possible.

Defaults are provided in table below if custom calculation is not performed. The savings are averages for common orifice diameters ( $1/8, 3/16, 1/4, 5/16$  inches) at an assumed 5 psig.

Savings per Steam Trap Orifice Size <sup>55</sup>		1/8	3/16	1/4	5/16
$S_a$	(lbs/hr)	3.84	8.64	15.35	23.99
$\Delta$ Therms	(Therms/trap/yr)	14.23	32.02	56.92	88.94

**Process Heating Savings Estimates**

Use the following equation, for all other steam systems and applications

$$S_a = 24.24 \times P_1 \times D^2 \times A \times FF$$

Where:

$$24.24 = \text{Constant, } lbm/(hr \times psia \times in^2)$$

Defaults are provided in table below if custom calculation is not performed.

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<sup>54</sup> Enbridge adjustment factor used as referenced in CLEAResult “Work paper Steam Traps Revision #2” Revision 3 dated March 2, 2012 and DOE Federal Energy Management Program Steam Trap Replacement Assessment.

<sup>55</sup> Default values are directly calculated using the equations above.

Steam System	Average Steam Trap Inlet Pressure (psig) <sup>56</sup>	Diameter of Orifice (in)	Adjustment Factor	Flow Factor	S <sub>a</sub> <sup>57</sup> (lbs/trap/hr)	ΔTherm
Commercial Dry Cleaners	82.8	0.1250	50%	100%	18.5	86
Commercial LPS Space Heating	11.2	0.2100	50%	100%	13.8	101
Industrial/Process Low Pressure: psig < 15	11.2 <sup>58</sup>	0.2100 <sup>19</sup>	50%	100%	13.8	121
Medium Pressure: 15 ≤ psig < 30	16	0.1875	50%	50%	6.5	57
Medium Pressure: 30 ≤ psig < 75	47	0.2500	50%	50%	23.4	209
High Pressure: 75 ≤ psig < 125	101	0.2500	50%	50%	43.8	395
High Pressure: 125 ≤ psig < 175	146	0.2500	50%	50%	60.7	551
High Pressure: 175 ≤ psig < 250	202	0.2500	50%	50%	82.1	745
High Pressure: 250 ≤ psig < 300	263	0.2500	50%	50%	105.2	954

**WATER AND OTHER NON-ENERGY IMPACT DESCRIPTIONS AND CALCULATION**

The hourly water volume saved per each repaired or replaced leaking trap is calculated by dividing the “Steam Loss per Leaking Trap (lbm/hr/trap)” by the density of water saved, 8.33 lbm/gal, that replaces the lost steam. The steam loss is provided in the table for parameter S<sub>a</sub>, the “Steam loss per leaking trap” in the Fossil Fuel savings section above. Annual water savings are calculated using Hours and P<sub>malfunctioning</sub>, the annual percentage of malfunctioning traps, as defined above.

Water savings only apply to situations where condensate is lost from the steam system. If a condensate recovery system is in place, assume zero water savings or provide a custom calculation based on site-specific operation.

The annual water savings for a replaced or repaired trap is given by:

$$\Delta Water = GAL \times Hours \times N \times P_{malfunctioning} \times F_o$$

Where:

GAL = average actual water volume saved per leaking trap, as listed in the following table and based on steam system type.

*Other variables as defined above*

Steam System	S <sub>a</sub>	GAL (gal/hr/trap)
Commercial Dry Cleaners	18.5	2.22
Multifamily LPS Space Heating	6.9	0.83

<sup>56</sup> Medium and high-pressure steam trap inlet pressure based on Navigant analysis of source collected during program implementation by Nicor Gas for GPY1 through GPY4. For each steam trap project, the data provided measure savings description, operating pressure, installation Zip code, business building type, program year, and annual operating hours. Dry cleaning steam trap inlet pressure based on C5 Steam Traps – Nicor FINAL 10.27.11.

<sup>57</sup> Default values are directly calculated using the equations above.

<sup>58</sup> Results from Armstrong International research through the steam trap management platform SAGE. The research population data included Commercial Heating LPS as well as Industrial or Process Low Pressure, < 15 psi applications. The search of the database yields 120,853 steam traps meeting these parameters: Average orifice size 0.21” and average pressure 11.2 psi.

Steam System	S <sub>a</sub>	GAL (gal/hr/trap)
Industrial/Process Low Pressure: psig < 15	13.8	1.66
Medium Pressure: 15 ≤ psig < 30	6.5	0.79
Medium Pressure: 30 ≤ psig < 75	23.4	2.81
High Pressure: 75 ≤ psig < 125	43.8	5.26
High Pressure: 125 ≤ psig < 175	60.9	7.31
High Pressure: 175 ≤ psig < 250	82.1	9.85
High Pressure: 250 ≤ psig < 300	105.2	12.63
High Pressure: 300 ≤ psig	Calculated	Calculated Steam Loss / 8.33

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-HVC-STMS-V2-250101**

**REVIEW DEADLINE: 1/1/2025**

#### 4.4.60 Variable Refrigerant Flow HVAC System

**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 ducted split-system heat pump for non-residential buildings 25,000 square feet or fewer and is 3 floors or fewer. For non-residential buildings over 25,000 square feet or 4 floors or higher, the baseline equipment is assumed to be a standard-efficiency air cooled heat pump roof top unit (RTU) system. For residential buildings types which utilize individual in-unit HVAC systems, such as multifamily, lodging, dormitories, etc., the baseline equipment is assumed to be a residential style standard-efficiency packaged terminal heat pump split system.

Fuel switch measures:

To calculate savings with a gas or fuel heating baseline, the baseline equipment is assumed to be single zone furnace and air-conditioning units for non-residential buildings 25,000 square feet or fewer and is 3 floors or fewer. For non-residential buildings over 25,000 square feet or taller than 3 floors, the baseline equipment is assumed to be a packaged variable-air-volume (VAV) system with DX cooling and hot water reheat. For residential buildings types which utilize individual in-unit HVAC systems, such as multifamily, lodging, dormitories, etc., the baseline equipment is assumed to be a packaged terminal air conditioner (PTAC) with hot-water radiator heating. If the residential building is 4 stories or more, the baseline system will be a water source heat pump (WSHP) system with a boiler and cooling tower.

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.

	Non-Fuel Switch	Fuel Switch
Multifamily or Lodging, 3 floors or fewer	Packaged Terminal Heat Pump	PTAC w/ Hot Water Radiator

	Non-Fuel Switch	Fuel Switch
Multifamily or Lodging, 4 floors or more	Packaged Terminal Heat Pump	Water Source Heat Pump with Cooling Tower and Natural Gas Boiler
Non-residential <25,000 SF and 3 floors or fewer	Ducted-Split System Heat Pump	Packaged Single Zone (Furnace) + Air Conditioner
Non-Residential >25,000 SF OR more than 3 floors	Heat Pump RTU	Packaged VAV RTU with Hot Water Reheat

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The expected measure life for VRF is 16 years<sup>59</sup>.

**DEEMED MEASURE COST**

**Time of Sale:** 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) <sup>60</sup>
Packaged Terminal Heat Pump	\$610
Ducted Split System Heat Pump	\$860
Heat Pump RTU	\$130
PTAC w/ Hot Water Radiator	\$160
Water Source Heat Pump	\$0
Packaged Single Zone (Furnace) + Air Conditioner	\$835
Packaged VAV RTU with Hot Water Reheat	\$540

**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)

<sup>59</sup> 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.

<sup>60</sup> Estimated measure incremental costs for PTHP, HP RTU and PTAC based other incremental costs and differences in installed cost from U.S. Energy Information Administration (EIA), Updated Buildings Sector Appliance and Equipment Costs and Efficiencies: <https://www.eia.gov/analysis/studies/buildings/equipcosts/pdf/full.pdf>. For Ducted Split HP, Packaged Single Zone Furnace + AC and Packaged VAV RTU is based on Mid-Atlantic Technical Reference Manual version 9, Variable Refrigerant Flow (VRF) Heat Pump Systems measure. Published October, 2019. Water-source HP systems estimated from data collected from manufacturers. Water-source heat pump systems were not very different compared to VRF systems.

$$= 91.3\%^{61}$$

$$\begin{aligned} CF_{PJM} &= \text{PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)} \\ &= 47.8\%^{62} \end{aligned}$$

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## Algorithm

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### CALCULATION OF ENERGY SAVINGS

#### ELECTRIC ENERGY SAVINGS

Savings are calculated as a sum of system switching savings and efficiency savings, analogous to the following equation:

$$\text{Annual Savings} = [\text{System Switch Savings}] + [\text{Savings from improved VRF efficiency}]$$

For fuel-switching calculations, the above equation is used for calculating the cooling savings, while the heating savings are calculated by as the following:

$$\begin{aligned} \text{Annual Savings} = & [\text{Gas Heat Replaced} \times \text{System Switch Adjustment Factor}] + [\text{Fan Savings}] - [\text{Heat Pump heat} \\ & \text{consumed} \times \text{System Switch Adjustment Factor}] + [\text{Heat Pump Cooling} * \text{System Switch Savings} + \\ & \text{Heat Pump Cooling Savings from improved VRF efficiency}] \end{aligned}$$

The system switching savings are calculated by multiplying the cooling or heating load (EFLH times heat or cool capacity) and multiplying it by system heating ( $\text{Heat}_{\text{adj}}$ ) and cooling ( $\text{Cool}_{\text{adj}}$ ) factors. These adjustment factors were calculated with energy model data of different building types. The VRF performance curves were calibrated based on independent field monitored data.

