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Volume 3: Residential Measures

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Ameren Missouri TRM – Volume 3: Residential Measures Revision Log

Revision	Date	Description
1.0	05/30/2018	Initial version filed for Commission approval.
2.0	12/21/2018	Updated "Deemed Tables" with PY2017 Evaluation results per Stipulation and Agreement (File No. EO-2018-0211). Added Demand Response language per Stipulation and Agreement.
3.0	1/01/2020	Updated "Deemed Tables" with PY2018 Evaluation results. Also includes revisions to HVAC measures and multifamily measures, based on feedback from evaluation contractor. This includes updates to Volume 3 of the TRM.
4.0	10/15/2020	Updated “Deemed Tables” with PY2019 Evaluation results and other revisions to improve consistency with Deemed tables.
5.0	09/15/21	Updated “Deemed Tables” with PY2020 Evaluation results and other revisions to improve consistency with Deemed tables.
6.0	09/26/2022	Updated “Deemed Tables” with PY2021 Evaluation results and other revisions to improve consistency with Deemed Tables. Other revisions include updates to incremental costs for low flow showerheads, in-service rates for low flow showerheads and faucet aerators based on PY2021 evaluation, incorporation of SEER to SEER2 and HSPF to HSPF2 conversion factors due to upcoming Code of Federal Regulation testing procedures, and updates to PTHP and PTAC baseline code efficiencies.
7.0	10/05/2023	Addition of Pay As You Save (PAYS®) ISR’s. Added language to clarify that ccASHP’s must meet the majority of a home’s heating needs. Updated HVAC baselines for heat pumps to CFR standards, with a TRM effective date of 1/1/2024 to allow for sell-through; Updates to lighting measures to address EISA updates to general service lamps (GSL), effective 8/1/2023. Updated deemed costs of light bulbs to reflect first year cost per bulb.
8.0	~~12~~01/~~1xx~~15/202~~4~~5	Removed measures to align with approved measure list from Commission on 01/~~xx~~15/25. Removed several measures currently not active in the programs and added cool roof measures. Updated incremental cost for some measures, including Heating and Cooling CAC/ASHP. Reviewed and updated all measures including source documentation.

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Volume 3: Residential Measures

3.1 Appliances

~~3.1.1 Refrigerator and Freezer Recycling (Retired, effective 1/1/2025)[1]~~

~~Description~~
~~This measure describes savings from the retirement and recycling of inefficient but operational refrigerators and freezers. Savings are provided in two ways. First, a regression equation is provided that requires the use of key inputs describing the retired unit (or population of units) and is based on a 2013 workpaper provided by Cadmus using data from a 2012 ComEd metering study and metering data from a Michigan study. The second methodology is a deemed approach based on 2011 Cadmus analysis of data from a number of evaluations.[2]~~

~~The savings are equivalent to the unit energy consumption of the retired unit and should be claimed for the assumed remaining useful life of that unit. A Part Use Factor is applied to account for those secondary units that are not in use throughout the entire year. The user should note that the regression algorithm is designed to provide an accurate portrayal of savings for the population as a whole and includes those parameters that have a significant effect on the consumption. The precision of savings for individual units will vary. This measure also includes a section accounting for the interactive effect of reduced waste heat on the heating and cooling loads.~~

~~This measure was developed to be applicable to the following program type: ERET.~~

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

~~Definition of Efficient Equipment~~
~~N/A~~

~~Definition of Baseline Equipment~~
~~The existing inefficient unit must be operational and have a capacity of between 10 and 30 cubic feet.~~

~~Deemed Lifetime of Efficient Equipment~~
~~The estimated remaining useful life of the recycling units is 8 years.[3]~~

~~Deemed Measure Cost~~
~~Measure cost includes the cost of pickup and recycling of the refrigerator and should be based on actual costs of running the program. If unknown, assume $140 per unit.[4]~~

~~Loadshape~~
~~Refrigeration RES~~
~~Freezer RES~~

~~Algorithm~~

~~Calculation of Savings~~

~~Energy Savings~~

~~Regression analysis: Refrigerators~~

~~Daily energy savings for refrigerators are based upon a linear regression model using the following coefficients:[5]~~

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[1] ~~"Retire" indicates that the measure is not anticipated to be offered through an Ameren Missouri-administered demand-side program during the period of TRM effectiveness.~~

[2] ~~Cadmus "2010 Residential Great Refrigerator Roundup Program – Impact Evaluation," 2011. See file '2010 Residential Great Refrigerator Roundup Program Evaluation.pdf'.~~

[3] ~~KEMA "Residential Refrigerator Recycling Ninth Year Retention Study," 2004, https://www.calmac.org/publications/RARP_report_to_SCE_040726ES.pdf.; 'RARP_report_to_SCE_040726ES.pdf', page E-1..~~

[4] ~~Based on average program costs for SCE Refrigerator Appliance Recycling Program. Innovologie, "Appliance Recycling Program Retailer Trial Final Report," a report prepared for Southern California Edison, 2013, https://www.epa.gov/sites/default/files/2014-06/documents/sce-appliance-recycling-program_retailer-trial-final-report.pdf, .; 'sce-appliance-recycling-program_retailer-trial-final-report.pdf'.~~

[5] ~~Coefficients provided in May 13, 2016, Cadmus evaluation report; Ameren Missouri Refrigerator Recycling Impact and Process Evaluation: PY2015, https://www.efis.psc.mo.gov/Document/Display/13810, page 20.~~

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~~Independent Variable Description~~	~~Estimate Coefficient~~
~~Intercept~~	~~0.5822~~
~~Age (years)~~	~~0.0269~~
~~Pre-1990 (=1 if manufactured pre-1990)~~	~~1.0548~~
~~Size (cubic feet)~~	~~0.0673~~
~~Dummy: Side-by-Side (= 1 if side-by-side)~~	~~1.0706~~
~~Dummy: Single Door (= 1 if single door)~~	~~-1.9767~~
~~Dummy: Primary Usage Type (in absence of the program) (= 1 if primary unit)~~	~~0.6046~~
~~Interaction: Located in Unconditioned Space x CDD/365~~	~~0.0200~~
~~Interaction: Located in Unconditioned Space x HDD/365~~	~~-0.0447~~

~~$\Delta kWh_{Unit} = \left[0.5822 + (Age * 0.0269) + (Pre-1990 * 1.0548) + (Size * 0.0673) + (Side-by-side * 1.0706) + (Single-door * -1.9767) + (Primary\ Usage * 0.6046) + \left(\frac{CDD}{365} * Unconditioned * 0.0200\right) + \left(\frac{HDD}{365} * Unconditioned * -0.0447\right)\right] * Days * Part\ Use\ Factor$~~

~~ΔkWh$_{Unit}$ = [0.5822 + (Age * 0.0269) + (Pre-1990 * 1.0548) + (Size * 0.0673) + (Side-by-side * 1.0706) + (Single-door * -1.9767) + (Primary Usage * 0.6046) + (CDD/365 * Unconditioned * 0.0200) + (HDD/365 * Unconditioned * -0.0447)] * Days * Part Use Factor~~

~~Where:~~

~~Age = Age of retired unit~~
~~Pre-1990 = Pre-1990 dummy (=1 if manufactured pre-1990, else 0)~~
~~Size = Capacity (cubic feet) of retired unit~~
~~Side-by-Side = Side-by-side dummy (= 1 if side-by-side, else 0)~~
~~Single-Door = Single-door dummy (= 1 if single-door, else 0)~~
~~Primary Usage = Primary Usage Type (in absence of the program) dummy (= 1 if Primary, else 0. If unknown, assume 0.262.[6])~~
~~CDD = Cooling Degree Days~~
~~= 1678.[7]~~
~~Unconditioned = If unit in unconditioned space = 1, otherwise 0. If unknown, assume 0.64.[8]~~
~~HDD = Heating Degree Days~~
~~= 4,486[9]~~
~~Days = Days per year~~
~~= 365~~
~~Part Use Factor = To account for those units that are not running throughout the entire year. If available, Part-Use Factor participant survey results should be used. If not available, assume 0.864.[10]~~

~~Deemed approach: Refrigerators~~

~~ΔkWh$_{Unit}$ = UEC * Part Use Factor~~

~~$\Delta kWh_{Unit} = UEC * Part\ Use\ Factor$~~

~~Where:~~

~~UEC = Unit Energy Consumption~~
~~= 1181 kWh[11]~~
~~Part Use Factor = To account for those units that are not running throughout the entire year. If available, Part-Use Factor participant survey results should be used. If not available, assume 0.864.[12]~~
~~ΔkWh$_{Unit}$ = 1181 * 0.864~~

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[6] ~~Ameren Missouri Appliance Recycling Impact and Process Evaluation: PY2019, https://www.efis.psc.mo.gov/Document/Display/15876.~~
[7] ~~Based on climate normals CDD data, with a base temp of 65°F.~~
[8] ~~Ameren Missouri Appliance Recycling Impact and Process Evaluation: PY2019, https://www.efis.psc.mo.gov/Document/Display/15876..~~
[9] ~~Based on climate normals HDD data, with a base temp of 65°F.~~
[10] ~~Ameren Missouri Appliance Recycling Impact and Process Evaluation: PY2019, https://www.efis.psc.mo.gov/Document/Display/15876.~~
[11] ~~This value is taken from the 2016 Cadmus evaluation of Ameren Missouri Refrigerator Recycling PY2015, https://www.efis.psc.mo.gov/Document/Display/13810, page 21.~~
[12] ~~Ameren Missouri Appliance Recycling Impact and Process Evaluation: PY2019, https://www.efis.psc.mo.gov/Document/Display/15877.~~

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~~= 1020 kWh~~

~~Regression analysis: Freezers:~~

~~Daily energy savings for freezers are based upon a linear regression model using the following coefficients:~~~~[13]~~

~~Independent Variable Description~~	~~Estimate Coefficient~~
~~Intercept~~	~~-0.8918~~
~~Age (years)~~	~~0.0384~~
~~Pre-1990 (=1 if manufactured pre-1990)~~	~~0.6952~~
~~Size (cubic feet)~~	~~0.1287~~
~~Chest Freezer Configuration (=1 if chest freezer)~~	~~0.3503~~
~~Interaction: Located in Unconditioned Space x CDD~~	~~0.0695~~
~~Interaction: Located in Unconditioned Space x HDD~~	~~-0.0313~~

~~ΔkWh~~~~$_{Unit}$~~ ~~= [0.8918 + (Age * 0.0384) + (Pre-1990 * 0.6952) + (Size * 0.1287) + (Chest Freezer * 0.3503) + (CDD/365 * Unconditioned *0.0695) + (HDD/365 * Unconditioned * -0.0313)] * Part Use Factor~~

~~$\Delta kWh_{Unit} = [-0.8918 + (Age * 0.0384) + (Pre - 1990 * 0.6952) + (Size * 0.1287) + (Chest\ Freezer * 0.3503) + (CDD/365 * Unconditioned * 0.0695) + (HDD/365 * Unconditioned * -0.0313)] * Part\ Use\ Factor$~~

~~Where:~~

~~Age = Age of retired unit~~
~~Pre-1990 = Pre-1990 dummy (=1 if manufactured pre-1990, else 0)~~
~~Size = Capacity (cubic feet) of retired unit~~
~~Chest Freezer = Chest Freezer dummy (= 1 if chest freezer, else 0)~~
~~CDD = Cooling Degree Days (see table in refrigerator section)~~
~~Unconditioned = If unit in unconditioned space = 1, otherwise 0. If unknown, assume 0.67.~~~~[14]~~
~~HDD = Heating Degree Days (see table in refrigerator section)~~
~~Days = Days per year = 365~~
~~Part Use Factor = To account for those units that are not running throughout the entire year. If available, Part-Use Factor participant survey results should be used. If not available, assume 0.778.~~~~[15]~~

~~Deemed approach: Freezers~~

~~ΔkWh~~~~$_{Unit}$~~ ~~= UEC * Part Use Factor~~

~~$\Delta kWh_{Unit} = UEC * Part\ Use\ Factor$~~

~~Where:~~

~~UEC~~~~$_{Retired}$~~ ~~= Unit Energy Consumption of retired unit~~
~~= 1061 kWh~~~~[16]~~
~~Part Use Factor = To account for those units that are not running throughout the entire year. If available, Part-Use Factor participant survey results should be used. If not available, assume 0.778.~~~~[17]~~
~~ΔkWh~~~~$_{Unit}$~~ ~~= 1061 * 0.778~~
~~= 825 kWh~~

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[13] ~~Coefficients provided in May 13, 2016, Cadmus evaluation report; Ameren Missouri Refrigerator Recycling Impact and Process Evaluation: PY2015, https://www.efis.psc.mo.gov/Document/Display/13810, page 21~~.

[14] ~~Ameren Missouri Appliance Recycling Impact and Process Evaluation: PY2019, https://www.efis.psc.mo.gov/Document/Display/15877~~..

[15] ~~Ameren Missouri Appliance Recycling Impact and Process Evaluation: PY2019, https://www.efis.psc.mo.gov/Document/Display/15877~~.

[16] ~~This value is taken from the 2016 Cadmus evaluation of Ameren Missouri Refrigerator Recycling PY2015, https://www.efis.psc.mo.gov/Document/Display/13810, page 21~~.

[17] ~~Ameren Missouri Appliance Recycling Impact and Process Evaluation: PY2019, https://www.efis.psc.mo.gov/Document/Display/15877~~.

~~Summer Coincident Peak Demand Savings~~

~~$\Delta kW = \Delta kWh_{unit} * CF$~~

~~$\Delta kW_{Unit} = \Delta kWh_{Unit} * CF$~~

~~Where:~~

~~ΔkWh_{unit} = Savings provided in algorithm above (not including $\Delta kWh_{wasteheat}$)~~
~~CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor[18]~~
~~Refrigerators = 0.0001285253~~
~~Freezers = 0.0001285253~~

~~Natural Gas Savings~~

~~$\Delta Therms = \Delta kWh_{Unit} * WHFeHeatGas * 0.03412$~~~~$\Delta Therms = \Delta kWh_{Unit} * WHFeHeatGas* 0.03412$~~

~~Where:~~

~~ΔkWh_{Unit} = kWh savings calculated from either method above, not including the $\Delta kWh_{WasteHeat}$~~
~~WHFeHeatGas = Waste Heat Factor for Energy to account for gas heating increase from removing waste heat from refrigerator/freezer~~
~~= - (HF / $\eta Heat_{Gas}$) * %GasHeat~~
~~If unknown, assume 0~~
~~HF = Heating Factor or percentage of reduced waste heat that must now be heated~~
~~= 58% for unit in heated space[19]~~
~~= 0% for unit in heated space or unknown~~
~~$\eta Heat_{Gas}$ = Efficiency of heating system~~
~~= 71%[20]~~
~~%GasHeat = Percentage of homes with gas heat – see table below.~~
~~0.03412 = Converts kWh to therms~~

~~Heating Fuel~~	~~%GasHeat~~
~~Electric~~	~~0%~~
~~Gas~~	~~100%~~
~~Unknown~~	~~65%[21]~~

~~Water Impact Descriptions and Calculation~~
~~N/A~~

~~Deemed O&M Cost Adjustment Calculation~~
~~N/A~~

~~Measure Code:~~

---

[18] ~~Based on Ameren Missouri 2016 Loadshape for Residential Refrigeration and Freezer End-Use.~~~~Ameren Missouri TRM Volume 1 – Appendix G: "Table 1 – Residential End Use Category Monthly Shapes and Coincident Peak Factors"~~

[19] ~~Based on 212 days where HDD 65>0, divided by 365.25.~~

[20] ~~This has been estimated assuming that natural gas central furnace heating is typical for Missouri residences. The predominant heating is gas furnace with 48% of Missouri homes (based on Energy Information Administration, 2009 Residential Energy Consumption Survey). In 2000, 29% of furnaces purchased in Missouri 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, so units purchased 16 years ago provide a reasonable proxy for the current mix of furnaces in the state. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows: ((0.29*0.92) + (0.71*0.8)) * (1-0.15) = 0.71.~~

[21] ~~Based on data from Energy Information Administration, 2009 Residential Energy Consumption Survey, see "HC6.9 Space Heating in Midwest Region.xls", https://www.eia.gov/consumption/residential/data/2009/hc/hc6.9.xls.; 'hc6.9.xls'."~~

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~~3.1.2 Air Purifier/Cleaner~~

~~DESCRIPTION~~

~~An air purifier (cleaner) meeting the efficiency specifications of ENERGY STAR® is purchased and installed in place of a model meeting the current federal standard.~~

~~THIS MEASURE WAS DEVELOPED TO BE APPLICABLE TO THE FOLLOWING PROGRAM TYPES: _TOS AND, NC.~~

~~IF APPLIED TO OTHER PROGRAM TYPES, THE MEASURE SAVINGS SHOULD BE VERIFIED.~~

~~DEFINITION OF EFFICIENT EQUIPMENT~~

~~The efficient equipment is defined as an air purifier meeting the efficiency specifications of ENERGY STAR® as provided below.~~

1. ~~Must produce a minimum 5030 Clean Air Delivery Rate (CADR) for DustSmoke[22] to be considered under this specification.~~
2. ~~_Minimum Performance Requirement: = 2.0 is expressed in Smoke CADR/Watt (Dust)~~
3. ~~Standby Powerand it shall be greater than or equal to the Minimum Smoke CADR/Watt Requirement: = 2.0 Watts Qualifying models that perform secondary consumer functions (e.g., clock, remote control) must meet the Standby Power Requirement. shown in the table below:~~

~~CADR Range~~	~~CADR/W~~
~~30 ≤ Smoke CADR < 100~~	~~1.90~~
~~100 ≤ Smoke CADR < 150~~	~~2.40~~
~~150 ≤ Smoke CADR < 200~~	~~2.90~~
~~200 ≤ Smoke CADR~~	~~2.90~~

~~"Partial On Mode" Requirements are to be calculated as per Section 3.4.1 of the ENERGY STAR Energy Star Eligibility Criteria.[23]~~

4. ~~UL Safety Requirement: Models that emit ozone as a byproduct of air cleaning must meet UL Standard 867 (ozone production must not exceed 50ppb)~~

~~DEFINITION OF BASELINE EQUIPMENT~~

~~The baseline equipment is assumed to be a conventional unit.[24][25] that does not meet ENERGY STAR Efficiency Requirements.[26]~~

~~DEEMED LIFETIME OF EFFICIENT EQUIPMENT~~

~~The measure life is assumed to be 9 years.[27]~~

~~DEEMED MEASURE COST~~

~~The incremental cost for this measure is $70.[28]dependent on the Air Purifier size in CADR of Smoke.[29]~~

~~Product Size~~	~~Minimum CADR/W~~	~~Average ENERGY STAR Purchase Cost ($)~~	~~Average Incremental Cost ($)~~	
			~~Non-IQ~~	~~IQ[30]~~

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[22] ~~Measured according to the latest ANSI/AHAM AC-1 (AC-1) Standard https://ahamverifide.org/wp-content/uploads/2020/06/Air-Cleaner-Performance-FAQs.pdf.; 'Air-Cleaner-Performance-FAQs.pdf'..~~

[23] ~~ENERGY STAR® Product Specification for Room Air Cleaners - Eligibility Criteria Version 2.0, effective October 17, 2020, . https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20Version%202.0%20Room%20Air%20Cleaners%20Specification%20%28Rev.%20May%202022%29.pdf.; 'ENERGY STAR Version 2.0 Room Air Cleaners Specification (Rev. May 2022).pdf'.~~

[24] ~~As defined as the average of non-ENERGY STAR® products found in EPA research, 2011, ENERGY STAR® Qualified Room Air Cleaner Calculator.~~

[25] ~~As defined in ENERGY STAR v.2.0 Room Air Cleaners Data Package and analysis. See file: ICF_EPA_AirPurifier_Summary Savings Calculations.xlsx.~~

[26] ~~ENERGY STAR® Product Specification for Room Air Cleaners – Eligibility Criteria Version 2.0, https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20Version%202.0%20Room%20Air%20Cleaners%20Specification%20%28Rev.%20May%202022%29.pdf.; 'ENERGY STAR Version 2.0 Room Air Cleaners Specification (Rev. May 2022).pdf'..~~

[27] ~~ENERGY STAR® Qualified Room Air Cleaner Calculator citing Appliance Magazine, Portrait of the U.S. Appliance Industry 1998, .'ENERGY STAR Appliance Calculator.xlsx'.~~

[28] ~~Ameren Missouri MEEIA 2016-18 TRM, January 1, 2018.~~

[29] ~~ENERGY STAR V2 Room Air Cleaners Data Package (October 11, 2019). See file '"ENERGY STAR V2 Room Air Cleaners Data Package_GH 05122020_VEIC.xlsx'."~~

[30] ~~IQ Incremental costs factor in the assumption that a secondhand unit costs on average 50% of a new baseline unit, and that 1/3 of IQ participants would have purchased a unit on the secondhand market. See '"IQ Appliance Calculations.xlsIQ Appliance Calculations.xlsx'" for information.~~

~~30 ≤ Smoke CADR < 100~~	~~1.9~~	~~$82.49~~	~~$8.44~~	~~$20.78~~
~~100 ≤ Smoke CADR < 150~~	~~2.4~~	~~$140.43~~	~~$22.33~~	~~$42.01~~
~~150 ≤ Smoke CADR < 200~~	~~2.9~~	~~$349.00~~	~~$92.34~~	~~$135.12~~
~~200 ≤ Smoke CADR~~	~~2.9~~	~~$264.49~~	~~$44.50~~	~~$81.17~~

~~LOADSHAPE~~

~~HVAC RES~~

~~Algorithm~~

~~CALCULATION OF SAVINGS~~

~~ELECTRIC ENERGY SAVINGS~~[31]

~~$Energy\ Savings\ (kWh_{Year}) = \{CADR\ \times (1/Eff_{BL} - 1/Eff_{ES}) \times (Hr_{oper}) + (SBBL - SBES) \times (24 - Hr_{oper})\} \times 365/1000\ *\ ISR$~~

~~ΔkWh = (kWh_base – kWh_eff) * ISR~~

~~kWh_base = (hours * (SmokeCADR_base / (SmokeCADR_per_watt_base * 1000)) + (8760 - hours) * PartialOnModePower_base / 1000)) * IQAdj~~

~~kWh_eff = (hours * (SmokeCADR_eff / (SmokeCADR_per_watt_eff * 1000)) + (8760 – hours) * PartialOnModePower_eff / 1000)~~

~~Where:~~

~~kWh_base = Annual Electrical Usage for baseline unit (kWh)~~

~~kWh_eff = Annual Electrical Usage for efficient unit (kWh)~~

~~hours = Annual active operating hours~~

~~= 5840~~[32]

~~SmokeCADR_base = Smoke CADR for baseline units, as provided in table below~~

~~SmokeCADR_per_watt_base = Smoke CADR delivery rate per watt for baseline units, as provided in table below~~

~~PartialOnModePower_base = Partial On Model Power for baseline units by category (watts), as provided in table below~~

~~1000 = Conversion factor from watts to kilowatts~~

~~IQAdj = Baseline consumption adjustment for IQ program participants to account for a portion of participants who would have utilized the secondary market.~~[33]

~~= 1.25 if IQ, 1.0 if non-IQ~~

~~SmokeCADR_eff = Smoke CADR for efficient unit~~

~~= Actual, if unknown use values provided in table below~~

~~SmokeCADR_per_watt_eff = Smoke CADR delivery rate per watt for efficient units~~

~~= Actual, if unknown use values provided in table below~~

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[31] ~~ENERGY STAR® Qualified Room Air Cleaner Calculator.~~

[32] ~~Consistent with ENERGY STAR v.2.0 Room Air Cleaners Data Package and analysis. See file: 'ICF_EPA_AirPurifier_Summary Savings Calculations_043021.xlsx'.~~

[33] ~~It is assumed that a second-hand unit is on average 1/3 of a measure's EUL years old (6 years). The baseline consumption from the TRM in 2018 was increased by an estimate of 0.4% * 6 years (based on review of the refrigerator/freezer regression algorithm used in the 5.1.8 Refrigerator and Freezer Recycling measure) to account for degradation of performance over time. This second hand consumption was then weighted 1/3: 2/3 current new baseline to estimate a multiplier for IQ participants. See '"IQ Appliance Calculations.xlsIQ Appliance Calculations.xlsx'" for information.~~

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~~PartialOnModePower_eff = Partial On Model Power for efficient units by category (watts)~~

~~= Actual, if unknown use values provided in table below~~

~~ISR = In service rate. Actual, or if unknown, 948%~~[34]

~~Parameter assumptions for units by CADR Range:~~[35]

~~Eff$_{BL}$~~ ~~CADR Range~~	~~= Clean air recovery rate for dust~~~~Smoke CADR~~	~~Smoke CADR per Watt~~	~~Partial On Mode Power (watts)~~
	~~= Clean air recovery rate for dust per watt for baseline unit~~ ~~Baseline Units~~		
~~Eff$_{ES}$~~~~30 ≤ Smoke CADR < 100~~	~~= Clean air recovery rate for dust per watt for ENERGY STAR® unit~~ ~~83.3~~	~~1.64~~	~~2~~
~~Hr$_{oper}$~~~~100 ≤ Smoke CADR < 150~~	~~= Hours per day of operation~~ ~~127.6~~	~~1.83~~	~~2~~
~~SBBL~~~~150 ≤ Smoke CADR < 200~~	~~= Standby for baseline unit~~ ~~175.2~~	~~1.94~~	~~2~~
~~SBES~~~~200 ≤ Smoke CADR~~	~~= Standby for ENERGY STAR® unit~~ ~~292.9~~	~~1.89~~	~~2~~
~~365~~	~~Efficient Units~~		
~~1,000~~~~30 ≤ Smoke CADR < 100~~	~~= Conversion factor (Wh/kWh)~~~~83.3~~	~~2.9~~	~~0.478~~
~~100 ≤ Smoke CADR < 150~~	~~127.6~~	~~4.08~~	~~0.325~~
~~150 ≤ Smoke CADR < 200~~	~~175.2~~	~~4.47~~	~~0.562~~
~~200 ≤ Smoke CADR~~	~~292.9~~	~~5.05~~	~~0.638~~

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[34] ~~PY2018 participant surveyAmeren Missouri PY2018 Efficient Products Evaluation Report, https://www.efis.psc.mo.gov/Document/Display/15869, page I-7.~~

[35] ~~Baseline values are consistent with ENERGY STAR v.2.0 Room Air Cleaners Data Package and analysis. See file: 'ICF_EPA_AirPurifier_Summary Savings Calculations_043021.xlsxICF_EPA_AirPurifier_Summary Savings Calculations.xlsx'. Efficient values are averages within each CADR range for all models on the ENERGY STAR Qualified products list (QPL accessed: February 18, 2021). Both Baseline & Efficienct Capacities (CADR) are also sourced from the ENERGY STAR QPL. For Final Savings Calcs for this measure please see: 'IL-TRM_AirPurifier_Summary Savings Calculations_06152021.xlsx', IL TRM v12.0, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_3_Res_09222023_FINAL_clean.pdf, page 8.~~

~~SB~~$_{ES}$	~~0.391~~
~~ISR~~	~~94%~~

~~SUMMER COINCIDENT PEAK DEMAND SAVINGS~~

~~ΔkW = ΔkWh * CF~~

~~Where:~~

~~ΔkWh = Electric energy savings, as calculated above.~~
~~CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor~~ ~~$\Delta kW = \Delta kWh * CF$~~

~~= 0.0004660805Where:~~

~~ΔkWh = Gross customer annual kWh savings for the measure~~
~~CF = 0.0004660805~~

~~NATURAL GAS SAVINGS~~

~~N/A~~

~~WATER IMPACT DESCRIPTIONS AND CALCULATION~~

~~N/A~~

~~DEEMED O&M COST ADJUSTMENT CALCULATION~~

~~There are no operation and maintenance cost adjustments for this measure.~~[36]

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[36] ~~Some types of room air cleaners require filter replacement or periodic cleaning, but this is likely to be true for both efficient and baseline units and so no difference in cost is assumed.~~

~~3.1.3 Clothes Dryer~~

~~DESCRIPTION~~

~~This measure relates to the installation of a residential clothes dryer meeting the ENERGY STAR® criteria. ENERGY STAR® qualified clothes dryers save energy through a combination of more efficient drying and reduced runtime of the drying cycle. More efficient drying is achieved through increased insulation, modifying operating conditions such as air flow and/or heat input rate, improving air circulation through better drum design or booster fans, and improving efficiency of motors. Reducing the runtime of dryers through automatic termination by temperature and moisture sensors is believed to have the greatest potential for reducing energy use in clothes dryers.[37] ENERGY STAR® provides criteria for both gas and electric clothes dryers.~~

~~This measure was developed to be applicable to the following program types: TOS and NC.~~

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

~~DEFINITION OF EFFICIENT EQUIPMENT~~

~~Clothes dryer must meet the ENERGY STAR® criteria, as required by the program.~~

~~DEFINITION OF BASELINE EQUIPMENT~~

~~The baseline condition is a clothes dryer meeting the minimum federal requirements for units manufactured on or after January 1, 2015.~~

~~DEEMED LIFETIME OF EFFICIENT EQUIPMENT~~

~~The expected measure life is assumed to be 14 years.[38]~~

~~DEEMED MEASURE COST~~

~~Dryer Size~~	~~Incremental Cost[39]~~
~~Standard~~	~~$75~~
~~Compact~~	~~$105~~

~~LOADSHAPE~~

~~Miscellaneous RES~~

~~Algorithm~~

~~CALCULATION OF SAVINGS~~

~~ELECTRIC ENERGY SAVINGS~~

~~ΔkWh = (Load/(CEFbase) – (Load)/CEFeff) * Ncycles * %Electric~~

$$\Delta kWh = \left(\frac{Load}{CEFbase} - \frac{Load}{CEFeff}\right) * Ncycles * \%Electric$$

~~Where:~~

~~Load = The average total weight (lbs) of clothes per drying cycle. If dryer size is unknown, assume standard.~~

~~Dryer Size~~	~~Load (lbs)[40]~~
~~Standard~~	~~8.45~~

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[37] ~~ENERGY STAR® Market & Industry Scoping Report. Residential Clothes Dryers. Table 8. November 2011. http://www.energystar.gov/ia/products/downloads/ENERGY_STAR_Scoping_Report_Residential_Clothes_Dryers.pdf; 'ENERGY_STAR_Scoping_Report_Residential_Clothes_Dryers.pdf'.~~

[38] ~~Based on an average estimated range of 12-16 years. ENERGY STAR® Market & Industry Scoping Report. Residential Clothes Dryers. November 2011. http://www.energystar.gov/ia/products/downloads/ENERGY_STAR_Scoping_Report_Residential_Clothes_Dryers.pdf Based on DOE Rulemaking Technical Support Document, LCC Chapter, 2011, as recommended in Navigant 'ComEd Effective Useful Life Research Report, 'ComEd Effective Useful Life Research Report.pdf'', May 2018.~~

[39] ~~Cost based on ENERGY STAR® Savings Calculator for ENERGY STAR® Qualified Appliances. https://dnr.mo.gov/sites/dnr/files/media/file/2021/01/energy-star-appliance-calculator.xlsx; 'energy-star-appliance-calculator.xlsx'. https://www.energystar.gov/sites/default/files/asset/document/appliance_calculator.xlsx~~

[40] ~~Based on ENERGY STAR® test procedures. https://www.energystar.gov/index.cfm?c=clothesdry.pr_crit_clothes_dryers~~

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~~Compact~~	~~3~~

~~CEFbase~~ ~~= Combined energy factor (CEF) (lbs/kWh) of the baseline unit is based on existing federal standards energy factor and adjusted to CEF as performed in the ENERGY STAR® analysis.~~[41] ~~If product class unknown, assume electric, standard.~~

~~Product Class~~	~~CEFbase~~
~~Vented Electric, Standard (≥ 4.4 ft^3)~~	~~3.11~~
~~Vented Electric, Compact (120V) (< 4.4~~	~~3.01~~
~~Vented Electric, Compact (240V) (<4.4~~	~~2.73~~
~~Ventless Electric, Compact (240V) (<4.4~~	~~2.13~~
~~Vented Gas~~	~~2.84~~[42]
~~Electric Heat Pump, Standard (≥ 4.4 ft^3)~~	~~3.11~~
~~Electric Heat Pump, Compact (120V) (<~~	~~3.01~~

~~CEFeff~~ ~~= CEF (lbs/kWh) of the ENERGY STAR® unit based on ENERGY STAR® or ENERGY STAR® Most Efficient requirements requirements.~~[43] ~~If product class unknown, assume electric, standard.~~

	~~ENERGY STAR~~	~~ENERGY STAR Most Efficient~~
~~Product Class~~	~~CEF (lbs/kWh)~~	~~CEF (lbs/kWh)~~
~~Vented or Ventless Electric, Standard (≥ 4.4 ft^3)~~	~~3.93~~	~~4.3~~
~~Vented or Ventless Electric, Compact (120V) (< 4.4~~	~~3.80~~	~~4.3~~
~~Vented Electric, Compact (240V) (< 4.4 ft^3)~~	~~3.45~~	~~4.3~~
~~Ventless Electric, Compact (240V) (< 4.4 ft^3)~~	~~2.68~~	~~3.7~~
~~Vented Gas~~	~~3.48~~[44]	~~3.8~~

~~Ncycles~~ ~~= Number of dryer cycles per year. Use actual data if available. If unknown, use 283 cycles per year.~~[45]

~~%Electric~~ ~~= The percent of overall savings coming from electricity~~

~~= 100% for electric dryers, 5% for gas dryers~~[46]

~~Using defaults provided above:~~

---

[41] ~~ENERGY STAR® Draft 2 Version 1.0 Clothes Dryers Data and Analysis, https://www.energystar.gov/sites/default/files/specs//ENERGY%20STAR%20Draft%202%20Version%201.0%20Clothes%20Dryers%20Data%20and%20Analysis.xlsx.; 'ENERGY STAR Draft 2 Version 1.0 Clothes Dryers Data and Analysis.xlsx'.~~

[42] ~~Federal standards report CEF for gas clothes dryers in terms of lbs/kWh. To determine gas savings, this number is later converted to therms.~~

[43] ~~ENERGY STAR® Clothes Dryers Key Product Criteria. https://www.energystar.gov/index.cfm?c=clothesdry.pr_crit_clothes_dryers~~

[44] ~~Federal standards report CEF for gas clothes dryers in terms of lbs/kWh. To determine gas savings, this number is later converted to therms.~~

[45] ~~Appendix D to Subpart B of Part 430 – Uniform Test Method for Measuring the Energy Consumption of Dryers, https://ecfr.io/Title-10/Part-430/Appendix-D.; 'Title 10 Part 430 Appendix D.pdf'.~~

[46] ~~One hundred percent for electric dryer accounts for the fact that some of the savings on gas dryers comes from electricity (motors, controls, etc.). Five percent for gas dryers was determined using a ratio of the electric to total savings from gas dryers given by ENERGY STAR® Draft 2 Version 1.0 Clothes Dryers Data and Analysis. Value reported in 2015 EPA ENERGY STAR® appliance calculator, https://dnr.mo.gov/sites/dnr/files/media/file/2021/01/energy-star-appliance-calculator.xlsx; 'energy-star-appliance-calculator.xlsx'.~~

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~~Product Class~~	~~ΔkWh~~
~~Vented Electric, Standard (≥ 4.4 ft³)~~	~~145.7~~
~~Vented Electric, Compact (120V) (< 4.4 ft³)~~	~~53.8~~
~~Vented Electric, Compact (240V) (<4.4 ft³)~~	~~58.9~~
~~Ventless Electric, Compact (240V) (<4.4 ft³)~~	~~74.3~~
~~Vented Gas~~	~~7.0~~

~~SUMMER COINCIDENT PEAK DEMAND SAVINGS~~

~~ΔkW = ΔkWh * CF~~

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~~$\Delta kW = \Delta kWh * CF$~~

~~Where:~~

~~ΔkWh = Energy Savings as calculated above~~

~~CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor~~
~~= 0.0001148238~~

~~Using defaults provided above:~~

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~~Product Class~~	~~ΔkW~~
~~Vented Electric, Standard (≥ 4.4 ft³)~~	~~0.0251~~
~~Vented Electric, Compact (120V) (< 4.4 ft³)~~	~~0.0092~~
~~Vented Electric, Compact (240V) (<4.4 ft³)~~	~~0.0101~~
~~Ventless Electric, Compact (240V) (<4.4 ft³)~~	~~0.0128~~
~~Vented Gas~~	~~0.0012~~

~~NATURAL GAS ENERGY SAVINGS~~

~~Natural gas savings only apply to ENERGY STAR® vented gas clothes dryers.~~

~~ΔTherm = (Load/(CEFbase) – (Load)/CEFeff) * Ncycles * Therm_convert * %Gas~~

~~$\Delta Therm = \left(\frac{Load}{CEFbase} - \frac{Load}{CEFeff}\right) * Ncycles * Therm\_convert * \%Gas$~~

~~Where:~~

~~Therm_convert = Conversion factor from kWh to therm~~
~~= 0.03413~~

~~%Gas = Percent of overall savings coming from gas~~
~~= 0% for electric units and 84% for gas units[47]~~

~~Using defaults provided above:~~

~~ΔTherm = (8.45/2.84 – 8.45/3.48) * 257 * 0.03413 * 0.84~~
~~= 4.03 therms~~

~~[47] Zero percent for gas dryers accounts for the fact that some of the savings on gas dryers comes from electricity (motors, controls, etc.). Eighty-four percent was determined using a ratio of the gas to total savings from gas dryers given by ENERGY STAR® Draft 2 Version 1.0 Clothes Dryers Data and Analysis, https://www.energystar.gov/sites/default/files/specs//ENERGY%20STAR%20Draft%202%20Version%201.0%20Clothes%20Dryers%20Data%20and%20Analysis.xlsx; 'ENERGY STAR Draft 2 Version 1.0 Clothes Dryers Data and Analysis.xlsx'..~~

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~~WATER IMPACT DESCRIPTIONS AND CALCULATION~~

~~N/A~~

~~DEEMED O&M COST ADJUSTMENT CALCULATION~~

~~N/A~~

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~~3.1.4 Clothes Washer~~

~~DESCRIPTION~~

~~This measure relates to the installation of a clothes washer meeting the ENERGY STAR® (CEE Tier1), ENERGY STAR® Most Efficient (CEE Tier 2), or CEE Tier 3Advanced Tier minimum qualifications. If the Domestic Hot Water (DHW) and dryer fuels of the installations are unknown (for example through a retail program), savings are based on a weighted blend using RECS data (the resultant values (kWh, therms and gallons of water) are provided). The algorithms can also be used to calculate site-specific savings where DHW and dryer fuels are known.~~

~~This measure was developed to be applicable to the following program types: TOS and NC.~~

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

~~DEFINITION OF EFFICIENT EQUIPMENT~~

~~Clothes washer must meet the ENERGY STAR® (CEE Tier1), ENERGY STAR® Most Efficient (CEE Tier 2), or CEE Advanced Tier 3 minimum qualifications (provided in the table below), as required by the program.~~

~~DEFINITION OF BASELINE EQUIPMENT~~

~~The baseline condition is a standard sized clothes washer meeting the minimum federal baseline as of January 2018.~~[48]

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~~Efficiency Level~~	~~Top Loading >2.5 Cu ft~~	~~Front Loading >2.5 Cu ft~~
~~Federal Standard~~	~~≥1.57 IMEF, ≤6.5 IWF~~	~~≥1.84 IMEF, ≤4.7 IWF~~
~~ENERGY STAR®~~	~~≥2.06 IMEF, ≤4.3 IWF~~	~~≥2.76 IMEF, ≤3.2 IWF~~
~~ENERGY STAR® Most Efficient/CEE Tier 2~~	~~≥2.92 IMEF, ≤3.2 IWF~~	
~~CEE Advanced Tier~~	~~≥3.1 IMEF, ≤3.0 IWF~~	

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~~The baseline condition is a standard-sized clothes washer meeting the minimum federal baseline as of March 2015.~~[49]

~~Efficiency Level~~		~~Top loading >2.5 Cu ft~~	~~Front Loading >2.5 Cu ft~~
~~Baseline~~	~~Federal Standard~~	~~≥1.29 IMEF, ≤8.4 IWF~~	~~≥1.84 IMEF, ≤4.7 IWF~~
~~Efficient~~	~~ENERGY STAR®, CEE Tier 1~~	~~≥2.06 IMEF, ≤4.3 IWF~~	~~≥2.38 IMEF, ≤3.7 IWF~~
	~~ENERGY STAR® Most Efficient, CEE Tier 2~~	~~≥2.76 IMEF, ≤3.5 IWF~~	~~≥2.74 IMEF, ≤3.2 IWF~~
	~~CEE Tier 3~~	~~≥2.92 IMEF, ≤3.2 IWF~~	

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~~The Integrated Modified Energy Factor (IMEF) includes unit operation, standby, water heating, and drying energy use, with the higher the value the more efficient the unit: "The quotient of the cubic foot (or liter) capacity of the clothes container divided by the total clothes washer energy consumption per cycle, with such energy consumption expressed as the sum of the machine electrical energy consumption, the hot water energy consumption, the energy required for removal of the remaining moisture in the wash load, and the combined low-power mode energy consumption."~~