- The difference in building code baseline efficiency between VRF and the baseline system.
- The improved part load performance of the VRF inverter driven compressor compared to single-stage or two-stage compressors.
- Heat recovery mode savings from the VRF units.
- Decrease in energy from cooling towers (WSHP baseline) and water pumps (baseline systems with hot water and WSHP).
- WSHP electric heating and boiler fuel consumption (WSHP baseline).
- Differences in treating ventilation between mixed recirculating systems and VRF systems with dedicated outdoor air systems (Heat Pump RTU and VAV baseline systems only).

Savings from improved VRF efficiency is similar to other efficiency savings from other TRM measures, where savings are calculated as the load multiplied by the change in efficiency.

#### Non-fuel switch measures:

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

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<sup>61</sup> 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.

<sup>62</sup> 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.

$$\begin{aligned} \Delta kWh &= \text{Annual kWh Savings}_{\text{cool}} + \text{Annual kWh Savings}_{\text{heat}} + \text{FanSavings} \\ \text{Annual kWh Savings}_{\text{cool}} &= [\text{System Switch Savings}] + [\text{Savings from improved VRF efficiency}] \\ &= (\text{Cool}_{\text{adj}} * \text{Capacity}_{\text{cool}} * \text{EFLH}_{\text{cool}} / 3,412) + (\text{Capacity}_{\text{cool}} * \text{EFLH}_{\text{cool}} * (1/\text{SEER}_{\text{base}} - 1/\text{SEER}_{\text{ee}})) / 1000 \\ \text{Annual kWh Savings}_{\text{heat}} &= [\text{System Switch Savings}] + [\text{Savings from improved VRF efficiency}] \\ &= (\text{Heat}_{\text{adj}} * \text{HeatLoad} / 3,412) + (\text{HeatLoad} * (1/\text{HSPF}_{\text{base}} - 1/\text{HSPF}_{\text{ee}})) / 1000 \\ \text{FanSavings} &= (\text{Flag} * \text{HeatLoad} * 1/\text{AFUE}_{\text{base}} * F_e) / 3,412 \end{aligned}$$

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

$$\begin{aligned} \Delta kWh &= \text{Annual kWh Savings}_{\text{cool}} + \text{Annual kWh Savings}_{\text{heat}} + \text{FanSavings} \\ \text{Annual kWh Savings}_{\text{cool}} &= [\text{System Switch Savings}] + [\text{Savings from improved VRF efficiency}] \\ &= (\text{Cool}_{\text{adj}} * \text{Capacity}_{\text{cool}} * \text{EFLH}_{\text{cool}} / 3,412) + (\text{Capacity}_{\text{cool}} * \text{EFLH}_{\text{cool}} * (1/\text{IEER}_{\text{base}} - 1/\text{IEER}_{\text{ee}})) / 1000 \\ \text{Annual kWh Savings}_{\text{heat}} &= [\text{System Switch Savings}] + [\text{Savings from improved VRF efficiency}] \\ &= (\text{Heat}_{\text{adj}} * \text{HeatLoad}) / 3,412 + (\text{HeatLoad} * (1/\text{COP}_{\text{base}} - 1/\text{COP}_{\text{ee}})) / 3,412 \\ \text{FanSavings} &= (\text{Flag} * \text{HeatLoad} * 1/\text{AFUE}_{\text{base}} * F_e) / 3,412 \end{aligned}$$

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):

$$\begin{aligned} \text{SiteEnergySavings (MMBTU)} &= \text{GasHeatReplaced} + \text{FanSavings} - \text{HPSiteHeatConsumed} + \text{HPSiteCoolingImpact} \\ \text{GasHeatReplaced (MMBTU)} &= (\text{GasHeat}_{\text{adj}} * \text{HeatLoad} * 1/\text{AFUE}_{\text{base}}) / 1,000,000 \\ \text{FanSavings (MMBTU)} &= (\text{Flag} * \text{HeatLoad} * 1/\text{AFUE}_{\text{base}} * F_e) / 1,000,000 \end{aligned}$$

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

$$\begin{aligned} \text{HPSiteHeatConsumed (MMBTU)} &= (\text{Heat}_{\text{adj}} * \text{HeatLoad} * (1/\text{HSPF}_{\text{ee}})) * 3,412 / 1,000 / 1,000,000 \\ \text{HPSiteCoolingImpact (MMBTU)} &= [\text{System Switch Savings}] + [\text{Savings from improved VRF efficiency}] \end{aligned}$$

$$= ((Cool_{adj} * Capacity_{cool} * EFLH_{cool}) / 1,000,000) + ((EFLH_{cool} * Capacity_{cool} * (1/SEER_{base} - 1/SEER_{ee})) * 3,412 / 1,000 / 1,000,000)$$

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

$$HPSiteHeatConsumed \text{ (MMBTU)} = (Heat_{adj} * HeatLoad * (1/COPEe)) / 1,000,000$$

$$HPSiteCoolingImpact \text{ (MMBTU)} = [System \ Switch \ Savings] + [Savings \ from \ improved \ VRF \ efficiency]$$

$$= ((Cool_{adj} * Capacity_{cool} * EFLH_{cool}) / 1,000,000) + ((EFLH_{cool} * Capacity_{cool} * (1/IEER_{base} - 1/IEER_{ee})) * 3,412 / 1,000 / 1,000,000)$$

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	GasHeat <sub>adj</sub>	Cool <sub>adj</sub>	Heat <sub>adj</sub>
Packaged Terminal Heat Pump	N/A	0.1	0.0
Ducted Split System Heat Pump	N/A	0.0	0.0
Heat Pump RTU	N/A	-0.2	0.5
PTAC w/ Hot Water Radiator	0.7	0.0	1.3
Water Source Heat Pump	0.4	0.1	0.5
Packaged Single Zone (Furnace) + Air Conditioner	1.4	0	1.6
Packaged VAV RTU with Hot Water Reheat	0.9	-0.2	1.8

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<sub>adj</sub> = This cooling adjustment factor is derived from energy modeling results to calibrate TRM

calculation savings to energy modeling savings estimates.<sup>63</sup> Adjustment factor values are presented in a table above.

Heat<sub>adj</sub> = This heating adjustment factor is derived from energy modeling results to calibrate TRM calculation savings to energy modeling savings estimates.<sup>64</sup> Adjustment factor values are presented in a table above.

GasHeat<sub>adj</sub> = This gas heating adjustment factor is derived from energy modeling results to calibrate TRM calculation savings to energy modeling savings estimates.<sup>65</sup> Adjustment factor values are presented in a table above.

Capacity<sub>cool</sub> = input capacity of the cooling equipment in Btu per hour (1 ton of cooling capacity equals 12,000 Btu/hr).

= Actual installed

SEER<sub>base</sub> = Seasonal Energy Efficiency Ratio of the baseline equipment

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

SEER<sub>ee</sub> = Seasonal Energy Efficiency Ratio of the energy efficient equipment.

= Actual installed

EFLH<sub>cool</sub> = Equivalent Full Load Hours for cooling in Existing Buildings or New Construction are provided in section 4.4 HVAC End Use.

HSPF<sub>base</sub> = Heating Seasonal Performance Factor of the baseline equipment

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

HSPF<sub>ee</sub> = Heating Seasonal Performance Factor of the energy efficient equipment.

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

IEER<sub>base</sub> = Integrated Energy Efficiency Ratio of the baseline equipment

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

IEER<sub>ee</sub> = Integrated Energy Efficiency Ratio of the energy efficient equipment.

= Actual installed

HeatLoad = Calculated heat load for the building

= EFLH<sub>heat</sub> \* Capacity<sub>heat</sub>

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<sup>63</sup> Based on Variable Refrigerant Flow Study. See 'Variable Refrigerant Flow Study 2023'.

<sup>64</sup> Based on Variable Refrigerant Flow Study. See 'Variable Refrigerant Flow Study 2023'.

<sup>65</sup> Based on Variable Refrigerant Flow Study. See 'Variable Refrigerant Flow Study 2023'.

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.

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

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

If rating is HSPF,  $COP = HSPF / 3.413$

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

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

$AFUE_{base}$  = Baseline Annual Fuel Utilization Efficiency Rating. Use appropriate code level efficiency.

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

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

= 7.7% for RTU replacement, 3% for multifamily (residential style) furnace replacement<sup>66</sup>

$\%IncentiveElectric$  = % of total incentive paid by electric utility

= Actual

$\%IncentiveGas$  = % of total incentive paid by gas utility

= Actual

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<sup>66</sup>  $F_e$  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  $F_e$  of the three building types. See "Fan Energy Factory Example Calculation 2021-06-23.xlsx" for reference. Multifamily is 3%, lower than commercial, due to typically lower fan static pressure in residential style applications.

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  <i>Electric resistance</i> (or none)	<i>VRF multisplit system</i>	13.0 SEER	AHRI 1230
				11.0 EER 12.9 IEER 14.6 IEER	
	<i>VRF multisplit system with heat recovery</i>		10.8 EER 12.7 IEER 14.4 IEER		
	≥135,000 Btu/h and <240,000 Btu/h		<i>VRF multisplit system</i>	10.6 EER 12.3 IEER 13.9 IEER	
			<i>VRF multisplit system with heat recovery</i>	10.4 EER 12.1 IEER 13.7 IEER	
	≥240,000 Btu/h		<i>VRF multisplit system</i>	9.5 EER 11.0 IEER 12.7 IEER	
	<i>VRF multisplit system with heat recovery</i>	9.3 EER 10.8 IEER 12.5 IEER			
VRF air cooled (heating mode)	<65,000 Btu/h (cooling capacity)		<i>VRF multisplit system</i>	7.7 HSPF	AHRI 1230
	≥65,000 Btu/h and <135,000 Btu/h (cooling capacity)		<i>VRF multisplit system</i> 47°F db/43°F wb <i>outdoor air</i>	3.3 COP <sub>H</sub>	
			17°F db/15°F wb <i>outdoor air</i>	2.25 COP <sub>H</sub>	
	≥135,000 Btu/h (cooling capacity)		<i>VRF multisplit system</i> 47°F db/43°F wb <i>outdoor air</i>	3.2 COP <sub>H</sub>	
	17°F db/15°F wb <i>outdoor air</i>	2.05 COP <sub>H</sub>			

**Non Fuel Switch example**, a heat recovery VRF system with 8 ton cooling capacity and 96 kbtu heating capacity, an efficient IEER of 18.5 and COP of 3.75, at a new construction low-rise office in Chicago in 2024 saves:

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

$$\text{Annual kWh Savings}_{\text{cool}} = (\text{Cooladj} * \text{Capacity}_{\text{cool}} * \text{EFLH}_{\text{cool}} / 3412) + (\text{Capacity}_{\text{cool}} * \text{EFLH}_{\text{cool}} * (1/\text{IEER}_{\text{base}} - 1/\text{IEER}_{\text{ee}}))/1000$$

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

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

$$\Delta kWh = (0.0 * 96000 * 989/3,412) + (96000 * 989 * (1/14.4 - 1/18.5))/1000 + (0.0 * 916 * 60000/3412) + (916 * 60000 * (1/3.3 - 1/3.75) / 3412) + (1 * 916 * 60000 * 1/0.8 * 0.077) / 3412$$

$$\Delta kWh = 3597 \text{ kWh}$$

**Fuel Switch example**, a heat recovery VRF system with 8-ton cooling capacity and 96 kbtu heating capacity, an efficient IEER of 18.5 and COP of 3.75, at a new construction low-rise office in Chicago, assuming a packaged single zone (furnace) and air conditioner baseline. Assuming 50%-50% Incentive agreement is used for joint programs, savings:

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

$$\begin{aligned} \text{GasHeatReplaced} &= (\text{GasHeat}_{\text{adj}} * \text{HeatLoad} * 1/\text{AFUE}_{\text{base}}) / 1,000,000 \\ &= 1.4 * (96000 * 916 * 1/0.8) / 1000000 \\ &= 153.9 \text{ MMBtu} \end{aligned}$$

$$\begin{aligned} \text{FanSavings} &= (\text{Flag} * \text{HeatLoad} * 1/\text{AFUE}_{\text{base}} * F_e) / 1,000,000 \\ &= (1 * 96000 * 916 * 1/0.8 * 0.030) / 1000000 \\ &= 3.30 \text{ MMBtu} \end{aligned}$$

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

$$\begin{aligned} \text{HPSiteHeatConsumed} &= (\text{Heat}_{\text{adj}} * \text{HeatLoad} * (1/\text{COP}_{\text{ee}})) / 1,000,000 \\ &= (1.6 * 96000 * 916 * (1/3.75)) / 1,000,000 \\ &= 37.9 \text{ MMBtu} \end{aligned}$$

$$\begin{aligned} \text{HPSiteCoolingImpact} &= (\text{Cool}_{\text{adj}} * \text{Capacity}_{\text{cool}} * \text{EFLH}_{\text{cool}} / 1,000,000) * (\text{FLH}_{\text{cool}} * \text{Capacity}_{\text{cool}} * \\ &\quad (1/\text{IEER}_{\text{base}} - 1/\text{IEER}_{\text{ee}})) * 3,412 / 1,000 / 1,000,000 \\ &= ((0.0 * 989 * 96000)/1,000,000) + (989 * 96000 * (1/14.4-1/18.5)) * 3,412 \\ &\quad / 1,000 / 1,000,000 \\ &= 5.0 \text{ MMBtu} \end{aligned}$$

$$\text{SiteEnergySavings (MMBTUs)} = 153.9 + 3.30 - 37.9 + 5.0 = 124.3 \text{ [Measure is eligible]}$$

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	$124.3 * 1,000,000/3,412$ = 36,430 kWh	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).	$0.5 * 124.3 * 1,000,000/3,412$ = 18,215 kWh	$0.5 * 124.3 * 10$ = 622 therms
Gas utility only	N/A	$124.3 * 10$ = 1,243 therms

### SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = (\text{Capacity}_{\text{cool}} / 1,000 * (1/\text{EER}_{\text{base}} - 1/\text{EER}_{\text{ee}})) * \text{CF}$$

Where:

**EER<sub>base</sub>** = 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<sup>67</sup>:

$$\text{EER} = (-0.02 * \text{SEER}^2) + (1.12 * \text{SEER})$$

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

= Actual installed

CF value is chosen between:

**CF<sub>SSP</sub>** = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)  
 = 91.3%

**CF<sub>PJM</sub>** = 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:

$$\begin{aligned} \Delta kW &= (96,000/1,000 * (1/10.8 - 1/12.5)) * 0.913 \\ &= 1.1 \text{ kW} \end{aligned}$$

### FOSSIL FUEL SAVINGS

Calculation provided together with Electric Energy Savings above.

### WATER AND OTHER NON-ENERGY IMPACT DESCRIPTIONS AND CALCULATION

N/A

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<sup>67</sup> 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.

**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.

$$\begin{aligned} \Delta\text{Therms} &= [\text{Heating Consumption Replaced}] \\ &= [\text{GasHeat}_{\text{Adj}} * \text{HeatLoad} * 1/\text{AFUE}_{\text{base}}] / 100,000 \end{aligned}$$

$$\Delta\text{kWh} = [\text{FurnaceFanSavings}] - [\text{HP heating consumption}] + [\text{Cooling savings}]$$

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

$$\begin{aligned} \Delta\text{kWh} &= [\text{FurnaceFlag} * \text{HeatLoad} * 1/\text{AFUE}_{\text{base}} * F_e * 0.000293] - [\text{Heat}_{\text{Adj}} * \text{HeatLoad}/3412 * (1/(\text{CO}_{\text{Pee}} \\ &)/1000)] + [\text{Cool}_{\text{Adj}} * (\text{Capacity}_{\text{cool}} * \text{EFLH}_{\text{cool}} * (1/\text{EER}_{\text{base}} - 1/\text{EER}_{\text{ee}}))/1000] \end{aligned}$$

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

$$\begin{aligned} \Delta\text{kWh} &= [\text{FurnaceFlag} * \text{HeatLoad} * 1/\text{AFUE}_{\text{base}} * F_e * 0.000293] - [\text{Heat}_{\text{Adj}} * \text{HeatLoad}/3412 * (1/\text{CO}_{\text{Pee}})] \\ &+ [\text{Cool}_{\text{Adj}} * (\text{Capacity}_{\text{cool}} * \text{EFLH}_{\text{cool}} * (1/\text{IEER}_{\text{base}} - 1/\text{IEER}_{\text{ee}}))/1000] \end{aligned}$$

**MEASURE CODE: CI-HVC-VFFY-V4-250101**

**REVIEW DEADLINE: 1/1/2026**

## 4.8.8 Commercial Secondary Windows

### DESCRIPTION

Commercial Secondary Windows (CSW) are window units with one or more transparent panes in a frame that attach to the interior or exterior of existing windows without replacing the original glass or frame. Secondary windows are retrofitted to existing commercial windows to improve their overall thermal performance by adding a layer of glazing. CSWs have a non-disruptive installation and can improve windows to meet current IECC<sup>68</sup> standards, resulting in heating and cooling energy savings.

Single-pane clear windows can increase the energy load through increased heat gain or heat loss, ultimately disrupting occupant comfort, and raising energy costs. Replacing windows can be costly, time-consuming, and disruptive to occupants, and hence it presents an opportunity of secondary window retrofits as a cost-effective energy efficiency measure.

A prescriptive methodology was developed to calculate energy savings associated with CSW retrofits in different commercial buildings across all Illinois climate zones through an energy modeling<sup>69</sup> analysis. An AERC<sup>70</sup> single-pane, metal-framed window was used as the baseline during the analysis and compared to a CSW retrofit meeting IECC 2021 standards for exterior fenestration assemblies. Heating and Cooling energy savings factors are derived from the energy modeling analysis for different building types and climate zones in Illinois and are utilized in the methodology section to calculate measure energy savings.

An external spreadsheet calculator<sup>71</sup> has been developed to calculate energy savings associate with this measure based on building-specific inputs listed below.

- Building Types
- Hospital, Hotel, Multifamily, Office, Restaurant, Retail/Strip Mall and School
- Total Area of CSW Retrofit
- Heating System Fuel
- Gas or Electric
- Gas Heating System Efficiency
- Electric Heating System Efficiency
- Cooling System Efficiency
- Building Location Zip Code
  - Zip codes for the state of Illinois matching one of the following climate zones:
    - 1 – Rockford
    - 2– Chicago
    - 3– Springfield
    - 4– Belleville
    - 5 – Marion

The calculator incorporates heating and cooling energy savings factors for different building types and locations based on the energy modeling analysis performed on the DOE's Prototype Building Models<sup>72</sup>.