~~The Integrated Water Factor (IWF) indicates the total water consumption of the unit, with the lower the value the less water required: "The quotient of the total weighted per-cycle water consumption for all 67 wash cycles in gallons divided by the cubic foot (or liter) capacity of the clothes washer."~~[50]

~~DEEMED LIFETIME OF EFFICIENT EQUIPMENT~~

~~The expected measure life is assumed to be 14 years.~~[51]

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[48] ~~DOE Energy Conservation Standards for Clothes Washers, Appliance and Equipment Standard, 10 CFR Part 430.32(g), https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C/section-430.32~~

[49] ~~See http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/39.~~

[50] ~~Definitions provided in ENERGY STAR® v7.1 specification on the ENERGY STAR® website, https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20Version%208.1%20Clothes%20Washer%20Final%20Specificaiton%20-%20Partner%20Commitments%20and%20Eligibility%20Criteria.pdf.; 'ENERGY STAR Version 8.1 Clothes Washer Final Specificaiton – Partner Commitments and Eligibility Criteria.pdf'.~~

[51] ~~Based on DOE Chapter 8 Life-Cycle Cost and Payback Period Analysis, https://www.federalregister.gov/documents/2023/03/03/2023-03862/energy-conservation-program-energy-conservation-standards-for-residential-clothes-washers.~~

~~DEEMED MEASURE COST~~

~~The incremental cost assumptions are provided below:[52][53]~~

~~Efficiency Level~~	~~Incremental Cost~~
~~ENERGY STAR®ENERGY STAR®, CEE Tier 1~~	~~$8732~~
~~ENERGY STAR® Most Efficient/CEE Tier 2ENERGY STAR® Most Efficient, CEE TIER 2~~	~~$85393~~
~~CEE Advanced TierCEE TIER 3~~	~~$99454~~

~~LOADSHAPE~~

~~Miscellaneous RES~~

~~Algorithm~~

~~CALCULATION OF SAVINGS~~

~~ELECTRIC ENERGY SAVINGS~~

~~ΔkWh = [(Capacity * 1/IMEFbase * Ncycles) * (%CWbase + (%DHWbase * %Electric~~~~$_{DHW}$~~ ~~)+ (%Dryerbase * %Electric~~~~$_{Dryer}$~~~~))] - [(Capacity * 1/IMEFeff * Ncycles) * (%CWeff + (%DHWeff * %Electric~~~~$_{DHW}$~~ ~~) + (%Dryereff * %Electric~~~~$_{Dryer}$~~~~))]~~

~~$\Delta kWh = \left[\left(Capacity * \frac{1}{IMEFbase} * Ncycles\right) * \left(\%CWbase + (\%DHWbase * \%Electric_{DHW}) + (\%Dryerbase * \%Electric_{Dryer})\right)\right] - \left[\left(Capacity * \frac{1}{IMEFeff} * Ncycles\right) * \left(\%CWeff + (\%DHWeff * \%Electric_{DHW}) + (\%Dryereff * \%Electric_{Dryer})\right)\right]$~~

~~Where:~~

~~Capacity = Clothes washer capacity (cubic feet)~~
~~= Actual - If capacity is unknown, assume 3.45 cubic feet~~[54]
~~IMEFbase = Integrated Modified Energy Factor of baseline unit~~
~~IMEFeff = Integrated Modified Energy Factor of efficient unit~~
~~= Actual. If unknown, assume average values provided below.~~
~~Ncycles = Number of Cycles per year~~
~~= 271~~[55]
~~%CW = Percentage of total energy consumption for Clothes Washer operation (different for baseline and efficient unit – see table below)~~

~~%DHW = Percentage of total energy consumption used for water heating (different for baseline and efficient unit – see table below)~~
~~%Dryer = Percentage of total energy consumption for dryer operation (different for baseline and efficient unit – see table below)~~
~~%Electric~~~~$_{DHW}$~~ ~~= Percentage of DHW savings assumed to be electric~~
~~%Electric~~~~$_{Dryer}$~~ ~~= Percentage of dryer savings assumed to be electric~~

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[52] ~~Cost estimates are based on analysis of cost data provided in the 2017 Department of Energy Technical Support Document (see 'IL TRM_CW Analysis_042022.xlsx'). This analysis looked at incremental cost and market data from the CEC Appliance Database and attempts to find the costs associated only with the efficiency improvements. Note that the incremental cost assumes a mix of top and front loading machines available in each efficiency tier. Since CEE T2 and Advanced Tier units are all front loading, and the incremental cost is lower for these machines, the T2 incremental cost is lower than ENERGY STAR which is based on a mix of front and top loading machines.~~

[53] ~~Based on weighted average of top loading and front loading units (based on available product from the California Energy Commission (CEC) Appliance database (https://cacertappliances.energy.ca.gov/Pages/ApplianceSearch.aspx) and cost data from Life-Cycle Cost and Payback Period Excel-based analytical tool. See "2015 Clothes Washer Analysis.xls" for details.~~

[54] ~~Based on the average clothes washer volume of all units that pass the new federal standard on the CEC database of clothes washer products (accessed on 08/28/2014). If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area, then they should be used.~~

[55] ~~Weighted average of 271 clothes washer cycles per year (based on 2009 Residential Energy Consumption Survey (RECS) national sample survey of housing appliances section, Midwest Census Region for state of Missouri): http://www.eia.gov/consumption/residential/data/2009/. See '"2015 Clothes Washer Analysis.xlsx'" for details.~~
~~If utilities have specific evaluation results providing a more appropriate assumption for single family or multifamily homes in a particular market or geographical area, then that should be used.~~

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~~Efficiency Level~~	~~IMEFbase~~	
	~~Top loading >2.5 Cu ft~~	~~Front Loading >2.5 Cu ftWeighted Average~~[56]
~~Federal Standard~~	~~1.291.57~~	~~1.84 1.66~~

	~~Percentage of Total Energy Consumption~~[57]		
	~~%CW~~	~~%DHW~~	~~%Dryer~~
~~Federal Standard~~	~~6.7%8%~~	~~15.8%31%~~	~~77.5%61%~~
~~ENERGY STAR®, CEE Tier 1~~	~~6.6%8%~~	~~13.0%23%~~	~~80.4%69%~~
~~ENERGY STAR® Most Efficient, CEE Tier 2~~	~~8.2%14%~~	~~8.8%10%~~	~~82.9%76%~~
~~CEE Advanced TierCEE Tier 3~~	~~8.9%14%~~	~~7.0%10%~~	~~84.1%76%~~

~~DHW fuel~~	~~%Electric$_{DHW}$~~
~~Electric~~	~~100%~~
~~Natural Gas~~	~~0%~~
~~Unknown~~	~~43%~~[58]

~~Dryer fuel~~	~~%Electric$_{Dryer}$~~
~~Electric~~	~~100%~~
~~Natural Gas~~	~~0%~~
~~Unknown~~	~~90%~~[59]

~~Using the default assumptions provided above, the prescriptive savings for each configuration are presented below:~~[60]

~~Front Loaders:~~

	~~ΔkWH~~			
	~~Electric DHW Electric Dryer~~	~~Gas DHW Electric Dryer~~	~~Electric DHW Gas Dryer~~	~~Gas DHW Gas Dryer~~
~~ENERGY STAR®, CEE Tier 1~~	~~149.3~~	~~52.6~~	~~96.4~~	~~-0.2~~
~~ENERGY STAR® Most Efficient, CEE Tier 2~~	~~222.1~~	~~85.9~~	~~132.2~~	~~-4.0~~
~~CEE Tier 3~~	~~243.1~~	~~104.8~~	~~137.2~~	~~-1.1~~

~~Top Loaders:~~

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[56] ~~Weighted average IMEF of Federal Standard rating for Front Loading and Top Loading units. Weighting is based upon the relative top v front loading percentage of available non-ENERGY STAR® product in the CEC database (accessed 08/28/2014). The relative weightings are: 67% front and 33% top for Baseline; 62% front and 38% top for ENERGY STAR CEE Tier 1; 98% front and 2% top for ENERGY STAR Most Efficient, CEE Tier 2; and 100% front for CEE Tier 3. See more information in "2015 Clothes Washer Analysis.xlsx."~~

[57] ~~The percentage of total energy consumption that is used for the machine, heating the hot water or by the dryer is different depending on the efficiency of the unit. Values are based on a weighted average of top loading and front loading units based on data from the 2017 DOE Life-Cycle Cost and Payback Period Excel-based analytical tool. See 'IL TRM_CW Analysis_042022.xlsx' for the calculationThe percentage of total energy consumption that is used for the machine, heating the hot water, or by the dryer is different depending on the efficiency of the unit. Values are based on a weighted average of top loading and front-loading units based on data from DOE Life-Cycle Cost and Payback Analysis. See "2015 Clothes Washer Analysis.xls" for details.~~

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

[59] ~~Default assumption for unknown fuel is based on EIA Residential Energy Consumption Survey (RECS) 2009 for Midwest Region, data for the state of Missouri, 'HC8.9 Water Heating in Midwest Region.xls'Default assumption for unknown is based on percentage of homes with clothes washers that use an electric dryer from EIA Residential Energy Consumption Survey (RECS) 2009 for Midwest Region, data for the state of Missouri. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area, then they should be used.~~

[60] ~~Note that the baseline savings for all cases (front, top and weighted average) is based on the weighted average baseline IMEF (as opposed to assuming front baseline for front-efficient unit and top baseline for top- efficient unit). The reasoning is that the support of the program of more efficient units (which are predominately front loading) will result in some participants switching from planned purchase of a top loader to a front loader.~~

	~~ΔkWH~~			
	~~Electric DHW Electric Dryer~~	~~Gas DHW Electric Dryer~~	~~Electric DHW Gas Dryer~~	~~Gas DHW Gas Dryer~~
~~ENERGY STAR®, CEE Tier 1~~	~~149.3~~	~~97.0~~	~~77.0~~	~~24.8~~
~~ENERGY STAR® Most Efficient, CEE Tier 2~~	~~222.1~~	~~132.6~~	~~117.1~~	~~27.5~~
~~CEE Tier 3~~	~~243.1~~	~~374.4~~	~~230.5~~	~~42.0~~

~~Weighted Average:~~

	~~ΔkWH~~			
	~~Electric DHW Electric Dryer~~	~~Gas DHW Electric Dryer~~	~~Electric DHW Gas Dryer~~	~~Gas DHW Gas Dryer~~
~~ENERGY STAR®, CEE Tier 1~~	~~149.3~~	~~70.6~~	~~88.0~~	~~9.4~~
~~ENERGY STAR® Most Efficient, CEE Tier 2~~	~~222.1~~	~~80.9~~	~~137.5~~	~~-3.7~~
~~CEE Tier 3~~	~~243.1~~	~~98.4~~	~~143.2~~	~~-1.5~~

~~If the DHW and dryer fuel is unknown, the prescriptive kWH savings based on defaults provided above should be:~~

	~~ΔkWH~~		
~~Efficiency Level~~	~~Front Loaders~~	~~Top Loaders~~	~~Weighted Average~~
~~ENERGY STAR®, CEE Tier 1~~	~~112.8~~	~~89.6~~	~~99.0~~
~~ENERGY STAR® Most Efficient, CEE Tier 2~~	~~161.5~~	~~136.6~~	~~134.3~~
~~CEE Tier 3~~	~~424.6~~	~~154.8~~	~~151.8~~

~~SUMMER COINCIDENT PEAK DEMAND SAVINGS~~

~~ΔkW = ΔkWh * CF~~

~~Where:~~

~~ΔkWh = Electric energy savings, as calculated above.~~
~~CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor~~
~~= 0.0001148238~~ ~~$\Delta kW = \Delta kWh * CF$~~

~~Where:~~

~~ΔkWh = Energy Savings as calculated above~~
~~CF = Summer peak coincidence factor for measure~~
~~= 0.0001148238~~

~~Using the default assumptions provided above, the prescriptive savings for each configuration are presented below:~~

~~Front Loaders:~~

	~~ΔkW~~			
	~~Electric DHW Electric Dryer~~	~~Gas DHW Electric Dryer~~	~~Electric DHW Gas Dryer~~	~~Gas DHW Gas Dryer~~
~~ENERGY STAR®, CEE Tier 1~~	~~0.022~~	~~0.008~~	~~0.015~~	~~0.000~~
~~ENERGY STAR® Most Efficient, CEE Tier 2~~	~~0.033~~	~~0.013~~	~~0.020~~	~~-0.001~~
~~CEE Tier 3~~	~~0.037~~	~~0.016~~	~~0.021~~	~~0.000~~

~~Top Loaders:~~

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	~~ΔkW~~			
	~~Electric DHW Electric Dryer~~	~~Gas DHW Electric Dryer~~	~~Electric DHW Gas Dryer~~	~~Gas DHW Gas Dryer~~
~~ENERGY STAR®, CEE Tier 1~~	~~0.022~~	~~0.015~~	~~0.012~~	~~0.004~~
~~ENERGY STAR® Most Efficient, CEE Tier 2~~	~~0.033~~	~~0.020~~	~~0.018~~	~~0.004~~
~~CEE Tier 3~~	~~0.037~~	~~0.056~~	~~0.035~~	~~0.006~~

~~Weighted Average:~~

	~~ΔkW~~			
	~~Electric DHW Electric Dryer~~	~~Gas DHW Electric Dryer~~	~~Electric DHW Gas Dryer~~	~~Gas DHW Gas Dryer~~
~~ENERGY STAR®, CEE Tier 1~~	~~0.022~~	~~0.011~~	~~0.013~~	~~0.001~~
~~ENERGY STAR® Most Efficient, CEE Tier 2~~	~~0.033~~	~~0.012~~	~~0.021~~	~~-0.001~~
~~CEE Tier 3~~	~~0.037~~	~~0.015~~	~~0.022~~	~~0.000~~

~~If the DHW and dryer fuel is unknown, the prescriptive kW savings should be:~~

	~~ΔkW~~		
~~Efficiency Level~~	~~Front Loaders~~	~~Top Loaders~~	~~Weighted Average~~
~~ENERGY STAR®, CEE Tier 1~~	~~0.013~~	~~0.017~~	~~0.015~~
~~ENERGY STAR® Most Efficient, CEE Tier 2~~	~~0.021~~	~~0.024~~	~~0.020~~
~~CEE Tier 3~~	~~0.023~~	~~0.064~~	~~0.023~~

~~NATURAL GAS SAVINGS~~

~~ΔTherms = [[(Capacity* 1/IMEFbase * Ncycles) * ((%DHWbase * %Gas$_{DHW}$ * R_$_{eff}$)+ (%Dryerbase * %Gas$_{Dryer}$))] - [(Capacity * 1/IMEFeff * Ncycles) * ((%DHW * %Gas$_{DHW}$ * %Gas$_{DHW}$ * R_$_{eff}$)+ (%Dryereff * %Gas$_{Dryer}$))]] * Therm_convert~~

~~$$\Delta Therms = \left[\left[\left(Capacity * \frac{1}{IMEFbase} * Ncycles\right) * \left(\left(\%DHWbase * \%Natural\ Gas_{DHW} * R_{eff}\right) + \left(\%Dryerbase * \%Gas_{Dryer}\right)\right)\right] - \left[\left(Capacity * \frac{1}{IMEFeff} * Ncycles\right) * \left(\left(\%DHW_{eff} * \%Gas_{DHW} * \%Natural\ Gas\_DHW * R\_eff\right) + \left(\%Dryereff * \%Gas_{Dryer}\right)\right)\right]\right] * Therm\_convert$$~~

~~Where:~~

~~%Gas$_{DHW}$~~ ~~= Percentage of DHW savings assumed to be~~ nNatural ~~g~~Gas
~~R_{eff}~~ ~~= Recovery efficiency factor~~
~~= 1.26~~[61]
~~%Gas$_{Dryer}$~~ ~~= Percentage of dryer savings assumed to be~~ nNatural ~~g~~Gas
~~Therm_convert~~ ~~= Conversion factor from kWh to therm~~
~~= 0.03412~~

~~Other factors as defined above.~~

~~DHW fuel~~	~~%Gas$_{DHW}$~~
~~Electric~~	~~0%~~
~~Natural Gas~~	~~100%~~

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[61] ~~To account for the different efficiency of electric and Natural Gas hot water heaters (gas water heater: recovery efficiencies ranging from 0.74 to 0.85 (0.78 used), and electric water heater with 0.98 recovery efficiency. (http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/Waste_Water_Heat_Recovery_Guidelines.pdf). Therefore, a factor of 0.98/0.78 (1.26) is applied.~~

~~DHW fuel~~	~~%Gas$_{DHW}$~~
~~Unknown~~	~~57%[62]~~

~~Dryer fuel~~	~~%Gas$_{Dryer}$~~
~~Electric~~	~~0%~~
~~Natural Gas~~	~~100%~~
~~Unknown~~	~~10%[6252]~~

~~Using the default assumptions provided above, the prescriptive savings for each configuration are presented below:~~

~~Front Loaders:~~

	~~ΔTherms~~			
	~~Electric DHW Electric Dryer~~	~~Gas DHW Electric Dryer~~	~~Electric DHW Gas Dryer~~	~~Gas DHW Gas Dryer~~
~~ENERGY STAR®, CEE Tier 1~~	~~0.0~~	~~2.2~~	~~2.5~~	~~4.7~~
~~ENERGY STAR® Most Efficient, CEE Tier 2~~	~~0.0~~	~~3.8~~	~~3.6~~	~~7.4~~
~~CEE Tier 3~~	~~0.0~~	~~8.1~~	~~11.3~~	~~19.4~~

~~Top Loaders:~~

	~~ΔTherms~~			
	~~Electric DHW Electric Dryer~~	~~Gas DHW Electric Dryer~~	~~Electric DHW Gas Dryer~~	~~Gas DHW Gas Dryer~~
~~ENERGY STAR®, CEE Tier 1~~	~~0.0~~	~~4.2~~	~~1.8~~	~~6.0~~
~~ENERGY STAR® Most Efficient, CEE Tier 2~~	~~0.0~~	~~5.9~~	~~3.1~~	~~8.9~~
~~CEE Tier 3~~	~~0.0~~	~~5.9~~	~~3.6~~	~~9.6~~

~~Weighted Average:~~

	~~ΔTherms~~			
	~~Electric DHW Electric Dryer~~	~~Gas DHW Electric Dryer~~	~~Electric DHW Gas Dryer~~	~~Gas DHW Gas Dryer~~
~~ENERGY STAR®, CEE Tier 1~~	~~0.0~~	~~3.4~~	~~2.1~~	~~5.5~~
~~ENERGY STAR® Most Efficient, CEE Tier 2~~	~~0.0~~	~~6.1~~	~~2.9~~	~~9.0~~
~~CEE Tier 3~~	~~0.0~~	~~6.2~~	~~3.4~~	~~9.6~~

~~If the DHW and dryer fuel is unknown, the prescriptive therm savings should be:~~

	~~ΔTherms~~		
~~Efficiency Level~~	~~Front Loaders~~	~~Top Loaders~~	~~Weighted Average~~
~~ENERGY STAR®, CEE Tier 1~~	~~1.51~~	~~2.52~~	~~2.11~~
~~ENERGY STAR® Most Efficient, CEE Tier 2~~	~~2.52~~	~~3.60~~	~~3.71~~
~~CEE Tier 3~~	~~5.66~~	~~3.70~~	~~3.84~~

~~WATER IMPACT DESCRIPTIONS AND CALCULATION~~

~~ΔWater = Capacity * (IWF$_{base}$ – IWF$_{eff}$) * Ncycles~~

~~$$\Delta Water\ (gallons) = Capacity * (IWFbase - IWFeff) * Ncycles$$~~

~~Where:~~

~~IWFbase = Integrated Water Factor of baseline clothes washer~~

~~[62] Default assumption for unknown fuel is based EIA Residential Energy Consumption Survey (RECS) 2009 for Midwest Region, data for the state of Missouri. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area, then that should be used.~~

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~~= 5.92[63]~~
~~IWFeff = Water Factor of efficient clothes washer~~
~~= Actual – If unknown assume average values provided below~~

~~Other factors as defined above.~~

~~Using the default assumptions provided above, the prescriptive water savings for each efficiency level are presented below:~~

	~~IWF[64]~~			~~ΔWater (gallons per year)~~		
~~Efficiency Level~~	~~Front Loaders~~	~~Top Loaders~~	~~Weighted Average~~	~~Front Loaders~~	~~Top Loaders~~	~~Weighted Average~~
~~Federal Standard~~	~~4.7~~	~~8.4~~	~~5.92~~	~~N/A~~		
~~ENERGY STAR®, CEE Tier 1~~	~~3.7~~	~~4.3~~	~~3.93~~	~~934~~	~~3,828~~	~~1,857~~
~~ENERGY STAR® Most Efficient, CEE Tier 2~~	~~3.2~~	~~3.5~~	~~3.21~~	~~1,400~~	~~4,575~~	~~2,532~~
~~CEE Tier 3~~	~~3.2~~		~~3.20~~	~~1,400~~	~~7,842~~	~~2,538~~

~~DEEMED O&M COST ADJUSTMENT CALCULATION~~

~~N/A~~

~~MEASURE CODE:~~

~~[63] Weighted average IWF of Federal Standard rating for front loading and top loading units. Weighting is based upon the relative top vs. front loading percentage of available non-ENERGY STAR® products in the CEC database.~~

~~[64] IWF values are the weighted average of the new ENERGY STAR® specifications. Weighting is based upon the relative top vs. front loading percentage of available ENERGY STAR® and ENERGY STAR® Most Efficient products in the CEC database. See "2015 Clothes Washer Analysis.xls" for the calculation.~~

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~~3.1.5 Dehumidifier~~

~~DESCRIPTION~~

~~A dehumidifier meeting the minimum qualifying efficiency standard established by the current ENERGY STAR® Version 45.0 (effective 2/1/201610/31/2019) and ENERGY STAR Most Efficient 2020 Criteria (effective 01/01/2020) is purchased and installed in a residential setting in place of a unit that meets the minimum federal standard efficiency.~~

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

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

~~DEFINITION OF EFFICIENT EQUIPMENT~~

~~To qualify for this measure, the new dehumidifier must meet the ENERGY STAR® standards as defined below:~~

~~Equipment Specification~~ ~~<75~~	~~Product Capacity (pints/day)~~	~~ENERGY STAR® Criteria (L/kWh)~~	~~ENERGY STAR Most Efficient Criteria~~
	~~≥2.00(Pints/Day)~~	~~(L/kWh)~~	~~(L/kWh)~~
~~Portable Dehumidifier~~ ~~75 to ≤185~~	~~≤ 25~~	~~≥1.57~~	~~≥1.70~~
	~~>25 and ≤ 50~~	~~≥21.80~~	~~≥1.90~~
	~~>50 and < 155~~	~~≥3.30~~	~~≥3.40~~

~~Qualifying units mustshall be equipped with an adjustable humidistat control or must haveshall require a remote humidistat control to operate. The Whole – Home option for Dehumidifiers was not included, due to the extremely limited availability of Qualified products on the market. As of May 5, 2020, there are zero models.~~

~~DEFINITION OF BASELINE EQUIPMENT~~

~~The baseline for this measure is defined as a new dehumidifier that meets the Code of Federal Regulations appliance federal standard efficiency standards. The federal standard for dehumidifiersAs of June 13, 2019, those are as of October 2012 is defined below for Dehumidifiers:~~

~~Equipment Specification~~	~~Capacity (pints/day)~~	~~Federal Standard Criteria (L/kWh)~~
~~Up to 35Portable Dehumidifier~~ ~~> 35 to ≤45~~	~~≤25~~	~~≥1.3530~~
	~~>25 and ≤ 50~~	~~≥1.5060~~
	~~>50 and <155~~	~~≥2.80~~
~~> 45 to ≤ 54~~		~~≥1.60~~
~~> 54 to ≤ 75~~		~~≥1.70~~
~~> 75 to ≤ 185~~	~~>50 and <155~~	~~≥2.5080~~

~~DEEMED LIFETIME OF EFFICIENT EQUIPMENT~~

~~The assumed lifetime of the measure is 12 years.~~[65]

~~DEEMED MEASURE COST~~

~~The assumed incremental capital cost is the difference in cost between a baseline and an ENERGY STAR® qualified unit. Please see the table below for this measure is $5.~~[66]~~cost assumptions used:~~

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[65] ~~Lifetime determined by EPA researchResearch, 2012.; ENERGY STAR® Qualified Room Air Cleaner Calculator. (ENERGY STAR® Appliance Calculator.xlsx)., Dehumidifier Section~~

[66] ~~Incremental costs determined by EPA research on available models, July 2016. ENERGY STAR® Qualified Room Air Cleaner Calculator. (ENERGY STAR® Appliance Calculator.xlsx).~~

~~Equipment Specification~~	~~Population~~	~~ENERGY STAR~~	~~ENERGY STAR Most Efficient~~
~~Portable Dehumidifier~~	~~Non-IQ~~	~~$10~~[67]	~~$75~~[68]
	~~IQ~~[69]	~~$35~~	~~$100~~

~~LOADSHAPE~~

~~Cooling RES~~

~~Algorithm~~

~~CALCULATION OF SAVINGS~~

~~ELECTRIC ENERGY SAVINGS~~

~~$\Delta kWh = (((Avg\ Capacity * 0.473) / 24) * Hours) * (1 / (L/kWh_{Base}) - 1 / (L/kWh_{Eff}))$~~

~~ΔkWh = ((((Avg_ Capacity * 0.473) / 24) * Hours) * (IQAdj / (L/kWh_Base) – 1 / (L/kWh_Eff))) * ISR~~

~~Where:~~

~~Avg_ Capacity = Average capacity of the unit (pints/day)~~
~~= Actual, if unknown assume capacity in each capacity range as provided in table below, or if capacity range unknown assume average.~~
~~0.473 = Constant to convert Pints to Liters~~
~~24 = Constant to convert Liters/day to Liters/hour~~
~~Hours = Run hours per year~~
~~= 2,200~~[70]
~~IQAdj = Baseline consumption adjustment for IQ program participants to account for a portion of participants who would have utilized the secondary market.~~ [71]
~~= 1.096 if IQ, 1.0 if non-IQ~~
~~L/kWh_Base = Baseline lLiters of water per kWh consumed, as provided in tables above.~~
~~L/kWh_Eff = Efficient liters of water per kWh consumed. Actual, or if unknown as provided in table above.~~
~~ISR = In-service rate.~~
~~= Actual.~~

~~Annual kWh usage and savings , for each capacity class and product type applicable if actual unit efficiency is unknown , are presented in the four tables below. If both unit efficiency and capacity are unknown, apply the average capacity value in the table below.:~~

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[67] ~~Based on incremental costs sourced from the 2016 ENERGY STAR Appliance Calculator and weighted by capacity based on ENERGY STAR qualified products, accessed on May 2019.~~

[68] ~~DOE Energy Conservation Standards for Residential Dehumidifiers, Appliance and Equipment Standard, 10 CFR Part 430, July 23, 2012, page 73. The sourced table is an analysis on the incremental manufacturer product costs on dehumidifiers with varying incentive levels. Assuming the markup costs between the baseline units and the most efficient units are equal. The incremental cost reproduced is a straight average of all the dehumidifiers, both portable and whole house, with an efficiency level meeting or exceeding ENERGY STAR's Most Efficient criteria. Opted to combine the incremental cost into one value because the stand alone and whole house incremental costs were near identical.~~

[69] ~~IQ Incremental costs factor in the assumption that a secondhand unit costs on average 50% of a new baseline unit, and that 1/3 of IQ participants would have purchased a unit on the secondhand market. The new baseline dehumidifier is assumed to cost $150. See ""IQ Appliance Calculations.xlsIQ Appliance Calculations.xlsx"" for information.~~

[70] ~~Based on Mattison et al., "Dehumidifiers: A Major Consumer of Residential Electricity", Cautley et al., "Dehumidification and Subslab Ventilation in Wisconsin Homes" and Yang et al., "Dehumidifier Use in the U.S. Residential Sector", all indicating average usage around 2,200 hours per year.~~

[71] ~~It is assumed that a second-hand unit is on average 1/3 of a measure's EUL years old (8 years). In 2019 a new Federal Standard became effective and "relative to the previous standard, the current standard represents energy savings of about 15-25%". 20% was used, and increased by an estimate of 0.4% * 8 years (based on review of the refrigerator/freezer regression algorithm used in the 5.1.8 Refrigerator and Freezer Recycling measure) to account for degradation of performance over time. This second hand consumption was then weighted 1/3: 2/3 current new baseline to estimate a multiplier for IQ participants. See ""IQ Appliance Calculations.xlsIQ Appliance Calculations.xlsx"" for information.~~

~~Portable Dehumidifiers~~				
~~Capacity Range~~	~~Capacity Used~~[72]	~~Federal Standard Criteria~~	~~ENERGY STAR Criteria~~	~~ENERGY STAR Most Efficient~~
~~(pints/day)~~	~~(pints/day)~~	~~(≥ L/kWh)~~	~~(≥ L/kWh)~~	~~(≥ L/kWh)~~
~~≤25~~	~~20~~	~~1.3~~	~~1.57~~	~~1.7~~
~~>25 and ≤50~~	~~37.5~~	~~1.6~~	~~1.8~~	~~1.9~~
~~>50 and <155~~	~~102.5~~	~~2.8~~	~~3.3~~	~~3.4~~
~~Average~~[73]	~~38.9~~	~~1.54~~	~~1.75~~	~~1.86~~

~~Portable Dehumidifier~~		~~Energy Savings (ΔkWh)~~			
		~~Non-IQ~~		~~IQ~~	
~~Capacity Range~~	~~Capacity Used~~	~~ENERGY STAR~~	~~ENERGY STAR Most Efficient~~	~~ENERGY STAR~~	~~ENERGY STAR Most Efficient~~
~~(pints/day)~~	~~(pints/day)~~				
~~≤25~~	~~20~~	~~115~~	~~157~~	~~179~~	~~221~~
~~>25 and ≤50~~	~~37.5~~	~~113~~	~~160~~	~~210~~	~~257~~
~~>50 and <155~~	~~102.5~~	~~241~~	~~280~~	~~392~~	~~432~~
~~Average~~	~~38.9~~	*~~134~~*	*~~188~~*	~~238~~	~~293~~

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[72] ~~Capacity Used in calculations for each bin is an average. See next footnote regarding overall average for Portable Dehumidifiers~~

[73] ~~Weighted Overall average based on ENERGY STAR Products List 2020 for Dehumidifiers, accessed May 2020. See sheet *ESTAR 2020-5* in file 'ENERGY STAR Dehumidifier TRM Analysis_2021.xlsx'.~~

~~Portable Dehumidifiers~~					~~Annual kWh~~			
~~Avg Capacity Range~~	~~= Average capacity of the unit (pints/day) = Actual, if unknown assume capacity in each capacity range as provided in table below, or if capacity range unknown assume average.Capacity Used74~~	~~Federal Standard Criteria~~	~~ENERGY STAR Criteria~~	~~ENERGY STAR Most Efficient~~	~~Non-IQ Baseline: Federal Standard~~	~~IQ Baseline~~	~~ENERGY STAR~~	~~ENERGY STAR Most Efficient~~

~~0.473~~ ~~= Constant to convert Pints to Liters~~

~~24~~ ~~= Constant to convert Liters/day to Liters/hour~~

~~Hours~~ ~~= Run hours per year~~

~~= 1632~~[75]

~~(pints/day)~~	~~(pints/day)~~	~~(≥ L/kWh)~~	~~= Liters of water per kWh consumed, as provided in tables above(≥ L/kWh)~~	~~(≥ L/kWh)~~				
~~≤25~~	~~20~~	~~1.3~~	~~1.57~~	~~1.7~~	~~667~~	~~731~~	~~552~~	~~510~~
~~>25 and ≤50~~	~~37.5~~	~~1.6~~	~~1.8~~	~~1.9~~	~~1016~~	~~1113~~	~~903~~	~~856~~
~~>50 and <155~~	~~102.5~~	~~2.8~~	~~3.3~~	~~3.4~~	~~1587~~	~~1739~~	~~1347~~	~~1307~~
~~Average~~[76]	~~38.9~~	~~1.54~~	~~1.75~~	~~1.86~~	~~1095~~	~~1200~~	~~962~~	~~907~~

~~Annual kWh results for each capacity class are presented below:~~

~~Portable Dehumidifier~~		~~Energy Savings (ΔkWh)~~				
		~~Non-IQ~~		~~IQ~~		
~~Capacity Range~~ ~~(pints/day)~~	~~Capacity Used~~ ~~Capacity Used(pints/day)~~	~~Federal Standard Criteria (≥ L/kWh)ENERGY STAR~~	~~ENERGY STAR® Criteria (≥ L/kWh) Most Efficient~~	~~Annual kWhENERGY STAR~~	~~ENERGY STAR Most Efficient~~	
~~(pints/day)~~	~~(pints/day)~~			~~Federal Standard~~	~~ENERGY STAR®~~	~~Savings~~

---

[74] ~~Capacity Used in calculations for each bin is an average. See next footnote regarding overall average for Portable Dehumidifiers~~

[75] ~~Based on 24 hour operation over 68 days of the year. ENERGY STAR® Qualified Room Air Cleaner Calculator. (ENERGY STAR® Appliance Calculator.xlsx).~~

[76] ~~Weighted Overall average based on ENERGY STAR Products List 2020 for Dehumidifiers, accessed May 2020. See sheet *ESTAR-2020-5* in file "ENERGY STAR Dehumidifier TRM Analysis_2021.xlsx"~~

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~~≤25~~	~~20~~	~~1.35115~~	~~2.0157~~	~~477179~~	~~322221~~	~~155~~
~~> 25 to ≤35and ≤50~~	~~3037.5~~	~~1.35113~~	~~2.0160~~	~~714210~~	~~482257~~	~~232~~
~~> 35 to ≤4550 and ≤155~~	~~40~~ ~~1102.5~~	~~2.0241~~	~~857280~~	~~643392~~	~~214432~~	
~~> 45 to ≤ 54~~	~~50~~	~~1.6~~	~~2.0~~	~~1005~~	~~804~~	~~201~~
~~> 54 to ≤ 75~~	~~65~~	~~1.7~~	~~2.0~~	~~1,229~~	~~1,045~~	~~184~~
~~> 75 to ≤ 185~~	~~130~~	~~2.5~~	~~2.8~~	~~1,672~~	~~1,493~~	~~179~~
~~**Average**~~[77]	~~38.9~~	~~*134*~~	~~*188*~~	~~238~~	~~293~~	~~204~~

~~SUMMER COINCIDENT PEAK DEMAND SAVINGS~~

~~ΔkW = ΔkWh * CF~~

~~Where:~~

~~ΔkWh = Electric energy savings, as calculated above.~~
~~CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor~~
~~ΔkWh = Energy Savings as calculated above~~
~~CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor~~
~~= 0.0009474181~~

~~Summer coincident peak demand results for each capacity class are presented below:~~

~~Capacity Range (pints/day)~~	~~Annual Summer peak kW Savings~~
~~≤25~~	~~0.095~~
~~> 25 to ≤35~~	~~0.142~~
~~> 35 to ≤45~~	~~0.131~~
~~> 45 to ≤ 54~~	~~0.123~~
~~> 54 to ≤ 75~~	~~0.113~~
~~> 75 to ≤ 185~~	~~0.110~~
~~Average~~	~~0.125~~

~~= 0.0009474181~~

~~NATURAL GAS SAVINGS~~

~~N/A~~

~~WATER IMPACT DESCRIPTIONS AND CALCULATION~~

~~N/A~~

~~DEEMED O&M COST ADJUSTMENT CALCULATION~~

~~N/A~~

~~MEASURE CODE:~~

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[77] ~~The relative weighting of each product class is based on number of units on the ENERGY STAR® certified list. See "Dehumidifier Calcs.xls."~~

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~~3.1.6 Dehumidifier Recycling (Retired, effective 1/1/2025)~~[78]

~~Description~~
~~This measure describes the savings resulting from the retirement of existing residential, inefficient dehumidifier units from service prior to end of their natural life. This measure assumes that a percentage of these units will be replaced with a baseline standard efficiency unit (note that if the unit is actually replaced by a new ENERGY STAR® qualifying unit, the savings increment between baseline and ENERGY STAR® will be recorded in the Efficient Products program).~~

~~This measure was developed to be applicable to the following program type: ERET.~~

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

~~Definition of Efficient Equipment~~
~~N/A. This measure relates to the retiring of an existing inefficient unit.~~

~~Definition of Baseline Equipment~~
~~The baseline condition is the existing inefficient dehumidifier unit.~~

~~Deemed Lifetime of Efficient Equipment~~
~~The measure life is assumed to be 85 years.~~[79]

~~Deemed Measure Cost~~
~~The incremental cost for this measure is $42.7649.00.~~[80]

~~Loadshape~~
~~HVAC RES~~

~~Algorithm~~

~~Calculation of Savings~~

~~Electric Energy Savings~~[81]
~~Program Deemed Savings estimate:~~

~~Gross Electric Savings (kWh/unit)~~	~~Gross Demand Savings (kW/home)~~
~~139~~	~~.0648~~

~~Summer Coincident Peak Demand Savings~~

~~$\Delta kW = \Delta kWh * CF$~~

~~ΔkW = ΔkWh * CF~~

~~Where:~~

~~ΔkWh = Electric energy savings, as calculated above.~~
~~CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor~~
~~= 0.0004660805~~
~~ΔkWh = Gross customer annual kWh savings for the measure~~
~~CF = 0.0004660805~~

---

[78] ~~"Retire" indicates that the measure is not anticipated to be offered through an Ameren Missouri-administered demand-side program during the period of TRM effectiveness.~~

[79] ~~2024 MEMD database, measure code N-RE-AP-010111-E-XX-XX-XX-XX-02, https://www.michigan.gov/mpsc/-/media/Project/Websites/mpsc/regulatory/ewr/MEMD-and-BRM/mi_master_measure_database_2024_11302023.xlsx?rev=3fd5e407267c4f9eaa344d1e22edf4ea&hash=8DE2A37856418390B47236A0368B9F06 .~~

[80] ~~Ibid.~~

[81] ~~Deemed value per 201824 MEMD database for a drop-off program, https://www.michigan.gov/mpsc/-/media/Project/Websites/mpsc/regulatory/ewr/MEMD-and-BRM/mi_master_measure_database_2024_11302023.xlsx?rev=3fd5e407267c4f9eaa344d1e22edf4ea&hash=8DE2A37856418390B47236A0368B9F06Ibid.~~

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~~3.1.7~~3.1.1 Refrigerator

DESCRIPTION

A refrigerator meeting either ENERGY STAR®/CEE Tier 1 specifications or the higher efficiency specifications of CEE Tier 2 or CEE Tier 3 is installed instead of a new unit of baseline efficiency. The measure applies to TOS and early replacement programs.

This measure also includes a section accounting for the interactive effect of reduced waste heat on the heating and cooling loads.

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

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

Energy usage specifications are defined in the table below (note, Adjusted Volume is calculated as the fresh volume + (1.63 * Freezer Volume):

Product Category	**Existing Unit**	**Assumptions after September 2014**	
	Based on Refrigerator Recycling algorithm	**Federal Baseline Maximum Energy Usage in kWh/year**[82]	**ENERGY STAR Maximum Energy Usage in kWh/year**[83]
1. Refrigerators and Refrigerator-freezers with manual defrost	Method to measure to estimate existing unit consumption defined below.	6.79AV + 193.6	6.11 * AV + 174.2
2. Refrigerator-Freezer--partial automatic defrost		7.99AV + 225.0	7.19 * AV + 202.5
3. Refrigerator-Freezers--automatic defrost with top-mounted freezer without through-the-door ice service and all-refrigerators--automatic defrost		8.07AV + 233.7	7.26 * AV + 210.3
4. Refrigerator-Freezers--automatic defrost with side-mounted freezer without through-the-door ice service		8.51AV + 297.8	7.66 * AV + 268.0
5. Refrigerator-Freezers--automatic defrost with bottom-mounted freezer without through-the-door ice service		8.85AV + 317.0	7.97 * AV + 285.3
5A Refrigerator-freezer—automatic defrost with bottom-mounted freezer with through-the-door ice service		9.25AV + 475.4	8.33 * AV + 436.3
6. Refrigerator-Freezers--automatic defrost with top-mounted freezer with through-the-door ice service		8.40AV + 385.4	7.56 * AV + 355.3
7. Refrigerator-Freezers--automatic defrost with side-mounted freezer with through-the-door ice service		8.54AV + 432.8	7.69 * AV + 397.9

DEFINITION OF EFFICIENT EQUIPMENT

The high-efficiency level is a refrigerator meeting ENERGY STAR® specifications effective September 15th, 2014 (10% above federal standard), a refrigerator meeting CEE Tier 2 specifications (15% above federal standard), or CEE Tier 3 specifications (20% above federal standards).

DEFINITION OF BASELINE EQUIPMENT

Time of Sale: Baseline efficiency is a new refrigerator meeting the minimum federal efficiency standard for refrigerators~~ effective September 15th, 2014, for all programs except low-income direct install programs. For low-income programs, the baseline is the existing equipment~~.