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<sup>68</sup> IECC 2021 – <https://codes.iccsafe.org/content/IECC2021P2> based on current state code defined under <https://www.energycodes.gov/status/states/illinois>

<sup>69</sup> Energy Modeling was Performed in EnergyPlus (E+), using the DOE's Office of Energy Efficiency & Renewable Energy (EERE) Prototype Building Models with different Illinois climate zones. Detailed information on energy modeling methodology, inputs and assumptions along with references are detailed in the calculator tool, see Energy Savings Calculator for CSW 05-15.xlsm

<sup>70</sup> AERC 1 – [Attachments Energy Rating Council](#)

<sup>71</sup> See Energy Savings Calculator for CSW 05-15.xlsm

<sup>72</sup> [DOE EERE Prototype Buildings](#)

**DEFINITION OF EFFICIENT EQUIPMENT**

Efficient equipment in this measure refers to commercial secondary windows (CSW) retrofitted in buildings. Retrofitted CSW assembly shall have minimum thermal properties as indicated in table below.

	Center of Glass U-Factor of the Overall window assembly with CSW Retrofit (Btu/hr °F ft2)	Solar Heat Gain Coefficient of the Overall window assembly with CSW Retrofit
Efficient CSW Unit <sup>73</sup>	0.36	0.58

**DEFINITION OF BASELINE EQUIPMENT**

Baseline equipment refers to existing non-operable clear single-pane windows in existing buildings.

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The measure life is assumed to be 30 years<sup>74</sup>.

**DEEMED MEASURE COST**

Total installation cost for retrofitting the Commercial Secondary Windows is the deemed measure cost. Total measure cost is assumed to be 32\$ per square feet<sup>75</sup> of CSW systems installed.

**LOADSHAPE**

Loadshape C03- Commercial Cooling

Loadshape C04 - Commercial Electric Heating

Loadshape C05 - Commercial Electric Heating and Cooling

**COINCIDENCE FACTOR**

CFSSP = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)

= 91.3%<sup>76</sup>

CFPJM = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)

= 47.8%<sup>77</sup>

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<sup>73</sup> Minimum thermal properties for the efficient Commercial Secondary Window unit are based on the 2021 International Energy Efficiency Code- maximum allowable U-factors and Solar Heat Gain Coefficients (SHGC) for fixed windows.

[https://codes.iccsafe.org/content/IECC2021P2/chapter-4-ce-commercial-energy-efficiency#IECC2021P2\\_CE\\_Ch04\\_SecC402](https://codes.iccsafe.org/content/IECC2021P2/chapter-4-ce-commercial-energy-efficiency#IECC2021P2_CE_Ch04_SecC402)

<sup>74</sup> Effective useful life based on commercial secondary glazing systems measure in regional technical forum, technical advisory committee to Northwest Power and Conservation Council.

[Commercial Secondary Glazing Systems \(nwcouncil.org\)](https://www.nwcouncil.org/commercial-secondary-glazing-systems)

<sup>75</sup> Average total installed cost for CSW systems from “Secondary Glazing Systems: Market and Deployment Development” by Slipstream prepared for the Nicor Gas Energy Efficiency Program.

<sup>76</sup> 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.

<sup>77</sup> 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.

**Algorithm**

**CALCULATION OF ENERGY SAVINGS**

**ELECTRIC ENERGY SAVINGS**

$$\Delta kWh = (\Delta kWh_{cooling} + \Delta kWh_{heatingElectric} + \Delta kWh_{heatingGas})$$

$$\Delta kWh_{cooling} = CSF * A * 3412.14 / (\eta_{Cool} * 1000)$$

Where:

$$CSF^{78} = \text{Cooling energy savings factor, kWh/ft}^2/\text{Btu/Wh}$$

Building Types <sup>79</sup>	Cooling Energy Savings Factor for Different Climate Zones and Building Types (kWh/ft <sup>2</sup> /BTU/Wh)				
	1-Rockford	2-Chicago	3-Springfield	4-Belleville	5-Marion
Hospital	19.48	19.41	21.42	21.37	21.24
Hotel	16.07	16.21	18.61	18.09	18.61
Multifamily	14.46	14.54	16.96	16.54	17.32
Office	16.24	15.87	17.91	17.06	17.91
Restaurant	13.54	13.63	16.19	15.63	16.55
Retail/Strip Mall	16.54	16.80	18.92	17.98	18.82
School	16.51	16.12	18.31	17.09	17.79

A = Area of CSW system installed, ft<sup>2</sup>

$\eta_{Cool}$  = Seasonal Energy Efficiency Ratio of cooling system (kBtu/kWh)

= Actual value (where new or where it is possible to measure or reasonably estimate) or refer to IECC 2012<sup>80</sup> minimum efficiency ratings based on the type of cooling equipment or refer to the table below if equipment type is unknown.

Equipment Type	$\eta_{Cool}$ Estimate <sup>81</sup>
Unknown cooling equipment	13

<sup>78</sup> Cooling energy savings factor based on energy modeling on U.S. Department of Energy – Commercial prototype building models comparing window performance with CSW Retrofits and baseline single pane windows. Energy model inputs, results and assumptions will be externally attached for the Illinois Stakeholder Advisory Group – Technical Advisory Committee (TAC).

<sup>79</sup> Building type classification should be based on definitions under Illinois Technical Reference Manual version 12, volume 1: overview and user guide, section 3.6. [IL-TRM Effective 010124 v12.0 Vol 1 Overview 09222023 FINAL clean.pdf \(ilsag.info\)](https://www.ilsag.info/IL-TRM_Effective_010124_v12.0_Vol_1_Overview_09222023_FINAL_clean.pdf). For building types unknown, building type should be selected to closely resemble one of the building types listed in the table per interpretation of the program implementor based on actual building usage.

<sup>80</sup> International Energy Efficiency Code 2012, chapter 4 Commercial Energy Efficiency, table c403.2.3(1) minimum efficiency requirements: electrically operated unitary air conditioners and condensing units. <https://codes.iccsafe.org/content/IECC2012/chapter-4-ce-commercial-energy-efficiency>

<sup>81</sup> IECC 2012 conservative minimum SEER rating of 13.0 is assumed for cooling system efficiency if the system type is unknown.

$$\Delta kWh_{\text{heatingElectric}} = HSF * A * 8.58 / \eta_{\text{Heat}}$$

Where:

HSF<sup>82</sup> = Heating energy savings factor, Therms/ft<sup>2</sup>/Btu/Wh

= Refer to Fossil Fuel Savings section

8.58 = Factor to account for Therms to Wh and for Btu to kWh unit conversions

$\eta_{\text{Heat}}$  = Efficiency of heating system

= Actual value (where new or where it is possible to measure or reasonably estimate) or refer to CFR 431 minimum efficiency ratings based on the type of heating equipment or refer to the table below if equipment type is unknown.

System Type	Age of Equipment	HSPF Estimate <sup>83</sup>	$\eta_{\text{Heat}}$ (Effective COP Estimate) (HSPF/3.413)
Resistance	N/A	N/A	1
Unknown	N/A	10.92	3.2

$\Delta kWh_{\text{heatingGas}}$  = If gas furnace heat, kWh savings for reduction in fan run time

$$= \Delta \text{Therms} * Fe * 29.3$$

Where:

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

$$= 7.7\%^{84}$$

29.3 = kWh per therm

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<sup>82</sup> Heating energy savings factor based on energy modeling on U.S. Department of Energy – Commercial prototype building models comparing window performance with CSW Retrofits and baseline single pane windows. Energy model inputs, results and assumptions will be externally attached for the Illinois Stakeholder Advisory Group – Technical Advisory Committee (TAC).

<sup>83</sup> U.S. Department of energy, federal code for standards, Title 10, chapter II, subchapter D, part 431.97(b). [eCFR :: 10 CFR Part 431 -- Energy Efficiency Program for Certain Commercial and Industrial Equipment](#)

<sup>84</sup> Fe is estimated using TRM models for the three most popular building types for programmable thermostats: low-rise office (10.2%), sit-down restaurant (8.6%), and retail-strip mall (4.4%). 7.7% reflects the average Fe of the three building types. See “Fan Energy Factor Example Calculation 2021-06-23.xlsx” for reference.

**For Example**, a hotel in Rockford with an all electric HVAC system installing 50 sqft of commercial secondary windows would save:

$$\Delta kWh = \Delta kWh \text{ Cooling} + \Delta kWh \text{ HeatingElectric} + \Delta kWh \text{ HeatingGas}$$

$$\Delta kWh \text{ Cooling} = CSF * A * 3,412.14 / (\eta_{Cool} * 1,000)$$

$$= 16.07 * 50 * 3412.14 / (13 * 1000)$$

$$= 210.9 \text{ kWh}$$

$$\Delta kWh \text{ Heating Electric} = HSF * A * 8.58 / \eta_{Heat}$$

$$= 0.94 * 50 * 8.58 / 3.2$$

$$= 126.1 \text{ kWh}$$

$$\Delta kWh = 210.9 + 126.1 + 0$$

$$= 337.0 \text{ kWh}$$

#### SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = (\Delta kWh_{cooling} / EFLH_{cooling}) * CF$$

Where:

EFLHcooling = Equivalent full load hours of air conditioning in Existing Buildings or New Construction are provided in Section 4.4, HVAC end use

CF<sub>SSP</sub> = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)

$$= 91.3\%^{85}$$

CF<sub>PJM</sub> = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)

$$= 47.8\%^{86}$$

#### FOSSIL FUEL SAVINGS

$$\Delta \text{Therms} = (HSF * A) / \eta_{Heat}$$

Where:

<sup>85</sup> 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.