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[82] See Department of Energy Federal Standards (10 CFR Part 430.32(a)), effective September 15th, 2014.

[83] See Version 5.1 ENERGY STAR specification.

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Early Replacement: the baseline is the existing refrigerator for the assumed remaining useful life of the unit and the time of sale baseline as defined above for the remainder of the measure life. Application of early replacement baseline is applicable to low income programs and requires information on pre-existing unit age and configuration.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure life is assumed to be 15~~7~~ years.[84]

Remaining life of existing equipment is assumed to be 5 years.[85]

DEEMED MEASURE COST

The full cost of a baseline unit is $742.[86]

The incremental cost to the ENERGY STAR® level is $28~~11~~, to CEE Tier 2 level is $112~~20~~, and to CEE Tier 3 is $134~~59~~.[87]

LOADSHAPE

Refrigeration RES

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

S~~S~~avings ~~by model may be pulled directly from~~will be calculated based on model ENERGY STAR® data, if available. ~~Alternatively~~If applicable model ENERGY STAR® data is unavailable, savings by product class may be calculated according to the algorithm below:

Time of sale:

$\Delta kWh_{Unit} = kWh_{base} - kWh_{ee}$

~~$\Delta kWh_{Unit} = kWh_{base} - (kWh_{new} * (1 - \%Savings))$~~

Early replacement:

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

$= kWh_{exist} - kWh_{ee}$

ΔkWH for remaining measure life (next 10 years):

---

[84] Illinois TRM Version 12.0, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_3_Res_09222023_FINAL_clean.pdf, page 35. Based on 2021 DOE Rulemaking Technical Support Document, 'DOE LCC Spreadsheet.xlsm'~~Mean from Figure 8.2.3, DOE, 2011-08-23 Technical Support Document for Energy Conservation Standards for Residential Refrigerators, Refrigerator-Freezers, and Freezers. http://www.regulations.gov/contentStreamer?objectId=0900006480f0c7df&disposition=attachment&contentType=pdfhttps://www1.eere.energy.gov/buildings/appliance_standards/pdfs/refrig_finalrule_tsd.pdf, page 8-32.~~

[85] Standard assumption of one third of effective useful life.

[86] Configurations weighted according to table under Energy Savings. Values inflated 8.9% from 2009 dollars to 2015. Table 8.1.1, DOE, 2011-08-23 Technical Support Document for Energy Conservation Standards for Residential Refrigerators, Refrigerator-Freezers, and Freezers. ~~http://www.regulations.gov/contentStreamer?objectId=0900006480f0c7df&disposition=attachment&contentType=pdf~~https://www1.eere.energy.gov/buildings/appliance_standards/pdfs/refrig_finalrule_tsd.pdf~~-~~; 'refrig_finalrule_tsd.pdf'.

[87] Illinois TRM Version 12.0, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_3_Res_09222023_FINAL_clean.pdf, p. 35. Costs are estimated using the data provided in the Department of Energy, "Refrigerator, Refrigerator-Freezer, and Freezer Life-Cycle Cost (LCC) Analysis Spreadsheet" posted November 9, 2021 as part of the 'Energy Conservation Standards for Consumer Refrigerators, Refrigerator-Freezers, and Freezers' rulemaking docket (see 'DOE LCC Spreadsheet.xlsm'). Install cost data was trended to provide estimates at the efficiency levels specified in this measure, and then weighted based on available product on the ENERGY STAR® Refrigerator QPI.~~Configurations weighted according to table under Energy Savings. Values inflated 8.9% from 2009 dollars to 2015. Table 8.2.2, DOE, 2011-08-23 Technical Support Document for Energy Conservation Standards for Residential Refrigerators, Refrigerator-Freezers, and Freezers. http://www.regulations.gov/contentStreamer?objectId=0900006480f0c7df&disposition=attachment&contentType=pdfhttps://www1.eere.energy.gov/buildings/appliance_standards/pdfs/refrig_finalrule_tsd.pdf~~

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= kWh_{base} - kWh_{ee}

Where:

kWh_{ee} = Actual. If unknown, calculate by product class:
= (kWh_{base} * (1 – %Savings))

kWh_{base} = Annual electric energy consumption of baseline unit as calculated in algorithm provided in table above,[88] if new model known; otherwise, assuming 22.5 ft^3 adjusted volume[89] using “all-refrigerators-automatic defrost” formula 8.07AV + 233.7, use value 415.28.

kWh_{exist} = If pre-existing unit age and configuration known: see table below to determine electric energy consumption of pre-existing unit based on unit age and configuration.
If pre-existing unit age and configuration not known: do not apply early replacement baseline.

%Savings = Specification of energy consumption below Federal Standard – see table below.

~~kWh_{base} = Baseline consumption,[90] assuming 22.5 ft^3 adjusted volume[91]~~
~~= Calculated using algorithms in table below, or using defaults provided based on 22.5 ft^3 adjusted volume [64]~~
~~%Savings = Specification of energy consumption below Federal Standard – see table below.~~

Tier	%Savings
Energy Star® and CEE Tier 1	10%
Energy Star® Most Efficient and CEE Tier 2	15%
CEE Tier 3	20%

~~For low-income programs~~If an early replacement baseline is applicable, the following table may be used to calculate the baseline usage used to calculate savings for the first six years of measure life:

Age	*Bottom Freezer (16 cu ft)*	*Side-by-Side (14 cu ft)*	*Side-by-Side (15 cu ft)*	*Side-by-Side (16 cu ft)*	*Top Freezer (cu ft 14)*	*Top Freezer (15 cu ft)*	*Top Freezer (16 cu ft)*	*Top Freezer (17 cu ft)*	*Top Freezer (18 cu ft)*
2011-2015	483	592	592	592	374	374	374	412	412
2001 (after July-2010	724	747	747	747	556	556	556	613	613
1993-2001(before June)	962	1,139	1,139	1,139	861	861	861	962	962
1990-1992	1,519	1,617	1,617	1,617	1,272	1,272	1,272	1,432	1,432
1980-1989	1,992	2,119	2,119	2,119	1,668	1,668	1,668	1,877	1,877
Before 1980	2,523	2,684	2,684	2,684	2,112	2,112	2,112	2,377	2,377

Additional Waste Heat Impacts

For units in conditioned spaces in the home (if unknown, assume unit is in conditioned space).

$\Delta kWh_{WasteHeat}$ = ΔkWh * (WHFeHeatElectric + WHFeCool)

~~$\Delta kWh_{WasteHeat} = \Delta kWh * (WHFeHeatElectric + WHFeCool)$~~

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[88] According to Federal Standard effective 9/15/14.
[89] DOE Building Energy Data Book~~,~~, https://ieer.org/wp/wp-content/uploads/2012/03/DOE-2011-Buildings-Energy-DataBook-BEDB.pdf; ‘DOE-2011-Buildings-Energy-DataBook-BEDB.pdf’~~http://buildingsdatabook.eren.doe.gov/TableView.aspx?table=5.7.5.~~
~~[90] According to Federal Standard effective 9/15/14.~~
~~[91] DOE Building Energy Data Book, http://buildingsdatabook.eren.doe.gov/TableView.aspx?table=5.7.5.~~

Where:

ΔkWh = kWh savings calculated from either method above

WHFeHeatElectric = Waste Heat Factor for Energy to account for electric heating increase from removing waste heat from refrigerator/freezer (if fossil fuel heating – see calculation of heating penalty in that section).

= - (HF / $\eta Heat_{Electric}$) * %ElecHeat

HF = Heating Factor or percentage of reduced waste heat that must now be heated

= 58% for unit in heated space or unknown [92]

= 0% for unit in unheated space

$\eta Heat_{Electric}$ = Efficiency in COP of Heating equipment

= Actual - If not available, use table below:[93]

%ElecHeat = Percentage of home with electric heat

~~System Type~~	~~Age of Equipment~~	~~HSPF Esitmate~~	~~ηHeat (COP Estimate)~~
~~Heat Pump~~	~~Before 2006~~	~~6.8~~	~~2.00~~
	~~2006-2014~~	~~7.7~~	~~2.26~~
	~~2015 on~~	~~8.2~~	~~2.40~~
~~Resistance~~	~~N/A~~	~~N/A~~	~~1.00~~
~~Unknown~~	~~N/A~~	~~N/A~~	~~1.28[94]~~

System Type	Age of Equipment	HSPF2 Estimate	ηHeat (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[95]	N/A	N/A	1.28

Heating Fuel	%ElecHeat
Electric	100%
Fossil Fuel	0%
Unknown	35%[96]

WHFeCool = Waste Heat Factor for Energy to account for cooling savings from removing waste heat from refrigerator/freezer.

= ~~(~~CoolF / (ηCool / 3.412) * %Cool

CoolF = Cooling Factor or percentage of reduced waste heat that no longer needs to be cooled

= 40% for unit in cooled space or unknown [97]

= 0% for unit in uncooled space

ηCool = Efficiency in COP of Cooling equipment

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[92] Based on 212 days where HDD 65>0, divided by 365.25.

[93] These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 and 2015 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.

~~[94] Calculation assumes 13% heat pump and 87% resistance, which is based upon data from Energy Information Administration, 2009 Residential Energy Consumption Survey, see “HC6.9 Space Heating in Midwest Region.xls.” Average efficiency of heat pump is based on the assumption that 50% are units from before 2006 and 50% 2006-2014.~~

[95] Calculation assumes 35% Heat Pump and 65% Resistance, which is based upon data from Energy Information Administration, 2009 Residential Energy Consumption Survey, ~~;~~ https://www.eia.gov/consumption/residential/data/2009/hc/hc6.9.xls ; ‘hc6.9.xls’. 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.

96 Based on data from Energy Information Administration, 2009 Residential Energy Consumption Survey, see ~~“HC6.9 Space Heating in Midwest Region.xls”.~~, https://www.eia.gov/consumption/residential/data/2009/hc/hc6.9.xls-; ‘hc6.9.xls’.~~”~~

[97] Based on 148 days where CDD 65>0, divided by 365.25.air

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= Actual - If not available, see table below ~~Actual – If not available, assume 2.8 COP[98]~~

%Cool = Percentage of home with cooling

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

Home	%Cool
Cooling	100%
No Cooling	0%
Unknown	91%[99]

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~~Algorithms for the most common refrigerator configurations, kWh$_{base}$, ΔkWh$_{WasteHeat}$ for unknown building characteristics and resulting deemed ΔkWh savings is provided below:~~

~~Product Class~~	~~Algorithm from Federal Standard~~	~~Baseline Usage kWh$_{base}$~~	~~Unit ΔkWh~~			~~ΔkWh$_{WasteHeat}$~~			~~Total ΔkWh~~		
			~~ENERGY STAR®/ CEE Tier 1~~	~~CEE Tier 2~~	~~CEE Tier 3~~	~~ENERGY STAR®/ CEE Tier 1~~	~~CEE Tier 2~~	~~CEE Tier 3~~	~~ENERGY STAR®/ CEE Tier 1~~	~~CEE Tier 2~~	~~CEE Tier 3~~
~~Top Freezer (PC 3)~~	~~8.40AV + 385.4~~	~~574~~	~~57.4~~	~~86.1~~	~~114.8~~	~~-0.9~~	~~-1.4~~	~~-1.9~~	~~56.5~~	~~84.7~~	~~112.9~~
~~Side-by-Side w/ TTD (PC 7)~~	~~8.54AV + 432.8~~	~~625~~	~~62.5~~	~~93.75~~	~~125~~	~~-1.0~~	~~-1.5~~	~~-2.1~~	~~61.5~~	~~92.2~~	~~122.9~~
~~Bottom Freezer (PC 5)~~	~~8.85AV + 317.0~~	~~516~~	~~51.6~~	~~77.4~~	~~103.2~~	~~-0.8~~	~~-1.3~~	~~-1.7~~	~~50.8~~	~~76.1~~	~~101.5~~
~~Bottom Freezer w/ TTD (PC 5A)~~	~~9.25AV + 475.4~~	~~684~~	~~68.4~~	~~102.6~~	~~136.8~~	~~-1.1~~	~~-1.7~~	~~-2.2~~	~~67.3~~	~~100.9~~	~~134.6~~

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~~If product class is unknown, the following table provides a market weighting that is applied to give a single deemed savings for each efficiency level:~~

~~Product Class~~	~~Market Weight[100]~~	~~Unit ΔkWh~~			~~ΔkWh$_{WasteHeat}$~~			~~Total ΔkWh~~		
		~~Energy Star®/ CEE Tier 1~~	~~CEE Tier 2~~	~~CEE Tier 3~~	~~Energy Star®/ CEE Tier 1~~	~~CEE Tier 2~~	~~CEE Tier 3~~	~~Energy Star®/ CEE Tier 1~~	~~CEE Tier 2~~	~~CEE Tier 3~~
~~Top Freezer (PC 3)~~	~~52%~~	~~59.2~~	~~88.8~~	~~118.4~~	~~-1.0~~	~~-1.5~~	~~-1.9~~	~~58.2~~	~~87.3~~	~~116.5~~
~~Side-by-Side w/ TTD (PC 7)~~	~~22%~~									
~~Bottom Freezer (PC 5)~~	~~13%~~									
~~Bottom Freezer w/ TTD (PC 5A)~~	~~13%~~									

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SUMMER COINCIDENT PEAK DEMAND SAVINGS

~~$$\Delta kW = (\Delta kWh_{wasteheatcooling}) * CF$$~~

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$\Delta kW = \Delta kWh$~~$_{WasteHeatCooling}$~~ $* CF$

Where:

ΔkWh~~$_{WasteHeatCooling}$~~ = gross customer connected load kWh savings for the measure. Including any cooling system savings.

~~[98] Starting from standard assumption of SEER 10.5 central AC unit, converted to 9.5 EER using algorithm (-0.02 * SEER^2) + (1.12 * SEER) (from Wassmer, M. (2003); A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder), converted to COP = EER/3.412 = 2.8COP.~~

[99] Based on 2009 Residential Energy Consumption Survey, see “HC7.9 Air Conditioning in Midwest Region~~.xls.~~”, https://www.eia.gov/consumption/residential/data/2015/hc/php/hc7.9.php.

~~[100] Personal Communication from Melisa Fiffer, ENERGY STAR® Appliance Program Manager, EPA 10/26/14.~~

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CF = Summer Peak Coincident Factor
= 0.0001285253[101]

~~Default values for each product class and unknown building characteristics are provided below:~~

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~~Product Class~~	~~ΔkW~~		
	~~Energy Star®/ CEE Tier 1~~	~~CEE Tier 2~~	~~CEE Tier 3~~
~~Top Freezer (PC 3)~~	~~0.0086~~	~~0.0130~~	~~0.0173~~
~~Side-by-Side w/ TTD (PC 7)~~	~~0.0094~~	~~0.0141~~	~~0.0188~~
~~Bottom Freezer (PC 5)~~	~~0.0078~~	~~0.0117~~	~~0.0155~~
~~Bottom Freezer w/ TTD (PC 5A)~~	~~0.0103~~	~~0.0155~~	~~0.0206~~

~~If product class is unknown, the following table provides a market weighting that is applied to give a single deemed savings for each efficiency level:~~

NATURAL GAS SAVINGS

Heating penalty for reduction in waste heat, only for units from conditioned space in gas heated home (if unknown, assume unit is from conditioned space).

ΔTherms = ΔkWh$_{Unit}$ * WHFeHeatGas * 0.03412

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~~$\Delta Therms = \Delta kWh_{Unit} * WHFeHeatGas * 0.03412$~~

Where:

ΔkWh$_{Unit}$ = kWh savings calculated from either method above, not including the ΔkWh$_{WasteHeat}$
WHFeHeatGas = Waste Heat Factor for Energy to account for gas heating increase from removing waste heat from refrigerator/freezer
= - (HF / ηHeat$_{Gas}$) * %GasHeat
HF = Heating Factor or percentage of reduced waste heat that must now be heated
= 58% for unit in heated space or unknown[102]
= 0% for unit in unheated space
ηHeat$_{Gas}$ = Efficiency of heating system
= 74%[103]
%GasHeat = Percentage of homes with gas heat
0.03412 = Converts kWh to therms

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[101] Ameren Missouri TRM Volume 1 - Appendix G: "Table 1 – Residential End Use Category Monthly Shapes and Coincident Peak Factors"~~Based on Ameren Missouri 2016 Loadshape for Residential Refrigeration End-Use.~~

[102] Based on 212 days where HDD 65>0, divided by 365.25.

[103] This has been estimated assuming that natural gas central furnace heating is typical for Missouri residences (the predominant heating is gas furnace with 52% of Missouri homes - based on Energy Information Administration, 2009 Residential Energy Consumption Survey). Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows: ((0.60*0.92) + (0.40*0.8)) * (1-0.15) = 0.74.

Heating Fuel	%GasHeat
Electric	0%
Gas	100%
Unknown	65%[104]

Default values for each product class and unknown building characteristics are provided below:

Product Class	ΔTherms		
	Energy Star®/ CEE Tier 1	CEE Tier 2	CEE Tier 3
Top Freezer (PC 3)	-1.19	-1.78	-2.37
Side-by-Side w/ TTD (PC 7)	-1.29	-1.94	-2.58
Bottom Freezer (PC 5)	-1.07	-1.60	-2.13
Bottom Freezer w/ TTD (PC 5A)	-1.41	-2.12	-2.83

If product class is unknown, the following table provides a market weighting that is applied to give a single deemed savings for each efficiency level:

Product Class	Market Weight[105]	ΔTherms		
		Energy Star®/ CEE Tier 1	CEE Tier 2	CEE Tier 3
Top Freezer (PC 3)	52%	-1.22	-1.84	-2.45
Side-by-Side w/ TTD (PC 7)	22%			
Bottom Freezer (PC 5)	13%			
Bottom Freezer w/ TTD (PC 5A)	13%			

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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[104] Based on data from Energy Information Administration, 2009 Residential Energy Consumption Survey, see ~~"HC6.9 Space Heating in Midwest Region.xls".,~~ https://www.eia.gov/consumption/residential/data/2009/hc/hc6.9.xls-; 'hc6.9.xls'.

[105] Personal Communication from Melisa Fiffer, ENERGY STAR® Appliance Program Manager, EPA 10/26/14.

~~3.1.8 Room Air Conditioner Recycling (Retired, effective 1/1/2025)~~ ~~[106]~~

~~Description~~

~~This measure describes the savings resulting from the retirement of existing residential, inefficient room air conditioner units from service prior to their natural end of life. This measure assumes that a percentage of these units will be replaced with a baseline standard efficiency unit (note that if it is actually replaced by a new ENERGY STAR® qualifying unit, the savings increment between baseline and ENERGY STAR® will be recorded in the Efficient Products program).~~

~~This measure was developed to be applicable to the following program type: ERET.~~

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

~~Definition of Efficient Equipment~~

~~N/A. This measure relates to the retiring of an existing inefficient unit.~~

~~Definition of Baseline Equipment~~

~~The baseline condition is the existing inefficient room air conditioning unit.~~

~~Deemed Lifetime of Efficient Equipment~~

~~The assumed remaining useful life of the existing room air conditioning unit being retired is 4 years.~~~~[107]~~

~~Deemed Measure Cost~~

~~The actual implementation cost for recycling the existing unit should be used.~~

~~Loadshape~~

~~Cooling RES~~

~~**Algorithm**~~

~~Calculation of Savings~~

~~Electric Energy Savings~~

~~ΔkWh = (Hours * Btuh) / (EERexist * 1,000) – (%replaced * (Hours * Btuh) / (EERNewBase * 1,000))~~

$$DkWh = kWhexist - (\%replaced * kWhnewbase)$$

$$= \frac{Hours * BtuH}{EERexist * 1000} - (\%replaced * \frac{Hours * BtuH}{EERNewBase * 1000})$$

~~Where:~~

~~Hours = Full lLoad hHours of room air conditioning unit~~
~~= 860 for primary use; and 556 for secondary use; if unknown, assume 556~~
~~EERexist = Efficiency of recycled unit~~
~~= Actual if recorded – If not, assume 9.0~~~~[108]~~
~~BtuhH = Average size of rebated unit. Use actual if available – if not, assume 8,500~~~~[109]~~

~~[106] "Retire" indicates that the measure is not anticipated to be offered through an Ameren Missouri-administered demand-side program during the period of TRM effectiveness.~~

~~[107] One third of assumed measure life for room air conditioners.~~

~~[108] Retirement programs will see a wide range of ages for retired units. For the most common type of unit (8,000–13,999 Btuh with side vents), the federal minimum efficiency standards have changed over time: from 1990-2000, it was 9.0 EER; from 2000-2014, it was 9.8 EER; and since 2015, it has been 10.9 CEER. The efficiency standard for 2000-2014 was chosen, acknowledging that the actual EER of many units will have significantly degraded over time.~~

~~[109] Based on maximum capacity average from the RLW Report; "Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008.", '117_RLW_CF Res RAC.pdf'.~~

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~~= Actual if recorded - If not, assume 9.0~~[110]
~~%replaced = Percentage of units that are replaced~~
~~EERNewBase = Estimated Efficiency of baselinereplacements unit efficiency~~
~~= 10.90.9~~[111]

~~Weather Basis (City based upon)~~	~~Hours~~[112]
~~St Louis, MO~~	~~860 for primary use and 556 for secondary use. If unknown, assume 556~~

~~Scenario~~	~~%replaced~~
~~Customer states unit will not be replaced~~	~~0%~~
~~Customer states unit will be replaced~~	~~100%~~
~~Unknown~~	~~76%~~[113]

~~Results using defaults provided above:~~

~~Weather Basis (City based upon)~~	~~ΔkWh~~		
	~~Unit not replaced~~	~~Unit replaced~~	~~Unknown~~
~~St Louis, MO~~	~~525.4~~	~~91.6~~	~~195.7~~

~~Summer Coincident Peak Demand Savings~~

~~ΔkW = ΔkWh * CF~~

~~Where:~~

~~ΔkWh = Electric energy savings, as calculated above.~~
~~CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor~~
~~= 0.0009474181~~[114]
~~CF = Summer Peak Coincidence Factor for measure~~
~~= 0.0009474181~~[115]

~~Results using defaults provided above:~~

~~Weather Basis (City based upon)~~	~~ΔkW~~		
	~~Unit not replaced~~	~~Unit replaced~~	~~Unknown~~
~~St Louis, MO~~	~~0.4978~~	~~0.0868~~	~~0.1854~~

---

[110] ~~The federal minimum for the most common type of unit (8000 – 13999 Btuh with side vents) from 1990-2000 was 9.0 EER, from 2000-2014 it was 9.8 EER, and is currently (2015) 10.9 CEER. Retirement programs will see a large array of ages being retired, and the true EER of many will have been significantly degraded. We have selected 9.0 as a reasonable estimate of the average retired unit. This is supported by material on the ENERGY STAR® website, which, if reverse-engineered, indicates that an EER of 9.16 is used for savings calculations for a 10-year old room air conditioner. Another statement indicates that units that are at least 10 years old use 20% more energy than a new ES unit, which equates to: 10.9EER/1.2 = 9.1 EER; http://www.energystar.gov/ia/products/recycle/documents/RoomAirConditionerTurn-InAndRecyclingPrograms.pdf.~~

[111] ~~Minimum federal standard for capacity range and most popular class (without reverse cycle, with louvered sides, and 8,000 to 13,999 Btu/h). Federal standard air conditioner baselines,. https://www.regulations.gov/document/EERE-2014-BT-STD-0059-0057https://ees.lbl.gov/product/room-air-conditionershttp://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/41.; 'EERE-2014-BT-STD-0059-0057_content.pdf'.~~

[112] ~~Ameren Missouri PY2013 CoolSavers evaluation, https://www.efis.psc.mo.gov/Document/Display/12007, page 56.~~
~~http://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/117_RLW_CF%20Res%20RAC.pdf) to FLH for Central Cooling for the same locations (provided by AHRI: http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_CAC.xls) is 31%. This factor was applied to published CDD65 climate normals data to provide an assumption for FLH for Room AC.~~

[113] ~~Based on Nexus Market Research Inc, RLW Analytics, December 2005; "Impact, Process, and Market Study of the Connecticut Appliance Retirement Program: Overall Report." Report states that 63% were replaced with ENERGY STAR® units and 13% with non-ENERGY STAR®. However, this formula assumes all are non-ENERGY STAR® since the increment of savings between baseline units and ENERGY STAR® would be recorded by the Efficient Products program when the new unit is purchased.~~

[114] ~~Ameren Missouri TRM Volume 1 – Appendix G: "Table 1 – Residential End Use Category Monthly Shapes and Coincident Peak Factors"~~

[115] ~~Based on Ameren Missouri 2016 loadshape for residential cooling end-use.~~

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~~Natural Gas Savings~~
~~N/A~~

~~Water Impact Descriptions and Calculation~~
~~N/A~~

~~Deemed O&M Cost Adjustment Calculation~~
~~N/A~~

~~**MEASURE CODE**~~

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3.2 Electronics

3.2.1 Advanced Tier 1 Power Strips

DESCRIPTION
This measure applies to Tier 1 Advanced Power Strips (APS), which are multi-plug power strips with the ability to automatically disconnect specific connected loads depending upon the power draw of a master control load, also plugged into the strip. Power is disconnected from the switched (controlled) outlets when the master control load power draw is reduced below a certain adjustable threshold, thus turning off the appliances plugged into the switched outlets. By disconnecting, the standby load of the controlled devices, the overall load of a centralized group of equipment (i.e. entertainment centers and home office) can be reduced. Uncontrolled outlets are also provided that are not affected by the control device and are always providing power to any device plugged into it. This measure characterization provides savings for use of an APS in a home entertainment system, home office, or unknown setting.

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

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

DEFINITION OF EFFICIENT EQUIPMENT
The efficient case is the use of a 4-8 plug Tier 1 master-controlled APS.

DEFINITION OF BASELINE EQUIPMENT
For TOS and NC applications, the baseline is a standard power strip that does not control connected loads.
For DI and KITS, the baseline is the existing equipment used in the home.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT
The assumed lifetime of the Tier 1 APS is 10 years.[116]

DEEMED MEASURE COST
~~For TOS and NC, the incremental cost of an APS over a standard power strip with surge protection is assumed to be $20.[117]~~
For DI~~ and KITS~~, the actual full installation cost of an APS (including equipment and labor) should be used. If DI cost is unknown, cost is assumed to be $30.00. [118]

LOADSHAPE
Miscellaneous RES

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

~~$\Delta kWh = (kWh_{Office} * Weighting_{Office} + kWh_{Ent} * Weighting_{Ent}) * ISR$~~

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[116] “Advanced Power Strip Research Report,” NYSERDA, August 2011, https://www.nyserda.ny.gov/-/media/Project/Nyserda/Files/EERP/Residential/Power-Management-Research-Report.pdf~~,~~; ‘NYSERDA Advanced Power Strip Research Report.pdf’, page 30 ~~.~~

~~[117] Incremental cost based on “Advanced Power Strip Research Report.” https://www.nyserda.ny.gov/-/media/Project/Nyserda/Files/EERP/Residential/Power-Management-Research-Report.pdf; ‘NYSERDA Advanced Power Strip Research Report.pdf’,, page 6. Typical cost of an advanced power strip is $35, and average cost of a standard power strip is $15.~~

[118] Ibid.

$\Delta kWh = (kWh_{Office} * Weighting_{Office} + kWh_{Ent} * Weighting_{Ent}) * ISR$

Where:

kWh$_{Office}$ = Estimated energy savings from using an APS in a home office
= 31.0 kWh[119]

Weighting$_{Office}$ = Relative penetration of use in home office

Installation Location	Weighting$_{Office}$
Home Office	100%
~~Home Entertainment System~~	~~0%~~
~~Unknown[120]~~	~~TOS, NC, DI: 36%~~ ~~KITS: 48%~~

~~kWh$_{Ent}$ = Estimated energy savings from using an APS in a home entertainment system~~
~~= 75.1 kWh[121]~~

~~Weighting$_{Ent}$ = Relative penetration of use with home entertainment systems~~

~~Installation Location~~	~~Weighting$_{Ent}$~~
~~Home Office~~	~~0%~~
~~Home Entertainment System~~	~~100%~~
~~Unknown[122]~~	~~TOS, NC, DI: 64%~~ ~~KITS: 52%~~

ISR = In-service rate. Actual, or if unknown, reference values in the table below~~In service rate,~~ dependent on program type

Program Type	ISR
~~TOS, NC, DI[123]~~	~~95%~~
~~KITS[124]~~	~~93.8%~~
Pay As You Save[125]	74.3%

Based on the default values above, default savings are provided in the table below:

Installation Location	Program Type	ΔkWh
Home Office	TOS, NC, DI	23.03~~9.45~~
	~~KITS~~	~~29.08~~
~~Home Entertainment System~~	~~TOS, NC, DI~~	~~71.35~~
	~~KITS~~	~~70.44~~
~~Unknown~~	~~TOS, NC, DI~~	~~56.26~~
	~~KITS~~	~~50.59~~

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$\Delta kW = \Delta kWh * CF$

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[119] "Advanced Power Strip Research Report." https://www.nyserda.ny.gov/-/media/Project/Nyserda/Files/EERP/Residential/Power-Management-Research-Report.pdf; 'NYSERDA Advanced Power Strip Research Report.pdf'. Note that estimates are not based on pre/post metering but on analysis based on frequency and consumption of likely products in active, standby, and off modes. This measure should be reviewed frequently to ensure that assumptions continue to be appropriate.

~~[120] Relative weightings of home office and entertainment systems is based on "Ameren Missouri Efficient Product Impact and Process Evaluation: Program Year 2015," Cadmus, May 13, 2016. https://www.efis.psc.mo.gov/Document/Display/13805, page 34. If the programs have their own evaluations of weightings, they should be used.~~

~~[121] "Advanced Power Strip Research Report." https://www.nyserda.ny.gov/-/media/Project/Nyserda/Files/EERP/Residential/Power-Management-Research-Report.pdf; 'NYSERDA Advanced Power Strip Research Report.pdf'.~~

~~[122] Relative weightings of home office and entertainment systems is based on "Ameren Missouri Efficient Product Impact and Process Evaluation: Program Year 2015," Cadmus, May 13, 2016, https://www.efis.psc.mo.gov/Document/Display/13805, page 34. If the programs have their own evaluations of weightings, they should be used.~~

~~[123] Ameren Missouri Single Family Low Income Evaluation: PY2019, Table 10-10, https://www.efis.psc.mo.gov/Document/Display/15877, page 214.~~

~~[124] Ameren Missouri Efficient Products Evaluation: PY2019, Table 6-9, https://www.efis.psc.mo.gov/Document/Display/15877, page 140 .~~

[125] Ameren Missouri Pay As You Save (PAYS®) Evaluation Appendices: PY2022, ~~Participant Survey~~ https://www.efis.psc.mo.gov/Document/Display/17591, page 7.

Where:

ΔkWh = Electric energy savings, as calculated above.
CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor

~~$\Delta kW = \Delta kWh * CF$~~

~~Where:~~

~~ΔkWh = Electric energy savings, as calculated above.~~

~~CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor~~
= 0.0001148238[126]

NATURAL GAS SAVINGS
N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION
N/A

DEEMED O&M COST ADJUSTMENT CALCULATION
N/A

MEASURE CODE:

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[126] Based on Ameren Missouri TRM Volume 1 - Appendix G: "Table 1 – Residential End Use Category Monthly Shapes and Coincident Peak Factors"~~Ameren Missouri 2016 loadshape~~ for residential miscellaneous end-use. This is deemed appropriate, because savings occur during hours when the controlled standby loads are turned off by the APS. This is estimated to be approximately 7,129, which representing the average of hours for controlled TV and computer from "Advanced Power Strip Research Report.", https://www.nyserda.ny.gov/-/media/Project/Nyserda/Files/EERP/Residential/Power-Management-Research-Report.pdf; 'NYSERDA Advanced Power Strip Research Report.pdf'.

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3.2.2 Tier 2 Advanced Power Strip – Residential Audio Visual

Description

This measure relates to the installation of a Tier 2 Advanced Power Strip / surge protector for household audio visual environments (Tier 2 AV APS). Tier 2 AV APS are multi-plug power strips that remove power from audio visual equipment through intelligent control and monitoring strategies.

By utilizing advanced control strategies such as a countdown timer, external sensors (e.g. of infra-red remote usage and/or occupancy sensors, true RMS (Root Mean Square) power sensing; both active power loads and standby power loads of controlled devices are managed by Tier 2 AV APS devices.[127] Monitoring and controlling both active and standby power loads of controlled devices will reduce the overall load of a centralized group of electrical equipment (i.e. the home entertainment center). This more intelligent sensing and control process has been demonstrated to deliver increased energy savings and demand reduction compared with 'Tier 1 Advanced Power Strips'.

~~This measure applies to the installation of a Tier 2 Advanced Power Strip for household audio visual environments (Tier 2 AV APS). Tier 2 AV APS are multi-plug power strips that remove power from audio visual equipment through intelligent control and monitoring strategies. Using advanced control strategies such as true RMS (Root Mean Square) power sensing, and/or external sensors,128 both active power loads and standby power loads of controlled devices are managed by Tier 2 AV APS devices. Monitoring and controlling both active and standby power loads of controlled devices will reduce the overall load of a centralized group of electrical equipment (i.e. the home entertainment center). This intelligent sensing and control process has been demonstrated to deliver increased energy savings and demand reduction compared with Tier 1 Advanced Power Strips.~~

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~~The Tier 2 AV APS market is a relatively new and developing one. With several new Tier 2 AV APS products coming to market, it is important that energy savings be clearly demonstrated through independent field trials. Field trial should effectively address the inherent variability in AV system usage patterns. Until there is enough independent evidence to demonstrate deemed savings for each of the various control strategies, it is recommended that products with independent field trial results be placed into performance bands and savings claimed accordingly.~~

~~This measure was developed to be applicable to the following program type: DI. If applied to other program types, the installation characteristics, including the number of AV devices under control and an appropriate in-service rate, should be verified through evaluation.~~

Definition of Efficient Equipment

The efficient case is the use of a Tier 2 AV APS in a residential AV (home entertainment) environment that includes control of at least 2 AV devices, one being the television.[129]

Definition of Baseline Equipment

The assumed baseline equipment is the existing equipment used in the home (e.g., a standard power strip or wall socket) that does not control loads of connected AV equipment.

Deemed Lifetime of Efficient Equipment

The assumed lifetime of the Tier 2 AV APS is assumed to be 10 years.[130]

Deemed Measure Cost

Direct Install: The actual installed cost (including labor) of the new Tier 2 AV APS equipment should be used, less baseline cost of $20.[131]
~~For non-direct install, incremental cost is assumed to be $65.132~~

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[127] Tier 2 AV APS identify when people are not engaged with their AV equipment and then remove power, for example a TV and its peripheral devices that are unintentionally left on when a person leaves the house or for instance where someone falls asleep
while watching television.

~~128 Tier 2 AV APS identify when people are not engaged with their AV equipment and then remove power (e.g., a TV and its peripheral devices that are unintentionally left on when a person leaves the house or falls asleep while watching television).~~

[129] Given this requirement, an AV environment consisting of a TV and DVD player or a TV and home theater would be eligible for a Tier 2 AV APS installation.

[130] "Advanced Power Strip Research Report," NYSERDA, August 2011, https://www.nyserda.ny.gov/-/media/Project/Nyserda/Files/EERP/Residential/Power-Management-Research-Report.pdf; 'NYSERDA Advanced Power Strip Research Report.pdf', page 30.

[131] Illinois TRM Version 12.0, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_3_Res_09222023_FINAL_clean.pdf, page 93. Price survey performed by Illume Advising LLC for IL TRM workpaper, see 'Current Surge Protector Costs and Comparison 7-2016.xlsx' spreadsheet~~.~~

~~132 California Technology Forum, June 2015. https://static1.squarespace.com/static/53c96e16e4b003bdba4f4fee/t/556e25a3e4b06957271187a1/1433281955286/2015-01-15+Tier+2+Advance+Power+Strip+Cal+TF+Workpaper+Presentation_January.pdf; 'Tier_2_Advance_Power_Strip_Cal_TF_Workpaper_01.2015.pdf'.~~

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~~THE ACTUAL FULL INSTALLATION COST OF THE TIER 2 AV APS (INCLUDING EQUIPMENT AND LABOR) SHOULD BE USED. THE ESTIMATED INCREMENTAL COST IS $30 BASED ON ONLINE MARKET RESEARCH IN 2019. PRODUCTS INSTALLED THROUGH DIRECT INSTALLATION CHANNELS MAY ALSO INCUR ADDITIONAL LABOR COSTS.~~

LOADSHAPE

Miscellaneous RES

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS

ΔkWh = ERP * $BaselineEnergy_{AV}$ * ISR

~~$\Delta kWh = ERP * BaselineEnergy_{AV} * ISR$~~

Where:

ERP = Energy Reduction Percentage of qualifying Tier2 AV APS product range as provided below. Savings are based upon independent field trials of two product manufacturers and the savings differences are assumed to relate to the product classifications provided below. Additional evaluation will be reviewed in future cycles to confirm if additional classification categories are appropriate.

Product Type	ERP used
Infrared Only	40%[133]
~~Infrared and Occupancy Sensor~~	~~25%~~[134]

~~Energy reduction percentage of qualifying Tier 2 AV APS product Class; see table below:~~[135]

~~Product Class~~	~~Field Trial ERP Range~~	~~ERP Used~~
~~A~~	~~55 – 60%~~	~~55%~~
~~B~~	~~50 – 54%~~	~~50%~~
~~C~~	~~45 – 49%~~	~~45%~~
~~D~~	~~40 – 44%~~	~~40%~~
~~E~~	~~35 – 39%~~	~~35%~~
~~F~~	~~30 – 34%~~	~~30%~~
~~G~~	~~25 – 29%~~	~~25%~~
~~H~~	~~20 – 24%~~	~~20%~~
~~Average~~[136]	~~–~~	~~37.5%~~

$BaselineEnergy_{AV}$ = 466~~32~~ kWh[137]

---

[133] Representative savings assumption based on the following independent field tests on Embertec's IR-only product. This includes both simulated saving results (based on recording what action the APS would have taken, but where equipment is not actually switched off allowing evaluation of the expected length of savings), and pre/post metering studies.

- AESC (page 30) - Valmiki, MM., Corradini, Antonio PE. 2015. *Tier 2 Advanced Power Strips in Residential and Commercial Applications*. Prepared for San Diego Gas & Electric by Alternative Energy Systems Consulting, Inc. (Simulated 50%, pre/post 32%).
- AESC- Valmiki, MM., Corradini, Antonio PE., Feb 2016. *Energy Savings of Tier 2 Advanced Power Strips in Residential AV Systems.* (Simulated 50%, pre/post 29%)
- CalPlug research (Page 12) - Wang, M. e. 2014. "*Tier 2 Advanced Power Strip Evaluation for Energy Saving Incentive*". California Plug Load Research Center (CalPlug), UC Irvine. (Simulated 51%)
- NMR Group Inc., *RLPNC 17-3: Advanced Power Strip Metering Study*, Revised March 18, 2019, submitted to Massachusetts Program Administrators and EEAC. (Pre/post with regression 50%, Pre/post only 20%).

~~[134] Representative savings assumption based on the following independent field tests on TrickeStar IR-OS product and reflect both simulated and pre/post meter study results.~~

- ~~AESC- Valmiki, MM., Corradini, Antonio PE., Feb 2016. *Energy Savings of Tier 2 Advanced Power Strips in Residential AV Systems.* (Simulated 27%, pre/post 25%)~~
- ~~NMR Group Inc., *RLPNC 17-3: Advanced Power Strip Metering Study*, Revised March 18, 2019, submitted to Massachusetts Program Administrators and EEAC. (Pre/post with regression 37%, Pre/post only 11%)~~

~~[135] Based on field test data for various APS products.~~

~~[136] Average of product classes B and G.~~

[137] "Energy Savings of Tier 2 Advanced Power Strips in Residential AV Systems," AESC, Inc., February 2016. Note this load represents the average *controlled* AV devices only and will likely be lower than total AV usage, https://www.aesc-inc.com/wp-content/uploads/2017/07/tier_2_aps_final_report_et13pge1441.pdf~~,~~; 'tier_2_aps_final_report_et13pge1441.pdf', page 7.

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ISR = In Service Rate, the percentage of units rebated that are actually in service. Actual, or if unknown, referencing the table below:

Program/Channel	In Service Rate (ISR)
~~TOS, NC, DI~~Income Eligible[138]	95%
~~Efficient Kits[139]~~	~~93.8%~~
~~SF Low Income Kits[140]~~	~~93.8%~~

Based on the default values above, default savings are provided in the table below:

Program Type	ΔkWh	
	Infrared Only	~~Infrared and Occupancy Sensor~~
~~TOS, NC, DI~~Income Eligible	177.08	~~110.68~~
~~Efficient Kits~~	~~174.84~~	~~109.28~~
~~SF Low Income Kits~~	~~174.84~~	~~109.28~~

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~~Program Type~~	~~ΔkWh~~
~~TOS, NC, DI~~	~~153.90~~
~~Efficient Kits~~	~~151.96~~
~~SF Low Income Kits~~	~~151.96~~

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$\Delta kW = \Delta kWh * CF$

Where:

ΔkWh = Electric energy savings, as calculated above.

CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor

~~$\Delta kW = \Delta kWh * CF$~~

~~Where:~~

~~ΔkWh = Electric energy savings, calculated above~~

~~CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor~~

= 0.0001148238[141]

NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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[138] Ameren Missouri Single Family Low Income Program Evaluation: PY2019, Table 10-10, https://www.efis.psc.mo.gov/Document/Display/15877, page 214.

~~[139] Ameren Missouri Efficient Products Program Evaluation: PY2019, Table 6-9, https://www.efis.psc.mo.gov/Document/Display/15877, page 140.~~

~~[140] Assume same as Efficient Kits.~~

[141] Based on Ameren Missouri TRM Volume 1 - Appendix G: "Table 1 – Residential End Use Category Monthly Shapes and Coincident Peak Factors" ~~Ameren Missouri 2016 loadshape~~ for residential miscellaneous end-use. This is deemed appropriate, as savings occur during hours which the controlled standby loads are turned off by the APS, estimated to be approximately 7,129 representing the average of hours for controlled TV and computer from "Advanced Power Strip Research Report.", https://www.nyserda.ny.gov/-/media/Project/Nyserda/Files/EERP/Residential/Power-Management-Research-Report.pdf; 'NYSERDA Advanced Power Strip Research Report.pdf'.

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MEASURE CODE:

3.3 Hot Water

3.3.1 Low Flow Faucet Aerator

This measure relates to the installation of a low flow faucet aerator in a household kitchen or bath faucet fixture.

This measure may be used for units provided through efficiency kits. However, the in-service rate for such measures should be derived through evaluation results specifically for this implementation methodology.

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

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

DEFINITION OF EFFICIENT EQUIPMENT

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

DEFINITION OF BASELINE EQUIPMENT

The baseline condition is assumed to be a standard bathroom faucet aerator rated at 2.25 GPM or greater or a standard kitchen faucet aerator rated at 2.75 GPM or greater. Average measured flow rates are used in the algorithm and are lower, reflecting the penetration of previously installed low flow fixtures ~~(and therefore the freerider rate for this measure should be 0)~~, use of the faucet at less than full flow, debris buildup, and lower water system pressure than fixtures are rated at.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 10 years.[142]

DEEMED MEASURE COST

The incremental cost for this measure is $11.33[143] or ~~program actual~~actual cost.

~~For faucet aerators provided in efficiency kits, the actual program delivery costs should be utilized. Absent of program data, for efficiency kits reference cost ofuse $3.00.[144]~~

LOADSHAPE

Water Heating RES

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

Note these savings are *per* faucet retrofitted[145] (unless faucet type is unknown, then it is per household).

$$\Delta kWh = \%ElectricDHW * (GPM_{base} * L_{base} - GPM_{low} * L_{low}) * Household * 365.25 * DF / FPH * EPG\_electric * ISR * (1 – Leakage)$$

~~$\Delta kWh = \%ElectricDHW * (GPM_{base} * L_{base} - GPM_{low} * L_{low}) * Household * 365.25 * DF / FPH * EPG\_electric * ISR$~~

Where:

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

DHW fuel	%ElectricDHW

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[142] ComEd Effective Useful Life Research Report, Navigant, May 14, 2018, ~~Measure lifetime is derived from the California DEER Effective Useful Life Table – 2014 Table Update~~. https://www.icc.illinois.gov/docket/P2017-0312/documents/287811/files/501915.pdf~~,~~; 'ComEd Effective Useful Life Research Report.pdf', page 20. ~~http://www.deeresources.com/files/DEER2013codeUpdate/download/DEER2014-EUL-table-update_2014-02-05.xlsx~~

[143] Direct-install price per showerhead assumes cost of showerhead (market research average of $3 and assess and install cost of $8.33) and also assumes 20min at $25 per hour, which is in line with the typical prevailing wage of a General Laborer, as per the Annual Wage Order No. 23 published by the Missouri Department of Labor.

~~[144] Illinois TRM Version 12.0, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_3_Res_09222023_FINAL_clean.pdf, page 259.~~

[145] This algorithm calculates the amount of energy saved per aerator by determining the fraction of water consumption savings for the upgraded fixture.

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Electric	100%
~~Natural Gas~~	~~0%~~
~~Unknown~~	~~42%[146]~~

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GPM_{base} = Average flow rate, in gallons per minute, of the baseline faucet "as-used." This includes the effect of existing low flow fixtures ~~and therefore the freerider rate for this measure should be 0~~.
= 2.2[147] or custom based on metering studies[148] or if measured during DI:
= Measured full throttle flow * 0.83 throttling factor[149]

GPM_{low} = Average flow rate, in gallons per minute, of the low-flow faucet aerator "as-used"
= 1.5[150] or custom based on metering studies[151] or if measured during DI:
= Rated full throttle flow * 0.95 throttling factor[152]

L_{base} = Average baseline daily length faucet use per capita for faucet of interest in minutes
= if available custom based on metering studies, if not use:

Faucet Type	L_{base} (min/person/day)	
	Kitchen	Bathroom
~~Efficient Kits (School Kits, MF, ARP Kits)~~	~~4.5[153]~~	~~1.6[154]~~
Income Eligible~~; MFMR~~, PAYS~~, Efficient Kits (SF LI Kits)~~[155]	3.7	3.7
~~If location unknown (total for household): Single-Family~~	~~7.8[156]~~	
~~If location unknown (total for household): Multi-Family~~	~~6.7[157]~~	

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L_{low} = Average retrofit daily length faucet use per capita for faucet of interest in minutes
= if available custom based on metering studies, if not use:

Faucet Type	L_{low} (min/person/day)	
	Kitchen	Bathroom
~~Efficient Kits (School Kits, ARP Kits)~~	~~4.5[158]~~	~~1.6[121][159]~~
Income Eligible~~; MFMR~~, PAYS~~, Efficient Kits (SFLI Kits)Efficient Kits (Multifamily, SFLI Kits); MFMR~~[160]	3.7	3.7
~~Income Eligible Common Area[161]~~	~~N/A~~	~~1.5~~
~~If location unknown (total for household): Single-Family~~	~~7.8[162]~~	

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~~[146] Ameren Missouri Energy Efficient Kits Impact and Process Evaluation: PY2019 https://www.efis.psc.mo.gov/Document/Display/15876, page 72.~~

[147] Federal rated maximum flow rate for faucets, https://www.energy.gov/femp/best-management-practice-7-faucets-and-showerheads~~(10 CFR 430.32 (p) (DOE 1998)~~.

[148] Measurement should be based on actual average flow consumed over a period of time rather than a one-time spot measurement for maximum flow. Studies have shown maximum flow rates do not correspond well to average flow rate due to occupant behavior, which does not always use maximum flow.

[149] 2008, Schultdt, Marc, and Debra Tachibana, "Energy related Water Fixture Measurements: Securing the Baseline for Northwest Single Family Homes," 2008 ACEEE Summer Study on Energy Efficiency in Buildings, pp. 1-265. ~~www.seattle.gov/light/Conserve/Reports/paper_10.pdf~~https://map-testing.com/wp-content/uploads/2022/11/2008_Seattle_Study.pdf~~;~~ '2008_Seattle_Study.pdf'.

[150] Program data, including PY2016 Program Data, per Community Savers 2016 EM&V report. https://www.efis.psc.mo.gov/Document/Display/35141, page 3-8.

[151] Measurement should be based on actual average flow consumed over a period of time rather than a one-time spot measurement for maximum flow. Studies have shown maximum flow rates do not correspond well to average flow rate due to occupant behavior, which does not always use maximum flow.

[152] 2008, Schultdt, Marc, and Debra Tachibana, "Energy related Water Fixture Measurements: Securing the Baseline for Northwest Single Family Homes," 2008 ACEEE Summer Study on Energy Efficiency in Buildings, pp. 1-265. ~~www.seattle.gov/light/Conserve/Reports/paper_10.pdf~~ https://map-testing.com/wp-content/uploads/2022/11/2008_Seattle_Study.pdf; '2008_Seattle_Study.pdf'.

~~[153] Cadmus and Opinion Dynamics Showerhead and Faucet Aerator Meter Study Memorandum, dated June 2013, directed to Michigan Evaluation Working Group. This study of 135 single and multifamily homes in Michigan metered energy parameters for efficient showerhead and faucet aerators.~~

~~[154] Cadmus and Opinion Dynamics Showerhead and Faucet Aerator Meter Study Memorandum dated June 2013, directed to Michigan Evaluation Working Group. This study of 135 single and multifamily homes in Michigan metered energy parameters for efficient showerhead and faucet aerators.~~

[155] Cadmus PY11~~2003~~ metering study. Cited in Ameren Missouri Low Income and Process Evaluation: program Year 2015. p.23 https://www.efis.psc.mo.gov/Document/Display/12018

~~[156] One kitchen faucet plus 2.04 bathroom faucets. Based on findings from a 2012 Ameren Missouri potential study for single family homes.~~

~~[157] One kitchen faucet plus 1.4 bathroom faucets. Based on findings from Ameren Missouri PY2013 data for multifamily homes.~~

~~[158] Cadmus and Opinion Dynamics Showerhead and Faucet Aerator Meter Study Memorandum dated June 2013, directed to Michigan Evaluation Working Group.~~

~~[159] Cadmus and Opinion Dynamics Showerhead and Faucet Aerator Meter Study Memorandum dated June 2013, directed to Michigan Evaluation Working Group.~~

[160] Cadmus PY11~~2003~~ metering study. Cited in Ameren Missouri Low Income and Process Evaluation: program Year 2015. p.23 https://www.efis.psc.mo.gov/Document/Display/12018

~~[161] PY2016 Program Data, per Community Savers 2016 EM&V report. https://www.efis.psc.mo.gov/Document/Display/35141, page 3-8~~

~~[162] One kitchen faucet plus 1.4 bathroom faucets. Based on findings from an Ameren Missouri PY2013 data for multifamily homes.~~

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Faucet Type	L_{low} (min/person/day)	
	Kitchen	Bathroom
~~If location unknown (total for household): Multi-Family~~	~~6.7~~[163]	

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[163] ~~One kitchen faucet plus 1.4 bathroom faucets. Based on findings from an Ameren Missouri PY2013 data for multifamily homes.~~

Household = Average number of people per household

Program Delivery and Household Unit Type	Value
~~Single-Family~~	~~2.67[164]~~
~~School Kits~~	~~4.286[165]~~
~~Efficient Kits (MF)~~	~~1.777[166]~~
~~Multi-Family MR – Deemed~~	~~1.56[167]~~
Income Eligible, ~~Efficient Kits (SFLI Kits),~~ PAYS	1.564[168]
~~ARP Kits~~	~~2.65[169]~~
Custom	Actual Occupancy or Number of Bedrooms[170]

365.25 = Days in a year, on average.

DF = Drain Factor

Program Delivery	Drain Factor	
	Kitchen	Bath
~~Non SFLI Kits[171]~~	~~75%~~	~~90%~~
Income Eligible, ~~MFMR~~,~~; SFLI Kits,~~ PAYS[172]	100%	100%
~~Unknown~~	~~79.5%~~	~~N/A~~

FPH = Faucets Per Household

Program Delivery	FPH	
	Kitchen (KFPH)	Bathroom (BFPH)
~~Single-Family~~	~~1.19[173]~~	~~2.04[174]~~
~~School Kits~~	~~1.19[175]~~	~~2.28[176]~~
~~Efficient Kits (MF)~~	~~1.00[177]~~	~~1.337[178]~~
~~Multi-Family (MFMR~~Income Eligible~~)~~, PAYS	1.00[179]	1.86[180]
~~Income Eligible, Efficient Kits (SFLI Kits)~~	~~1.00~~	~~1.86[181]~~
~~If location unknown (total for household): Single-Family~~	~~3.04~~	
~~If location unknown (total for household): Multi-Family~~	~~2.4~~	

EPG_electric = Energy per gallon of water used by faucet supplied by electric water heater
= (8.33 * 1.0 * (WaterTemp - SupplyTemp)) / (RE_electric * 3412)

~~[164] Ameren Missouri Efficient Products Impact and Process Evaluation: Planning Year 2015, provided by Cadmus. https://www.efis.psc.mo.gov/Document/Display/13805, page 36~~

~~[165] Ameren Missouri Energy Efficient Kits Program Impact and Process Evaluation: PY2019, https://www.efis.psc.mo.gov/Document/Display/15876, page 72.~~

~~[166] PY2018 Energy Efficiency Kits Property Manager Survey results (I1-I2), https://www.efis.psc.mo.gov/Document/Display/15870, page 34.~~

~~[167] Ameren Missouri Community Savers Evaluation: PY2018, https://www.efis.psc.mo.gov/Document/Display/36053.~~

[168] PY2006 program data (not reported in PY2016). ~~Ameren Missouri Low Income and Process Evaluation: program Year 2015. p.23~~

~~[169] Ameren Missouri Appliance Recycling Program Evaluation: PY2019, https://www.efis.psc.mo.gov/Document/Display/15876, page 91.~~

~~[170] Bedrooms are suitable proxies for household occupancy and may be preferable to actual occupancy due to turnover rates in residency and non-adult population impacts.~~

~~[171] Because faucet usages are at times dictated by volume (e.g., filling a cooking pot), only usage of the sort that would go straight down the drain will provide savings. VEIC is unaware of any metering study that has determined this specific factor and so recommends these values to be 75% for the kitchen and 90% for the bathroom. If the aerator location is unknown, an average of 79.5% should be used, which is based on the assumption that 70% of household water runs through the kitchen faucet and 30% through the bathroom (0.7*0.75)+(0.3*0.9)=0.795.~~

[172] Ameren Missouri Community Savers Evaluation PY2018, https://www.efis.psc.mo.gov/Document/Display/36053.

~~[173] Ameren Missouri Energy Efficient Kits Evaluation: PY2018, https://www.efis.psc.mo.gov/Document/Display/15870, page 34.~~

~~[174] Based on findings from a 2012 Ameren Missouri potential study for single family homes.~~

~~[175] Ameren Missouri Energy Efficient Kits Evaluation: PY2018, https://www.efis.psc.mo.gov/Document/Display/15870, page 34.~~

~~[176] Ameren Missouri Energy Efficient Kits Program Impact and Process Evaluation: PY2018, https://www.efis.psc.mo.gov/Document/Display/15870, page 36.~~

~~[177] Ameren Missouri EE Kits PY2018 Program Data, https://www.efis.psc.mo.gov/Document/Display/15870, page 34~~

~~[178] Ameren Missouri Energy EfficientCommunity Savers Evaluation: PY2018, https://www.efis.psc.mo.gov/Document/Display/15870, page 36.~~

[179] Ameren Missouri EE Kits PY2018 Program Data, https://www.efis.psc.mo.gov/Document/Display/15870, page 34.

[180] Ameren Missouri Community Savers Evaluation: PY2018, https://www.efis.psc.mo.gov/Document/Display/36053, page 23.

~~[181] Ameren Missouri Community Savers Evaluation: PY2018, https://www.efis.psc.mo.gov/Document/Display/36053, page 23.~~

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Field Code Changed

8.33 = Specific weight of water (lbs/gallon)

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

WaterTemp = Assumed temperature of mixed water

= 86F for Bathroom (80F for Income Eligible, PAYS and MFMR), 93F for Kitchen, 91F for Unknown[182]

SupplyTemp = Assumed temperature of water entering house

= 58~~61~~.4~~3~~F[183]

RE_electric = Recovery efficiency of electric water heater

= 98%[184]

3,412 = Converts Btu to kWh (btu/kWh)

ISR = In-service rate. Actual, or if unknown, reference applicable assumed value in the table below:~~In service rate of faucet aerators dependant on install method as listed in table below~~

Selection	In-Service Rate	
	Kitchen	Bathroom
~~Direct Install, Efficiency Kit – Low Income[185]~~	~~89%~~	~~89%~~
~~Efficiency Kit (School) – Single Family[186]~~	~~40%~~	~~48%~~
~~Efficiency Kit – Appliance Recycling[187]~~	~~20%~~	~~24%~~
~~Efficiency Kit (School) – Multi Family[188]~~	~~100%~~	~~100%~~
Income Eligible, PAYS~~Direct Install (Income Eligible and MFMR)~~[189]	95%	95%
~~Income Eligible, Non-Direct Install[190]~~	~~40%~~	~~48%~~
~~Income Eligible, Common Area~~	~~N/A~~	~~97.7%~~
~~Pay As You Save[191]~~	~~80.9%~~	~~80.9%~~

Leakage = Percent homes outside service territory

Program	Leakage
~~School Kits~~	~~28%[192]~~
~~Other Programs~~Income Eligible, PAYS	0%

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$\Delta kW = \Delta kWh * CF$

Where:

~~$\Delta kW = \Delta kWh * CF$~~

~~Where:~~

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[182] Cadmus and Opinion Dynamics Showerhead and Faucet Aerator Meter Study Memorandum, dated June 2013, directed to Michigan Evaluation Working Group. If the aerator location is unknown, an average of 91% should be used which is based on the assumption that 70% of household water runs through the kitchen faucet and 30% through the bathroom (0.7*93)+(0.3*86)=0.91.

[183] National Weather Service. Average soil temperature at 40" depth during 2015 - 2023 data of six stations in Ameren Missouri service territory. https://www.weather.gov/ncrfc/LMI_SoilTemperatureDepthMaps. ~~Ameren Missouri 2012 Technical Resource Manual. Appendix A. pp. 43. Available online: https://www.efis.psc.mo.gov/mpsc/commoncomponents/viewdocument.asp?DocId=935658483.~~

[184] Electric water heaters have recovery efficiency of 98%: ~~http://www.ahridirectory.org/ahridirectory/pages/home.aspx.~~NREL Building America Research Benchmark Definition, December 2009, page 12, https://www.nrel.gov/docs/fy10osti/47246.pdf.

~~[185] Ameren Missouri Single Family Low Income Evaluation PY2019 (Table 10-10), https://www.efis.psc.mo.gov/Document/Display/15877, page 214.~~

~~[186] Ameren Missouri Efficient Kits Impact and Process Evaluation: PY2019, https://www.efis.psc.mo.gov/Document/Display/15877, page 154.~~

~~[187] Ameren Missouri Appliance Recycling Evaluation: PY2019, https://www.efis.psc.mo.gov/Document/Display/15877, page 179.~~

~~[188] Ameren Missouri Efficient Products Impact and Process Evaluation: Program Year 2015, https://www.efis.psc.mo.gov/Document/Display/13805.~~

[189] Ameren Missouri Community Savers Evaluation PY2018, https://www.efis.psc.mo.gov/Document/Display/36053, page 23.

~~[190] Ameren Missouri Efficient Kits Impact and Process Evaluation: PY2019, https://www.efis.psc.mo.gov/Document/Display/15877, page 154.~~

~~[191] Ameren Missouri Pay As You Save (PAYS®) Evaluation: PY2022 Participant Survey, https://www.efis.psc.mo.gov/Document/Display/17591, page 7.~~

~~[192] PY2018 Energy Efficiency Kits School Evaluation Report, page 74.~~

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ΔkWh = as calculated above

CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor

= 0.0000887318[193]

NATURAL GAS SAVINGS

$\Delta Therms = \%GasDHW * (GPM_{base} * L_{\_base} - GPM_{low} * L_{low}) * Household * 365.25 * DF / FPH * EPG\_gas * ISR * (1 – Leakage)$

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~~$\Delta Therms = \%GasDHW * ((GPM_{base} * L_{base} - GPM_{low} * L_{low}) * Household * 365.25 * DF / FPH) * EPG\_gas * ISR$~~

Where:

%GasDHW = proportion of water heating supplied by Natural Gas heating

DHW fuel	%GasHW
Electric	0%
Natural Gas	100%
Unknown	48%[194]

EPG_gas = Energy per gallon of Hot water supplied by gas

= (8.33 * 1.0 * (WaterTemp - SupplyTemp)) / (RE_gas * 100,000)

RE_gas = Recovery efficiency of gas water heater

= 78% For SF homes[195]

= 67% For MF homes[196]

100,000 = Converts Btus to therms (btu/therm)

Other variables as defined above.

WATER IMPACT DESCRIPTIONS AND CALCULATION

$\Delta Gallons = ((GPM_{base} * L_{\_base} - GPM_{low} * L_{low}) * Household * 365.25 * DF / FPH) * ISR * (1 – Leakage)$

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~~$\Delta gallons = ((GPM\_base * L\_base - GPM\_low * L\_low) * Household * 365.25 * DF / FPH) * ISR$~~

Variables as defined above.

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE:

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[193] Based on Ameren Missouri TRM Volume 1 - Appendix G: "Table 1 – Residential End Use Category Monthly Shapes and Coincident Peak Factors"~~Ameren Missouri 2016 loadshape~~ for residential water heating end-use.

[194] Default assumption for unknown fuel is based on EIA Residential Energy Consumption Survey (RECS) 2009 for Midwest Region, data for the state of Missouri, 'HC8.9 Water Heating in Midwest Region.xls'~~. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area, then that should be used~~.

[195] DOE final rule discusses recovery efficiency with an average around 0.76 for gas- fired storage water heaters and 0.78 for standard efficiency gas fired tankless water heaters up to 0.95 for the highest efficiency gas fired condensing tankless water heaters. These numbers represent the range of new units however, not the range of existing units in stock. Review of AHRI Directory suggests range of recovery efficiency ratings for new gas DHW units of 70-87%. Average of existing units is estimated at 78%.

[196] Water heating in multifamily buildings is often provided by a larger central boiler. This suggests that the average recovery efficiency is somewhere between a typical central boiler efficiency of 0.59 and the 0.75 for single family homes. An average efficiency of 0.67 is used for this analysis as a default for multifamily buildings.

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3.3.2 Low Flow Showerhead

DESCRIPTION

This measure relates to the installation of a low flow showerhead in a single or multifamily household.

This measure may be used for units provided through efficiency kit's. However, the in-service rate for such measures should be derived through evaluation results specifically for this implementation methodology.

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

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

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed equipment must be a low flow showerhead, typically rated at 2.0 gallons per minute (GPM) or less. Savings are calculated on a per showerhead fixture basis.

DEFINITION OF BASELINE EQUIPMENT

For DI programs, the baseline condition is assumed to be a standard showerhead rated at 2.5 GPM[197] or greater.

~~For RF and TOS programs, the baseline condition is assumed to be a representative average of existing showerhead flow rates of participating customers including a range of low flow showerheads, standard flow showerheads, and high flow showerheads.~~

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 10 years.[198]

DEEMED MEASURE COST

~~The incremental cost for TOS, NC, or KITS is $7[199] for standard showerheads and $15.02 for handheld showerheads or program actual.~~

For low flow showerheads provided in ~~RF or~~ DI programs, the actual program delivery costs should be utilized; if unknown assume $15.33[200] for standard showerheads and $23.35 for handheld showerheads.

LOADSHAPE

Water Heating RES

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

Note these savings are per showerhead fixture

$\Delta kWh = \%ElectricDHW * ((GPM_{base} * L_{base} - GPM_{low} * L_{low}) * Household * SPCD * 365.25 / SPH) * EPG\_electric * ISR * (1 – Leakage)$

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~~$\Delta kWh = \%ElectricDHW * ((GPM_{base} * L_{base} - GPM_{low} * L_{low}) * Household * SPCD * 365.25 / SPH) * EPG\_electric * ISR$~~

Where:

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

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[197] Maximum showerhead flow rate at 80 PSI is 2.5 GPM in accordance with federal standard 10 CFR Part 430.32(p). See docket filed at https://www.regulations.gov/document?D=EERE-2011-BT-TP-0061-0039

[198] Table C-6, "Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures," GDS Associates, June 2007. Evaluations indicate that consumer dissatisfaction may lead to reductions in persistence, particularly in Multifamily, ~~-~~https://www.caetrm.com/media/reference-documents/HVAC_Ltg_measure_life_GDS_2007.pdf~~,~~; 'HVAC_Ltg_measure_life_GDS_2007.pdf', page C-6 ~~http://neep.org/uploads/EMV%20Forum/EMV%20Studies/measure_life_GDS%5B1%5D.pdf.~~

~~[199] Based on online pricing market research 2/6/2017.~~

[200] Direct-install price per showerhead assumes cost of showerhead (market research average of $7) and also assumes assess and install cost of $8.33 (20min at $25 per hour, which is in line with the typical prevailing wage of a General Laborer, as per the Annual Wage Order No. 23 published by the Missouri Department of Labor).

DHW fuel	%ElectricDHW
Electric	100%
~~Natural Gas~~	~~0%~~
~~Unknown~~	~~42%[201]~~

GPM_{base} = Flow rate of the baseline showerhead

Program Delivery	GPM_base
Direct-install~~, SFLI Kits~~	2.2[202]
~~Retrofit, Efficiency Kits, NC or TOS~~	~~2.35[203]~~
~~MFMR~~	~~2.5[204]~~

GPM_{low} = As-used flow rate of the lowflow showerhead[205], which may, as a result of measurements of program evaulations deviate from rated flows. If the as-used flow rate is not available, the rated flow rate should be applied~~,~~. ~~see table below:~~

~~Rated Flow~~
~~2.0 GPM~~
~~1.75 GPM~~
~~1.5 GPM~~
~~Custom or Actual[206]~~

L_{base} = Shower length in minutes with baseline showerhead
= ~~7.8 min[207] and~~ 8.66 for Income Eligible and PAYS~~, MFMR, SFIE Kits~~[208]

L_{low} = Shower length in minutes with low-flow showerhead
= ~~7.8 min[209] and~~ 8.66 for Income Eligible and PAYS~~, MFMR, SFIE Kits~~[210]

Household = Average number of people per household

Program Delivery	Household
Single-Family ~~TOS, Income Eligible (SFIE Kits)~~	2.67[211]
~~School Kits~~	~~4.29[212]~~
~~Efficient Kits (MF)~~	~~1.777[213]~~

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~~[201] Ameren Missouri Energy Efficient Kits Impact and Process Evaluation: PY2019, https://www.efis.psc.mo.gov/Document/Display/15876, page 73.~~

[202] Ameren Missouri Community Savers Evaluation: PY2018, https://www.efis.psc.mo.gov/Document/Display/36053.

~~[203] Representative value from sources 1, 2, 4, 5, 6, and 7 (See Source Table at end of measure section) adjusted slightly upward to account for program participation, which is expected to target customers with existing higher flow devices rather than those with existing low flow devicesIL TRM v12.0, Volume 3, page 271, https://www.ilsag.info/wp-content/uploads/IL_TRM_Effective_010124_v12.0_Vol_3_Res_09222023_FINAL_clean.pdf.~~

~~[204] PY2019 Program Data, https://www.efis.psc.mo.gov/Document/Display/15876, page 86.~~

[205] Note that actual values may be either: a) program-specific minimum flow rate, or b) program-specific evaluation-based value of actual effective flow-rate due to increased duration or temperatures. The latter increases in likelihood as the rated flow drops and may become significant at or below rated flows of 1.5 GPM. The impact can be viewed as the inverse of the throttling described in the footnote for baseline flowrate.

~~[206] Note that actual values may be either: a) program-specific minimum flow rate, or b) program-specific evaluation-based value of actual effective flow-rate due to increased duration or temperatures. The latter increases in likelihood as the rated flow drops and may become significant at or below rated flows of 1.5 GPM. The impact can be viewed as the inverse of the throttling described in the footnote for baseline flowrate.~~

~~[207] Cadmus and Opinion Dynamics Showerhead and Faucet Aerator Meter Study Memorandum, dated June 2013, directed to Michigan Evaluation Working Group. This study of 135 single and multifamily homes in Michigan metered energy parameters for efficient showerhead and faucet aerators.~~

[208] DeOreo, William, P. Mayer, L. Martien, M. Hayden, A. Funk, M. Kramer-Duffield, and R. Davis (2011). "California Single Family Water Use Efficiency Study.", https://www.waterboards.ca.gov/waterrights/water_issues/programs/hearings/byron_bethany/docs/exhibits/pt/wr71.pdf~~.~~; 'California Single Family Water Use Study.pdf', page 91.

~~[209] Cadmus and Opinion Dynamics Showerhead and Faucet Aerator Meter Study Memorandum dated June 2013, directed to Michigan Evaluation Working Group. This study of 135 single and multifamily homes in Michigan metered energy parameters for efficient showerhead and faucet aerators.~~

[210] DeOreo, William, P. Mayer, L. Martien, M. Hayden, A. Funk, M. Kramer-Duffield, and R. Davis (2011). "California Single Family Water Use Efficiency Study.", https://www.waterboards.ca.gov/waterrights/water_issues/programs/hearings/byron_bethany/docs/exhibits/pt/wr71.pdf~~.~~; 'California Single Family Water Use Study.pdf', page 91.

[211] Ameren Missouri Efficient Products Impact and Process Evaluation: Planning Year 2015, provided by Cadmus, https://www.efis.psc.mo.gov/Document/Display/13805, page 38.

~~[212] Ameren Missouri Energy Efficient Kits Evaluation: PY2019, https://www.efis.psc.mo.gov/Document/Display/15876, page 74.~~

~~[213] PY2018 Energy Efficiency Kits Property Manager Survey results (I1-I2), https://www.efis.psc.mo.gov/Document/Display/15870, page 32.~~

Program Delivery	Household
~~Income Eligible~~ Multi-Family~~, PAYS Multi-Family~~	1.52[214]
~~Appliance Recycling Kits~~	~~2.65[215]~~
~~Multi-Family TOS, MFMR~~	~~2.07[216]~~
Custom	Actual Occupancy or Number of Bedrooms[217]

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[214] Ameren Missouri Community Savers Evaluation: PY2018, https://www.efis.psc.mo.gov/Document/Display/36053, page 39.

~~[215] Ameren Missouri Appliance Recycling Evaluation PY2019 (Appendix Table 55), https://www.efis.psc.mo.gov/Document/Display/15876, page 92.~~

~~[216] Matches PY2015 Community Savers EM&V, https://www.efis.psc.mo.gov/Document/Display/13809, page 20.~~

[217] Bedrooms are suitable proxies for household occupancy and may be preferable to actual occupancy due to turnover rates in residency and non-adult population impacts.

SPCD = Showers Per Capita Per Day
= ~~0.832[218] and~~ 0.66 for Income~~m~~ Eligible~~, MFMR, SFIE Kits,~~ and PAYS[219]
365.25 = Days per year, on average.
SPH = Showerheads Per Household so that per-showerhead savings fractions can be determined

Program Delivery	SPH
~~Single-Family,~~ Income Eligible Single Family, PAYS~~(SFIE Kits)~~	2.05[220]
~~School Kits~~	~~2.14[221]~~
~~Efficient Kits (MF)~~	~~1.34[222]~~
Income Eligible Multi-Family~~, PAYS Multi-Family~~	1.0[223]
~~MFMR~~	~~1.4[224]~~
Custom	Actual

EPG_electric = Energy per gallon of hot water supplied by electric
= (8.33 * 1.0 * (ShowerTemp - SupplyTemp)) / (RE_electric * 3412)
= (8.33 * 1.0 * (101 – 60.83)) / (0.98 * 3412)
= 0.100 kWh/gal
8.33 = Specific weight of water (lbs/gallon)
1.0 = Heat capacity of water (btu/lb-°)
ShowerTemp = Assumed temperature of water
= 105.0 F[225]
SupplyTemp = Assumed temperature of water entering house
= 58.4F[226]~~61.3 F[227]~~
RE_electric = Recovery efficiency of electric water heater
= 98%[228]
3,412 = Converts Btu to kWh (btu/kWh)
ISR = In service rate of showerhead
= Actual, or if unknown, reference applicable assumed value in the table below~~Dependant on program delivery method as listed in table below~~:

Program Delivery	ISR
~~Direct Install[229]~~	~~100%~~
~~Efficiency Kit – School (Single Family)[230]~~	~~54%~~
~~Efficiency Kit – Multifamily[231]~~	~~100%~~
~~Efficiency Kit – Appliance Recycling[232]~~	~~24%~~

~~[218] Ameren Missouri Energy Efficient Kits Program Impact and Process Evaluation: PY2019, https://www.efis.psc.mo.gov/Document/Display/15876, page 74.~~

[219] DeOreo, William, P. Mayer, L. Martien, M. Hayden, A. Funk, M. Kramer-Duffield, and R. Davis (2011). "California Single Family Water Use Efficiency Study~~.~~", https://www.waterboards.ca.gov/waterrights/water_issues/programs/hearings/byron_bethany/docs/exhibits/pt/wr71.pdf~~.; 'California Single Family Water Use Study.pdf'.~~

[220] Ameren Missouri Efficient Products Impact and Process Evaluation: Planning Year 2015, provided by Cadmus, https://www.efis.psc.mo.gov/Document/Display/12014, page 38.

~~[221] Ameren Missouri Energy Efficient Kits Program Impact and Process Evaluation: PY2019, https://www.efis.psc.mo.gov/Document/Display/15876, page 74.~~

~~[222] Ameren Missouri PY2018 EE Kits Evaluation, https://www.efis.psc.mo.gov/Document/Display/15870, page 32.~~

[223] Ameren Missouri Community Savers Evaluation: PY2017, https://www.efis.psc.mo.gov/Document/Display/36053, page 22.

~~[224] Ameren Missouri Efficient Products Impact and Process Evalluation: Planning Year 2015, page 38, https://www.efis.psc.mo.gov/Document/Display/12014 Matches Community Savers EM&V~~

[225] Ameren Missouri Efficient Kits Evaluation: PY2018, https://www.efis.psc.mo.gov/Document/Display/15870, page 32.

[226] National Weather Service. Average soil temperature at 40" depth during 2015 - 2023 data of six stations in Ameren Missouri service territory. https://www.weather.gov/ncrfc/LMI_SoilTemperatureDepthMaps.

~~[227] Based on the DOE's Building America Standard DHW Event Schedule calculator. Average annual water main temperatures were determined for each defined weather zone in Missouri. The overall average of 60.83 is taken to represent the statewide average input water temperature.~~

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

~~[229] Ameren Missouri Community Savers Tenant Surveys and Site Visits PY2017, https://www.efis.psc.mo.gov/Document/Display/28281.~~

~~[230] Ameren Missouri Efficient Kits Impact and Process Evaluation: PY2019, Table 7-10, https://www.efis.psc.mo.gov/Document/Display/15877, page 154.~~

~~[231] Ameren Missouri PY2018 EE Kits Evaluation, https://www.efis.psc.mo.gov/Document/Display/15870, page 32.~~

~~[232] Ameren Missouri Appliance Recycling Evaluation: PY2019, Table 9-10, https://www.efis.psc.mo.gov/Document/Display/15877, page 186.~~

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Program Delivery	ISR
Income Eligible (Single Family Direct Install) , PAYS[233]	94%
Income Eligible (Multifamily Direct Install~~), MFMR Direct Install~~[234]	96.4%
~~Income Eligible (Non-Direct Install), MFMR (Non-Direct Install), SFLI Kits~~~~[235]~~	~~91.3%~~
~~Pay As You Save~~~~[236]~~	~~65%~~

3,412 = Converts Btu to kWh (btu/kWh)
Leakage = Percent homes outside service territory

Program	Leakage
~~School Kits~~	~~28%~~~~[237]~~
~~Other Programs~~SFIE, MFIE, PAYS	0%

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ΔkWh * CF

Where:

~~ΔkW = ΔkWh * CF~~

~~Where:~~

ΔkWh = as calculated above
CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor
= 0.0000887318[238]

NATURAL GAS SAVINGS

ΔTherms = %GasDHW * ((GPM_{base} * L_{base} - GPM_{low} * L_{low}) * Household * SPCD * 365.25 / SPH) * EPG_gas * ISR * (1 – Leakage)

~~ΔTherms = %GasDHW ∗ ((GPM_base ∗ L_base − GPM_low ∗ L_low) ∗ Household ∗ SPCD ∗ 365.25 / SPH) ∗ EPG_gas ∗ ISR~~

Where:
%GasDHW = proportion of water heating supplied by natural gas heating

DHW fuel	%GasDHW
Electric	0%
Natural Gas	100%
Unknown	48%[239]

EPG_gas = Energy per gallon of Hot water supplied by gas
= (8.33 * 1.0 * (ShowerTemp - SupplyTemp)) / (RE_gas * 100,000)
~~-~~= 0.00429 therm/gal for SF homes

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[233] Ameren Missouri Single Family Low Income Evaluation PY2019 (Table 10-10), https://www.efis.psc.mo.gov/Document/Display/15877, page 214.

[234] Ameren Missouri Community Savers Evaluation PY2018 Tenant Surveys and Site Visits, https://www.efis.psc.mo.gov/Document/Display/36053, page 22.

~~[235] PY2017 CommunitySavers Report, page 3-7, https://www.efis.psc.mo.gov/Document/Display/2828107 Tenant surveys.~~

~~[236] Ameren Missouri Pay As You Save (PAYS®) Evaluation: PY2022 Participant Survey, https://www.efis.psc.mo.gov/Document/Display/17591, page 7.~~

~~[237] PY2018 Energy Efficiency Kits School Evaluation Report, https://www.efis.psc.mo.gov/Document/Display/15870, page 74.~~

[238] Based on Ameren Missouri TRM Volume 1 - Appendix G: "Table 1 – Residential End Use Category Monthly Shapes and Coincident Peak Factors"~~Ameren Missouri 2016 loadshape~~ for residential water heating end-use.

[239] Default assumption for unknown fuel is based on EIA Residential Energy Consumption Survey (RECS) 2009 for Midwest Region, data for the state of Missouri, 'HC8.9 Water Heating in Midwest Region.xls'~~Default assumption for unknown fuel is based on EIA Residential Energy Consumption Survey (RECS) 2009 for Midwest Region, data for the state of Illinois. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area, then that should be used~~.

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= 0.00499 therm/gal for MF homes

RE_gas = Recovery efficiency of gas water heater

= 78% For SF homes[240]

= 67% For MF homes[241]

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

Other variables as defined above.

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WATER IMPACT DESCRIPTIONS AND CALCULATION

$\Delta Gallons = ((GPM_{base} * L_{base} - GPM_{low} * L_{low}) * Household * SPCD * 365.25 / SPH) * ISR * (1 – Leakage)$

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~~$\Delta gallons = ((GPM\_base * L\_base - GPM\_low * L\_low) * Household * SPCD * 365.25 / SPH) * ISR$~~

Variables as defined above

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE:

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[240] DOE final rule discusses recovery efficiency with an average around 0.76 for gas-fired storage water heaters and 0.78 for standard efficiency gas fired tankless water heaters up to 0.95 for the highest efficiency gas-fired condensing tankless water heaters. However, these numbers represent the range of new units, not the range of existing units in stock. Review of AHRI Directory suggests range of recovery efficiency ratings for new gas DHW units of 70-87%. Average of existing units is estimated at 78%.

[241] Water heating in multifamily buildings is often provided by a larger central boiler. This suggests that the average recovery efficiency is somewhere between a typical central boiler efficiency of 0.59 and the 0.75 for single family homes. An average efficiency of 0.67 is used for this analysis as a default for multifamily buildings.

3.3.3 Water Heater Wrap (Retired, effective 1/1/2025)[242]

DESCRIPTION
This measure applies to a tank wrap or insulation "blanket" that is wrapped around the outside of an electric or gas domestic hot water (DHW) tank to reduce stand-by losses.

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

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

DEFINITION OF EFFICIENT EQUIPMENT
The efficient condition is an electric or gas DHW tank with wrap installed that has an R-value that meets program requirements.

DEFINITION OF BASELINE EQUIPMENT
The baseline condition is an uninsulated electric or gas DHW tank.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT
The measure life is assumed to be 12 years.[243]

DEEMED MEASURE COST
The measure cost is the actual cost of material and installation. If actual costs are unknown, assume $58[244] for material and installation.

LOADSHAPE
Water Heating RES

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS
Custom calculation below for electric DHW tanks, otherwise use default values from table that follows:

$\Delta kWh = ((A_{Base}/R_{Base} – A_{EE}/R_{EE}) * \Delta T * Hours) / (\eta DHW_{Elec} * 3,412)$

$$\Delta kWh = ((A_{Base}/R_{Base} - A_{EE}/R_{EE}) * \Delta T * Hours)/(\eta DHW_{Elec} * 3,412)$$

Where:

A_{Base} = Surface area (ft^2) of storage tank prior to adding tank wrap[245]
= Actual or if unknown, use default based on tank capacity (gal) from table below

R_{Base} = Thermal resistance coefficient (hr-°F-ft^2/BTU) of uninsulated tank
= Actual or if unknown, assume 14[246]

A_{EE} = Surface area (ft^2) of storage tank after addition of tank wrap[247]
= Actual or, if unknown, use default based on tank capacity (gal) from table below

---

[242] ~~"Retire" indicates that the measure is not anticipated to be offered through an Ameren Missouri-administered demand-side program during the period of TRM effectiveness.~~

[243] ~~2014 Database for Energy-Efficiency Resources (DEER), Version 2014, "Cost Values and Summary Documentation," California Public Utilities Commission, January 2014. Average of values for electric DHW (13 years) and gas DHW (11 years).~~

[244] ~~Average cost of R-10 tank wrap installation from the National Renewable Energy Laboratory's National Residential Efficiency Measures Database, https://remdb.nrel.gov/ . http://www.nrel.gov/ap/retrofits/measures.cfm?gId=6&ctId=270.~~

[245] ~~Area includes tank sides and top to account for typical wrap coverage.~~

[246] ~~Baseline R-value based on information from Chapter 6 of *The Virginia Energy Savers Handbook*, Third Edition: The best heaters have 2 to 3 inches of urethane foam, providing R-values as high as R-20. Other less expensive models have fiberglass tank insulation with R-values ranging between R-7 and R-10.~~

[247] ~~Area includes tank sides and top to account for typical wrap coverage.~~

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R_{EE} = Thermal resistance coefficient ((hr-°F-ft2/BTU) of tank after addition of tank wrap (R-value of uninsulated tank + R-value of tank wrap)
= Actual or if unknown, assume 24

ΔT = Average temperature difference (°F) between tank water and outside air
= Actual or if unknown, assume 60°F[248]

Hours = Hours per year
= 8,766

ηDHW_{Elec} = Recovery efficiency of electric hot water heater
= Actual or if unknown, assume 0.98[249]

3,412 = Conversion factor from Btu to kWh

The following table contains default savings for various tank capacities.