<sup>86</sup> 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.

HSF<sup>87</sup> = Heating energy savings factor, Therms/ft<sup>2</sup>

Building Types <sup>88</sup>	Heating Energy Savings Factor for Different Climate Zones and Building Types (Therms/ft <sup>2</sup> )				
	1-Rockford	2-Chicago	3-Springfield	4-Belleville	5-Marion
Hospital	0.83	0.80	0.64	0.62	0.61
Hotel	0.94	0.89	0.77	0.71	0.69
Multifamily	1.03	0.99	0.88	0.79	0.76
Office	0.82	0.80	0.72	0.65	0.63
Restaurant	0.96	0.90	0.81	0.76	0.73
Retail/Strip Mall	0.90	0.84	0.76	0.72	0.69
School	0.85	0.83	0.75	0.69	0.66

$\eta$ Heat = Efficiency of heating system in Et or Ec where Et is the thermal efficiency and Ec is the combustion efficiency as defined in 10 CFR 431.

= Actual or if known use values from table below

Equipment type	Certified rated input	$\eta$ Heat <sup>89 90</sup>
Gas Furnaces	≥300,000 Btu/h (from 01/01/1994 – 01/01/2023)	80% Et
	≥300,000 Btu/h (After 01/01/2023)	81% Et
Gas-fired hot water Boilers	≥300,000 Btu/h and ≤2,500,000 Btu/h	80% Et
	>2,500,000 Btu/h	82% Ec
Gas-fired steam Boilers	≥300,000 Btu/h (till 03/02/2022)	77% Et
	≥300,000 Btu/h (after 03/02/2022)	79% Et

<sup>87</sup> Heating energy savings factor based on energy modeling on U.S. Department of Energy – Commercial prototype building models comparing window performance with CSW Retrofits and baseline single pane windows. Energy model inputs, results and assumptions will be externally attached for the Illinois Stakeholder Advisory Group – Technical Advisory Committee (TAC).

<sup>88</sup> Building type classification should be based on definitions under Illinois Technical Reference Manual version 12, volume 1: overview and user guide, section 3.6. [IL-TRM Effective 010124 v12.0 Vol 1 Overview 09222023 FINAL clean.pdf \(ilsag.info\)](#). For building types unknown, building type should be selected to closely resemble one of the building types listed in the table based on the interpretation of the program implementor.

<sup>89</sup> Code of federal regulations, title 10, chapter ii, subchapter D, part 431, subpart C Energy and water conservation standards. [eCFR :: 10 CFR Part 431 Subpart D -- Commercial Warm Air Furnaces](#)

<sup>90</sup> Code of federal regulations, title 10, chapter ii, subchapter D, part 431, subpart E Energy Efficiency standards. [eCFR :: 10 CFR Part 431 Subpart E -- Commercial Boilers](#)

**For Example**, a hotel in Rockford with a gas furnace installed before 2023 installing 50 sqft of Commercial Secondary Windows would save:

$$\Delta kWh = \Delta kWh \text{ Cooling} + \Delta kWh \text{ Heating Electric} + \Delta kWh \text{ Heating Gas}$$

$$\Delta kWh \text{ Heating Gas} = \Delta \text{ Therms} * Fe * 29.3$$

$$\Delta \text{ Therms} = HSF * A * \eta_{\text{Heat}}$$

$$= 0.94 * 50 * 80\%$$

$$= 37.6 \text{ Therms}$$

$$\Delta kWh \text{ Heating Gas} = 37.6 * 7.7\% * 29.3$$

$$= 84.8 \text{ kWh}$$

$$\Delta kWh = 210.9 + 0 + 84.8$$

$$= 295.7 \text{ kWh}$$

**WATER AND OTHER NON-ENERGY IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-SHL-CSW-V02-250101**

**REVIEW DEADLINE: 1/1/2029**

### 5.5.12 Connected LED Lamps

**DESCRIPTION**

Many home devices in the market have become integrated with smart technology in recent years. Home devices able to connect to Wifi or a mobile network allow the user to control the device over the internet. This measure defines the savings associated with connected lighting. Connected LEDs allow for remote user control through a smart device, such as smart phone, tablet, or smart speaker. The standard LED provides light in one shade at one lumen level and color temperature. Connected LEDs have options integrated that allow for customizable color, color temperature, and lumen output. The Connected LED can also be turned on and off with a set schedule or controlled remotely. Savings from this measure come from both reduced hours of operation and dimming.

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

**DEFINITION OF EFFICIENT EQUIPMENT**

For this characterization to apply, the efficient condition must be LED lighting that is controlled by a smart device. The savings for this measure are the estimated incremental control savings compared to a non-connected efficient lamp. Some connected LEDs come with hubs for managing their operations. Connected LEDs with hubs do not qualify for this savings characterization, as the energy use by the hub cancels out the savings attributed to the connectivity of the lamp.

**DEFINITION OF BASELINE EQUIPMENT**

The baseline condition is the efficient LED without the connected capabilities.

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The deemed measure life is 6.1 years for exterior application.<sup>91</sup> For all other applications, lifetimes are capped at 10 years.<sup>92</sup>

**DEEMED MEASURE COST**

The incremental cost can be assumed to be \$20, the difference between the average cost of the baseline non-connected LED and the average cost of the connected LED.<sup>93</sup>

**LOADSHAPE**

Loadshape R06 – Residential Indoor Lighting

Loadshape R07 – Residential Outdoor Lighting

**COINCIDENCE FACTOR**

The summer peak coincidence factor is provided below:

Bulb Location	CF
Interior Omnidirectional	0.128 <sup>94</sup>
Interior Specialty	0.109 <sup>95</sup>

<sup>91</sup> ENERGY STAR v2.1 requires omnidirectional LED bulbs to be rated for at least 15,000 hours. 15000/2475 (exterior hours of use) = 6.1 years.

<sup>92</sup> Based on recommendation in the Dunsky Energy Consulting, Livingston Energy Innovations and Opinion Dynamics Corporation; NEEP Emerging Technology Research Report, p 6-18.

<sup>93</sup> Estimate based on review of available product and estimates provided in King J., ACEEE, “Energy Impacts of Smart Home Technologies”, April 2018.

<sup>94</sup> 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.

<sup>95</sup> 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.

Bulb Location	CF
Exterior	0.273 <sup>96</sup>
Unknown Omnidirectional	0.135 <sup>97</sup>
Unknown Specialty	0.117 <sup>98</sup>

Use Multifamily if: Building meets utility’s definition for multifamily.

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### Algorithm

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#### CALCULATION OF ENERGY SAVINGS

##### ELECTRIC ENERGY SAVINGS

$$\Delta kWh = ((\text{Watts}_{EE}/1000) * \text{HOURS} * \text{SVGe} * \text{WHFe}) - \text{Standby}_{kWh} * \text{ISR} * (1 - \text{Leakage})$$

Where:

**WattsEE** = Actual wattage of LED. If unknown, then use defaults in 5.5.6 LED Specialty Lamps or 5.5.8 LED Screw Based Omnidirectional Bulbs.

**HOURS** = Average hours of use per year

Installation Location	Hours
Residential and in-unit Multi Family Omnidirectional	1,089 <sup>99</sup>
Residential and in-unit Multi Family Specialty	763 <sup>100</sup>
Exterior	2,475 <sup>101</sup>
Unknown Omnidirectional	1,159 <sup>102</sup>
Unknown Specialty	1,020 <sup>103</sup>

**SVGe** = Percentage of annual lighting energy saved by lighting control; determined on a site-specific basis or using default below

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<sup>96</sup> 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.

<sup>97</sup> 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.

<sup>98</sup> 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.

<sup>99</sup> 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.

<sup>100</sup> 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.

<sup>101</sup> 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.

<sup>102</sup> 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.

<sup>103</sup> Based on a weighted average of interior and exterior hours of use from the IL Statewide LED Lighting Logger study conducted as part of the PY8/PY9 evaluations of the Ameren Illinois and ComEd Residential Lighting programs, assuming 15% exterior specialty lighting. The distribution of LEDs is based on the on-site lighting inventory conducted as part of the IL Statewide LED Lighting Logger study.

= 0.37<sup>104</sup>

ISR = In Service Rate, the percentage of lamps rebated that are actually in service.

Program		Weighted Average 1 <sup>st</sup> year In Service Rate (ISR) <sup>105</sup>
Retail (Time of Sale)		98.0%
Direct Install		94.5%
Efficiency Kits	LED Distribution	83%
	School Kits	84%
	Direct Mail Kits	93%
	Direct Mail Kits, Income Qualified	95%
	Community Distributed Kits	95%
Food Bank / Pantry Distribution		98%

Leakage = Adjustment to account for the percentage of program bulbs that move out (and in if deemed appropriate)<sup>106</sup> of the Utility Jurisdiction.

KITS programs = Determined through evaluation

Upstream (TOS) Lighting programs = Use deemed assumptions below:<sup>107</sup>

ComEd: 0.8%

Ameren: 13.1%

All other programs = 0

WHFe = Waste heat factor for energy to account for cooling savings

Bulb Location	WHFe
Interior single family	1.06 <sup>108</sup>

<sup>104</sup> Based on Lockheed Martin, 'Home Energy Management System/Smart Lighting Pilot for National Grid's Massachusetts and Rhode Island Residential Energy Efficiency Programs', Final Report, March 18, 2019. The study found the energy consumption of the LED to be 11.5/1000 \* 1200 hours = 13.8kWh. Savings from the smart lamp included both geo fencing (96% of studied homes providing 5.1kWh of savings) and in-room occupancy (3% of studied homes providing 6.6kWh of savings), for a total savings of 5.1kWh (0.96\*5.1 + 0.03\*6.6). As a percentage of the LED consumption this is 5.1/13.8 = 37%.

<sup>105</sup> ISRs are consistent with the LED Screw Based Standard Lamp measure, however since 2<sup>nd</sup> and 3<sup>rd</sup> year savings for this measure are so minimal, for ease of implementation the 3 year installs are discounted using the real discount rate to a single assumption.

<sup>106</sup> 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.

<sup>107</sup> Leakage rate is based upon review of PY8-CY2018 evaluations from ComEd and PY8 for Ameren.

<sup>108</sup> 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 SEER2 13.4 central AC unit, converted to

Bulb Location	WHFe
Multifamily in unit	1.04 <sup>109</sup>
Exterior or uncooled location	1.0
Unknown location Omnidirectional	1.051 <sup>110</sup>
Unknown location Specialty	1.046 <sup>111</sup>

StandbykWh = Standby power draw of the controlled lamp. Use actual value from manufacturer specification. If not known then assume:

$$= 0.63 \text{ kWh}^{112}$$

**For example**, a 9W Connected LED is purchased through a ComEd upstream program.

$$\begin{aligned} \Delta\text{kWh}_{1\text{st year installs}} &= (((9/1000) * 1,089 * 0.37 * 1.051) - 0.63) * 0.9 * (1 - 0.008) \\ &= 2.84 \text{ kWh} \end{aligned}$$

### HEATING PENALTY

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

$$\Delta\text{kWh}^{113} = - \frac{((\text{WattsEE} * \text{Hours} * \text{SVGe}) - \text{StandbykWh}) * \text{ISR} * (1 - \text{Leakage}) * \text{HF}}{1000 * \eta\text{Heat}}$$

Where:

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

= 49% for interior<sup>114</sup>

$\eta\text{Heat}$  = Efficiency in COP of Heating equipment

11.4 EER2 using algorithm  $(-0.02 * \text{SEER}^2) + (1.12 * \text{SEER})$  (from Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder), converted to COP and including distribution efficiency =  $\text{EER2} * 0.85/3.412 = 2.8\text{COP}$  and 66% of homes in Illinois having central cooling ("Table HC7.9 Air Conditioning in Homes in Midwest Region, Divisions, and States, 2009 from Energy Information Administration", 2009 Residential Energy Consumption Survey)

<sup>109</sup> 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)

<sup>110</sup> 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.

<sup>111</sup> 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.

<sup>112</sup> Based on Lockheed Martin, 'Home Energy Management System/Csmart Lighting Pilot for National Grid's Massachusetts and Rhode Island Residential Energy Efficiency Programs', Final Report, March 18, 2019.

<sup>113</sup> Negative value because this is an increase in heating consumption due to the efficient lighting.

<sup>114</sup> 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.

= Actual. If not available use: <sup>115</sup>

System Type	Age of Equipment	HSPF2 Estimate	COP <sub>HEAT</sub> (COP Estimate) = (HSPF2/3.413)*0.85
Heat Pump (if age unknown assume 2006-2014)	Before 2006	5.8	1.44
	After 2006 - 2014	6.5	1.62
	2015 on	7.0	1.74
Resistance	N/A	N/A	1.00
Unknown <sup>116</sup>	N/A	N/A	1.28

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

$$\Delta kWh = (\text{Watts}_{SE}/1000) * \text{SVGd} * \text{WHFd} * \text{ISR} * (1 - \text{Leakage}) * \text{CF}$$

Where:

SVGd = Percentage of annual lighting demand saved by lighting control; determined on a site-specific basis or using default below

$$= 0.37^{117}$$

WHFd = Waste heat factor for demand to account for cooling savings from efficient lighting.

Bulb Location	WHFd
Interior single family	1.11 <sup>118</sup>
Multifamily in unit	1.07 <sup>119</sup>
Exterior or uncooled location	1.0
Unknown location Omnidirectional	1.093 <sup>120</sup>
Unknown location Specialty	1.083 <sup>121</sup>

<sup>115</sup> 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.

<sup>116</sup> 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.

<sup>117</sup> Assumed equal to SVGe.

<sup>118</sup> 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.

<sup>119</sup> 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)

<sup>120</sup> 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.

<sup>121</sup> 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.

CF = Summer Peak Coincidence Factor for measure.

Bulb Location	CF
Interior Omnidirectional	0.128 <sup>122</sup>
Interior Specialty	0.109 <sup>123</sup>
Exterior	0.273 <sup>124</sup>
Unknown Omnidirectional	0.135 <sup>125</sup>
Unknown Specialty	0.117 <sup>126</sup>

**For example**, a 9W Connected LED is purchased through a ComEd upstream program.

$$\begin{aligned} \Delta kW_{1st \text{ year installs}} &= (((9/1000) * 0.37 * 1.093)) * 0.9 * (1 - 0.008) \\ &= 0.0032 \text{ kW} \end{aligned}$$

### FOSSIL FUEL SAVINGS

Heating penalty if Natural Gas heated home, or if heating fuel is unknown.

$$\Delta \text{Therms} = - \frac{((\text{WattsEE} * \text{Hours} * \text{SVGe}) - \text{StandbykWh}) * \text{ISR} * (1 - \text{Leakage}) * \text{HF} * 0.03412}{1000 * \eta \text{Heat}}$$

Where:

HF = Heating factor, or percentage of lighting savings that must be replaced by heating system.

= 49% for interior<sup>127</sup>

0.03412 = Converts kWh to Therms

$\eta$ Heat = Average heating system efficiency

= 0.70<sup>128</sup>

<sup>122</sup> 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.

<sup>123</sup> 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.

<sup>124</sup> 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.

<sup>125</sup> 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.

<sup>126</sup> 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.

<sup>127</sup> Average result from REMRate modeling of several different configurations and IL locations of homes

<sup>128</sup> 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.

Other factors as defined above

**WATER AND OTHER NON-ENERGY IMPACT DESCRIPTIONS AND CALCULATION**

NA

**DEEMED O&M COST ADJUSTMENT CALCULATION**

NA

**MEASURE CODE: RS-LTG-LEDC-V05-250101**

**REVIEW DEADLINE: 1/1/2026**

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Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows:

$$(0.24*0.92) + (0.76*0.8) * (1-0.15) = 0.70$$

### 5.6.3 Floor Insulation Above Crawlspace

#### **DESCRIPTION**

Insulation is added to the floor above a vented crawl space that does not contain pipes or HVAC equipment. If there are pipes, HVAC, or a basement, it is desirable to keep them within the conditioned space by insulating the crawl space walls and ground. Insulating the floor separates the conditioned space above from the space below the floor, and is only acceptable when there is nothing underneath that could freeze or would operate less efficiently in an environment resembling the outdoors. Even in the case of an empty, unvented crawl space, it is still considered best practice to seal and insulate the crawl space perimeter rather than the floor. Not only is there generally less area to insulate this way, but there are also moisture control benefits. There is a “Basement Insulation” measure for perimeter sealing and insulation. This measure assumes the insulation is installed above an unvented crawl space and should not be used in other situations.

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

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

#### **DEFINITION OF EFFICIENT EQUIPMENT**

This measure requires a member of the implementation staff or a participating contractor to evaluate the pre and post R-values and measure surface areas. The requirements for participation in the program will be defined by the utilities.

#### **DEFINITION OF BASELINE EQUIPMENT**

The existing condition will be evaluated by implementation staff or a participating contractor and is likely to be no insulation on any surface surrounding a crawl space.

#### **DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The expected measure life is assumed to be 30 years.<sup>129</sup>

Note a mid-life adjustment to account for replacement of HVAC equipment during the measure life should be applied after 10 years or 13 years for boilers.<sup>130</sup> See section below for detail.

#### **DEEMED MEASURE COST**

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

#### **DEEMED O&M COST ADJUSTMENTS**

N/A

#### **LOADSHAPE**

- Loadshape R08 - Residential Cooling
- Loadshape R09 - Residential Electric Space Heat
- Loadshape R10 - Residential Electric Heating and Cooling

#### **COINCIDENCE FACTOR**

The summer peak coincidence factor for cooling is provided in two different ways below. The first is used to estimate peak savings during the utility peak hour and is most indicative of actual peak benefits, and the second represents

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<sup>129</sup> As recommended in Guidehouse ‘EMV Group A, Deliverable 16 EUL Research – Residential Insulation’, prepared for California Public Utilities Commission, June 2021.

<sup>130</sup> This is intentionally longer than the assumptions found in the early replacement measures as the application of this measure will occur in a variety of homes that will not be targeted for early replacement HVAC systems.

the *average* savings over the defined summer peak period, and is presented so that savings can be bid into PJM’s capacity market.