Capacity (gal)	A_{Base} (ft^2)[250]	A_{EE} (ft^2)[251]	ΔkWh	ΔkW
30	19.16	20.94	78.0	0.00890
40	23.18	25.31	94.6	0.01079
50	24.99	27.06	103.4	0.01180
80	31.84	34.14	134.0	0.01528

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$\Delta kW = \Delta kWh * CF$

Where:

ΔkWh $\Delta kW = \Delta kWh * CF$

Where:

ΔkWh = = Electric energy savings, as calculated above.

CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor
= 0.0000887318[252]

The table above contains default kW savings for various tank capacities.

NATURAL GAS SAVINGS

Custom calculation below for gas DHW tanks, otherwise use default values from table that follows:

$\Delta Therms = ((A_{Base}/R_{Base} – A_{EE}/R_{EE}) * \Delta T * Hours) / (\eta DHW_{Gas} * 100,000)$

$$\Delta Therms = ((A_{Base}/R_{Base} - A_{EE}/R_{EE}) * \Delta T * Hours)/(\eta DHW_{Gas} * 100,000)$$

Where:

ηDHW_{Gas} = Recovery efficiency of gas hot water heater
= 0.78[253]

100,000 = Conversion factor from Btu to therms

Other variables as defined above

The following table contains default savings for various tank capacities.

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[248] ~~Assumes 125°F hot water tank temperature and average basement temperature of 65°F.~~

[249] ~~Electric water heater recovery efficiency from AHRI database: http://www.ahridirectory.org/ahridirectory/pages/home.aspx.~~

[250] ~~Surface area assumptions from the June 2016 Pennsylvania TRM. Area values were calculated from average dimensions of several commercially available units, with radius values measured to the center of the insulation. Area includes tank sides and top to account for typical wrap coverage.~~

[251] ~~Surface area assumptions from the June 2016 Pennsylvania TRM. A_{EE} was calculated by assuming that the water heater wrap is a 2" thick fiberglass material.~~

[252] ~~Based on Ameren Missouri TRM Volume 1 – Appendix G: "Table 1 – Residential End Use Category Monthly Shapes and Coincident Peak Factors"2016 Ameren Missouri Coincident Peak Demand Factor for Residential Water Heating. See reference "Ameren Missouri 2016 Appendix E - End Use Shapes and Coincident Factors.pdf."~~

[253] ~~Review of AHRI directory suggests range of recovery efficiency ratings for new gas DHW units of 70-87%. Average of existing units is estimated at 78%.~~

Capacity (gal)	A_{Base} (ft^2)[254]	A_{EE} (ft^2)[255]	ΔTherms	ΔPeakTherms
30	19.16	20.94	3.3	0.0092
40	23.18	25.31	4.1	0.0111
50	24.99	27.06	4.4	0.0121
80	31.84	34.14	5.7	0.0157

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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[254] ~~Area values were calculated from average dimensions of several commercially available units, with radius values measured to the center of the insulation. Area includes tank sides and top to account for typical wrap coverage. Recommend updating with Missouri-specific data when available.~~

[255] ~~A_{EE} was calculated by assuming that the water heater wrap is a 2" thick fiberglass material. Recommend updating with Missouri-specific data when available.~~

3.3.4 Heat Pump Water Heater

DESCRIPTION

This measure applies to the installation of a heat pump water heater (HPWH) in place of a standard electric water heater in a home. Savings are presented dependent on the heating system installed in the home due to the impact of the heat pump water heater on the heating and cooling loads.

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

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

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure, the installed equipment must be an ENERGY STAR® heat pump water heater with a storage volume ≤ 55 gallons.[256]

DEFINITION OF BASELINE EQUIPMENT

The baseline equipment is assumed to be a new, electric storage water heater meeting federal minimum efficiency standards[257] for units ≤55 gallons:

Draw Pattern	Federal Standard – Uniform Energy Factor[258]
Very small	UEF = 0.8808 – (0.0008 * Rated Storage Volume in Gallons)
Low	UEF = 0.9254 – (0.0003 * Rated Storage Volume in Gallons)
Medium	UEF = 0.9307 – (0.0002 * Rated Storage Volume in Gallons)
High	UEF = 0.9349 – (0.0001 * Rated Storage Volume in Gallons)

0.96 – (0.0003 * rated volume in gallons).The same draw pattern (very small, low, medium and high draw) should be used for both baseline and efficient units.

If unknown, assume a 50 gallon resistance tank baseline, at medium draw, therefore 0.9207 UEF. [259]

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 13 years.[260]

DEEMED MEASURE COST

Actual costs should be used where available. The Ddefault incremental cost valuese for incremental capital costs is $588are provided in the table below.[261]

Efficiency Range	Baseline Installed Cost	Efficient Installed Cost	Incremental Installed Cost
<2.6 UEF	$1,032	$2,062	$1,030
>2.6 UEF	$1,032	$2,231	$1,199

LOADSHAPE

Water Heating RES

Algorithm

~~[256] Since the federal standard effectively requires a heat pump water heater for units over 55 gallons, this measure is limited to units ≤ 55 gallons.~~

~~[257] Minimum federal standard up to date as of 8/15/2024as of 4/16/2015: https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430; '10 CFR Part 430 (up to date as of 8-15-2024).pdf'. http://www.gpo.gov/fdsys/pkg/CFR-2012-title10-vol3/pdf/CFR-2012-title10-vol3-sec430-32.pdf. http://www.gpo.gov/fdsys/pkg/CFR-2012-title10-vol3/pdf/CFR-2012-title10-vol3-sec430-32.pdf.~~

~~[258] All Residential sized Federal Standards are from DOE Standard 10 CFR 430, Residential-Duty and Commercial Federal Standard are from DOE Standard 10 CFR 431.~~

~~[259] Illinois TRM Version 12.0, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_3_Res_09222023_FINAL_clean.pdf, page 249.~~

~~[260] 2010 Residential Heating Products Final Rule Technical Support Document, U.S. DOE, Table 8.7.2.~~

~~[261] Illinois TRM Version 12.0, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_3_Res_09222023_FINAL_clean.pdf, p. 250. Costs for <2.6 UEF are based upon averages from the NEEP Phase 3 Incremental Cost Study ('NEEP Incremental Cost Study FINAL_061016.pdf'). The assumption for higher efficiency tanks is based upon averaged from NEEP Phase 4 Incremental Cost StudyAmeren Missouri MEEIA 2016-18 TRM – January 1, 2018.~~.

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CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

ΔkWh = $[(((1/EF_{BASE} - 1/EF_{EE}) * GPD * Household * 365.25 * \gamma Water * (T_{OUT} - T_{In}) * 1.0)) / 3{,}412) + kWh_{cool} - kWh_{heat}] * ISR$

$$\Delta kWh = \left[\left(\frac{(1/EF_{BASE} - 1/EF_{EE}) * GPD * Household * 365.25 * \gamma Water * (T_{Out} - T_{In}) * 1.0)}{3{,}412}\right) + kWh_{cool} - kWh_{heat}\right] * ISR$$

Where:

UEF_{BASE} = UEF of standard electric water heater according to federal standards
= If new unit draw pattern unknown,0.96 – (0.0003 * rated volume in gallons 0.9207[262].)

U= If rated volume is unknown, assume 0.945 for a 50-gallon water heater

EF_{EE} = UEF of heat pump water heater
= Actual

GPD = Gallons per day of hot water use per person
= 17.6[263]

Household = Average number of people per household

Household Unit Type[264]	Household
~~Single-Family - Deemed~~All	2.65[265]
~~Multi-Family - Deemed~~	~~2.07[266]~~
Custom	Actual Occupancy or Number of Bedrooms[267]

365.25 = Days per year
γWater = Specific weight of water
= 8.33 pounds per gallon
T_{OUT} = Tank temperature
= Actual, if unknown assume 125°F
T_{IN} = Incoming water temperature from well or municipal system
= 58.4F[268]57.898°F[269]
1.0 = Heat capacity of water (1 Btu/lb*°F)
3,412 = Conversion factor from Btu to kWh
ISR = In-service rate. Actual, or if unknown, assume In Service Rate = 100%[270]
kWh_cool = Cooling savings from conversion of heat in home to water heat[271]
= $[(((1- 1/UEF_{EE}) * GPD * Household * 365.25 * \gamma Water * (T_{OUT} - T_{In}) * 1.0) * LF * WHF_{C} * LM) / (COP_{COOL} * 3{,}412)] * \%Cool$

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~~[262] Federal Register :: Energy Conservation Program: Energy Conservation Standards for Consumer Water Heaters~~
~~[263] GPD based on 45.5 gallons of hot water per day per household and 2.59 people per household, from "Residential End Uses of Water Study 2013 Update," by Deoreo, B., and P. Mayer, for the Water Research Foundation, 2014, https://www.awwa.org/Portals/0/AWWA/ETS/Resources/WaterConservationResidential_End_Uses_of_Water.pdf.; 'WaterConservationResidential_End_Uses_of_Water.pdf'.~~
~~[264] If household type is unknown, as may be the case for TOS measures, then single family deemed value shall be used.~~
~~[265] Ameren Missouri Efficient Products Evaluation: PY2018, https://www.efis.psc.mo.gov/Document/Display/15869, page 32.~~
~~[266] Ameren Missouri Efficient Products Evaluation: PY2015, https://www.efis.psc.mo.gov/Document/Display/13805, page 36.~~
~~[267] Bedrooms are suitable proxies for household occupancy and may be preferable to actual occupancy due to turnover rates in residency and non-adult population impacts.~~
~~[268] National Weather Service. Average soil temperature at 40" depth during 2015 – 2023 data of six stations in Ameren Missouri service territory. https://www.weather.gov/ncrfc/LMI_SoilTemperatureDepthMaps.~~
~~[269] Using 40" deep soil temp as a proxy at Powell Gardens SCAN site. Average by month of available data from 3/28/02 -10/11/14: 12-month average is 57.898. http://www.wcc.nrcs.usda.gov/nwcc/site?sitenum=2061.~~
~~[270] Ameren Missouri Efficient Products Evaluation: PY2019, https://www.efis.psc.mo.gov/Document/Display/15877, page 140.~~
~~[271] This algorithm calculates the heat removed from the air by subtracting the heat pump water heater electric consumption from the total water heating energy delivered. This is then adjusted to account for location of the heat pump unit and the coincidence of the waste heat with cooling requirements, the efficiency of the central cooling, and latent cooling demands.~~

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$$= \left[\frac{\left(\left(1 - \frac{1}{EF_{EE}}\right) * GPD * Household * 365.25 * \gamma Water * (T_{OUT} - T_{IN}) * 1.0\right) * LF * WHF_C * LM}{COP_{COOL} * 3{,}412} \right] * \%Cool$$

Where:

LF = Location Factor
= 1.0 for HPWH installation in a conditioned space
= 0.0 for installation in an unconditioned space
= 0.81 if unknown[272]

WHF_C = Portion of reduced waste heat that results in cooling savings (if unknown, assume 53%) [273]

COP_{COOL} = COP of central air conditioner
= Actual, or if unknown, assume 2.8 COP[274]

LM = Latent multiplier to account for latent cooling demand [275]

Weather Basis (City based upon)	LM
St. Louis, MO	1.33

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[272] ~~Wisconsin Focus on Energy 2023 Technical Reference Manual, https://assets.focusonenergy.com/production/inline-files/Focus_on_Energy_2023_TRM.pdf, page 787.~~

[273] ~~Based on Ameren Missouri Efficient Products Evaluation PY2018, https://www.efis.psc.mo.gov/Document/Display/15869, page 32.~~

[274] ~~Starting from standard assumption of SEER 10.5 central AC unit, converted to 9.5 EER using algorithm (-0.02 * SEER²) + (1.12 * SEER) (from Wassmer, M. (2003), "A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations," (Masters thesis), University of Colorado at Boulder), converted to COP = EER/3.412 = 2.8COP.~~

[275] ~~The Latent Multiplier is used to convert the sensible cooling savings calculated to a value representing sensible and latent cooling loads. The values are derived from the methodology outlined in "Infiltration Factor Calculation Methodology" by Bruce Harley, Senior Manager, Applied Building Science, CLEAResult 11/18/2015, and are based upon an 8760 analysis of sensible and total heat loads using hourly climate data. (Ameren Missouri Efficient Products Evaluation PY2018, https://www.efis.psc.mo.gov/Document/Display/15869, page 32)~~

Weather Basis (City based upon)	LM

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Weather Basis (City based upon)	LM
St Louis, MO	1.33

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%Cool = Percentage of homes with central cooling

Home	%Cool
Cooling	100%
No Cooling	0%
Unknown	95%[276]

kWh_heat = Heating cost from conversion of heat in home to water heat (dependent on heating fuel)
= [(((1- 1/UEF_EE) * GPD * Household * 365.25 * γWater * (T_{OUT} – T_{In}) * 1.0) * LF * WHF_H *LM) / (COP_{HEAT} * 3,412)] * %ElectricHeat

$$= \left(\frac{\left(\left(1 - \frac{1}{EF_{EE}}\right) * GPD * Household * 365.25 * \gamma Water * (T_{OUT} - T_{IN}) * 1.0\right) * LF * WHF_H}{COP_{HEAT} * 3{,}412} \right) * \%ElectricHeat$$

Where:

WHF_H = Portion of reduced waste heat that results in increased heating load (if unknown, assume 43%) [277]

COP_{HEAT} = COP of electric heating system
= Actual, or if unknown, assume:[278]

System Type	Age of Equipment	HSPF2 Estimate	ηHeat (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[279]	N/A	N/A	1.28

System Type	Age of Equipment	Heating Seasonal Performance Factor (HSPF) Estimate	COP (Effective COP Estimate) (HSPF/3.412)* 0.85
Heat Pump	Before 2006	6.8	1.7
	2006 - 2014	7.7	1.92
	2015 and after	8.2	2.04
Resistance	N/A	N/A	1

%ElectricHeat = Percentage of homes with electric heat

Heating fuel	%ElectricHeat
Electric	100%
Natural Gas	0%

~~[276] Ameren Missouri PY2019 Residential Baseline Study (Saturation of non-low income homes with central cooling).~~

~~[277] Based on Ameren Missouri Efficient Products Evaluation PY2018, https://www.efis.psc.mo.gov/Document/Display/15869, page 31.~~

~~[278] 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.~~

~~[279] Calculation assumes 35% Heat Pump and 65% Resistance, which is based upon data from Energy Information Administration, 2009 Residential Energy Consumption Survey, , https://www.eia.gov/consumption/residential/data/2009/hc/hc6.9.xls ; 'hc6.9.xls'. 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.,~~

~~https://www.eia.gov/consumption/residential/data/2009/hc/hc6.9.xls~~

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Field Code Changed

Heating fuel	%ElectricHeat
Unknown	35%[280]

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$\Delta kW = \Delta kWh * CF$

Where:

ΔkWh $\Delta kW = kWh * CF$

Where:

kWh = Electric energy savings, as calculated above

CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor

= 0.0000887318[281]

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~~[280] Average (default) value of 35% electric space heating from 2009 Residential Energy Consumption Survey for Missouri. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area, then they should be used.~~

~~[281] Based on Ameren Missouri TRM Volume 1 – Appendix G: "Table 1 – Residential End Use Category Monthly Shapes and Coincident Peak Factors"Ameren Missouri 2016 loadshape for residential water heating end-use.~~

NATURAL GAS SAVINGS

$$\Delta\text{Therms} = [(((1- 1/EF\_{EE}) * GPD * Household * 365.25 * \gamma Water * (T_{OUT} - T_{In}) * 1.0) * LF * 0.43) / (\eta Heat * 100,000)] * \%GasHeat$$

$$\Delta Therms = -\left(\frac{\left(\left(1-\frac{1}{EF_{EE}}\right) * GPD * Household * 365.25 * \gamma Water * (T_{OUT} - T_{IN}) * 1.0\right) * LF * 43\%}{\eta Heat * 100,000}\right) * \%GasHeat$$

Where:

ΔTherms = Heating cost from conversion of heat in home to water heat for homes with Natural Gas heat[282]

100,000 = Conversion factor from Btu to therms

ηHeat = Efficiency of heating system
= 71%[283]

%GasHeat = Percentage of homes with gas heat

Heating Fuel	%GasHeat
Electric	0%
Gas	100%
Unknown	65%[284]

Other factors as defined above

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE:

~~[282] This is the additional energy consumption required to replace the heat removed from the home during the heating season by the heat pump water heater. The variable kWh_heating (electric resistance) is that additional heating energy for a home with electric resistance heat (COP 1.0). This formula converts the additional heating kWh for an electric resistance home to the MMBtu required in a natural gas heated home, applying the relative efficiencies.~~

~~[283] This has been estimated assuming that natural gas central furnace heating is typical for Missouri residences (the predominant heating is gas furnace with 48% of Missouri homes (based on Energy Information Administration, 2009 Residential Energy Consumption Survey)). See reference "HC6.9 Space Heating in Midwest Region.xls.", https://www.eia.gov/consumption/residential/data/2009/hc/hc6.9.xls ; 'hc6.9.xls'. In 2000, 29% of furnaces purchased in Missouri 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 15 years ago provide a reasonable proxy for the current mix of furnaces in the State. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows: ((0.29*0.92) + (0.71*0.8)) * (1-0.15) = 0.71.~~

~~[284] Based on data from Energy Information Administration, 2009 Residential Energy Consumption Survey, see "HC6.9 Space Heating in Midwest Region.xls.", https://www.eia.gov/consumption/residential/data/2009/hc/hc6.9.xls; 'hc6.9.xls'.~~

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3.3.5 Hot Water Pipe Insulation

DESCRIPTION

This measure applies to the addition of insulation to uninsulated domestic hot water (DHW) pipes. The measure assumes the pipe wrap is installed on the first length of both the hot and cold pipes up to the first elbow or the first three feet of pipe length, whichever is longer. This is the most cost-effective section to insulate since, close to the tank, the water pipes act as an extension of the hot water tank, which acts as a heat trap. Insulating this section helps to reduce standby losses~~This measure applies to the addition of insulation to uninsulated domestic hot water (DHW) pipes. The measure assumes the pipe wrap is installed on the first length of both the hot and cold pipe up to the first elbow. This is the most cost effective section to insulate since the water pipes act as an extension of the hot water tank up to the first elbow, which acts as a heat trap. Insulating this section helps to reduce standby losses~~.

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

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

DEFINITION OF EFFICIENT EQUIPMENT

The efficient condition is a domestic hot or cold water pipe with pipe wrap installed that has an R value that meets program requirements.

DEFINITION OF BASELINE EQUIPMENT

The baseline condition is an uninsulated, domestic hot or cold water pipe.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 12 years.[285]

DEEMED MEASURE COST

The measure cost is the actual cost of material and installation. If the actual cost is unknown, ~~f~~~~For a kit program, assume a default cost of \$2.87.~~~~[286]~~~~; otherwise,~~ assume a default cost of \$7.10 [287] per linear foot, including material and installation. ~~For a kit program, assume a default cost of \$2.87.~~~~[288]~~

LOADSHAPE

Water Heating RES

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

Custom calculation below for electric systems, otherwise assume 24.7 kWh per 6 linear feet of ¾ in, R-4 insulation or 35.4 kWh per 6 linear feet of 1 in, R-6 insulation:

$\Delta kWh = \%ElectricDHW * ((C_{Base}/R_{Base} - C_{EE}/R\_{}_{EE}) * L * \Delta T * Hours)/(\eta DHW_{Elec} * 3{,}412) * ISR * (1 - Leakage)$

~~$\Delta kWh = \%ElectricDHW * ((C_{Base}/R_{Base} - C_{EE}/R_{EE}) * L * \Delta T * Hours)/(\eta DHW_{Elec} * 3{,}412) * ISR$~~

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Where:

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

DHW fuel	%ElectricDHW
Electric	100%

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[285] 2014 Database for Energy-Efficiency Resources (DEER), Version 2014, “Cost Values and Summary Documentation,” California Public Utilities Commission, January 2014. Average of values for electric DHW (13 years) and gas DHW (11 years).

~~[286] Cost based on RS Means 2018 data~~

[287] Average cost of R-5 pipe wrap installation from the National Renewable Energy Laboratory’s National Residential Efficiency Measures Database, https://remdb.nrel.gov/. ~~http://www.nrel.gov/ap/retrofits/measures.cfm?gId=6&ctId=323~~

~~[288] Cost based on RS Means 2018 data~~

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~~Natural Gas~~	~~0%~~
~~Unknown~~	~~42%[289]~~

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C_{Base} = Circumference (ft) of uninsulated pipe
= Diameter (in) * π/12
= Actual or, if unknown, assume 0.144” based on a weighted average of 80% 0.50-inch diameter pipe and 20% 0.75-inch diameter pipe.

R_{Base} = Thermal resistance coefficient (hr-°F-ft^2)/Btu) of uninsulated pipe
= 1.0[290]
C_{EE} = Circumference (ft) of insulated pipe
= Diameter (in) * π/12
= Based on actual pipe diameter and insulation thickness; if unknown, assume 0.55” pipe diameter based on a weighted average of 80% 0.50-inch diameter pipe and 20% 0.75-inch diameter pipe and 0.5” insulation thickness – using both assumed values results in C_{EE} of (0.55 + (0.5 * 2)) * π / 12 = 0.4058
. For instance, for a pipe insulated with 3/4 in, R-4 wrap, assume 0.524 ft for a 0.46 in diameter pipe ((0.75 + 1/2 + 1/2) * π/12)

~~= Actual or if unknown, assume 0.524 ft for a 0.46 in diameter pipe insulated with 3/4 in, R-4 wrap ((0.75 + 1/2 + 1/2) * π/12)~~
R_{EE} = Thermal resistance coefficient (hr-°F-ft^2)/Btu) of insulated pipe
= 1.0 + R value of insulation
= Actual ~~or if unknown, assume 5.0 for R-4 wrap or 7.0 for R-6 wrap~~
L = Length of pipe from water heating source covered by pipe wrap (ft)
= Actual ~~or if unknown, assume 6 ft~~
ΔT = Average temperature difference (°F) between supplied water and outside air
= Actual or if unknown, assume 58.9°F[291] for low income programs or 60°F[292] for other programs.
Hours = Hours per year
= 8,766
ηDHW_{Elec} = Recovery efficiency of electric hot water heater
= 0.98[293]
3,412 = Conversion factor from Btu to kWh
ISR = ~~Installation rate (varies by program~~ Actual, or if unknown, d~~D~~ependent on program delivery method as listed in table below~~)~~

Program	ISR
~~School Kits~~	~~56%[294]~~
~~Multifamily~~	~~100%[295]~~
~~SFIE Kits~~Income Eligible, PAYS	96%[296]
~~PAYS~~	~~100%[297]~~

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Leakage = Percent homes outside service territory

~~[289] Ameren Missouri Energy Efficient Kits Impact and Process Evaluation: PY2019, https://www.efis.psc.mo.gov/Document/Display/15876, page 78.~~
[290] “Measures and Assumptions for Demand Side Management (DSM) Planning; Appendix C Substantiation Sheets,” Navigant, April 2009, https://www.oeb.ca/oeb/_Documents/EB-2008-0346/Navigant_Appendix_C_substantiation_sheet_20090429.pdf~~,~~; ‘Navigant_Appendix_C_substantiation_sheet_20090429.pdf’, page C-77.
[291] Ameren Missouri Community Savers Evaluation PY2018, page 24.
[292] Assumes 125°F water leaving the hot water tank and average basement temperature of 65°F.
[293] Electric water heater recovery efficiency from AHRI database: http://www.ahridirectory.org/ahridirectory/pages/home.aspx.
~~[294] Ameren Missouri EE Kits Evaluation PY2019 Appendices Page 78.~~
~~[295] PY18 Energy Efficiency Kits School Evaluation Report, page 39.~~
[296] Ameren Missouri Community Savers Evaluation PY2018, page 24.
~~[297] Ameren Missouri PAYS Evaluation PY2022 Appendix, page 7.~~

Program	Leakage
~~School Kits~~	~~8.13%[298]~~
~~Other Programs~~Income Eligible, PAYS	0%

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$\Delta kW = \Delta kWh * CF$

Where:

ΔkWh ~~$\Delta kW = \Delta kWh * CF$~~
~~Where:~~
~~ΔkWh =~~= Electric energy savings, as calculated above.
CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor
= 0.0000887318

NATURAL GAS SAVINGS

Custom calculation below for gas DHW systems, otherwise assume 1.1 therms per 6 linear feet of ¾ in, R-4 insulation or 1.5 therms per 6 linear feet of 1 in, R-6 insulation:

$\Delta Therms = (1 - \%ElectricDHW) * ((C_{Base}/R_{Base} – C_{EE}/R_{EE}) * L * \Delta T * Hours)/(\eta DHW_{Gas} * 100,000)$

~~$\Delta Therms = ((C_{Base}/R_{Base} - C_{EE}/R_{EE}) * L * \Delta T * Hours)/(\eta DHW_{Gas} * 100,000)$~~

Where:
ηDHW_{Gas} = Recovery efficiency of gas hot water heater
= 0.78[299]
100,000 = Conversion factor from Btu to therms
Other variables as defined above.

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE:

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~~[298] PY2018 Energy Efficiency Kits School Evaluation Report, page 39.~~

[299] Review of AHRI directory suggests range of recovery efficiency ratings for new gas DHW units of 70-87%. Average of existing units is estimated at 78%.

~~3.3.6 Thermostatic Restrictor Shower Valve (Retired, effective 1/1/2025)~~[300]

~~Description~~

~~The measure is the installation of a thermostatic restrictor shower valve in a single or multifamily household. This is a valve attached to a residential showerhead which restricts hot water flow through the showerhead once the water reaches a set point (generally 95F or lower).~~

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

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

~~Definition of Efficient Equipment~~

~~To qualify for this measure the installed equipment must be a thermostatic restrictor shower valve installed on a residential showerhead.~~

~~Definition of Baseline Equipment~~

~~The baseline equipment is the residential showerhead without the restrictor valve installed.~~

~~Deemed Lifetime of Efficient Equipment~~

~~The expected measure life is assumed to be 10 years.~~[301]

~~Deemed Measure Cost~~

~~The incremental cost of the measure should be the actual program cost (including labor if applicable) or $30~~[302] ~~plus $20 labor~~[303] ~~if not available.~~

~~Loadshape~~

~~Water Heating RES~~

~~Coincidence Factor~~

~~CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor~~
~~= 0.0000887318~~

~~Algorithm~~

~~Calculation of Savings~~

~~Electric Energy Savings~~

~~ΔkWh = %ElectricDHW * ((GPM_base_S * L_showerdevice) * Household * SPCD * 365.25 / SPH) * EPG_electric * ISR~~

~~Where:~~

~~$\Delta kWh = \%ElectricDHW * ((GPM\_base\_S * L\_showerdevice) * Household * SPCD * 365.25 / SPH) * EPG\_electric * ISR$~~

~~Where:~~

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

~~DHW fuel~~	~~%ElectricDHW~~
~~Electric~~	~~100%~~
~~Natural Gas~~	~~0%~~
~~Unknown~~	~~16%~~[304]

---

[300] ~~"Retire" indicates that the measure is not anticipated to be offered through an Ameren Missouri-administered demand-side program during the period of TRM effectiveness.~~

[301] ~~Assumptions based on NY TRM, Pacific Gas and Electric Company Work Paper PGECODHW113 and measure life of lowflow showerhead.~~

[302] ~~Based on actual cost of the SS-1002CP-SB Ladybug Water-Saving Shower-Head adapter from Evolve showerheads.~~

[303] ~~Estimate for contractor installation time.~~

[304] ~~Default assumption for unknown fuel is based on EIA Residential Energy Consumption Survey (RECS) 2009 for Midwest Region, data for the state of Missouri, 'HC8.9 Water Heating in Midwest Region.xls'Default assumption for unknown fuel is based on EIA Residential Energy Consumption Survey (RECS) 2009 for Midwest Region, data for the state of Illinois. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area, then that should be used.~~

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~~GPM_base_S = Flow rate of the base case showerhead, or actual if available~~

~~Program~~	~~GPM~~
~~Direct-install, device only~~	~~2.241.5~~[305]
~~New Construction or direct install of device and low flow showerhead~~	~~Rated or actual flow of program-installed showerhead~~
~~Retrofit or TOS~~	~~2.35~~[306]

~~L_showerdevice = Hot water waste time avoided due to thermostatic restrictor valve~~
~~= 0.89 minutes~~[307]
~~Household = Average number of people per household~~

~~Household Unit Type~~[308]	~~Household~~
~~Single-Family - Deemed~~	~~2.67~~[309]
~~Multi-Family - Deemed~~	~~2.07~~[310]
~~Custom~~	~~Actual Occupancy or Number of Bedrooms~~[311]

~~SPCD = Showers Per Capita Per Day~~
~~= 0.66~~[312]
~~365.25 = Days per year, on average.~~
~~SPH = Showerheads Per Household so that per-showerhead savings fractions can be determined~~

~~Household Type~~	~~SPH~~
~~Single-Family~~	~~2.05~~[313]
~~Multi-Family~~	~~1.4~~[314]
~~Custom~~	~~Actual~~

~~EPG_electric = Energy per gallon of hot water supplied by electric~~
~~= (8.33 * 1.0 * (ShowerTemp - SupplyTemp)) / (RE_electric * 3,412)~~
~~= (8.33 * 1.0 * (105 – 61.3)) / (0.98 * 3,412)~~
~~= 0.109 kWh/gal~~
~~8.33 = Specific weight of water (lbs/gallon)~~
~~1.0 = Heat capacity of water (btu/lb °)~~
~~ShowerTemp = Assumed temperature of water~~

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[305] ~~Illinois TRM Version 12.0, https://www.ilsag.info/wp-content/uploads/IL_TRM_Effective_010124_v12.0_Vol_3_Res_09222023_FINAL_clean.pdf, page 285Illinois Statewide Technical Reference Manual for Energy Efficiency Version 5.0. pp. 184. 2016. http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_5/Final/IL-TRM_Version_5.0_dated_February-11-2016_Final_Compiled_Volumes_1-4.pdf. Based on measurements conducted from June 2013 to January 2014 by Franklin Energy. Over 300 residential sites in the Chicago area were testedAssumes low flow showerhead is included in direct installation.~~

[306] ~~Representative value from sources 1, 2, 4, 5, 6 and 7 (See Source Table at end of measure section) adjusted slightly upward to account for program participation which is expected to target customers with existing higher flow devices rather than those with existing low flow devices.~~

[307] ~~Average of the following sources: ShowerStart LLC survey; "Identifying, Quantifying and Reducing Behavioral Waste in the Shower: Exploring the Savings Potential of ShowerStart" City of San Diego Water Department survey; "Water Conservation Program: ShowerStart Pilot Project White Paper," and PG&E Work Paper PGECODHW113.~~

[308] ~~If household type is unknown, as may be the case for TOS measures, then single family deemed value should be used.~~

[309] ~~Ameren Missouri Efficient Products Impact and Process Evaluation: Planning Year 2015, provided by Cadmus, https://www.efis.psc.mo.gov/Document/Display/13805, page 38Missouri TRM 2017 - Low Flow Showerheads 3.3.2.~~

[310] ~~Ameren Missouri Efficient Products Impact and Process Evaluation: Planning Year 2015, provided by Cadmus, https://www.efis.psc.mo.gov/Document/Display/13805, page 38Missouri TRM 2017 – Low Flow Showerheads 3.3.2.~~

[311] ~~Bedrooms are suitable proxies for household occupancy and may be preferable to actual occupancy due to turnover rates in residency and non-adult population impacts.~~

[312] ~~DeOreo, William, P. Mayer, L. Martien, M. Hayden, A. Funk, M. Kramer-Duffield, and R. Davis (2011). "California Single Family Water Use Efficiency Study.", https://www.waterboards.ca.gov/waterrights/water_issues/programs/hearings/byron_bethany/docs/exhibits/pt/wr71.pdf.; 'California Single Family Water Use Study.pdf'.~~

[313] ~~Ameren Missouri Efficient Products Impact and Process Evaluation: Planning Year 2015, provided by Cadmus, https://www.efis.psc.mo.gov/Document/Display/13805, page 38Missouri TRM 2017 – Low Flow Showerheads 3.3.2.~~

[314] ~~Ameren Missouri Efficient Products Impact and Process Evaluation: Planning Year 2015, provided by Cadmus, https://www.efis.psc.mo.gov/Document/Display/13805, page 38Missouri TRM 2017 - Low Flow Showerheads 3.3.2.~~

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~~= 105F~~[315]
~~SupplyTemp = Assumed temperature of water entering house~~
~~= 58.4F[316]61.3F[317]~~
~~RE_electric = Recovery efficiency of electric water heater~~
~~= 98%~~[318]
~~3412 = Converts Btu to kWh (btu/kWh)~~
~~ISR = In service rate of showerhead~~
~~= Actual, or if unknown, dDependent on program delivery method as listed in table below~~

~~Selection~~	~~ISR~~
~~Direct Install - Single Family~~	~~0.91~~
~~Direct Install – Multi Family~~	~~0.91~~[319]
~~Efficiency Kits~~	~~To be determined through evaluation~~

EXAMPLE

For example, a direct installed valve in a single-family home with electric DHW:
ΔkWh = 1.0 * (2.67 * 0.89 * 1.5 * 0.66 * 365.25 / 2.05) * 0.108 * 0.91
= 42 kWh

~~Summer Coincident Peak Demand Savings~~

~~ΔkW = ΔkWh / Hours * CF~~

~~Where:~~

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

~~Where:~~
~~ΔkWh = calculated value above~~
~~CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor~~
~~= 0.0000887318~~

~~Hours = Annual electric DHW recovery hours for wasted showerhead use prevented by device~~
~~= ((GPM_base_S * L_showerdevice) * Household * SPCD * 365.25) * 0.712[320] / GPH~~
~~GPH = Gallons per hour recovery of electric water heater calculated for 65.9F temp rise (120-54.1), 98% recovery efficiency, and typical 4.5kW electric resistance storage tank.~~
~~= 27.51~~
~~= 34.4 for SF direct install; 28.3 for MF direct install~~
~~= 30.3 for SF Retrofit and TOS; 24.8 for MF Retrofit and TOS~~

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[315] ~~Ameren Missouri Efficient Kits Evaluation: PY2018, https://www.efis.psc.mo.gov/Document/Display/15870, page 32Illinois Statewide Technical Reference Manual for Energy Efficiency Version 5.0. 2016. pp 103. Available Online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_5/Final/IL-TRM_Version_5.0_dated_February-11-2016_Final_Compiled_Volumes_1-4.pdf.~~
[316] ~~National Weather Service. Average soil temperature at 40" depth during 2015 – 2023 data of six stations in Ameren Missouri service territory. https://www.weather.gov/ncrfc/LMI_SoilTemperatureDepthMaps.~~
[317] ~~Ameren Missouri 2012 Technical Resource Manual. Appendix A. pp. 43. https://www.efis.psc.mo.gov/mpsc/commoncomponents/viewdocument.asp?DocId=935658483.~~
[318] ~~Electric water heaters have recovery efficiency of 98%: http://www.ahridirectory.org/ahridirectory/pages/home.aspx.~~
[319] ~~Based on Ameren Missouri Community Savers Evaluation.~~
[320] ~~71.2% is the proportion of hot 120F water mixed with 54.1F supply water to give 101F shower water.~~

EXAMPLE

For example, a direct installed thermostatic restrictor device in a single family home with electric DHW where the number of showers is not known.

ΔkW = 85.3/34.4 * 0.0022
= 0.0055 kW

~~Water Heating RES~~

EXAMPLE

For example, a direct installed thermostatic restrictor device in a single family home with electric DHW where the number of showers is not known.

ΔkW = 85.3/34.4 * 0.0022
= 0.0055 kW

~~Natural Gas Savings~~

~~ΔTherms = %FossilDHW * ((GPM_base_S * L_showerdevice) * Household * SPCD * 365.25 / SPH) * EPG_gas * ISR~~

~~ΔTherms = %FossilDHW * ((GPM_base_S * L_showerdevice) * Household * SPCD * 365.25 / SPH) * EPG_gas * ISR~~

~~Where:~~

~~%FossilDHW = proportion of water heating supplied by Natural Gas heating~~

~~DHW fuel~~	~~%Fossil_DHW~~
~~Electric~~	~~0%~~
~~Natural Gas~~	~~100%~~
~~Unknown~~	~~84%~~[321]

~~EPG_gas = Energy per gallon of Hot water supplied by gas~~
~~= (8.33 * 1.0 * (ShowerTemp - SupplyTemp)) / (RE_gas * 100,000)~~
~~= 0.00501 therm/gal for SF homes~~
~~= 0.00583 therm/gal for MF homes~~
~~RE_gas = Recovery efficiency of gas water heater~~
~~= 78% For SF homes~~[322]
~~= 67% For MF homes~~[323]
~~100,000 = Converts Btus to therms (btu/therm)~~

~~Other variables as defined above.~~

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

[322] ~~DOE final rule discusses recovery efficiency with an average around 0.76 for gas-fired storage water heaters and 0.78 for standard efficiency gas fired tankless water heaters up to 0.95 for the highest efficiency gas fired condensing tankless water heaters. These numbers represent the range of new units however, not the range of existing units in stock. Review of AHRI Directory suggests range of recovery efficiency ratings for new gas DHW units of 70-87%. Average of existing units is estimated at 78%.~~

[323] ~~Water heating in multifamily buildings is often provided by a larger central boiler. This suggests that the average recovery efficiency is somewhere between a typical central boiler efficiency of 0.59 and the 0.75 for single family homes. An average efficiency of 0.67 is used for this analysis as a default for multifamily buildings.~~

EXAMPLE

For example, a direct installed thermostatic restrictor device in a gas fired DHW single family home where the number of showers is not known:

ΔTherms = 1.0 * ((2.67 * 0.89) * 2.56 * 0.6 * 365.25 / 1.79) * 0.00501 * 0.98
= 3.7 therms

~~Water Impact Descriptions and Calculation~~

~~ΔGallons = ((GPM_base_S * L_showerdevice) * Household * SPCD * 365.25 / SPH) * ISR~~

~~*Δgallons = ((GPM_base_S ∗ L_showerdevice) ∗ Household ∗ SPCD ∗ 365.25 / SPH) ∗ ISR*~~

~~Variables as defined above~~

EXAMPLE

For example, a direct installed thermostatic restrictor device in a single family home where the number of showers is not known:

Δgallons = ((2.67 * 0.89) * 2.56 * 0.6 * 365.25 / 1.79) * 0.98
= 730 gallons

~~Deemed O&M Cost Adjustment Calculation~~

~~N/A~~

~~Sources~~

~~Source ID~~	~~Reference~~
~~1~~	~~2011, DeOreo, William. California Single Family Water Use Efficiency Study. April 20, 2011. 'California Single Family Water Use Study.pdf'~~
~~2~~	~~2000, Mayer, Peter, William DeOreo, and David Lewis. Seattle Home Water Conservation Study. December 2000.~~
~~3~~	~~1999, Mayer, Peter, William DeOreo. Residential End Uses of Water. Published by AWWA Research Foundation and American Water Works Association. 1999.~~
~~4~~	~~2003, Mayer, Peter, William DeOreo. Residential Indoor Water Conservation Study. Aquacraft, Inc. Water Engineering and Management. Prepared for East Bay Municipal Utility District and the US EPA. July 2003.~~
~~5~~	~~2011, DeOreo, William. Analysis of Water Use in New Single Family Homes. By Aquacraft. For Salt Lake City Corporation and US EPA. July 20, 2011.~~
~~6~~	~~2011, Aquacraft. Albuquerque Single Family Water Use Efficiency and Retrofit Study. For Albuquerque Bernalillo County Water Utility Authority. December 1, 2011.~~
~~7~~	~~2008, Schultdt, Marc, and Debra Tachibana. Energy related Water Fixture Measurements: Securing the Baseline for Northwest Single Family Homes. 2008 ACEEE Summer Study on Energy Efficiency in Buildings.~~
~~8~~	~~2011, Lutz, Jim. "Water and Energy Wasted During Residential Shower Events: Findings from a Pilot Field Study of Hot Water Distribution Systems," Energy Analysis Department Lawrence Berkeley National Laboratory, September 2011.~~
~~9~~	~~2008, Water Conservation Program: ShowerStart Pilot Project White Paper, City of San Diego, CA.~~
~~10~~	~~2012, Pacific Gas and Electric Company, Work Paper PGECODHW113, Low Flow Showerhead and Thermostatic Shower Restriction Valve, Revision # 4, August 2012.~~
~~11~~	~~2008, "Simply & Cost Effectively Reducing Shower Based Warm-Up Waste: Increasing Convenience & Conservation by Attaching ShowerStart to Existing Showerheads," ShowerStart LLC.~~
~~12~~	~~2014, New York State Record of Revision to the TRM, Case 07-M-0548, June 19, 2014.~~

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3.4 HVAC

3.4.1 Advanced Thermostat

DESCRIPTION

This measure characterizes the household energy savings from the installation of a new thermostat(s) for reduced heating and cooling consumption through a configurable schedule of temperature setpoints (like a programmable thermostat) *and* automatic variations to that schedule to better match HVAC system runtimes to meet occupant comfort needs. These schedules may be defaults, established through user interaction, and be changed manually at the device or remotely through a web or mobile app. Automatic variations to that schedule could be driven by local sensors and software algorithms and/or through connectivity to an internet software service. Data triggers to automatic schedule changes might include, for example: occupancy/activity detection, arrival & departure of conditioned spaces, optimization based on historical or population-specific trends, or weather data and forecasts.[324] This class of products and services are relatively new, diverse, and rapidly changing. Generally, the savings expected for this measure aren't yet established at the level of individual features, but rather at the system level and how it performs overall. Like programmable thermostats, it is not suitable to assume that heating and cooling savings follow a similar pattern of usage and savings opportunity, so this measure treats these savings independently. This is a very active area of ongoing study to better map features to savings value and establish standards of performance measurement based on field data so that a standard of efficiency can be developed.[325] That work is not yet complete but does inform the treatment of some aspects of this characterization and recommendations. Energy savings are applicable at the household level; installation of multiple advanced thermostats per home does not accrue additional savings.