CF <sub>SSP</sub>	= Summer System Peak Coincidence Factor for Central A/C (during utility peak hour) = 68% <sup>131</sup>
CF <sub>SSP SF</sub>	= Summer System Peak Coincidence Factor for Heat Pumps in single family homes (during system peak hour) = 72% <sup>132</sup>
CF <sub>SSP, MF</sub>	= Summer System Peak Coincidence Factor for Heat Pumps in multifamily homes (during system peak hour) = 67% <sup>133</sup>
CF <sub>PJM</sub>	= PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period) = 46.6% <sup>134</sup>
CF <sub>PJM SF</sub>	= PJM Summer Peak Coincidence Factor for Heat Pumps in single family homes (average during PJM peak period) = 46.6% <sup>135</sup>
CF <sub>PJM, MF</sub>	= PJM Summer Peak Coincidence Factor for Heat Pumps in multifamily homes (average during peak period) = 28.5%

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**Algorithm**

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**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

Where available savings from shell insulation measures should be determined through a custom analysis. When that is not feasible for the program the following engineering algorithms can be used with the inclusion of an adjustment factor to de-rate the heating savings.

$$\Delta kWh = (\Delta kWh_{cooling} + \Delta kWh_{heatingElectric} + \Delta kWh_{heatingFurnace})$$

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<sup>131</sup> Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.

<sup>132</sup> 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)’.

<sup>133</sup> Multifamily coincidence factors both from; *All-Electric Homes PY6 Metering Results: Multifamily HVAC Systems*, Cadmus, October 2015

<sup>134</sup> 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.

<sup>135</sup> Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.

Where:

$\Delta kWh_{cooling}$  = If central cooling, reduction in annual cooling requirement due to insulation

$$= \left( \frac{1}{R_{old}} - \frac{1}{R_{added} + R_{old}} \right) * Area * (1 - Framing\_factor) * 24 * CDD * DUA / (1000 * \eta_{Cool}) * ADJ_{FloorCool} * \%Cool$$

$R_{old}$  = R-value value of floor before insulation, assuming 3/4" plywood subfloor and carpet with pad

= Actual. If unknown assume 3.53 <sup>136</sup>

$R_{added}$  = R-value of additional spray foam, rigid foam, or cavity insulation.

Area = Total floor area to be insulated

Framing\_factor = Adjustment to account for area of framing

= 12% <sup>137</sup>

24 = Converts hours to days

CDD = Cooling Degree Days

Climate Zone (City based upon)	Conditioned CDD 65
1 (Rockford)	877
2 (Chicago)	1047
3 (Springfield)	1183
4 (Belleville)	1641
5 (Marion)	1450
Weighted Average <sup>138</sup>	1098

DUA = Discretionary Use Adjustment (reflects the fact that people do not always operate their AC when conditions may call for it).

= 0.75 <sup>139</sup>

1000 = Converts Btu to kBtu

$\eta_{Cool}$  = Seasonal Energy Efficiency Ratio of cooling system (kBtu/kWh)

= Actual (where it is possible to measure or reasonably estimate). Note where new HVAC is installed in addition to shell measures, the old HVAC unit efficiency should be used and

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<sup>136</sup> Based on 2005 ASHRAE Handbook – Fundamentals: assuming 3/4" subfloor, 1/2" carpet with rubber pad, and accounting for a still air film above and below: 0.68 + 0.94 + 1.23 + 0.68 = 3.53

<sup>137</sup> ASHRAE, 2001, "Characterization of Framing Factors for New Low-Rise Residential Building Envelopes (904-RP)," Table 7.1

<sup>138</sup> Weighted based on number of occupied residential housing units in each zone (US Census 2010).

<sup>139</sup> Energy Center of Wisconsin, May 2008 metering study; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research", p31.

the shell measure savings calculated first, the HVAC measure then assuming the reduced heat/cooling loads. If using rated efficiencies, derate efficiency value by 1% per year (maximum of 30 years) to account for degradation over time,<sup>140</sup> or if unknown assume the following.<sup>141</sup> If unknown value is used, it should not be derated by age.

Age of Equipment	ηCool Estimate
Before 2006	9.5
2006 - 2014	12.4
Central AC After 1/1/2015	12.4
Heat Pump After 1/1/2015	13.3
Unknown (for use in program evaluation only)	10.0

ADJ<sub>FloorCool</sub> = Adjustment for cooling savings from floor to account for prescriptive engineering algorithms overclaiming savings<sup>142</sup>

= 75%

%Cool = Percent of homes that have cooling

Central Cooling?	%Cool
Yes	100%
No	0%
Unknown (for use in program evaluation only) <sup>143</sup>	66%

ΔkWh<sub>heatingElectric</sub> = If electric heat (resistance or heat pump), reduction in annual electric heating due to insulation

$$= ((1/R_{old} - 1/(R_{added} + R_{old})) * Area * (1-Framing\_factor) * 24 * HDD) / (3,412 * \eta_{Heat}) * ADJ_{FloorHeat} * \%ElectricHeat$$

HDD = Heating Degree Days:<sup>144</sup>

<sup>140</sup> 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)<sup>Equipment Age</sup>).

<sup>141</sup> These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Central AC was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time means that using the minimum standard is appropriate. Note all ratings have been converted to SEER2 equivalents – since the new rating better reflects the actual efficiency of the units.

<sup>142</sup> As demonstrated in two years of metering evaluation by Opinion Dynamics, see Memo “Results for AIC PY6 HPwES Billing Analysis”, dated February 20, 2015. TAC negotiated adjustment factor is 80%. During update cycle for version v.12, applied the percent change of NCEI Annual Normals CDD65 from 30 yr data set (1981-2010) to more recent 15 yr data (2006-2020) for all cooling-related adjustment values.

<sup>143</sup> Percentage of homes in Illinois that have central cooling from “Table HC7.9 Air Conditioning in Homes in Midwest Region, Divisions, and States, 2009” from Energy Information Administration, 2009 Residential Energy Consumption Survey

<sup>144</sup> National Centers for Environmental Information (NCEI) Annual Normals, from 2006 - 2020, calculated with a base temp of 50°F to account for lower impact of unconditioned space on heating system. There is a county mapping table in Volume 1, Section 3.7 providing the appropriate city to use for each county of Illinois.

Climate Zone (City based upon)	Conditioned HDD 60
1 (Rockford)	5230
2 (Chicago)	4798
3 (Springfield)	4266
4 (Belleville)	3188
5 (Marion/Murphysboro)	3390
Weighted Average <sup>145</sup>	4631

$\eta_{Heat}$  = Efficiency of heating system

= Actual Heating Efficiency \* Distribution Efficiency (where it is possible to measure or reasonably estimate). Note where new HVAC is installed in addition to shell measures, the old HVAC unit efficiency should be used and the shell measure savings calculated first, the HVAC measure then assuming the reduced heat/cooling loads. If using rated efficiencies, derate efficiency value by 1% per year (maximum of 30 years) to account for degradation over time,<sup>146</sup> or if not available refer to default table below.<sup>147</sup> If unknown value is used, it should not be derated by age. If actual Distribution Efficiency is not available, use 85%.

System Type	Age of Equipment	HSPF2 Estimate	$\eta_{Heat}$ (Effective COP Estimate * Distribution Efficiency) (HSPF2/3.413)*0.85
Heat Pump (if age unknown, assume 2006-2014)	Before 2006	5.8	1.44
	After 2006 -2014	6.5	1.62
	2015 on	7	1.74
Resistance	N/A	N/A	1
Unknown (for use in program evaluation only)	N/A	N/A	1.32

$ADJ_{FloorHeat}$  = Adjustment for floor insulation to account for prescriptive engineering algorithms overclaiming savings<sup>148</sup>

= 63%

<sup>145</sup> Weighted based on number of occupied residential housing units in each zone.

<sup>146</sup> 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).

<sup>147</sup> These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Heat Pumps was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time means that using the minimum standard is appropriate. An 85% distribution efficiency is then applied to account for duct losses for heat pumps. Note all ratings have been converted to HSPF2 equivalents – since the new rating better reflects the actual efficiency of the units.

<sup>148</sup> As demonstrated in two years of metering evaluation by Opinion Dynamics, see Memo "Results for AIC PY6 HPwES Billing Analysis", dated February 20, 2015. TAC negotiated adjustment factor is 60%. During update cycle for version v.12, applied the percent change of NCEI Annual Normals HDD60 from 30 yr data set (1981-2010) to more recent 15 yr data (2006-2020) for all heating-related adjustment values.

%ElectricHeat = Percent of homes that have electric space heating

= 100 % for Electric Resistance or Heat Pump

= 0 % for Fossil Fuel heating

= If unknown<sup>149</sup>, use the following table:

Utility	Location				
	Single Family	Single Family Low Income	Multi Family	Multi Family Low Income	Unknown
Ameren	18%	26%	38%	39%	29%
ComEd	14%	22%	43%	48%	21%
PGL	1.0%	1.5%	4.0%	2.8%	2.2%
NSG	1.3%	0.8%	32.5%	1.2%	3.3%
Nicor	1.3%	0.8%	32.5%	1.2%	3.3%
<b>All DUs<sup>150</sup></b>					26%

**Note:** If a measure is supported by a gas and electric utility through a joint program, and it is unknown whether the participant has a gas supply, the electric utility values in the table above should be used. If it is known that the participant has a gas supply, the values from the gas utility above should be applied.

Other factors as defined above.