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

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

DEFINITION OF EFFICIENT EQUIPMENT

This measure involves replacement of a manual-only or programmable thermostat with one that has the default-enabled capability or the automatic capability to establish a schedule of temperature setpoints according to driving device inputs above and beyond basic time and temperature data of conventional programmable thermostats. As summarized in the description, this category of products and services is broad and rapidly advancing with regard to thermostat capability, usability, and sophistication. At a minimum, a qualifying thermostat must be capable of two-way communication[326] and exceed the typical performance of manual and conventional programmable thermostats through the automatic or default capabilities described above.

DEFINITION OF BASELINE EQUIPMENT

The baseline is either the actual thermostat type (manual or programmable), if known,[327] or an assumed mix of both types based upon information available from evaluations or surveys that represent the population of program participants. This mix may vary by program, but as a default, 44% programmable and 56% manual thermostats may be assumed.[328]

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life for advanced thermostats is assumed to be 11 years.~~The expected measure life for advanced thermostats is assumed to be similar to that of a programmable thermostat, 10 years,~~[329]~~ based upon equipment life only.~~~~[330]~~

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[324] For example, the capabilities of products and added services that use ultrasound, infrared, or geofencing sensor systems, automatically develop individual models of a home's thermal properties through user interaction. The thermostats optimize system operation based on equipment type and performance traits, such as using n weather forecasts, to demonstrate the type of automatic schedule change functionality that apply to this measure characterization.

[325] The ENERGY STAR® program discontinued its support for basic programmable thermostats effective 12/31/09 and is presently developing a new specification for "Residential Climate Controls."

[326] This measure recognizes that field data may be available, through the thermostat's two-way communication capability, to more accurately establish efficiency criteria and make savings calculations. It is recommended that program implementations incorporate this data into their planning and operation activities to improve understanding of the measure to manage risks and enhance savings results.

[327] If the actual thermostat is programmable and is found to be used in override mode or otherwise is effectively being operated like a manual thermostat, then the baseline may be considered to be a manual thermostat.

[328] Value for blend of baseline thermostats comes from an Illinois potential study conducted by ComEd in 2013; Opinion Dynamics Corporation, "ComEd Residential Saturation/End Use, Market Penetration & Behavioral Study," Appendix 3: Detailed Mail Survey Results, April 2013, p. 34.

[329] Illinois TRM Version 12.0, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_3_Res_09222023_FINAL_clean.pdf, page 204. Based on 2017 Residential Smart Thermostat Workpaper, prepared by SCE and Nest for SCE (Work Paper SCE17HC054, Revision #0, https://www.peakload.org/assets/SCE17HC054.0_Residential_Sma.pdf; 'SCE17HC054.0_Residential_Sma.pdf'). Estimate ability of smart systems to continue providing savings after disconnection and conduct statistical survival analysis which yields 9.2-13.8 year range~~Table 1, HVAC Controls, Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007~~.

~~[330] Future evaluation is strongly encouraged to inform the persistence of savings to further refine measure life assumption. As this characterization depends heavily upon a number of savings studies that lasted a single year or less, the longer-term impacts should be assessed.~~

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DEEMED MEASURE COST

For DI and other programs where installation services are provided, the actual material, labor, and other costs should be referenced, and incremental cost of the advanced thermostat is equal to the actual total advanced thermostat material, labor, and other costs, minus the $50 baseline thermostat cost~~For DI and other programs for which installation services are provided, the actual material, labor, and other costs should be used~~.

~~.~~ For retail or other program types where actual advanced thermostat costs are known, the incremental cost of the advanced thermostat is equal to the total cost of the advanced thermostat, minus the $50 baseline thermostat cost~~For retail, Bring Your Own Thermostat (BYOT) programs,[331] or other program types, actual costs are still preferable~~.[332]

~~-~~If actual costs are unknown, then the incremental cost for the advanced thermostat is assumed to be $79~~If actual costs are unknown, then the average incremental cost for the new installation measure is assumed to be $125~~.[333]

LOADSHAPE

Cooling RES
Heating RES

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

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

$\Delta kWh = \Delta kWh_{heating} + \Delta kWh_{cooling}$

$\Delta kWh_{heating} = \%ElectricHeat * HeatingConsumption_{Electric} * HF * HeatingReduction* Eff\_ISR + (\Delta Therms * Fe * 29.3)$

$\Delta kWh_{cool} = \%AC * ((EFLH_{cool} * Capacity_{Cool} * 1/SEER2)/1000) * CoolingReduction * Eff\_ISR$

~~$\Delta kWh = \Delta kWh_{heating} + \Delta kWh_{cooling}$~~

~~$\Delta kWh_{heating} = \%ElectricHeat * HeatingConsumption_{Electric} * HF * HeatingReduction * Eff\_ISR + (\Delta Therms * Fe * 29.3)$~~

~~$\Delta kWh_{cool} = \%AC * ((EFLHcool * CapacityCool * 1/SEER)/1000) * CoolingReduction * Eff\_ISR$~~

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Where:

%ElectricHeat = Percentage of heating savings assumed to be electric

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Heating fuel	%ElectricHeat
Electric	100%
Natural Gas	0%
Unknown	33%[334]

~~[331] In contrast to program designs that utilize program-affiliated contractors or other trade ally partners that support customer participation through thermostat distribution, installation, and other services, BYOT programs enroll customers after the time of purchase through online rebate and program integration sign-ups.~~

[332] Actual costs include any one-time software integration, annual software maintenance, and/or individual device energy feature fees.

[333] Market prices vary considerably in this category, generally increasing with thermostat capability and sophistication. The core suite of functions required by this measure's eligibility criteria are available on units readily available in the market roughly in the range of $100 and $150, excluding the availability of time or market-limited wholesale or volume pricing. Analysis of the 2021 Pricing data from AIC's Retail Products Program finds an average retail cost of $129 for Advanced Thermostats.The assumed cost for the baseline equipment (blend of manual and programmable thermostats) is $50 which leads to an incremental cost of $79 for the measure. Illinois TRM Version 12.0, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_3_Res_09222023_FINAL_clean.pdf, page 204~~Market prices vary considerably in this category, generally increasing with thermostat capability and sophistication. The core suite of functions required by this measure's eligibility criteria can be found on units readily available in the market. Prices are in the range of $200 and $250, excluding the availability of any wholesale or volume discounts. The assumed incremental cost is based on the middle of the range ($175) minus a cost of $50 for the baseline equipment blend of manual. Add-on energy service costs, which may include one-time setup and/or annual per device costs, are not included in this assumption~~.

[334] Ameren Missouri Efficient Products Evaluation: PY2020, https://www.efis.psc.mo.gov/Document/Display/13830, page 40.

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HeatingConsumption$_{Electric}$ = If heating equipment characteristics are known, equals ((EFLHheat * CapacityHeat * 1/HSPF2)/1000); otherwise, e~~E~~stimate of annual household heating consumption for electrically heated ~~single-family~~ homes.[335]

Weather Basis (Ameren Missouri Average)	Elec_Heating_ Consumption (kWh)[336]		
	Electric Resistance	Electric Heat Pump	Unknown Electric
SF or MF	14,202	8,355	11,456
MFc (comprehensive envelope)	4,832	2,843	3,898

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EFLHheat = Equivalent Full Load Heating Hours:[337]

Weather Basis (Ameren Missouri Average)	EFLHheat (Hours)
SF or MF	1496
~~MFc (comprehensive envelope)~~	~~510~~

CapacityHeat = Capacity of air cooling system (Btu/hr) (Note: One ton is equal to 12,000 Btu/hr.)
= Actual

HSPF2 = the cooling equipment's Seasonal Energy Efficiency Ratio rating (kBtu/kWh)
= Actual

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[335] Ameren Missouri Efficient Products Evaluation PY2018 workpapers. For Comprehensive Envelope (CompE) Measures, the ratio of MF effective full load hours (1496) to the Opinion Dynamic recommendation for Comprehensive Envelope full load hours (509) was used to scale heating consumption values.

[336] Ibid.

[337] Evaluation - Opinion Dynamics review PY2019. The recommended values are constructed based on weather conditions (heating degree days and cooling degree days) in select Missouri cities (St. Louis, Cape Girardeau, Kansas City), weighted by partial year 2019 installations.

HF = Household factor, to adjust heating consumption for non-single-family households.

Household Type	HF
Single-Family	100%
Multi-Family	65%[338]
If heating equipment characteristics are referenced to calculate $HeatingConsumption_{Electric}$	100%
Actual	Custom[339]

HeatingReduction = Assumed percentage reduction in total household heating energy consumption due to advanced thermostat

Existing Thermostat Type	Heating_Reduction[340]
Manual	8.8%
Programmable	5.6%
Blended Average	6.67%

Eff_ISR = Effective In-Service Rate, the percentage of thermostats installed and configured effectively for 2-way communication
~~= If programs are evaluated during program deployment then custom ISR assumptions should be applied. If in service rate is captured within the savings percentage, ISR should be 100%.~~ = Actual, or if unknown, for Efficient Products, use 98.8%.[341], and for other programs, i~~I~~f using default savings, use 100%.[342]

ΔTherms = Therm savings if natural gas heating system
= See calculation in natural gas section below

F_e = Furnace fan energy consumption as a percentage of annual fuel consumption
= 3.14%[343]

29.3 = kWh per therm

%AC = Fraction of customers with thermostat-controlled air-conditioning

Thermostat control of air conditioning?	%AC
Yes	100%
No	0%
Unknown	Actual population data, or 91%[344]

$EFLH_{cool}$ = Equivalent full load hours of air conditioning:

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[338] Multifamily household heating consumption relative to single family households is affected by overall household square footage and exposure to the exterior. This 65% reduction factor is applied to multifamily homes with electric resistance, based on professional judgment that average household size, and heat loads of multifamily households are smaller than single family homes.

[339] Program-specific household factors may be utilized on the basis of sufficiently validated program evaluations.

[340] These values represent adjusted baseline savings values for different existing thermostats, as presented in Navigant's IL TRM Workpaper on Impact Analysis from Preliminary Gas savings findings (page 28) https://www.ilsag.info/wp-content/uploads/SAG_files/Meeting_Materials/2015/December_2015_Meetings/Presentations/Smart_Tstat_Preliminary_Gas_Impact_Findings_2015-12-08_to_IL_SAG.pdf~~.~~; 'Smart_Tstat_Preliminary_Gas_Impact_Findings_2015-12-08_to_IL_SAG.pdf'. The unknown assumption is calculated by multiplying the savings for manual and programmable thermostats by their respective share of baseline. Further evaluation and regular review of this key assumption is encouraged. Ameren Missouri Efficient Products Evaluation PY2017, https://www.efis.psc.mo.gov/Document/Display/14206, page 47.

[341] Ameren Missouri Efficient Products Evaluation PY2019, https://www.efis.psc.mo.gov/Document/Display/15877, page 140 ~~(Table 6-9)~~.

[342] As a function of the method for determining savings impact of these devices, in-service rate effects are already incorporated into the savings value for heating reduction above.

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

[344] 91% of homes have central cooling in Missouri (based on 2009 Residential Energy Consumption Survey, see '~~"~~RECS 2009 Air Conditioning_hc7.9.xls'~~"~~), https://www.eia.gov/consumption/residential/data/2009/.

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Weather Basis (Ameren Missouri Average)	$EFLH_{cool}$ (Hours)
SF or MF	869[345]
~~MFc (comprehensive envelope)~~	~~632[346]~~

CapacityCool = Capacity of air cooling system (Btu/hr) (Note: One ton is equal to 12,000 Btu/hr.)
= Actual installed - If actual size unknown, assume 36,000 Btu/h

SEER2 = the cooling equipment's Seasonal Energy Efficiency Ratio rating (kBtu/kWh)
= Use actual SEER2 rating where it is possible to measure or reasonably estimate. If unknown assume 13.4 SEER2~~13~~.[347]

1/1000 = kBtu per Btu

CoolingReduction = Assumed percentage reduction in total household cooling energy consumption due to installation of advanced thermostat
= If programs are evaluated during program deployment then custom savings assumptions should be applied. Otherwise use:
= 8.0%[348]

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$\Delta kW = \Delta kWh_{Cooling} * CF$

Where:

$\Delta kWh_{Cooling}$ ~~$\Delta kW = \Delta kWh_{cooling} * CF$~~

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~~Where:~~

~~$kWh_{cooling}$~~ = Electric energy savings for cooling, calculated above

CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor
= 0.0009474181[349]

NATURAL GAS ENERGY SAVINGS

$\Delta Therms = \%FossilHeat * HeatingConsumption_{Gas} * HF * HeatingReduction * Eff_{ISR}$

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~~$\Delta Therms = \%FossilHeat * HeatingConusmption_{Gas} * HF * HeatingReduction * Eff\_ISR$~~

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Where:

%FossilHeat = Percentage of heating savings assumed to be n~~N~~atural g~~G~~as

Heating fuel	%FossilHeat
Electric	0%
Natural Gas	100%
Unknown	67%[350]

$HeatingConsumption_{Gas}$

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[345] PY2019 evaluation report, https://www.efis.psc.mo.gov/Document/Display/15876, page 30~~Based on full load hour assumptions (for St Louis and Kansas City) taken from the ENERGY STAR® calculator (http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_CAC.xls) and reduced by 28.5% based on the evaluation results in Ameren Missouri territory, which suggests an appropriate EFLH of 869.The other weather basis values are calculated using the relative climate normals cooling degree day ratios (at 65F set point).~~

~~[346] Evaluation - Opinion Dynamics review PY2019. The recommended values are constructed based on weather conditions (heating degree days and cooling degree days) in select Missouri cities (St. Louis, Cape Girardeau, Kansas City), weighted by partial year 2019 installations.~~

[347] Based on minimum federal standard~~: http://www1.eere.energy.gov/buildings/appliance_standards/residential/residential_cac_hp.html~~.

[348] This assumption is based upon the review of many evaluations from other regions in the United States. Cooling savings are more variable than heating due to significantly more variability in control methods and potential population and product capability.

[349] Based on Ameren Missouri TRM Volume 1 - Appendix G: "Table 1 – Residential End Use Category Monthly Shapes and Coincident Peak Factors"~~2016 Ameren Missouri Coincident Peak Demand Factor~~ for Residential Cooling.~~ See reference "Ameren Missouri 2016 Appendix E - End Use Shapes and Coincident Factors.pdf."~~

[350] Ameren Missouri Efficient Products Evaluation: PY2020, https://www.efis.psc.mo.gov/Document/Display/13830, page 41.

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= Estimate of annual household heating consumption for gas heated single-family homes.[351]

Weather Basis (City based upon)	Gas_Heating_ Consumption (Therms)
St Louis, MO	682

Other variables as provided above.

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE:

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[351] Values in table are based on average household heating load (834 therms) for Chicago based on Illinois furnace metering study (~~‘~~(Table E-1, Energy Efficiency/Demand Response Nicor Gas Plan Year 1: Research Report: Furnace Metering Study, Draft, https://www.icc.illinois.gov/docket/P2012-0528/documents/201939/files/355536.pdf ; ‘355536.pdf’, Navigant, August 1 2013~~Table E-1, Energy Efficiency/Demand Response Nicor Gas Plan Year 1: Research Report: Furnace Metering Study, Draft, Navigant, August 1 2013~~) and adjusted for Missouri climate region values using the relative climate- normal HDD data with a base temp ratio of 60°F. This load value is then divided by standard assumption of existing unit efficiency of 83.5% (estimate based on 29% of furnaces purchased in Missouri were condensing in 2000 (based on data from GAMA, provided to Department of Energy) (see ‘Thermostat_ FLH and Heat Load Calcs~~Thermostat_FLH and Heat Load Calcs~~.xls’). The resulting values are generally supported by data provided by Laclede Gas, which showed an average pre-furnace replacement consumption of 1009 therms for St Louis, and a post-replacement consumption of 909. Assuming a typical hot water consumption at 225 therms (using defaults from http://energy.gov/eere/femp/energy-cost-calculator-electric-and-gas-water-heaters-0#output), this indicates a heating load of 684-784 therms. Ameren Missouri Efficient Products Evaluation PY2017, https://www.efis.psc.mo.gov/Document/Display/14206, page 47.

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3.4.2 Air Source Heat Pump Including Dual Fuel Heat Pumps

DESCRIPTION

An air source heat pump (ASHP) provides heating and/or cooling by moving heat between indoor and outdoor air. A cold climate air source heat pump (ccASHP) operates the same as a traditional ASHP, but is able to meet a home's full heating load at lower outdoor temperatures approaching 0°F. A dual fuel heat pump (DFHP) pairs an air source heat pump with a gas furnace such that the air source heat pump provides heating in mild weather, and as temperature drops the heat pump shuts off and the furnace provides heating. This measure may also apply to replacing a Central Air Conditioner with non-electric heating with an Air Source Heat Pump. In this case, only cooling savings (ER1, ER2, ROF) may be claimed using the ASHP cooling algorithm. This measure applies to central ducted systems and single zone split-systems with ductless indoor units that are capable of meeting a home's full cooling and heating demand.

This measure characterizes:

1. TOS, NC: The installation of a new residential sized (<= 65,000 Btu/hr) air source heat pump that is more efficient than required by federal standards. This could relate to the replacement of an existing ASHP at the end of its useful life or the installation of a new ASHP in a new home.
2. EREP: The early removal of functioning electric heating and cooling systems from service, prior to its natural end of life, and replacement with a new high efficiency ASHP unit. For the early replacement baseline to apply, program participants or installation contractors must provide documentation asserting that the existing units operated when turned on—whether or not they provided cooling—and the existing unit brand name and model number must be documented; or, if the nameplate is not readable, a photograph of the unit in context and the nameplate specifically must be provided~~To qualify as Early Replacement, the existing unit must be operational when replaced~~. If the SEER and/or HSPF of the existing unit are known, the baseline SEER and/or baseline HSPF should be the actual values of the unit replaced. If unknown, use the assumptions provided in the variable list below~~If the SEER of the existing unit is known and the Baseline SEER is the actual SEER value of the unit replaced and if unknown use assumptions in the variable list below~~ (SEER2_{exist} and HSPF2_{exist}). If the operational status of the existing unit is unknown, use TOS assumptions.

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

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

DEFINITION OF EFFICIENT EQUIPMENT

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

The heating capacity of the efficient heat pump should be within 90% to 120% of the capacity of the existing equipment, unless the trade ally can provide documentation confirming the existing system is oversized. It is recommended to collect the existing and new unit capacities to confirm that the heat pump has sufficient capacity to minimize use of backup electric resistance heating.

Using a dual fuel heat pump, which uses a gas furnace for heating at lower outside air temperatures, or a cold climate rated heat pump are two options to ensure minimal use of backup electric resistance heating.

DEFINITION OF BASELINE EQUIPMENT

A new residential-sized (<= 65,000 Btu/hr) air source heat pump meeting federal standards.

~~New federal standards affecting heat pumps became effective January 1, 2023; however, these new federal standards will be adopted by the program, beginning 1/1/2024. Under the new standards, t~~The baseline for the TOS measure is the federal standard efficiency level; ~~15 SEER (14.3 SEER2)~~14.3 SEER2 and ~~8.6 HSPF (7.5 HSPF2)~~7.5 HSPF2, when replacing an existing air source heat pump; and ~~14 SEER (13.4 SEER2)~~13.4 SEER2 and 3.41 HSPF when replacing a central air conditioner and electric resistance heating. Non-electric heating replaced with an air source heat pump can only claim cooling savings. Under the new federal standards, the M1 testing protocol was revised, resulting in new SEER and HSPF performance metrics, now called SEER2 and HSPF2. When quantifying energy savings, the SEER2 and HSPF2 ~~same~~ metrics should be used for the existing, baseline, and new equipment. The following conversion formulas can be used to convert between efficiency metrics:

SEER2 = SEER ~~x~~ * 0.96
HSPF2 = HSPF ~~x~~ * 0.87

~~Through December 31, 2023, the baseline for the TOS measure is the previous federal standard efficiency level; 14 SEER and 8.2 HSPF, when replacing an existing air source heat pump; and 14 SEER and 3.41 HSPF when replacing a central air conditioner and electric resistance heating.~~ Non-electric heating replaced with an air source heat pump can only claim cooling savings.

The baseline for the early replacement measure is the efficiency of the existing equipment for the assumed remaining useful life of the unit and the new baseline as defined above for the remainder of the measure life.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 18 years.[352]
Remaining life of existing ASHP/CAC equipment is assumed to be 6 years[353] and 18 years for electric resistance.

DEEMED MEASURE COST

~~Dual Fuel Heat Pump:~~

~~Efficiency (EER)~~	~~Cost (including labor) per measure~~
~~DFHP - SEER 19 MF heat pump base~~	~~$2,936.60~~
~~DFHP - SEER 20 MF heat pump base~~	~~$3,176.60~~
~~DFHP - SEER 21 MF heat pump base~~	~~$3,626.60~~

~~Air Source Heat Pump:~~

~~TOS/ROF: The incremental capital cost for this measure is dependent on the efficiency and capacity of the new unit.:~~

~~Efficiency (SEER)~~	~~ROF Incremental Cost ($)~~	~~Source~~
~~SEER 15~~	~~$303.00~~	~~IL TRM V8.0~~
~~SEER 16~~	~~$438.00~~	~~IL TRM V8.0~~
~~SEER 17~~	~~$724.00~~	~~IL TRM V8.0~~
~~SEER 18~~	~~$962.92~~	~~Derived using IL TRM ($/unit) and the % change in Mid Atlantic TRM V9 ($/ton)~~
~~SEER 19~~	~~$1,203.65~~	
~~SEER 20~~	~~$1,444.38~~	
~~SEER 21~~	~~$1,689.92~~	

~~Early Replacement (ER): The full install cost for this measure is the actual cost of removing the existing unit and installing the new one. If this is unknown, assume the following (note these costs are per ton of unit capacity):~~

~~Efficiency (SEER)~~	~~*ER Incremental Cost for 3 ton unit ($)~~	~~Source~~
~~SEER 15~~	~~$1,019.81~~	~~IL TRM V8.0~~
~~SEER 16~~	~~$1,154.81~~	~~IL TRM V8.0~~
~~SEER 17~~	~~$1,440.81~~	~~IL TRM V8.0~~
~~SEER 18~~	~~$1,679.73~~	~~Derived using IL TRM ($/unit) and the percent change in Mid-Atlantic TRM V9 ($/ton)~~
~~SEER 19~~	~~$1,920.46~~	
~~SEER 20~~	~~$2,161.19~~	
~~SEER 21~~	~~$2,406.74~~	
~~*Hypothetical values calculated based on a 3 ton system.~~ ~~Actual values based on system size and SEER combinations.~~		

New Construction and Time of Sale: The actual installed cost of the ASHP (including any necessary electrical or distribution upgrades required) should be used minus the assumed installation cost of the baseline equipment ($6,865 + $600 per ton for a new baseline ASHP[354], $2,011 for a new baseline 80% AFUE furnace or $4,053 for a new 84% AFUE boiler[355] and $3,338 for new baseline Central AC replacement[356]).

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[352] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007, https://energizect.com/sites/default/files/documents/Measure%20Life%20Report%202007.pdf~~,~~ ~~http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf, page 1-3.~~; 'Measure Life Report 2007.pdf', page 1-3.

[353] Assumed to be one third of effective useful life.

[354] Full install ASHP costs are based upon data provided by Ameren. See 'ASHP Costs_06242022'. Efficiency cost increment consistent with Cadmus "HVAC Program: Incremental Cost Analysis Update", December 19, 2016 study results.

[355] See 'Technical Standard Document_APPENDIX_E.pdf'.

[356] See 'CAC Costs 09.02.2024.xlsx'.

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Early Replacement: The actual full installation cost of the ASHP (including any necessary electrical or distribution upgrades required) should be used. The assumed deferred cost (after the appropriate number of years described above) of replacing existing equipment with a new baseline unit is assumed to be $7,722 + $674 per ton for a new baseline ASHP, or $2,296 for a new baseline 80% AFUE furnace or $4,627 for a new 84% AFUE boiler and $3,670 for new baseline Central AC replacement.[357] This future cost should be discounted to present value using a 2.31% nominal societal discount rate, based on the ten year average (1/1/2014 – 12/31/2023) of the 10 year Treasury bond yield rates.[358]

If the install cost of the efficient ASHP is unknown, assume the following (note these costs are per ton of unit capacity);[359]

Efficiency (SEER2)	Full Efficient ASHP Cost (including labor)
15.2	$7,000 + $600/ ton
16.2	$7,286 + $600/ ton
17.1	$7,495 + $600/ ton
18.1	$7,720 + $600/ ton
19.0+	$7,946 + $600/ ton

When a non-electric heating system is replaced with an ASHP, and the program administrator is only claiming energy savings from cooling (i.e., no heating savings are claimed due to the fuel switch), the incremental costs should be adjusted to reflect the proportion of claimed savings.

The incremental cost of the ASHP shall be adjusted by applying a factor that represents the ratio of the claimed cooling savings to the total potential energy savings (inclusive of both cooling and unclaimed heating savings). This adjustment ensures that the incremental cost used in cost-effectiveness testing is proportional to the benefits being claimed, thus avoiding a mismatch between costs and benefits.

Calculation Method:

1. Determine Total Potential Savings: Calculate the sum of the potential energy savings from both cooling and heating (even if heating savings are not being claimed).
2. Determine Claimed Savings: Identify the portion of energy savings that is being claimed, typically the cooling savings only.
3. Apply the Adjustment Factor: The adjustment factor is calculated as the ratio of claimed savings to total potential savings. This factor is then applied to the full incremental cost of the ASHP.

Adjusted Incremental Cost = (Claimed Savings (kWh) / Total Potential Savings (kWh)) * Full Incremental Cost)

~~Assumed deferred cost (after 6 years) of replacing existing equipment with new baseline unit is assumed to be $1,525~~[~~360~~] ~~per ton of capacity. This cost should be discounted to present value using the utilities' real discount rate.~~

LOADSHAPE
Cooling RES
Heating RES

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

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[357] All baseline replacement costs are consistent with their respective measures and include inflation rate of 1.98%.

[358] 'Societal_Discount_Rate_Calculation_08082024.xlsx'.

[359] Full install ASHP costs are based upon data provided by Ameren. See 'ASHP Costs_06242022'. Efficiency cost increment consistent with Cadmus "HVAC Program: Incremental Cost Analysis Update", December 19, 2016 study results.

~~[360] Ibid. $1381 per ton (IL TRM V8.0) inflated using rate of 2.0%~~

$\Delta kWh = [((EFLH_{cool} * Capacity_{cool} * (1/SEER2_{base} - 1/SEER2_{ee})) / 1000) + ((EFLH_{heat} * Capacity_{heat} * (1/HSPF2_{base} - 1/HSFP2_{ee})) / 1{,}000)] * ISR$

Cooling only for Central Air Conditioning and Non-Electric Heating Backup

$\Delta kWh = [((EFLH_{cool} * Capacity_{cool} * (1/SEER2_{base} - 1/SEER2_{ee})) / 1000) * ISR$

EREP:[361]

ΔkWh for remaining life of existing unit (1st 6 years for replacing an ASHP, 18 years for replacing electric resistance):

$= [((EFLH_{cool} * Capacity_{cool} * (1/SEER2_{exist} - 1/SEER2_{ee})) / 1000) + ((EFLH_{heat} * Capacity_{heat} * (1/HSPF2_{exist} - 1/HSFP2_{ee})) / 1{,}000)] * ISR$

Cooling only for Central Air Conditioning and Non-Electric Heating Backup

$\Delta kWh =[((EFLH_{cool} * Capacity_{cool} * (1/SEER2_{exist} - 1/SEER2_{ee})) / 1000) *ISR$

ΔkWh for remaining measure life (next 12 years if replacing an ASHP):

$=[((EFLH_{cool} * Capacity_{cool} * (1/SEER2_{base} - 1/SEER2_{ee})) / 1000) + ((EFLH_{heat} * Capacity_{heat} * (1/HSPF2_{base} - 1/HSFP2_{ee})) / 1{,}000)] * ISR$

Cooling only for Central Air Conditioning and Non-Electric Heating Backup

$\Delta kWh = [((EFLH_{cool} * Capacity_{cool} * (1/SEER2_{base} - 1/SEER2_{ee})) / 1000) * ISR$

~~TOS:~~

~~$\Delta kWh = [((EFLH_{cool} * Capacity_{cool} * (1/SEER_{base} - 1/SEER_{ee})) / 1000) + ((EFLH_{heat} * Capacity_{heat} * (1/HSPF_{base} - 1/HSFP_{ee})) / 1{,}000)] * ISR$~~

~~Cooling only for Central Air Conditioning and Non-Electric Heating Backup~~

~~$\Delta kWh = [((EFLH_{cool} * Capacity_{cool} * (1/SEER_{base} - 1/SEER_{ee})) / 1000) * ISR$~~

~~EREP:~~[~~362~~]

~~ΔkWh for remaining life of existing unit (1st 6 years for replacing an ASHP, 18 years for replacing electric resistance):~~

~~$= [((EFLH_{cool} * Capacity_{cool} * (1/SEER_{exist} - 1/SEER_{ee})) / 1000) + ((EFLH_{heat} * Capacity_{heat} * (1/HSPF_{exist} - 1/HSFP_{ee})) / 1{,}000)] * ISR$~~

~~Cooling only for Central Air Conditioning and Non-Electric Heating Backup~~

~~$\Delta kWh = [((EFLH_{cool} * Capacity_{cool} * (1/SEER_{exist} - 1/SEER_{ee})) / 1000) * ISR$~~

~~ΔkWh for remaining measure life (next 12 years if replacing an ASHP):~~

~~$= [((EFLH_{cool} * Capacity_{cool} * (1/SEER_{base} - 1/SEER_{ee})) / 1000) + ((EFLH_{heat} * Capacity_{heat} * (1/HSPF_{base} - 1/HSFP_{ee})) / 1{,}000)] * ISR$~~

~~Cooling only for Central Air Conditioning and Non-Electric Heating Backup~~

~~$\Delta kWh = [((EFLH_{cool} * Capacity_{cool} * (1/SEER_{base} - 1/SEER_{ee})) / 1000) * ISR$~~

Where:

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[361] 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 either the new base to efficient savings or the (existing to efficient savings.

[~~362~~] ~~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 either the new base to efficient savings or the (existing to efficient savings.~~

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EFLH$_{cool}$ = Equivalent full load hours of air conditioning:[363]

Weather Basis (Ameren Missouri Average)	EFLH$_{cool}$ (Hours)
SF or MF	869
~~MFc (comprehensive envelope)~~	~~632[364]~~

Capacity$_{cool}$ = Cooling Capacity of Air Source Heat Pump (Btu/hr)
= Actual (1 ton = 12,000Btu/hr)

SEER2$_{exist}$ = Seasonal Energy Efficiency Ratio of existing cooling system (kBtu/kWh)
= Use actual SEER2 rating where it is possible to measure or reasonably estimate. If using rated efficiencies, derate the efficiency value based on the age of the existing equipment (up to a maximum of 30 years) to account for degradation over time.[365] If age is unknown, use 12 years.
= SEER2 * (1-0.01~~1-1.44%~~)^{Age}
If rated efficiency is unknown, use defaults provided below, which are already adjusted to account for age-related degradation:

Existing Cooling System	SEER2$_{exist}$[366]
Air Source Heat Pump	~~7.2~~6.91
Central AC	6.~~8~~53
No central cooling[367]	Let '1/SEER2$_{exist}$' = 0

SEER2$_{base}$ = Seasonal Energy Efficiency Ratio of baseline Air Source Heat Pump (kBtu/kWh)[368]
= ~~14[369] through 12/31/2023 and 15 (~~14.3 SEER2~~) beginning 1/1/2024~~[370] when replacing an ASHP
= ~~14 (~~SEER2 13.4~~)~~ when replacing a CAC

SEER2$_{ee}$ = Seasonal Energy Efficiency Ratio of efficient Air Source Heat Pump (kBtu/kWh)
= Actual

EFLH$_{heat}$ = Equivalent full load hours of heating:[371]

Weather Basis (Ameren Missouri Average)	EFLH$_{heat}$ (Hours)
SF or MF	1496 for ASHP, 1119 for DFHP, and 1769[372] for ccAHSP

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[363] PY2019 HVAC Evaluation, https://www.efis.psc.mo.gov/Document/Display/13830, page 4. ~~Based on Full Load Hour assumptions (for St Louis and Kansas City) taken from the ENERGY STAR® calculator (http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_CAC.xls) and reduced by 28.5% based on the evaluation results in Ameren Missouri' service territory, suggesting an appropriate EFLH of 869.The other weather basis values are calculated using the relative climate normals cooling degree day ratios (at 65F set point).~~

~~[364] Evaluation – Opinion Dynamics review PY2019. The recommended values are constructed based on weather conditions (heating degree days and cooling degree days) in select Missouri cities (St. Louis, Cape Girardeau, Kansas City), weighted by partial year 2019 installations.~~

[365] Illinois TRM Version 12.0, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_3_Res_09222023_FINAL_clean.pdf, page 112. Justification for degradation factors can be found on page 14 of 'AIC HVAC Metering Study Memo FINAL 2_28_2018.docx'. Estimate efficiency as (Rated Efficiency * (1-0.01)^Equipment Age)~~Based on IL TRM V8.0, which bases justification for degradation factors on page 21 of 'AIC HVAC Metering Study Memo FINAL 2_28_2018'. Default of 12 years based on the remaining measure life of the equipment~~.

[366] ASHP existing efficiency assumes degradation and is sourced from the Ameren Missouri Heating and Cooling Program Impact and Process Evaluation: Program Year 2015. CAC assumed to follow the same trend in degradation as the ASHP: 9.12 SEER nameplate to 7.2 (6.91 SEER2) operations SEER represents degradation to 78.9% of nameplate. 78.9% of 8.6 SEER CAC nameplate gives an operational SEER of 6.8 (6.53 SEER2).

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

[368] SEER to SEER2 conversion factor: SEER2 = SEER *~~x~~ 96%. Conversion factor for SEER to SEER2 is used when converting an existing system that is rated in SEER to SEER2. This is to meet the DOE M1 CFR Standard beginning January 1, 2023. The efficiency levels of the existing, baseline, and efficient case must be expressed in SEER2 terms before applying formulas~~The efficiency levels of the existing, baseline, and efficient case must be expressed in the same metrics (e.g., both SEER or SEER2) before applying formulas~~.

~~[369] Based on minimum federal standard effective 1/1/2015: http://www.gpo.gov/fdsys/pkg/CFR-2012-title10-vol3/pdf/CFR-2012-title10-vol3-sec430-32.pdf.~~

[370] Based on minimum federal standard effective 1/1/2023: 10 CFR 430.32(c)(5)

[371] Ameren Missouri HVAC Evaluation PY2017, https://www.efis.psc.mo.gov/Document/Display/14208, page 37.

[372] Evaluation – Opinion Dynamics review PY2022. The recommended values are constructed based on weather conditions (heating degree days and cooling degree days) for St. Louis and technological differences between traditional and cold climate heat pumps, which are capable of meeting whole home heating requirements at lower temperatures than traditional heat pumps, resulting in increased effective full load operating hours.

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Weather Basis (Ameren Missouri Average)	EFLH$_{heat}$ (Hours)
~~MFc (comprehensive envelope)~~	~~510[373] for ASHP and DFHP, and 603 for ccASHP~~

Capacity$_{heat}$ = Heating Capacity of Air Source Heat Pump (Btu/hr)
= Actual (1 ton = 12,000Btu/hr)

HSPF2$_{exist}$ = Heating Seasonal Performance Factor of existing heating system (kBtu/kWh)
= Use actual HSPF2 rating where it is possible to measure or reasonably estimate. If using rated efficiencies, derate the efficiency value based on the age of the existing equipment (up to a maximum of 30 years) to account for degradation over time.[374] If age is unknown, use 12 years.
= HSPF2 * $(1-0.01)^{Age}$
~~=~~ If rated efficiency is unknown, use defaults provided below, which should not be further adjusted to account for age-related degradation~~Use actual HSPF rating where it is possible to measure or reasonably estimate. If not available use~~:

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Existing Heating System	HSPF$_{exist}$
Air Source Heat Pump	~~5.44~~4.91[375]
Electric Resistance	3.41[376]

HSPF2$_{base}$ = Heating Seasonal Performance Factor of baseline Air Source Heat Pump (kBtu/kWh)[377]
= ~~8.33[378] through 12/31/2023 and 8.6 (~~7.5 HSPF2~~) beginning 1/1/2024~~[379]

HSFP2$_{ee}$ = Heating Seasonal Performance Factor of efficient Air Source Heat Pump (kBtu/kWh)
= Actual

ISR = In~~-s~~ ~~S~~ervice r~~R~~ate. Actual, or if unknown, assume ~~=~~ 100%[380]

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$\Delta kW = \Delta kWh_{Cooling} * CF$

Where:

$\Delta kWh_{Cooling}$ = Electric energy savings for cooling, calculated above

CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor
= 0.0009474181

~~Time of sale:~~

~~$\Delta kW = \Delta kWh_{cooling} * CF$~~

~~CF = 0.0009474181~~

NATURAL GAS SAVINGS

N/A

~~[373] Evaluation - Opinion Dynamics review PY2019. The recommended values are constructed based on weather conditions (heating degree days and cooling degree days) in select Missouri cities (St. Louis, Cape Girardeau, Kansas City), weighted by partial year 2019 installations.~~

[374] Illinois TRM Version 12.0, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_3_Res_09222023_FINAL_clean.pdf, page 112. Justification for degradation factors can be found on page 14 of 'AIC HVAC Metering Study Memo FINAL 2_28_2018.docx'. Estimate efficiency as (Rated Efficiency * (1-0.01)^Equipment Age).

[375] Ibid., page 110~~This is estimated based on finding the average HSPF/SEER ratio from the AHRI directory data (using the least efficient models – SEER 12 and SEER 13) – 0.596 and applying to the average nameplate SEER rating of all early replacement qualifying equipment in Ameren PY2003-PY2004. This estimation methodology appears to provide a result within 10% of actual HSPF~~.

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

[377] HSPF to HSPF2 conversion factor: HSPF2 = HSPF * ~~x~~ 87%. Conversion factor for HSPF to HSPF2 is used when converting an existing system that is rated in HSPF to HSPF2. This is to meet the DOE M1 CFR Standard beginning January 1, 2023. The efficiency levels of the existing, baseline, and efficient case must be expressed in ~~the same metrics (e.g., both HSPF or~~ HSPF2 terms~~)~~ before applying formulas.

~~[378] Ameren Missouri HVAC Evaluation: PY2017.~~

[379] Based on minimum federal standard effective 1/1/2023: 10 CFR 430.32(c)(5)

[380] Ameren Missouri HVAC Evaluation: PY2020, https://www.efis.psc.mo.gov/Document/Display/13831, page 53.