**For example**, a single family home in Chicago with a 20 by 25 footprint, insulated with R-30 spray foam above the crawlspace, a 10.5 SEER Central AC and a newer heat pump:

$$\begin{aligned}
 \Delta kWh &= (\Delta kWh_{cooling} + \Delta kWh_{heating}) \\
 &= (((1/3.53 - 1/(30+3.53)) * (20*25) * (1-0.12) * 24 * 1047 * 0.75) / (1000 * 10.5)) * 0.75 * 1 + \\
 &\quad (((1/3.53 - 1/(30+3.53)) * (20*25) * (1-0.15) * 24 * 4798) / (3412 * 1.92)) * 0.63 * 1) \\
 &= (150.1 + 1192.9) \\
 &= 1343 kWh
 \end{aligned}$$

$\Delta kWh_{heatingFurnace}$  = If fossil fuel *furnace* heat, kWh savings for reduction in fan run time

$$= \Delta Therms * F_e * 29.3$$

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

$$= 3.14\%^{151}$$

<sup>149</sup> Based on the average % Natural Gas used for space heating in Unknown residential structure types across all utilities covered by the IL program. Residence types include: SF, SF LI, MF & MF LI. Utilities included: Ameren, ComEd, People’s Gas, Northshore Gas & Nicor. Data provided from 2016 Ameren Illinois Demand Side Management (DSM) Market Potential Study by Applied Energy Group, ComEd’s 2019 Baseline Survey on residential space heating share, and PY2022-2023 Implementation Contractors Data for People’s Gas, Northshore Gas & Nicor .

<sup>150</sup> For the weighted average calculations, please see the Analysis file. PGL, NSG, Nicor & gas customers were assumed to follow the provided split. ComEd total customers, minus overlap with PGL, NSG & Nicor, therefore electric only homes. Ameren is total customers minus Nicor.

<sup>151</sup>  $F_e$  is not one of the AHRI certified ratings provided for residential furnaces, but can be reasonably estimated from a

29.3 = kWh per therm

**For example**, a single family home in Chicago with a 20 by 25 footprint, insulated with R-30 spray foam above the crawlspace, and a 70% efficient furnace (for therm calculation see Fossil Fuel Savings section):

$$\begin{aligned} \Delta kWh &= 112.4 * 0.0314 * 29.3 \\ &= 103.4 \text{ kWh} \end{aligned}$$

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

$$\Delta kW = (\Delta kWh_{cooling} / FLH_{cooling}) * CF$$

Where:

FLH\_cooling = Full load hours of air conditioning

= Dependent on location:<sup>152</sup>

Climate Zone (City based upon)	Single Family	Multifamily
1 (Rockford)	547	499
2 (Chicago)	709	629
3 (Springfield)	779	707
4 (Belleville)	1082	982
5 (Marion)	956	868
Weighted Average <sup>153</sup>		
ComEd	676	603
Ameren	875	791
Statewide	731	655

Use Multifamily if: Building meets utility’s definition for multifamily and HVAC system serves single unit. For residential sized systems serving 2 or more units, assume single family hours.

CF<sub>SSP</sub> = Summer System Peak Coincidence Factor for Central A/C (during utility peak hour)  
= 68%<sup>154</sup>

CF<sub>SSP SF</sub> = Summer System Peak Coincidence Factor for Heat Pumps in single family homes (during system peak hour)

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<sub>e</sub>. See “Programmable Thermostats Furnace Fan Analysis.xlsx” for reference.

<sup>152</sup> 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. During update cycle for version v.12, applied percent change of CDD65, NCEI Annual Normals from 30 yr data set (1981-2010) to more recent 15 yr data (2006-2020) to all FLHcool values.

<sup>153</sup> 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.

<sup>154</sup> Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.

	= 72% <sup>155</sup>
CF <sub>SSP, MF</sub>	= Summer System Peak Coincidence Factor for Heat Pumps in multifamily homes (during system peak hour)
	= 67% <sup>156</sup>
CF <sub>PJM</sub>	= PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)
	= 46.6% <sup>157</sup>
CF <sub>PJM SF</sub>	= PJM Summer Peak Coincidence Factor for Heat Pumps in single family homes (average during PJM peak period)
	= 46.6% <sup>158</sup>
CF <sub>PJM, MF</sub>	= PJM Summer Peak Coincidence Factor for Heat Pumps in multifamily homes (average during peak period)
	= 28.5%

**For example**, a single family home in Chicago with a 20 by 25 footprint, insulated with R-30 spray foam above the crawlspace, a 10.5 SEER Central AC and a newer heat pump:

$$\begin{aligned} \Delta kW_{SSP} &= 150.1 / 709 * 0.68 \\ &= 0.144 \text{ kW} \\ \Delta kW_{SSP} &= 150.1 / 709 * 0.466 \\ &= 0.099 \text{ kW} \end{aligned}$$

### FOSSIL FUEL SAVINGS

If Fossil Fuel heating:

$$\Delta \text{Therms} = \left( \left( \frac{1}{R_{\text{old}}} - \frac{1}{R_{\text{added}} + R_{\text{old}}} \right) * \text{Area} * (1 - \text{Framing\_factor}) * 24 * \text{HDD} \right) / \left( 100,000 * \eta_{\text{Heat}} \right) * \text{ADJ}_{\text{FloorHeat}} * \% \text{FossilHeat}$$

Where:

$\eta_{\text{Heat}}$  = Efficiency of heating system

= Equipment efficiency \* distribution efficiency

= Actual (where it is possible to measure or reasonably estimate). Note where new HVAC is installed in addition to shell measures, the old HVAC unit efficiency should be used and

<sup>155</sup> 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)'.

<sup>156</sup> Multifamily coincidence factors both from; *All-Electric Homes PY6 Metering Results: Multifamily HVAC Systems*, Cadmus, October 2015

<sup>157</sup> 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.

<sup>158</sup> 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.

the shell measure savings calculated first, the HVAC measure then assuming the reduced heat/cooling loads. If using rated efficiencies, derate efficiency value by 1% per year (maximum of 30 years) to account for degradation over time,<sup>159</sup> or if unknown assume 72% for existing system efficiency.<sup>160</sup> If unknown value is used, it should not be derated by age. If actual Distribution Efficiency is not available, use 85%.

- %FossilHeat = Percent of homes that have fossil fuel space heating
- = 100 % for Fossil Fuel heating
- = 0 % for Electric Resistance or Heat Pump
- = If unknown<sup>161</sup>, use the following table:

Utility	Location				
	Single Family	Single Family Low Income	Multi Family	Multi Family Low Income	Unknown
Ameren	82%	74%	62%	61%	71%
ComEd	86%	78%	57%	52%	79%
PGL	98.9%	98.5%	96.0%	96.9%	97.7%
NSG	98.3%	99.2%	67.5%	98.8%	96.6%
Nicor	98.3%	99.2%	67.5%	98.8%	96.6%
All DUs <sup>162</sup>					74%

**Note:** If a measure is supported by a gas and electric utility through a joint program, and it is unknown whether the participant has a gas supply, the electric utility values in the table above should be used. If it is known that the participant has a gas supply, the values from the gas utility above should be applied.

*Other factors as defined above.*

**For example,** a single family home in Chicago with a 20 by 25 footprint, insulated with R-30 spray foam above the crawlspace, and a 72% efficient furnace:

$$\Delta\text{Therms} = ((1 / 3.53 - 1 / (30 + 3.53)) * (20 * 25) * (1 - 0.12) * 24 * 4798) / (100,000 * 0.72) * 0.63 * 1$$

$$= 112.4 \text{ therms}$$

### Mid-Life adjustment

In order to account for the likely replacement of existing heating and cooling equipment during the lifetime of this

<sup>159</sup> 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).

<sup>160</sup> Based on average Nicor PY4 nameplate efficiencies derated by 15% for distribution losses.

<sup>161</sup> Based on the average % Natural Gas used for space heating in Unknown residential structure types across all utilities covered by the IL program. Residence types include: SF, SF LI, MF & MF LI. Utilities included: Ameren, ComEd, People’s Gas, Northshore Gas & Nicor. Data provided from 2016 Ameren Illinois Demand Side Management (DSM) Market Potential Study by Applied Energy Group, ComEd’s 2019 Baseline Survey on residential space heating share, and PY2022-2023 Implementation Contractors Data for People’s Gas, Northshore Gas & Nicor .

<sup>162</sup> For the weighted average calculations, please see the Analysis file. PGL, NSG, Nicor & gas customers were assumed to follow the provided split. ComEd total customers, minus overlap with PGL,NSG & Nicor, therefore gas only homes. Ameren is total customers minus Nicor.

measure, a mid-life adjustment should be applied. To calculate the adjustment, re-calculate the savings above using the following new baseline system efficiency assumptions:

Efficiency Assumption	System Type	New Baseline Efficiency
ηCool	Central AC	13.4 SEER2
	Heat Pump	14.3 SEER2
ηHeat	Electric Resistance	1.0 COP
	Heat Pump (7.5HSPF/3.413)*0.85	1.87 COP
	Gas Furnace 80% AFUE * 0.85	68% AFUE
	Oil Furnace 83% AFUE * 0.85	71% AFUE
	Gas Boiler	84% AFUE
	Oil Boiler	86% AFUE

This reduced annual savings should be applied following the assumed remaining useful life of the existing equipment, estimate to be 10 years or 13 years for boilers.<sup>163</sup> Note if the existing equipment efficiency is greater than the new baseline efficiency listed above, do not apply a mid-life adjustment.

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: RS-SHL-FINS-V17-250101**

**REVIEW DEADLINE: 1/1/2030**

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<sup>163</sup> This is intentionally longer than the assumption found in the early replacement measures as the application of this measure will occur in a variety of homes and will not be targeting those homes appropriate for early replacement HVAC systems.