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WATER IMPACT DESCRIPTIONS AND CALCULATION
N/A

DEEMED O&M COST ADJUSTMENT CALCULATION
N/A

MEASURE CODE:

3.4.3 Duct Sealing and Duct Repair

DESCRIPTION

This measure describes evaluating the savings associated with performing duct sealing to the distribution system of homes with central cooling and/or a ducted heating system. While sealing ducts in conditioned space can help with control and comfort, energy savings are largely limited to sealing ducts in unconditioned space where the heat loss is to outside the thermal envelope. Therefore, for this measure to be applicable at least 30% of ducts should be within unconditioned space (e.g., attic with floor insulation, vented crawlspace, unheated garages; basements should be considered conditioned space).

Three methodologies for estimating the savings associate from sealing the ducts are provided.

1. **Modified Blower Door Subtraction** – this technique is described in detail on p. 44 of the Energy Conservatory Blower Door Manual; http://dev.energyconservatory.com/wp-content/uploads/2014/07/Blower-Door-model-3-and-4.pdf.
   It involves performing a whole house depressurization test and repeating the test with the ducts excluded.
2. **Duct Blaster Testing** - as described in RESNET Test 803.7:
   ~~http://www.resnet.us/standards/DRAFT_Chapter_8_July_22.pdf.~~ https://energyconservatory.com/wp-content/uploads/2014/09/RESNET-Standards-Chapter-8.pdf
   This involves using a blower door to pressurize the house to 25 Pascals and pressurizing the duct system using a duct blaster to reach equilibrium with the inside. The air required to reach equilibrium provides a duct leakage estimate.
3. **Deemed Savings per Linear Foot** – this method provides a deemed conservative estimate of savings and should only be used where performance testing described above is not possible.

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

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

DEFINITION OF EFFICIENT EQUIPMENT

The efficient condition is sealed duct work throughout the unconditioned space in the home.

DEFINITION OF BASELINE EQUIPMENT

The existing baseline condition is leaky duct work with at least 30% of the ducts within the unconditioned space in the home.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The assumed lifetime of this measure is 20 years.[381]

DEEMED MEASURE COST

The actual duct sealing measure cost should be used.

LOADSHAPE

HVAC RES

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

Methodology 1: Modified Blower Door Subtraction

a. Determine Duct Leakage rate before and after performing duct sealing:

$$\text{Duct Leakage } (CFM50_{DL}) = (CFM50_{Whole\ House} - CFM50_{EnvelopeOnly}) * SCF$$

~~a.~~

~~$Duct\ Leakage\ (CFM50_{DL}) = (CFM50_{Whole\ House} - CFM50_{Envelope\ Only}) * SCF$~~

Where:

---

[381] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007, https://www.caetrm.com/media/reference-documents/HVAC_Ltg_measure_life_GDS_2007.pdf; 'HVAC_Ltg_measure_life_GDS_2007.pdf', page 1-3.

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$CFM50_{Whole\ House}$ = Standard Blower Door test result finding Cubic Feet per Minute at 50 Pascal pressure differentials

$CFM50_{Envelope\ Only}$ = Blower Door test result finding Cubic Feet per Minute at 50 Pascal pressure differentials with all supply and return registers sealed

SCF = Subtraction Correction Factor to account for underestimation of duct leakage due to connections between the duct system and the home. Determined by measuring pressure with respect to the building in the sealed duct system, with the building pressurized to 50 Pascals with respect to the outside. Use the following look up table provided by energy conservatory to determine the appropriate subtraction correction factor:

House to Duct Pressure	Subtraction Correction Factor
50	1.00
49	1.09
48	1.14
47	1.19
46	1.24
45	1.29
44	1.34
43	1.39
42	1.44
41	1.49
40	1.54
39	1.60
38	1.65
37	1.71
36	1.78
35	1.84
34	1.91
33	1.98
32	2.06
31	2.14

House to Duct Pressure	Subtraction Correction Factor
30	2.23
29	2.32
28	2.42
27	2.52
26	2.64
25	2.76
24	2.89
23	3.03
22	3.18
21	3.35
20	3.54
19	3.74
18	3.97
17	4.23
16	4.51
15	4.83
14	5.20
13	5.63
12	6.12
11	6.71

b. Calculate duct leakage reduction, convert to $CFM25_{DL}$[382] and factor in Supply and Return Loss Factors:

Duct Leakage Reduction ($\Delta CFM25_{DL}$) = ($PreCFM50_{DL}$ – $PostCFM50_{DL}$) * 0.64 * (SLF + RLF)

~~$Duct\ Leakage\ Reduction\ (\Delta CFM25_{DL}) = (Pre\ CFM50_{DL} - Post\ CFM50_{DL}) * 0.64 * (SLF + RLF)$~~

Where:

0.64 = Converts $CFM50_{DL}$ to $CFM25_{DL}$[383]

SLF = Supply Loss Factor[384]
= % leaks sealed located in Supply ducts * 1
Default = 0.5[385]

---

[382] 25 Pascals is the standard assumption for typical pressures experienced in the duct system under normal operating conditions.

[383] To convert CFM50 to CFM25, multiply by 0.64 (inverse of the "Can't Reach Fifty" factor for CFM25; see Energy Conservatory Blower Door Manual).

[384] Assumes that for each percent of supply air loss there is one percent annual energy penalty. This assumes supply leaks are direct losses to the outside and are not recaptured back to the house. This could be adjusted downward to reflect regain of usable energy to the house from duct leaks. For example, during the winter some of the energy lost from supply leaks in a crawlspace will probably be regained back to the house (sometimes 1/2 or more may be regained). More information provided in "Appendix E Estimating HVAC System Loss From Duct Airtightness Measurements" from Energy Conservatory Blower Door Manual.

[385] Assumes 50% of leaks are in supply ducts.

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RLF = Return Loss Factor[386]
= % leaks sealed located in Return ducts * 0.5
Default = 0.25[387]

c. Calculate electric savings

$\Delta kWh = \Delta kWh_{Cooling} + \Delta kWh_{Heating}$

If the home has central cooling, the electric energy saved in annual cooling due to the duct sealing and repair is:

~~b.~~ $\Delta kWh_{Cooling} = (\Delta CFM25_{DL}/((Capacity_{Cool}/12{,}000 * 400)) * EFLHcool * Capacity_{Cool})/(1{,}000 * SEER2)$

~~$\Delta kWh = \Delta kWhCooling + \Delta kWhHeating$~~

~~$\Delta kWhCooling = \frac{\frac{\Delta CFM25_{DL}}{(CapacityCool/12{,}000 * 400)} * EFLHcool * CapacityCool}{1{,}000 * SEER}$~~

~~$\Delta kWhHeating_{Electric} = \frac{\frac{\Delta CFM25_{DL}}{(CapacityHeat/12{,}000 * 400)} * EFLHheat * CapacityHeat}{COP * 3{,}412}$~~

~~$\Delta kWhHeating_{Gas} = (\Delta Therms * Fe * 29.3)$~~

Where:

$\Delta CFM25_{DL}$ = Duct leakage reduction in CFM2 as calculated above
CapacityCool = Capacity of Air Cooling system (Btu/hr)
= Actual
12,000 = Converts Btu/H capacity to tons
400 = Conversion of Capacity to CFM (400CFM / ton)[388]
EFLHcool = Equivalent Full Load Cooling Hours:[389]

Weather Basis (Ameren Missouri Average)	EFLHcool (Hours)
SF or MF	869
~~MFc (comprehensive envelope)~~	~~632[390]~~

1,000 = Converts Btu to kBtu
SEER2 = Seasonal Energy Efficiency Ratio of Air Conditioning equipment (kBtu/kWh)
= Actual - If not available, following:[391]

Age of Equipment	ηCool Estimate
Before 2006	9.5

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[386] Assumes that for each percent of return air loss there is a half percent annual energy penalty. Note that this assumes that return leaks contribute less to energy losses than do supply leaks. This value could be adjusted upward if there was reason to suspect that the return leaks contribute significantly more energy loss than "average" (e.g., pulling return air from a super-heated attic), or can be adjusted downward to represent significantly less energy loss (e.g., pulling return air from a moderate temperature crawl space). More information provided in "Appendix E Estimating HVAC System Loss From Duct Airtightness Measurements" from Energy Conservatory Blower Door Manual.

[387] Assumes 50% of leaks are in return ducts.

[388] This conversion is an industry rule of thumb. E.g., see ~~http://www.hvacsalesandsupply.com/Linked%20Documents/Tech%20Tips/61-Why%20400%20CFM%20per%20ton.pdf.~~ https://www.brinco.com/2016/02/04/is-there-a-rule-of-thumb-that-i-can-use-that-would-tell-me-how-many-cfms-an-ac-would-need-per-ton-of-cooling-capacity/

[389] ~~Based on Full Load Hour assumptions (for St Louis and Kansas City) taken from the ENERGY STAR® calculator (http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_CAC.xls) and reduced by 28.5% based on the evaluation results in Ameren territory suggesting an appropriate EFLH of 869.The other weather basis values are calculated using the relative climate normals cooling degree day ratios (at 65F set point).~~ https://www.efis.psc.mo.gov/Document/Display/15876, page 30

~~[390] Evaluation - Opinion Dynamics review PY2019. The recommended values are constructed based on weather conditions (heating degree days and cooling degree days) in select Missouri cities (St. Louis, Cape Girardeau, Kansas City), weighted by partial year 2019 installations.~~

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

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2006 - 2014	12.4
Central AC After 1/1/2015	12.4
Heat Pump After 1/1/2015	13.3

~~use:[392]~~

~~Equipment Type~~	~~Age of Equipment~~	~~SEER Estimate~~
~~Central AC~~	~~Before 2006~~	~~10~~
	~~After 2006~~	~~13~~
~~Heat Pump~~	~~Before 2006~~	~~10~~
	~~2006-2014~~	~~13~~
	~~2015 on~~	~~14~~

If the home is heated with electric heat (resistance or heat pump), the electric energy saved in annual heating due to the added insulation is:

$$\Delta kWhHeating_{Electric} = (\Delta CFM25_{DL}/((Capacity_{Heat}/12{,}000 * 400)) * EFLH_{heat} * Capacity_{Heat})/(COP * 3{,}412)$$

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Where:

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CapacityHeat = Heating output capacity (Btu/hr) of electric heat
= Actual

EFLHheat = Equivalent Full Load Heating Hours:[393]

Weather Basis (Ameren Missouri Average)	EFLHheat (Hours)
SF or MF	1496
~~MFc (comprehensive envelope)~~	~~510~~

COP = Efficiency in COP of Heating equipment
= Actual - If not available, use:~~[394]~~

System Type	Age of Equipment	HSPF2 Estimate	ηHeat (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[395]	N/A	N/A	1.28

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~~System Type~~	~~Age of Equipment~~	~~HSPF Estimate~~	~~COP (Effective COP Estimate) (HSPF/3.412)*0.85~~

~~[392] These default system efficiencies are based on the applicable minimum federal standards. In 2006 the federal standard for central AC was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate.~~

[393] Evaluation - Opinion Dynamics review PY2019. The recommended values are constructed based on weather conditions (heating degree days and cooling degree days) in select Missouri cities (St. Louis, Cape Girardeau, Kansas City), weighted by partial year 2019 installations.

~~[394] 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.~~

[395] Calculation assumes 35% Heat Pump and 65% Resistance, which is based upon data from Energy Information Administration, 2009 Residential Energy Consumption Survey, ~~;~~ https://www.eia.gov/consumption/residential/data/2009/hc/hc6.9.xls; 'hc6.9.xls'. 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.

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~~Heat Pump~~	~~Before 2006~~	~~6.8~~	~~1.7~~
	~~2006 - 2014~~	~~7.7~~	~~1.92~~
	~~2015 on~~	~~8.2~~	~~2.04~~
~~Resistance~~	~~N/A~~	~~N/A~~	~~1~~

3412 = Converts Btu to kWh

If the home is heated with natural gas, the electric energy saved in annual heating due to the added insulation is:

~~ΔTherms = Therm savings as calculated in Natural Gas Savings~~

$\Delta kWhHeating_{Gas}$ = (ΔTherms * Fe * 29.3)

Where:

ΔTherms = Therm savings as calculated in Natural Gas Savings

F_e = Furnace fan energy consumption as a percentage of annual fuel consumption
= 3.14%[396]

29.3 = kWh per therm

Methodology 2: Duct Blaster Testing

ΔkWh = ΔkWhCooling + ΔkWhHeating

$\Delta kWh_{Cooling}$ = ((Pre_CFM25 – Post_CFM25)/(CapacityCool/12,000 * 400) * EFLHcool * CapacityCool)/(1,000 * SEER2)

$\Delta kWhHeating_{Electric}$ = ((Pre_CFM25 – Post_CFM25)/(CapacityHeat/12,000 * 400) * EFLHheat * CapacityHeat)/(COP * 3,412)

$\Delta kWhHeating_{Gas}$ = ΔTherms * Fe * 29.3

~~$\Delta kWh = \Delta kWhCooling + \Delta kWhHeating$~~

~~$\Delta kWhCooling = \frac{\frac{Pre\_CFM25 - Post\_CFM25}{CapacityCool/12{,}000 * 400} * EFLHcool * CapacityCool}{1{,}000 * SEER}$~~

~~$\Delta kWhHeating_{Electric} = \frac{\frac{Pre\_CFM25 - Post\_CFM25}{CapacityCool/12{,}000 * 400} * EFLHheat * CapacityHeat}{COP * 3{,}412}$~~

~~$\Delta kWhHeating_{Gas} = (\Delta Therms * Fe * 29.3)$~~

Where:

Pre_CFM25 = Duct leakage in CFM25 as measured by duct blaster test before sealing
Post_CFM25 = Duct leakage in CFM25 as measured by duct blaster test after sealing
All other variables as provided above

Methodology 3: Deemed Savings[397]

ΔkWh = $\Delta kWh_{Cooling}$ + $\Delta kWh_{HeatingElectric}$ + $\Delta kWh_{HeatingGas}$

$\Delta kWh_{cooling}$ = CoolSavingsPerUnit * $Duct_{Length}$

$\Delta kWhHeating_{Electric}$ = HeatSavingsPerUnit * $Duct_{Length}$

$\Delta kWhHeating_{Ga}$ = ΔTherms * Fe * 29.3

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

[397] Savings per unit are based upon analysis performed by Cadmus for the 2011 Iowa Joint Assessment of Potential. It was based on 10% savings in system efficiency. This would represent savings from homes with significant duct work outside of the thermal envelope. With no performance testing or verification, a deemed savings value should be very conservative and therefore the values provided in this section represent half of the savings – or 5% improvement. These values are provided as a conservative deemed estimate for Missouri, while encouraging the use of performance testing and verification for determination of more accurate savings estimates.

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~~$\Delta kWh = \Delta kWh_{Cooling} + \Delta kWh_{HeatingElectric} + \Delta \mathrm{kWh}_{\mathrm{HeatingGas}}$~~

~~$\Delta kWhcooling = CoolSavingsPerUnit * Duct_{Length}$~~
~~$\Delta kWh_{HeatingElectric} = HeatSavingsPerUnit * Duct_{Length}$~~
~~$\Delta kWh_{HeatingGas} = (\Delta Therms * Fe * 29.3)$~~

Where:
CoolSavingsPerUnit = Annual cooling savings per linear foot of duct[398]

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[398] MO TRM, page 97, https://dnr.mo.gov/document-search/missouri-technical-reference-manual-2017-volume-3-residential-measures

Building Type	HVAC System	CoolSavingsPerUnit (kWh/ft)
Multifamily	Cool Central	0.70
Single-family	Cool Central	0.81
Manufactured	Cool Central	0.95
Multifamily	Heat Pump—Cooling	0.70
Single-family	Heat Pump—Cooling	0.81
Manufactured	Heat Pump—Cooling	0.95

$\text{Duct}_{\text{Length}}$ = Linear foot of duct
= Actual
HeatSavingsPerUnit = Annual heating savings per linear foot of duct[399]

Building Type	HVAC System	HeatSavingsPerUnit (kWh/ft)
Manufactured	Heat Pump—Heating	5.06
Multifamily	Heat Pump - Heating	3.41
Single-family	Heat Pump— Heating	4.11

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$\Delta kW = \Delta kWh * CF$

Where:

ΔkWh = Electric energy savings, as calculated above

~~$\Delta kW = \Delta kWh * C$~~

~~Where:~~

CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor
= 0.0004660805[400]

NATURAL GAS SAVINGS

For homes with Natural Gas Heating:

Methodology 1: Modified Blower Door Subtraction

ΔTherm = (ΔCFM25DL/((CapacityHeat * 0.0136)) * EFLHheat * CapacityHeat * ηEquipment / ηSystem)/100,000

~~$$\Delta Therm = \frac{\frac{\Delta CFM25_{DL}}{CapacityHeat * 0.0136} * EFLHheat * CapacityHeat * \frac{\eta Equipment}{\eta System}}{100,000}$$~~

Where:

$\Delta CFM25_{DL}$ = Duct leakage reduction in CFM25
= As calculated in Methodology 1 under electric savings
CapacityHeat = Heating input capacity (Btu/hr)
= Actual
0.0125 = Conversion of Capacity to CFM (0.0125CFM / Btu/hr)[401]
ηEquipment = Heating Equipment Efficiency

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[399] MO TRM, page 97, https://dnr.mo.gov/document-search/missouri-technical-reference-manual-2017-volume-3-residential-measures

[400] Based on Ameren Missouri TRM Volume 1 - Appendix G: "Table 1 – Residential End Use Category Monthly Shapes and Coincident Peak Factors"~~2016 Ameren Missouri Coincident Peak Demand Factor~~ for Residential Cooling. ~~See reference "Ameren Missouri 2016 Appendix E - End Use Shapes and Coincident Factors.pdf.~~"

[401] Based on natural draft furnaces requiring 100 CFM per 10,000 Btu, induced draft furnaces requiring 130CFM per 10,000Btu, and condensing furnaces requiring 150 CFM per 10,000 Btu (rule of thumb from ~~-~~https://www.contractingbusiness.com/archive/article/20861289/calculating-heating-system-airflow~~http://contractingbusiness.com/enewsletters/cb_imp_43580/~~). Data provided by GAMA during the federal rulemaking process for furnace efficiency standards, suggested that in 2000, 29% of furnaces purchased in Missouri were condensing units. Therefore, a weighted average required airflow rate is calculated assuming a 50:50 split of natural v induced draft non-condensing furnaces, as 125 per 10,000Btu or 0.0125/Btu.

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= Actual[402] - If not available, use 83.5%[403]

ηSystem = Pre duct sealing Heating System Efficiency (Equipment Efficiency * Pre Distribution Efficiency)[404]

= Actual - If not available use 71.0%[405]

100,000 = Converts Btu to therms

Methodology 2: Duct Blaster Testing

ΔTherms = ((Pre_CFM25 – Post_CFM25)/(ΔCFM25DL/CapacityHeat) * 0.0136 * EFLHgasheat * Equipment / ηSystem)/100,000

~~$$\Delta Therms = \frac{\frac{Pre\_CFM25 - Post\_CFM25}{CapacityHeat * 0.0136} * EFLHgasheat * CapacityHeat * \frac{\eta Equipment}{\eta System}}{100,000}$$~~

Where:

All variables as provided above

Methodology 3: Deemed Savings[406]

ΔTherms = HeatSavingsPerUnit*Duct$_{Length}$

~~$\Delta Therms = HeatSavingsPerUnit * Duct_{Length}$~~

~~Where:~~

Where:

HeatSavingsPerUnit = Annual heating savings per linear foot of duct[407]

Building Type	HVAC System	HeatSavingsPerUnit (Therms/ft)
Multifamily	Heat Central Furnace	0.19
Single-family	Heat Central Furnace	0.21
Manufactured	Heat Central Furnace	0.26

Duct$_{Length}$ = Linear foot of duct

= Actual

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[402] The actual Heating Equipment Efficiency can be obtained either by recording the AFUE of the unit, or performing a steady state efficiency test. If there is more than one heating system, the weighted (by consumption) average efficiency should be used.
If the heating system or distribution is being upgraded within a package of measures together with the insulation upgrade, the new average heating system efficiency should be used.

[403] In 2000, 29% of furnaces purchased in Missouri 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, so units purchased 16 years ago provide a reasonable proxy for the current mix of furnaces in the state. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows: (0.29*0.92) + (0.71*0.8) = 0.835.

[404] The distribution efficiency can be estimated via a visual inspection and by referring to a look-up table such as that provided by the Building Performance Institute - (https://www.bpi.org/__cms/docs/Guidance%20on%20Estimating%20Distribution%20Efficiency.pdf~~http://www.bpi.org/files/pdf/DistributionEfficiencyTable-BlueSheet.pdf~~); 'Guidance on Estimating Distribution Efficiency.pdf') - or by performing duct blaster testing.

[405] Estimated as follows: 0.835 * (1-0.15) = 0.710.

[406] Savings per unit are based upon analysis performed by Cadmus for the 2011 Joint Assessment of Potential. It was based on 10% savings in system efficiency. This would represent savings from homes with significant duct work outside of the thermal envelope. With no performance testing or verification, a deemed savings value should be very conservative and therefore the values provided in this section represent half of the savings – or 5% improvement. These values are provided as a conservative deemed estimate for Missouri, while encouraging the use of performance testing and verification for determination of more accurate savings estimates.

[407] Iowa TRM v8.0, page 204, https://wcc.efs.iowa.gov/cs/idcplg?IdcService=GET_FILE&allowInterrupt=1&RevisionSelectionMethod=latest&dDocName=2129208&noSaveAs=1

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MEASURE CODE:

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3.4.4 Mini/Multi-Split Air Source Heat Pump and Air Conditioners

DESCRIPTION

This measure is designed to calculate electric savings from retrofitting existing electric HVAC systems with ductless and/or ducted mini/multi-split heat pumps (MMSHPs) or mini/multi-split air conditioners. MMSHPs save energy in heating mode because they provide heat more efficiently than electric resistance heat and central ASHP systems. Additionally, MMSHPs use less fan energy to move heat and don't incur heat loss through a lengthy duct distribution system while operating at very low static pressure. Often MMSHPs are installed in addition to (do not replace) existing heating or cooling equipment because the existing heating or cooling equipment is inadequate to efficiently heat or cool the space. Both ductless and ducted indoor units can be installed as a mixed mini/multi-split heat pump or air conditioner under this measure. Duct runs for a ducted mini/multi-split indoor unit should be installed within the conditioned envelope, be well-sealed and insulated ducts, and maintain low static pressure per manufacturer specifications for the installation configuration to maximize energy savings.

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For cooling, the proposed savings calculations are aligned with those of typical replacement systems. MMSHPs save energy in cooling mode because they provide cooling capacity more efficiently than other types of unitary cooling equipment. A MMSHPs installed in a home with an existing central ASHP or CAC system will save energy by offsetting some of the cooling energy of the ASHP or CAC. In order for this measure to apply, the control strategy for the heat pump or air conditioner is assumed to be chosen to maximize savings per installer recommendation.[408]

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This measure was developed to be applicable to the following program type: NC, ROF, and ER.

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

DEFINITION OF EFFICIENT EQUIPMENT

In order for this characterization to apply, the new equipment must be a high-efficiency, variable-capacity (typically "inverter-driven" DC motor) ductless and/or ducted mini/multi-split heat pump or air conditioning system that exceeds the program minimum efficiency requirements.

DEFINITION OF BASELINE EQUIPMENT

In order for this characterization to apply, baseline equipment must include a permanent electric resistance heating source or a ducted air-source heat pump or ducted air conditioner. For residences with central air conditioner/non-electric heating, cooling savings will only apply. For multifamily buildings, each residence must have existing individual heating equipment. Multifamily residences with central heating do not qualify for this characterization. Existing cooling equipment is assumed to be standard efficiency. Note that in order to claim cooling savings, there must be an existing air conditioning system (e.g. central air conditioning, Window ACs, or air source heat pump).

New federal standards affecting heat pumps became effective January 1, 2023. ~~These new federal standards will be adopted by programs on January 1, 2024.~~ Under the new standards, the baseline for a ROF measure is the federal standard efficiency; ~~15 SEER (14.3 SEER2)~~14.3 SEER2 and ~~8.6 HSPF (7.5 HSPF2)~~7.5 HSPF2 when replacing a ducted air-source heat pump; ~~14 SEER (13.4 SEER2)~~13.4 SEER2 and 3.41 HSPF2 when replacing a central air conditioner and electric resistance heating; ~~14 SEER (13.4 SEER2)~~13.4 SEER2 when replacing central air conditioner with non-electric heating or no heating.

Under the new federal standards, the M1 testing protocol was revised, resulting in new SEER and HSPF performance metrics, now called SEER2 and HSPF2. When quantifying energy savings, the SEER2 and HSPF2 metrics should be used for the existing, baseline, and new equipment. ~~When quantifying energy savings, the same metric should be used for the existing, baseline, and new equipment.~~ The following conversion formulas can be used to convert between efficiency metrics:

SEER2 = SEER *~~x~~ 0.96
HSPF2 = HSPF ~~x~~ * 0.87

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[408] The whole purpose of installing ductless heat pumps is to conserve energy, so the installer can be assumed to be capable of recommending an appropriate control strategy. For most applications, the heating setpoint for the ductless heat pump should be at least 2F higher than any remaining existing system and the cooling setpoint should be at least 2F cooler than the existing system (this should apply to all periods of a programmable schedule, if applicable). This helps ensure that the ductless heat pump will be used to meet as much of the load as possible before the existing system operates to meet the remaining load. Ideally, the new ductless heat pump controls should be set to the current comfort settings, while the existing system setpoints should be adjusted down (heating) and up (cooling) to capture savings.

For the early replacement baseline to apply, program participants or installation contractors must provide documentation asserting that the existing units operated when turned on—whether or not they provided cooling—and the existing unit brand name and model number must be documented; or, if the nameplate is not readable, a photograph of the unit in context and the nameplate specifically must be provided. The baseline for the early replacement measure is the efficiency of the existing equipment for the assumed remaining useful life of the unit and the new baseline as defined above for the remainder of the measure life.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 18 years.[409]
Remaining life of existing ASHP/CAC equipment is assumed to be 6 years[410] and 18 years for electric resistance.

DEEMED MEASURE COST

~~The incremental cost for this measure is provided below:~~Default full cost of the MMSHP is provided below. Note, for smaller units a minimum cost of $2,000 should be applied:[411]

Unit HSPF2	Full Install Cost ($/ton)[412]
8.1-8.9	$1,443
9-9.8	$1,605
9.9-11.6	$1,715
11.7+	$2,041

New Construction and Time of Sale: If the unit is not displacing electric resistance heating or facilitating fuel switching, apply the incremental cost of the MMSHP compared to a baseline minimum efficiency MMSHP provided in the table below:[413]

Efficiency (HSPF2)	Incremental Cost ($/ton) over an HSPF2 7.5 MMSHP
8.1-8.9	$62
9-9.8	$224
9.9-11.6	$334
11.7+	$660

Otherwise, the incremental cost should be calculated as the greater of:

- Actual installed cost of the MMSHP should be used (defaults are provided above), minus the assumed installation cost of the baseline equipment ($2,011 for a new baseline 80% AFUE furnace,[414] and $3,338 for new baseline Central AC replacement [415]). If replacing electric resistance heat, there is no deferred cost for replacing the electric resistance heating unit.
- Applicable incremental cost relative to MMSHP identified in the table above.

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[409] Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, Inc., June 2007, https://www.caetrm.com/media/reference-documents/HVAC_Ltg_measure_life_GDS_2007.pdf; 'HVAC_Ltg_measure_life_GDS_2007.pdf', page 1-3.

[410] Assumed to be one third of effective useful life.

[411] 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.

[412] 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.

[413] Memo from Opinion Dynamics Evaluation Team, Ductless Mini-Split Heat Pumps: Incremental Cost Analysis, April 27, 2017

[414] See 'Technical Standard Document_APPENDIX_E.pdf'.

[415] See 'CAC Costs 09.02.2024.xlsx'.

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Early Replacement/retrofit (replacing existing equipment): ~~The~~If available, the actual full installation cost of the MMSHP should be used; if unavailable, the default full cost specified above should be used. The assumed deferred cost of replacing existing equipment with a new baseline unit is assumed to be $~~7,722 + $674~~1,518[416] per ton for a new baseline ~~Air Source Heat Pump~~MMSHP, or $2,296 for a new baseline 80% AFUE furnace and $3,670 for new baseline Central AC replacement.[417] If replacing electric resistance heat, there is no deferred ~~replacement cost~~cost for replacing the electric resistance heating unit. This future cost should be discounted to present value using a 2.31% nominal societal discount rate, based on the ten year average (1/1/2014 – 12/31/2023) of the 10 year Treasury bond yield rates.[418]

If the deferred replacement cost exceeds the full installation cost of the MMSHP, the incremental cost shall be set to zero.

When a non-electric heating system is replaced with an MMSHP, and the program administrator is only claiming energy savings from cooling (i.e., no heating savings are claimed due to the fuel switch), the incremental costs should be adjusted to reflect the proportion of claimed savings.

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The incremental cost of the MMSHP shall be adjusted by applying a factor that represents the ratio of the claimed cooling savings to the total potential energy savings (inclusive of both cooling and unclaimed heating savings). This adjustment ensures that the incremental cost used in cost-effectiveness testing is proportional to the benefits being claimed, thus avoiding a mismatch between costs and benefits.

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Calculation Method:

1. Determine Total Potential Savings: Calculate the sum of the potential energy savings from both cooling and heating (even if heating savings are not being claimed).
2. Determine Claimed Savings: Identify the portion of energy savings that is being claimed, typically the cooling savings only.
3. Apply the Adjustment Factor: The adjustment factor is calculated as the ratio of claimed savings to total potential savings. This factor is then applied to the full incremental cost of the MMSHP.

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Adjusted Incremental Cost = (Claimed Savings (kWh) / Total Potential Savings (kWh)) * Full Incremental Cost)

LOADSHAPE
Cooling RES
Heating RES

Algorithms

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS
Electric savings

$\Delta kWh = \Delta kWh_{heating} + \Delta kWh_{cooling}$

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Heating savings:

TOS:

$\Delta kWh_{heating} = ((Capacity_{heat} * EFLH_{heat} * (1/HSPF2_{base} - 1/HSPF2_{ee})) / 1000) * HF * ISR$

EREP:

$\Delta kWh_{heating} = ((Capacity_{heat} * EFLH_{heat} * (1/HSPF2_{exist} - 1/HSPF2_{ee})) / 1000) * HF * ISR$

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[416] Based on implicit standard efficiency cost of $1,381 per ton (8.1-8.9 HSPF2 per ton full cost minus incremental cost), account for inflation rate of 1.91%.
[417] All baseline replacement costs are consistent with their respective measures and include inflation rate of 1.91%.
[418] 'Societal_Discount_Rate_Calculation_08082024.xlsx'.

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Where:

Capacity$_{heat}$ = Heating capacity of the ductless heat pump unit in Btu/hr
= Actual

EFLH$_{heat}$ = Equivalent Full Load Hours for heating. See table below:

Weather Basis (Ameren Missouri Average)	EFLH$_{heat}$[419]
SF or MF	1,034
~~MFc (comprehensive envelope)~~	~~393~~

HSPF2$_{exist}$ = Use actual HSPF2 rating where it is possible to measure or reasonably estimate. HSPF2 rating of existing equipment. If rated efficiency is unknown, use defaults provided below

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Existing Equipment Type	HSPF2$_{exist}$[420]
Electric resistance heating	3.412
Air Source Heat Pump	6.58

HSPF2$_{base}$ = HSPF2 rating of baseline equipment (kBtu/kWh)
= 7.5 HSPF2[421] when replacing an ASHP
= 3.412 when replacing electric resistance heating
HSPF2$_{ee}$ = HSPF rating of new equipment (kBtu/kWh)
= Actual installed
ISR = In-service rate. Actual, or if unknown, assume 100%[422]

~~$\Delta kWh = \Delta kWh_{heating} + \Delta kWh_{cooling}$~~

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~~$\Delta kWh_{heating} = ((Capacity_{heat} * EFLH_{heat} * (1/HSPF_{exist} - 1/HSPF_{ee})) / 1000) * HF * ISR$~~
~~$\Delta kWh_{cooling} = ((Capacity_{cool} * EFLH_{cool} * (1/SEER_{exist} - 1/SEER_{ee})) / 1000) * HF * ISR$~~
~~$\Delta kW = \Delta kWh_{cooling} * CF$ $\Delta kW = \Delta kWh_{heating} * CF$~~

~~Electric savings –~~ C~~c~~ooling savings calculated only in presence of non-electric heating or MMAC (Mini/Multi-Split AC):

TOS:

$\Delta kWh_{cooling}$ = ((Capacity$_{cool}$* EFLH$_{cool}$ * (1/SEER2$_{base}$ - 1/SEER2$_{ee}$)) / 1000) * HF * ISR

EREP:

$\Delta kWh_{cooling}$ = ((Capacity$_{cool}$* EFLH$_{cool}$ * (1/SEER2$_{exist}$ - 1/SEER2$_{ee}$)) / 1000) * HF * ISR

Where:

~~$\Delta kWh_{cooling} = ((Capacity_{cool} * EFLH_{cool} * (1/SEER_{exist} - 1/SEER_{ee})) / 1000) * HF * ISR$~~

~~$\Delta kW = \Delta kWh_{cooling} * CF$~~

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[419] Evaluation - Opinion Dynamics review PY2019. The recommended values are constructed based on weather conditions (heating degree days and cooling degree days) in select Missouri cities (St. Louis, Cape Girardeau, Kansas City), weighted by partial year 2019 installations.
[420] Ameren Missouri Heating and Cooling Evaluation PY2018, https://www.efis.psc.mo.gov/Document/Display/15871, page 36.
[421] Based on minimum federal standard effective 1/1/2023: 10 CFR 430.32(c)(5)
[422] Ameren Missouri HVAC Evaluation: PY2020, https://www.efis.psc.mo.gov/Document/Display/13831, page 53.

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~~Where:~~

~~$Capacity_{heat}$ = Heating capacity of the ductless heat pump unit in Btu/hr~~
~~= Actual~~

~~$EFLH_{heat}$ = Equivalent Full Load Hours for heating. See table below:~~

~~Weather Basis (Ameren Missouri Average)~~	~~$EFLH_{heat}$[423]~~
~~SF or MF~~	~~1,034~~
~~MFc (comprehensive envelope)~~	~~393~~

~~$HSPF_{exist}$ = HSPF rating of existing equipment (kBtu/kWh)~~

~~Existing Equipment Type~~	~~$HSPF_{exist}$[424]~~
~~Electric resistance heating~~	~~3.412~~
~~Air Source Heat Pump~~	~~6.58~~

~~$HSPF_{base}$ = HSPF rating of baseline equipment (kBtu/kWh)~~
~~= 8.2[425] through 12/31/2023 and 8.6 (7.5 HSPF2) beginning 1/1/2024[426] when replacing an ASHP~~
~~= 3.412 when replacing electric resistance heating~~
~~$HSPF_{ee}$ = HSPF rating of new equipment (kBtu/kWh)~~
~~= Actual installed~~
$Capacity_{cool}$ = the cooling capacity of the ductless heat pump unit in Btu/hr.[427]
= Actual installed
$SEER2_{exist}$ = SEER rating of existing equipment (kBtu/kWh)

= Use actual SEER rating where possible to measure or reasonably estimate. If using rated efficiencies, derate the efficiency value based on the age of the existing equipment (up to a maximum of 30 years) to account for degradation over time.[428] If age is unknown, use 12 years.
= $SEER2 * (1-0.01)^{Age}$ ~~$SEER * (1-1.44\%)^{Age}$~~

If unknown, see table below

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[423] ~~Evaluation - Opinion Dynamics review PY2019. The recommended values are constructed based on weather conditions (heating degree days and cooling degree days) in select Missouri cities (St. Louis, Cape Girardeau, Kansas City), weighted by partial year 2019 installations.~~
[424] ~~Ameren Missouri Heating and Cooling Evaluation PY2018~~
[425] ~~Based on minimum federal standard effective 1/1/2015: http://www.gpo.gov/fdsys/pkg/CFR-2012-title10-vol3/pdf/CFR-2012-title10-vol3-sec430-32.pdf.~~
[426] ~~Based on minimum federal standard effective 1/1/2023: 10 CFR 430.32(c)(5)~~
[427] 1 Ton = 12 kBtu/hr.
[428] Illinois TRM Version 12.0, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_3_Res_09222023_FINAL_clean.pdf, page 112. Justification for degradation factors can be found on page 14 of ‘AIC HVAC Metering Study Memo FINAL 2_28_2018.docx’. Estimate efficiency as (Rated Efficiency * (1-0.01)^Equipment Age)~~Based on IL TRM V8.0, which bases justification for degradation factors on page 21 of ‘AIC HVAC Metering Study Memo FINAL 2_28_2018’. Default of 12 years based on the remaining measure life of the equipment~~.

Existing Cooling System	SEER2$_{exist}$[429]
Air Source Heat Pump	~~7.2~~6.91
Central AC	6.~~8~~53
Room AC	6.3[430]
No existing cooling[431]	Let ‘1/SEER_exist’ = 0

SEER2$_{base}$ = Seasonal Energy Efficiency Ratio of baseline equipment (kBtu/kWh)[432]
= ~~14[433] through 12/31/2023 and 15 (~~14.3 SEER2~~) beginning 1/1/2024~~[434] when replacing an ASHP
= ~~14 (~~13.4 SEER2~~)~~ when replacing a CAC
SEER2$_{ee}$ = SEER rating of new equipment (kBtu/kWh)
= Actual installed[435]
EFLH$_{cool}$ = Equivalent Full Load Hours for cooling. See table below

Weather Basis (Ameren Missouri Average)	EFLH$_{cool}$
SF or MF	635
~~MFc (comprehensive envelope)~~	~~417~~

~~ISR = In Service Rate = 100%[436]~~

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = \Delta kWh_{Cooling} * CF$$

Where:

$\Delta kWh_{Cooling}$ = Electric energy savings for cooling, calculated above
CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor
= 0.0009474181
~~$\Delta kW = \Delta kWh_{cooling} * CF$~~

~~Where:~~
~~CF = 0.0009474181~~

NATURAL GAS SAVINGS

N/A

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[429] ASHP existing efficiency assumes degradation and is sourced from the Ameren Missouri Heating and Cooling Program Impact and Process Evaluation: Program Year 2015. CAC assumed to follow the same trend in degradation as the ASHP: 9.12 SEER nameplate to 7.2 (6.91 SEER2) operations SEER represents degradation to 78.9% of nameplate. 78.9% of 8.6 SEER CAC nameplate gives an operational SEER of 6.8 (6.53 SEER2). ~~ASHP existing efficiency assumes degradation and is sourced from the Ameren Missouri Heating and Cooling Program Impact and Process Evaluation: Program Year 2015. CAC assumed to follow the same trend in degradation as the ASHP: 9.12 SEER nameplate to 7.2 operations SEER represents degradation to 78.9% of nameplate. 78.9% of 8.6 SEER CAC nameplate gives an operational SEER of 6.8,~~ 78.9% of 8.0 SEER RAC nameplate gives an operational SEER of 6.3.

[430] Estimated by converting the EER assumption using the conversion equation; EER_base = (-0.02 * SEER_base^2) + (1.12 * SEER). From Wassmer, M. (2003), “A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations,” (Masters thesis) University of Colorado at Boulder. Adjusted to account for degradation per above footnote.

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

[432] SEER to SEER2 conversion factor: SEER2 = SEER ~~x~~ * 96%. Conversion factor for SEER to SEER2 is used when converting an existing system that is rated in SEER to SEER2. This is to meet the DOE M1 CFR Standard beginning January 1, 2023. The efficiency levels of the existing, baseline, and efficient case must be expressed in ~~the same metrics (e.g., both SEER or~~ SEER2~~)~~ terms before applying formulas.

~~[433] Based on minimum federal standard effective 1/1/2015: http://www.gpo.gov/fdsys/pkg/CFR-2012-title10-vol3/pdf/CFR-2012-title10-vol3-sec430-32.pdf.~~

[434] Based on minimum federal standard effective 1/1/2023: 10 CFR 430.32(c)(5)

[435] Note that if only an EER rating is available, use the following conversion equation; EER_base = (-0.02 * SEER_base^2) + (1.12 * SEER). From Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder.

~~[436] Ameren Missouri HVAC Evaluation: PY2020.~~

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WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE:

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3.4.5 Standard Programmable Thermostat

DESCRIPTION

This measure characterizes the household energy savings from the installation of a new standard programmable thermostat for reduced heating and cooling energy consumption through temperature set-back during unoccupied or reduced demand times.

Energy savings are applicable at the household level; installation of multiple programmable thermostats per home does not accrue additional savings.

If the home has a heat pump, a programmable thermostat specifically designed for heat pumps should be used to minimize the use of backup electric resistance heat systems.

This measure was developed to be applicable to the following program types: ~~RF, and~~ DI. This measure is only applicable for low income programs. Savings will not be claimed for this measure for programs other than low income programs.

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

DEFINITION OF EFFICIENT EQUIPMENT

The criteria for this measure are established by replacement of a manual-only temperature control with one that has the capability to adjust temperature setpoints according to a schedule without manual intervention.

DEFINITION OF BASELINE EQUIPMENT

For new thermostats the baseline is a non-programmable thermostat requiring manual intervention to change temperature set point.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected equipment life of a programmable thermostat is assumed to be 10 years.[437]

DEEMED MEASURE COST

Actual material and labor costs should be used if the implementation method allows. If unknown (e.g., through a retail program), the capital cost for the new installation is assumed to be $70.[438]

LOADSHAPE

Cooling RES
Heating RES

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

For central air conditioners and air source heat pumps:

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$\Delta kWh_{cool} = EFLH_{cool} * Capacity_{Cooling} * (1/SEER2) * SBdegrees * SF * EF / 1,000 * ISR$

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[437] Table 1, Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, https://energizect.com/sites/default/files/documents/Measure%20Life%20Report%202007.pdf; ‘Measure Life Report 2007.pdf’, page 1-3. ~~HVAC Controls, Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007, https://energizect.com/sites/default/files/documents/Measure%20Life%20Report%202007.pdf, page 1-3~~. Future evaluation is strongly encouraged to inform the persistence of savings to further refine measure life assumption. As this characterization depends heavily upon a large scale but only 2-year study of the energy impacts of programmable thermostats, the longer-term impacts should be assessed.

[438] Market prices vary significantly in this category, generally increasing with thermostat capability and sophistication. The basic functions required by this measure's eligibility criteria are available on units readily available in the market for $30. Labor is assumed to be one hour at $40 per hour.

~~$\Delta kWh_{cool} = EFLH_{cool} * Capacity_{cooling} * \left(\frac{1}{SEER}\right) * SBdegrees * SF * EF/1000$~~

For air source heat pumps there are additional heating savings:

ΔkWh_{heat} = $EFLH_{heat}$ * $Capacity_{Heating}$ * (1/HSPF2) * SBdegrees * SF * EF / 1,000 * ISR

~~$\Delta kWh_{heat} = EFLH_{heat} * Capacity_{Heating} * \left(\frac{1}{HSPF}\right) * SBdegrees * SF * EF/1000$~~

Where:

$EFLH_{cool}$ = Equivalent full load hours of air conditioning[439]:

Weather Basis (Ameren Missouri Average)	$EFLH_{cool}$ (Hours)
SF or MF	869
~~MFc (comprehensive envelope)~~	~~632~~

$Capacity_{Cooling}$ = Cooling capacity of system in BTU/hr (1 ton = 12,000 BTU/hr)
= Use Actuals based upon units served

SEER2 = Seasonal Energy Efficiency Ratio of cooling system (kBtu/kWh)
= Actual. If unknown, use defaults provided below:

Cooling System	SEER
Air Source Heat Pump	10[440]
Central AC	10[441]

HSPF2 = Heating Season Performance Factor of heating system (kBtu/kWh)
= Actual. If unknown, use defaults provided below:

Existing Heating System	HSPF2~~$_{exist}$~~
Air Source Heat Pump	7.00[442]
Electric Resistance	3.41[443]

$EFLH_{heat}$ = Equivalent full load hours of heating:[444]

Weather Basis (Ameren Missouri Average)	$EFLH_{heat}$ (Hours)
SF or MF	1496
~~MFc (comprehensive envelope)~~	~~510~~

$Capacity_{Heating}$ = Heating capacity of system in BTU/hr (1 ton = 12,000 BTU/hr)
= Use Actuals based upon units served

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[439] ~~Based on Full Load Hour assumptions (for St Louis and Kansas City) taken from the ENERGY STAR® calculator (http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_CAC.xls) and reduced by 28.5% based on the evaluation results in Ameren Missouri' service territory, suggesting an appropriate EFLH of 869.The other weather basis values are calculated using the relative climate normals cooling degree day ratios (at 65F set point).~~ Ameren Missouri Program Year 2019 Annual EM&V Report Volume 2: Residential Portfolio Appendices, https://www.efis.psc.mo.gov/Document/Display/15876, page 30.

[440] ~~IL-TRM (V5) - based on minimum federal standards between 1992 and 2006 –~~ Ameren Missouri Community Saver Program Evaluation PY2018 https://www.efis.psc.mo.gov/Document/Display/36053, page 26.

[441] ~~IL-TRM - based on minimum federal standards between 1992 and 2006 –~~ Ameren Missouri Community Saver Program Evaluation PY2018, https://www.efis.psc.mo.gov/Document/Display/36053, page 26.

[442] IL-TRM (Based on minimum federal standards between 1992 and 2006) – Ameren Missouri Community Saver Program Evaluation PY2018.

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

[444] Evaluation - Opinion Dynamics review PY2019. The recommended values are constructed based on weather conditions (heating degree days and cooling degree days) in select Missouri cities (St. Louis, Cape Girardeau, Kansas City), weighted by partial year 2019 installations, https://www.efis.psc.mo.gov/Document/Display/15876, page 76.

SBdegrees = weighted sum of setback degrees to comfort temperature
= SBdegrees Heating = 1.8[445]
= SBdegrees Cooling = 1.91[446]
SF = Savings factors from ENERGY STAR® calculator
= 3% / degree heat, 6% / degree cool
EF = Efficiency ratio from Cadmus metering study
= 13% heat[447]
= 100% cool[448]
ISR = In-service rate
= Actual, or if unknown, assume 100%.

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$\Delta kW = \Delta kWh_{Cooling} * CF$

Where:

$\Delta kWh_{Cooling}$ = Electric energy savings for cooling, calculated above
CF = 0.0009474181
~~CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor~~
~~= 0.0009474181~~

NATURAL GAS ENERGY SAVINGS

$\Delta Therms = \%FossilHeat * HeatingConusmption_{Gas} * HF * Heating_{Reduction} * Eff_{ISR} * PF$

~~$\Delta Therms = \%FossilHeat * HeatingConusmption_{Gas} * HF * Heating_{Reduction} * Eff_{ISR} * PF$~~

Where:

%FossilHeat = Percentage of heating savings assumed to be n~~N~~atural g~~G~~as

Heating fuel	%FossilHeat
Electric	0%
Natural Gas	100%
Unknown	65%[449]

$HeatingConsumption_{Gas}$ = Estimate of annual household heating consumption for gas heated single-family homes.[450]

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[445] Ameren Missouri Community Saver Program Evaluation PY2018 Site Visit Thermostat SB Data.
[446] Ameren Missouri Community Saver Program Evaluation PY2018
Site Visit Thermostat SB Data.
[447] Ameren Missouri Community Saver Program Evaluation PY2014 Cadmus metering study, https://www.efis.psc.mo.gov/Document/Display/15857, (PY2014 pg. 31).
[448] Ameren Missouri Community Saver Program Evaluation PY2017, https://www.efis.psc.mo.gov/Document/Display/28281.
[449] Average (default) value of 65% gas space heating from 2009 Residential Energy Consumption Survey for Missouri. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area, then they should be used.
[450] Values in table are based on average household heating load (834 therms) for Chicago based on Illinois furnace metering study (‘Table E-1, Energy Efficiency/Demand Response Nicor Gas Plan Year 1: Research Report: Furnace Metering Study, Draft, https://www.icc.illinois.gov/docket/P2012-0528/documents/201939/files/355536.pdf ; ‘355536.pdf’, Navigant, August 1 2013~~Table E-1, Energy Efficiency/Demand Response Nicor Gas Plan Year 1: Research Report: Furnace Metering Study, Draft, Navigant, August 1, 2013, https://www.icc.illinois.gov/docket/P2012-0528/documents/201939/files/355536.pdf~~) and adjusted for Missouri weather basis values using the relative climate normals HDD data with a base temp ratio of 60°F. This load value is then divided by standard assumption of existing unit efficiency of 83.5% (estimate based on 29% of furnaces purchased in Missouri were condensing in 2000 (based on data from GAMA, provided to Department of Energy) (see ‘Thermostat_ FLH and Heat Load Calcs~~Thermostat_FLH and Heat Load Calcs~~.xls’). The resulting values are generally supported by data provided by Laclede Gas, which showed an average pre-furnace replacement consumption of 1009 therms for St Louis, and a post-replacement consumption of 909. Assuming a typical hot water consumption at 225 therms (using defaults from http://energy.gov/eere/femp/energy-cost-calculator-electric-and-gas-water-heaters-0#output), this indicates a heating load of 684-784 therms.

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Weather Basis (City based upon)	Gas_Heating_ Consumption (Therms)
St Louis, MO	680

Other variables as provided above.

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE:

3.4.6 HVAC Tune-Up (Central Air Conditioning or Air Source Heat Pump)

DESCRIPTION

This measure involves the measurement of refrigerant charge levels and airflow over the central air conditioning or heat pump unit coil, correction of any problems found, and post-treatment re-measurement. Tune-up activities include a general tune-up, refrigerant charge, indoor coil cleaning, and outdoor coil cleaning. These tune-up actions may be performed individually or as a packaged service with more than one tune-up activity.

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

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

DEFINITION OF EFFICIENT EQUIPMENT

A tuned and commissioned residential central air conditioning unit or air source heat pump.

DEFINITION OF BASELINE EQUIPMENT

An existing residential central air conditioning unit or air source heat pump that has required tuning to restore optimal performance.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure life is assumed to be 2 years.[451]

DEEMED MEASURE COST

As a RF measure, actual costs should be used. If unavailable, the measure cost should be assumed to be $175.[452] The table below identifies more specific costs for varying services.

Tune- up Service for HP or AC	Incremental Cost ($)	
~~General Tune-Up (no charge or coil clean)~~	~~$70.00~~	
Tune-up / refrigerant charge	$81.00	~~$175.00~~
~~Tune-up / Indoor Coil (Evaporator) Cleaning~~	~~$63.00~~	
~~Tune-up / Outdoor Coil (Condenser) Cleaning~~	~~$31.00~~	
Tune-Up / Packaged Service	$185[453]	

LOADSHAPE

Cooling RES

Heating RES

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$\Delta kWh_{Central\ AC} = ((EFLH_{cool} * Capacity_{cool} * (1/SEER_{test\text{-}in} – 1/SEER_{test\text{-}out})) / 1,000)$

$\Delta kWh_{ASHP} = ((EFLH_{cool} * Capacity_{cool} * (1/SEER_{test\text{-}in} – 1/SEER_{test\text{-}out})) / 1,000) + ((EFLH_{heat} * Capacity_{heat} * (1/HSPF_{test\text{-}in} – 1/HSFP_{test\text{-}out})) / 1,000)$

~~$\Delta kWh_{Central\ AC} = ((EFLH_{cool} * Capacity_{cool} * (1/SEER_{test-in} - 1/SEER_{test-out})) / 1,000)$~~

~~$\Delta kWh_{ASHP} = ((EFLH_{cool} * Capacity_{cool} * (1/SEER_{test-in} - 1/SEER_{test-out})) / 1,000) + ((EFLH_{heat} * Capacity_{heat} * (1/HSPF_{test-in} - 1/HSFP_{test-out})) / 1,000)$~~

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[451] Sourced from DEER Database Technology and Measure Cost Data.

[452] Based on personal communication with HVAC efficiency program consultant Buck Taylor of Roltay Inc., 6/21/10, who estimated the cost of tune up at $125 to $225, depending on the market and the implementation details.

[453] Estimated average packaged tune-up cost based on implementer data from 2015-2016.

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Where:

$EFLH_{cool}$ = Equivalent full load hours of air conditioning
= dependent on location:[454]

$Capacity_{cool}$ = Cooling Capacity of Air Source Heat Pump (Btu/hr)
= Actual ~~(1 ton = 12,000Btu/hr)~~

$SEER_{test-in}$ = Seasonal Energy Efficiency Ratio of existing cooling system before tuning (kBtu/kWh)
= In most instances, test-in EER will be determined and noted prior to tuning. SEER rating can be estimated by using the following relationship:[455] $EER = (-0.02 * SEER^2) + (1.12 * SEER)$
When unknown,[456] assume SEER = 11.9

$SEER_{test-out}$ = Seasonal Energy Efficiency Ratio of existing cooling system after tuning (kBtu/kWh)
= In most instances, test-out EER will be determined and noted after tuning. SEER rating can be estimated by using the following relationship:[457] $EER = (-0.02 * SEER^2) + (1.12 * SEER)$; if unknown, reference applicable assumed value in table below.

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$EFLH_{heat}$ = Equivalent full load hours of heating:

$Capacity_{heat}$ = Heating Capacity of Air Source Heat Pump (Btu/hr)
= Actual ~~(1 ton = 12,000Btu/hr)~~

$HSPF_{test-in}$ = Heating Seasonal Performance Factor of existing ASHP before tuning (kBtu/kWh)
= Actual, or if unknown, ~~Use actual HSPF rating where it is possible to measure or reasonably estimate. If not available,~~ assume HSPF = 6.3.[458]

$HSPF_{test-out}$ = Heating System Performance Factor of existing ASHP after tuning (kBtu/kWh)
= Actual, or if unknown, reference applicable assumed value in table below~~Use actual HSPF rating where it is possible to measure or reasonably estimate~~.

Weather Basis (Ameren Missouri Average)	$EFLH_{cool}$ (Hours)	$EFLH_{heat}$ (Hours)
SF or MF	869[459]	1496[460]
~~MFc (comprehensive envelope)~~	~~632[461]~~	~~510[462]~~

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When SEER test-in and test-out values are unknown, tune-ups are assumed to improve efficiency as follows:

Measure	% Improvement	$SEER_{test-out}$ (based on default 11.9 test-in value)

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[454] PY2019 Residential Evaluation Report Appendices, https://www.efis.psc.mo.gov/Document/Display/15876, page 35. ~~Based on Full Load Hour assumptions (for St Louis and Kansas City) taken from the ENERGY STAR® calculator (http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_CAC.xls) and reduced by 28.5% based on the evaluation results in Ameren territory suggesting an appropriate EFLH of 869.The other weather basis values are calculated using the relative climate normals cooling degree day ratios (at 65F set point).~~

Field Code Changed

[455] 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.

[456] Using aforementioned relationship and test-in efficiency of 10.5 EER, as listed in "Ameren Missouri Heating and Cooling Program Impact and Process Evaluation: Program Year 2015~~.~~" https://www.efis.psc.mo.gov/Document/Display/13806, page 43.

[457] 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.

[458] Based on evaluation results outlined in "Ameren Missouri Heating and Cooling Program Impact and Process Evaluation: Program Year 2015.", https://www.efis.psc.mo.gov/Document/Display/13806

[459] ~~Based on Full Load Hour assumptions (for St Louis and Kansas City) taken from the ENERGY STAR® calculator (http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_CAC.xls) and reduced by 28.5% based on the evaluation results in Ameren Missouri' service territory, suggesting an appropriate EFLH of 869.The other weather basis values are calculated using the relative climate normals cooling degree day ratios (at 65F set point)~~. PY2019 Evaluation Report Appendices, https://www.efis.psc.mo.gov/Document/Display/15876, page 76.

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[460] Evaluation - Opinion Dynamics review PY2019. The recommended values are constructed based on weather conditions (heating degree days and cooling degree days) in select Missouri cities (St. Louis, Cape Girardeau, Kansas City), weighted by partial year 2019 installations, https://www.efis.psc.mo.gov/Document/Display/15876, page 76.

~~[461] Evaluation - Opinion Dynamics review PY2019. The recommended values are constructed based on weather conditions (heating degree days and cooling degree days) in select Missouri cities (St. Louis, Cape Girardeau, Kansas City), weighted by partial year 2019 installations.~~

~~[462] Ibid.~~

Refrigerant charge adjustment	~~22.0%~~28.4%[463]	15.3
~~Condenser Cleaning Only~~	~~7.9%[464]~~	~~12.8~~
~~Indoor coil cleaning~~	~~3.8%[465]~~	~~12.4~~
~~General tune-up~~	~~5.6%[466]~~	~~12.6~~
Packaged Service	13.6%[467]	13.8

When HSPF test-out values are unknown, use the following default test-out values based on the tune-up service(s) performed:

Measure	$HSPF_{test-out}$ (based on default 6.3 test-in value)
Refrigerant charge adjustment	6.72
~~Condenser Cleaning Only~~	~~6.42~~
~~Indoor coil cleaning~~	~~6.36~~
~~General tune-up~~	~~6.38~~
Packaged Service	7.29[468]

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$\Delta kW = \Delta kWh_{Cooling} * CF$

Where:

$\Delta kWh_{Cooling}$ = Electric energy savings for cooling, calculated above
CF = 0.0009474181

~~$\Delta kW = \Delta kWh_{cooling} * CF$~~

~~Where:~~

~~CF = 0.0009474181~~

NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE:

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[463] Ameren Missouri PY2015 Evaluation, page 42, https://www.efis.psc.mo.gov/Document/Display/13806.
~~[464] Ibid.~~
~~[465] Ibid.~~
~~[466] MO TRM, page 114, https://dnr.mo.gov/document-search/missouri-technical-reference-manual-2017-volume-3-residential-measures.~~
[467] Average percentage improvement across 74 packaged service tune-up measures in the Ameren Missouri PY2019 Low Income Multifamily program.
[468] Average percentage improvement across 74 packaged service tune-up measures in the Ameren Missouri PY2019 Low Income Multifamily program.

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3.4.7 Blower Motor

DESCRIPTION

This measure describes savings from a brushless permanent magnet (BPM) motor (known and referred in this measure as an electronically commutated motor (ECM)) compared to a lower efficiency motor. Time of Sale and New Construction replacement scenarios no longer apply to this measure, as federal standards make ECM blower fan motors a requirement for residential furnaces. Savings however are available from retrofitting an ECM motor into an existing furnace, or replacing an operational inefficient furnace with a new furnace with an ECM prior to the end of its life.

This measure characterizes the electric savings associated with the fan and the interactive negative therm savings due to a reduction in waste heat of the fan when operating in heating mode.

Savings decrease sharply with static pressure so duct improvements, and clean, low pressure drop filters can maximize savings. Savings occur when the blower is used for heating, cooling as well as when it is used for continuous ventilation, but only if the non-ECM motor would have been used for continuous ventilation too. If the resident runs the ECM blower continuously because it is a more efficient motor and would not run a non-ECM motor that way, savings are near zero and possibly negative. This characterization uses a 2009 Focus on Energy study of BPM blower motor savings in Wisconsin, which accounted for the effects of this behavioral impact.

Retrofitting an existing blower motor with a new ECM reduces the potential impact of the high efficiency motor over a new system designed for an ECM blower motor because existing systems were not designed to capitalize and take advantage of the ECM's multi-staging features. Energy and demand savings are limited to the efficiency gains from the motor itself.

Note: as part of a Time of Sale measure, it is not appropriate to claim additional ECM fan savings due to installing a new furnace or CAC unit as ECM motors are now baseline for new furnaces and the SEER2/EER2 ratings of a CAC unit already account for this electrical load.

In an early replacement furnace situation, ECM fan heating savings can be claimed for the RUL of the existing furnace, and cooling savings can be claimed for the RUL of the CAC if an existing cooling unit is not replaced.

If a new CAC unit is installed in a home where the existing furnace is not replaced, heating ECM savings should only be claimed if it can be demonstrated that the new CAC motor will be used for the heating load.

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

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

~~A new furnace with a brushless permanent magnet (BPM) blower motor is installed instead of a new furnace with a lower efficiency motor. This measure characterizes only the electric savings associated with the fan and could be coupled with gas savings associated with a more efficient furnace. Savings decrease sharply with static pressure so duct improvements, and clean, low pressure drop filters can maximize savings. Savings improve when the blower is used for cooling as well and when it is used for continuous ventilation, but only if the non-BPM motor would have been used for continuous ventilation too. If the resident runs the BPM blower continuously because it is a more efficient motor and would not run a non-BPM motor that way, savings are near zero and possibly negative. This characterization uses a 2009 Focus on Energy study of BPM blower motor savings in Wisconsin, which accounted for the effects of this behavioral impact.~~

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

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

DEFINITION OF EFFICIENT EQUIPMENT

A furnace with a brushless permanent magnet (BPM) blower motor, also known by the trademark ECM, BLDC, and other names.

DEFINITION OF BASELINE EQUIPMENT

A furnace with a non-BPM blower motor. As part of the Code of Federal Regulations, energy conservation standards for covered residential furnace fans became effective on July 3, 2019 (10 CFR 430.32(y)). This code requirement effectively makes ECMs part of the baseline for New Construction (NC), Replace-on-Fail (ROF), Time-of-Replacement (TOS), and Early Replacement (EREP) scenarios.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 6 years, which is the remaining life of existing furnaces~~The expected measure life is assumed to be 20 years~~.[469]

DEEMED MEASURE COST

The capital cost for this measure as a retrofit should be actual if known; if unknown, assume $350.[470] In cases of furnace early replacements, it is assumed the incremental cost of the ECM is $0.~~The capital cost for this measure is assumed to be:~~

~~Incremental Cost ($)~~	
~~$74.33~~[471]	~~Time of Sale~~
~~$475~~[472]	~~Early Replacement~~

LOADSHAPE

HVAC RES

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$\Delta kWh_{Heating\ Mode}$ = (1 - %_with_New_ASHP) * (400 kWh/year * HeatingEFLH / WisconsinHeatingEFLH) * HF * ISR
$\Delta kWh_{Cooling\ Mode}$ = (1 - %_with_New_Central_Cooling) * (70 kWh/year * CoolingEFLH / WisconsinCoolingEFLH) * HF * ISR
$\Delta kWh_{Auto\ Circulation}$ = (25 kWh/year * CoolingEFLH / WisconsinCoolingEFLH + 2,960 kWh/year * RT% - 30 kWh/year) * HF * ISR
~~$\Delta kWh_{Continous\ Circulation}$ = (25 kWh/year * CoolingEFLH / WisconsinCoolingEFLH + 2,960 kWh/year * RT% - 30 kWh/year) * HF * ISR~~

~~$\Delta kWh_{Heating\ Mode} = (1 - \%\ with\ New\ ASHP) \times \left(400\frac{kWh}{year} \times \frac{Heating\ EFLH}{Wisconsin\ Heating\ EFLH}\right) * HF * ISR$~~

~~$\Delta kWh_{Cooling\ Mode} = (1 - \%\ with\ New\ Central\ Cooling) \times \left(70\frac{kWh}{year} \times \frac{Cooling\ EFLH}{Wisconsin\ CoolingEFLH}\right) * HF * ISR$~~

~~$\Delta kWh_{Auto\ Circulation} = \left(25\frac{kWh}{year} \times \frac{CoolingEFLH}{Wisconsin\ CoolingEFLH} + 2960\frac{kWh}{year} \times RT\% - 30\frac{kWh}{year}\right) * HF * ISR$~~

~~$\Delta kWh_{Continous\ Circulation} = \left(25\frac{kWh}{year} \times \frac{CoolingEFLH}{Wisconsin\ CoolingEFLH} + 2960\frac{kWh}{year} \times RT\% - 30\frac{kWh}{year}\right) * HF * ISR$~~

Where:

Parameter	Value
Wisconsin Cooling Savings kWh/year	70.00[473]
Cooling Savings All Systems	25.00[474]
Wisconsin Cooling EFLH	542.50[475]
Wisconsin Heating Savings kWh/year	400.00[476]
Wisconsin Heating EFLH	2,545.25[477]

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[469] Illinois TRM Version 12.0, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_3_Res_09222023_FINAL_clean.pdf, page 150~~Consistent with assumed life of a new gas furnace. Table 8.3.3 The technical support documents for federal residential appliance standards: http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/fb_fr_tsd/chapter_8.pdf~~.

[470] Ibid., p. 151. The cost of a typical replacement motor is estimated at $180 based on quotes from online suppliers, plus $17 for the bracket. Typical labor costs are estimated at between $140 and $190 based on program experience provided by Staples in April 2022. A total retrofit measure cost is therefore estimated at $350.

~~[471] Adapted from Tables 8.2.3 and 8.2.13 in http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/hvac_ch_08_lcc_2011-06-24.pdf.~~

~~[472] Minnesota TRM, https://www.energy.gov/sites/prod/files/2014/02/f7/case_study_variablespeed_furnacemotor.pdf.~~

[473] Ameren Missouri HVAC Program Evaluation PY2017, page 41, https://www.efis.psc.mo.gov/Document/Display/14208

[474] Ibid.

[475] Ibid.

[476] Ibid.

[477] Ibid.

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Parameter	Value
Wisconsin Circulation Savings kWh/year	2,960.00[478]
RT=Percent additional run time factor	8.81%[479]
Standby losses	30[480]
Saint Louis Heating EFLH	2,009.00[481]
Saint Louis Cooling EFLH	1,215.00[482]
% with New Central Cooling	82%[483]
% with New ASHP	~~10~~16%[484]
ISR	Actual, or if unknown, assume 100%[485]
HF	100%[486]

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$\Delta kW = \Delta kWh * CF$

Where:

ΔkWh = Electric energy savings, as calculated above
CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor
= 0.0004660805
~~CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor~~
~~= 0.0004660805~~

NATURAL GAS SAVINGS

$\Delta therms^{487} = - \text{Heating Savings} * 0.03412 / AFUE$

Where:

0.03412 = Converts kWh to therms
AFUE = Efficiency of the Furnace
= Actual. If unknown assume 95%[488] if in new furnace or 64.4 AFUE%[489] if in existing furnace

Using defaults:

For new Furnace = - (430 * 0.03412) / 0.95
= - 15.4 therms
For existing Furnace = - (430 * 0.03412) / 0.644
= - 22.8 therms

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[478] Ibid.
[479] Ameren Missouri HVAC Program Evaluation PY2019, page 39, https://www.efis.psc.mo.gov/Document/Display/15876.
[480] Ameren Missouri HVAC Program Evaluation PY2017, page 41, https://www.efis.psc.mo.gov/Document/Display/14208
[481] Ibid.
[482] Ibid.
[483] Ameren Missouri HVAC Program Evaluation PY2019, https://www.efis.psc.mo.gov/Document/Display/15877, page 90.
[484] Ibid.
[485] Ameren Missouri HVAC Program Evaluation PY2020, https://www.efis.psc.mo.gov/Document/Display/13831, page 53.
[486] Household Factor (HF) is assumed to be 100%. 65% multifamily value is not applicable for this measure, as savings should be based upon pressure drop in the system.
[487] The blower fan is in the heating duct so all, or very nearly all, of its waste heat is delivered to the conditioned space. Negative value since this measure will increase the heating load due to reduced waste heat.
[488] Minimum efficiency rating from ENERGY STAR® Furnace Specification v4.0, effective February 1, 2013, https://www.energystar.gov/sites/default/files/specs/private/Final_Version_4.0_Specification.pdf~~,~~; ‘Final_Version_4.0_Specification.pdf’, page 2.
[489] Average nameplate efficiencies of all early replacement qualifying equipment in Ameren IL PY2003-PY2004.

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WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE:

3.4.8 Central Air Conditioner

DESCRIPTION

This measure characterizes:

1. TOS: The installation of a new residential sized (<= 65,000 Btu/hr) central air conditioning ducted split system meeting ENERGY STAR® efficiency standards presented below. This could relate to the replacement of an existing unit at the end of its useful life, or the installation of a new system in a new home.
2. EREP: For the early replacement baseline to apply, program participants or installation contractors must provide documentation asserting that the existing units operated when turned on—whether or not they provided cooling—and the existing unit brand name and model number must be documented; or, if the nameplate is not readable, a photograph of the unit in context and the nameplate specifically must be provided.~~Early Replacement determination will be defined by program requirements.~~ All other conditions will be considered TOS. The baseline SEER2 of the existing central air conditioning unit replaced: If the SEER2 of the existing unit is known and, the baseline SEER2 is the actual SEER2 value of the unit replaced. If the SEER2 of the existing unit is unknown, use assumptions in variable list below (SEER2_exist).

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

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

DEFINITION OF EFFICIENT EQUIPMENT

In order for this characterization to apply, the efficient equipment is assumed to be a ducted split central air conditioning unit meeting the minimum ENERGY STAR® efficiency level standards~~; 15 SEER and 12 EER~~. For reference, the minimum ENERGY STAR® version 6.1 efficiency level standards are provided below[490]:

- Split system central air conditioners – 15.2 SEER2 and 12.0 EER2
- Single package central air conditioners – 15.2 SEER2 and 11.5 EER2
- Space constrained units – 13.4 SEER2[491]

The measure characterization recommends sourcing the efficiency specifications from the actually installed equipment. If those values are not known, the default equipment efficiency recommendations are conservatively based on ENERGY STAR® version 6.1 specifications.

DEFINITION OF BASELINE EQUIPMENT

~~New federal standards affecting testing protocols for central air conditioners became effective January 1, 2023, but did not affect the standard efficiency of central air conditioners.~~ The baseline for the TOS measure is based on the current federal standard efficiency level[492]: ~~14 SEER (13.4 SEER2) and 11 EER (10.6 EER2).~~

- Standard sized Split system air conditioners – 13.4 SEER2
- Standard sized Single-package air conditioners – 13.4 SEER2
- Space constrained air conditioners – 11.7 SEER2

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[490] ENERGY STAR Program Requirements Product Specification for Central Air Conditioner and Heat Pump Equipment, v6.1, effective January 1, 2023, https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Version%206.1%20Central%20Air%20Conditioner%20and%20Heat%20Pump%20Final%20Specification%20%28Rev.%20January%20%202022%29.pdf; 'ENERGY STAR Version 6.1 Central Air Conditioner and Heat Pump Final Specification (Rev. January 2022).pdf', are in terms of an updated metric, depicted as SEER2 and EER2. The updated test method as well as the updated ENERGY STAR specifications mimic the updated federal appliance standards. An equivalent stringency of these new standards for split system air conditioners are 16 SEER and 13 EER and for single-package air conditioners are 16 SEER and EER 12, as detailed in: Consortium for Energy Efficiency (CEE) Residential HVAC Specifications, Estimated Appendix M1 Equivalents, January 15 2021.

[491] The ENERGY STAR specification does not provide an efficiency level for space constrained products but this is a proposed level for this product type that the marketplace has developed solutions to meet.

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

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Under the new federal standards, the M1 testing protocol was revised, resulting in a new SEER performance metric called SEER2. When quantifying energy savings, the SEER2 metric should be used for the existing, baseline, and new equipment~~When quantifying energy savings, the same metric should be used for the existing, baseline, and new equipment~~. The following conversion formula can be used to convert between efficiency metrics:

SEER2 = SEER ~~x~~ * 0.96

The baseline for the early replacement measure is the efficiency of the existing equipment for the assumed remaining useful life of the unit and the new baseline as defined above[493] for the remainder of the measure life.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 18 years.[494]

Remaining life of existing equipment is assumed to be 6 years.[495]

DEEMED MEASURE COST

Time of sale: The incremental capital cost for this measure is dependent on efficiency. Assumed incremental costs are provided below:[496]

Efficiency Level (SEER2)	Incremental Cost
13.9	$111
14.4	$230
14.9	$453
15.4	$635
16.3	$861
16.8	$891
17.3	$921
19.2	$1,006
21.1	$1,120
22.4	$1,240
13.9	$111
14.4	$230
14.9	$453
15.4	$635

Early replacement: The full install cost for this measure is the actual cost of removing the existing unit and installing the new one. If this is unknown, assume defaults below.[497]

Efficiency Level (SEER2)	Full Retrofit Cost
13.9	$3,450
14.4	$3,569
14.9	$3,791
15.4	$3,973
16.3	$4,200
16.8	$4,229

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[493] Baseline SEER and EER should be updated when new minimum federal standards become effective.

[494] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, https://energizect.com/sites/default/files/documents/Measure%20Life%20Report%202007.pdf; 'Measure Life Report 2007.pdf'.~~Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007, https://energizect.com/sites/default/files/documents/Measure%20Life%20Report%202007.pdf.~~

~~http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf.~~

~~The "lifespan" of a central air conditioner is about 15 to 20 years (US DOE: http://www.energysavers.gov/your_home/space_heating_cooling/index.cfm/mytopic=12440).~~

[495] Assumed to be one third of effective useful life.

[496] See 'CAC Costs 09.02.2024.xlsx'.

[497] Ibid.

Efficiency Level (SEER2)	Full Retrofit Cost
17.3	$4,259
19.2	$4,345
21.1	$4,458
22.4	$4,579
13.9	$3,450
14.4	$3,569
14.9	$3,791
15.4	$3,973

Assumed deferred cost (after 6 years) of replacing existing equipment with new baseline unit is assumed to be $3,670.[498] This future cost should be discounted to present value using a 2.31% nominal societal discount rate, based on the ten year average (1/1/2014 – 12/31/2023) of the 10 year Treasury bond yield rates. [499]~~TOS: The incremental capital cost for this measure is dependent on efficiency. Assumed incremental costs are provided below:~~

~~Early replacement: The full install cost for this measure is the actual cost of removing the existing unit and installing the new one. If this is unknown, assume the following:~~

~~Efficiency Level~~	~~ROF Cost ($)~~	~~*Early Replacement Cost~~ [500]	~~Source~~
~~SEER 14~~	~~$0.00~~	~~$447.06~~	~~IL-TRM v8.0~~
~~SEER 15~~	~~$108~~	~~$555.06~~	~~IL-TRM v8.0~~
~~SEER 16~~	~~$221~~	~~$668.06~~	~~IL-TRM v8.0~~
~~SEER 17~~	~~$620.00~~	~~$1,067.06~~	~~IL-TRM v8.0~~
~~SEER 18~~	~~$826.67~~	~~$1,273.73~~	~~Derived using IL-TRM ($/unit) and the percentage change in Mid-Atlantic TRM V9 (NEEP)($/ton)~~
~~SEER 19~~	~~$1,033.33~~	~~$1,480.39~~	
~~SEER 20~~	~~$1,240.00~~	~~$1,687.06~~	
~~SEER 21~~	~~$1,446.67~~	~~$1,893.73~~	
~~Average~~	~~$686.96~~	~~$1,134.02~~	
~~*Hypothetical values calculated based on a 3 ton system.~~ ~~Actual values based on system size and SEER combinations.~~			

~~Assumed deferred cost (after 6 years) of replacing existing equipment with new baseline unit is assumed to be $3,217.~~[501] ~~This cost is based on a 3 ton unit and should be discounted to present value using the utilities' discount rate.~~

LOADSHAPE

Cooling RES

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

Time of sale:

$\Delta kWh = ((FLH_{cool} * Capacity * (1/SEER2_{base} - 1/SEER2_{ee}))/1,000) * HF * ISR$

~~$\Delta kWh = ((FLH_{cool} * Capacity * (1/SEER_{base} - 1/SEER_{ee}))/1,000) * HF * ISR$~~

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[498] Ibid.

[499] 'Societal_Discount_Rate_Calculation_08082024.xlsx'.

[500] ~~These values are calculated in the deemed tables based on the unit size and SEER combination.~~

[501] ~~Based on 3 ton initial cost estimate for a conventional unit from ENERGY STAR® central AC calculator, $2,857, and applying inflation rate of 2.0% (https://dnr.mo.gov/sites/dnr/files/media/file/2021/01/energy-star-assumptions-for-central-air-conditioners-calculator.xlshttp://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_CAC.xls). While baselines are likely to shift in the future, there is currently no good indication of what the cost of a new baseline unit will be in 6 years. In the absence of this information, assuming a constant federal baseline cost is within the range of error for this prescriptive measure.~~

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Early replacement:[502]

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

$=((FLH_{cool} * Capacity * (1/SEER2_{exist} - 1/SEER2_{ee}))/1,000) * HF * ISR$ ~~$= ((FLH_{cool} * Capacity * (1/SEER_{exist} - 1/SEER_{ee}))/1,000) * HF * ISR$~~

ΔkWh for remaining measure life (next 12 years):

$= ((FLH_{cool} * Capacity * (1/SEER2_{base} - 1/SEER2_{ee}))/1,000) * HF * ISR$

~~$= ((FLH_{cool} * Capacity * (1/SEER_{base} - 1/SEER_{ee}))/1,000) * HF * ISR$~~

Where:

FLH_{cool} = Full load cooling hours:[503]

Weather Basis (Ameren Missouri Average)	EFLHcool (Hours)
SF or MF	869
~~MFc (comprehensive envelope)~~	~~632~~[504]

Capacity = Size of new equipment in Btu/hr (note 1 ton = 12,000Btu/hr)
= Actual installed, or if actual size unknown 33,600Btu/hr for single-family buildings[505]

$SEER2_{base}$ = Seasonal Energy Efficiency Ratio of baseline unit (kBtu/kWh)[506]
= ~~14 or~~ 13.4 SEER2 for standard sized units or 11.7 SEER2 for space constrained units~~13.4 SEER2~~[507]

$SEER2_{exist}$ = Seasonal Energy Efficiency Ratio of existing unit (kBtu/kWh)
= Use actual SEER2 rating where it is possible to measure or reasonably estimate. If using rated efficiencies, derate the efficiency value based on the age of the existing equipment (up to a maximum of 30 years) to account for degradation over time.[508] If age is unknown, use 12 years~~Use actual SEER rating where it is possible to measure or reasonably estimate. If using rated efficiencies, derate the efficiency value based on the age of the existing equipment (up to a maximum of 30 years) to account for degradation over time.[509] If age is unknown, use 12 years~~.
= $SEER2 * (1-0.01)^{Age}$ ~~$SEER * (1-1.44\%)^{Age}$~~
If unknown, assume 8.9~~10.0~~.[510], which is already adjusted to account for age-related degradation.

$SEER2_{ee}$ = Seasonal Energy Efficiency Ratio of ENERGY STAR® unit (kBtu/kWh)

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[502] 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).

[503] ~~Based on Full Load Hour assumptions (for St Louis and Kansas City) taken from the ENERGY STAR® calculator (http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_CAC.xls) and reduced by 28.5% based on the evaluation results in Ameren territory suggesting an appropriate EFLH of 869.The other weather basis values are calculated using the relative climate normals cooling degree day ratios (at 65F set point).~~ Evaluation - Opinion Dynamics review PY2019. https://www.efis.psc.mo.gov/Document/Display/15876, page 30.

[504] ~~Evaluation – Opinion Dynamics review PY2019. The recommended values are constructed based on weather conditions (heating degree days and cooling degree days) in select Missouri cities (St. Louis, Cape Girardeau, Kansas City), weighted by partial year 2019 installations.~~

[505] Actual unit size required for multifamily building, no size assumption provided because the unit size and resulting savings can vary greatly depending on the number of units.

[506] SEER to SEER2 conversion factor: SEER2 = SEER * ~~x~~ 96%. Conversion factor for SEER to SEER2 is used when converting an existing system that is rated in SEER to SEER2. This is to meet the DOE M1 CFR Standard beginning January 1, 2023. The efficiency levels of the existing, baseline, and efficient case must be expressed in SEER2 terms before applying formulas. ~~The efficiency levels of the existing, baseline, and efficient case must be expressed in the same metrics (e.g., both SEER or both SEER2) before applying formulas.~~

[507] Based on minimum federal standard effective 1/1/2023: 10 CFR 430.32(c)(5)

[508] Illinois TRM Version 12.0, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_3_Res_09222023_FINAL_clean.pdf, page 112. Justification for degradation factors can be found on page 14 of 'AIC HVAC Metering Study Memo FINAL 2_28_2018.docx'. Estimate efficiency as (Rated Efficiency * (1-0.01)^Equipment Age).

[509] ~~Based on IL TRM V8.0, which bases justification for degradation factors on page 21 of 'AIC HVAC Metering Study Memo FINAL 2_28_2018'. Default of 12 years based on the remaining measure life of the equipment.~~

[510] Illinois TRM Version 12.0, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_3_Res_09222023_FINAL_clean.pdf, page 130~~Estimate based on Department of Energy standard between 1992 and 2006. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area, then that should be used~~.

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= Actual installed or ~~14.5~~15.2 if unknown.

HF = For Multifamily units, use a factor of 65% to convert residential single family to multifamily capacity. If actual capacity is used apply 100%.

ISR = In service rate

= Actual, or if unknown, assume 100%[511]

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$\Delta kW = \Delta kWh * CF$

Where:

ΔkWh = Electric energy savings, as calculated above

CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor

= 0.0009474181

~~CF = 0.0009474181~~

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NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE:

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[511] Ameren Missouri HVAC Evaluation: PY2020, https://www.efis.psc.mo.gov/Document/Display/13831, page 53.

3.4.9 Filter Cleaning or Replacement and Dirty Filter Alarms

DESCRIPTION

An air filter on a central forced air heating system is replaced prior to the end of its useful life with a new filter, resulting in a lower pressure drop across the filter. As filters age, the pressure drop across them increases as filtered medium accumulates. Replacing filters before they reach the point of becoming ineffective can save energy by reducing the pressure drop required by filtration, subsequently reducing the load on the blower motor.

This measure was developed to be applicable to the following program type: RET.

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

DEFINITION OF EFFICIENT EQUIPMENT

A new filter offering a lower pressure drop across the filter medium compared to the existing filter.

DEFINITION OF BASELINE EQUIPMENT

A filter that is nearing the end of its effective useful life, defined by having a pressure drop twice that of its original state.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 1 year[512] for a filter replacement and 5 years[513]~~14 years~~ for a dirty filter alarm.

DEEMED MEASURE COST

Actual material and labor cost should be used if known, since there is a wide range of filter types and costs. If unknown,[514] the cost of a fiberglass filter is assumed to be $7.33 and the cost of a pleated filter is assumed to be $15.66. If unknown, the cost of a dirty filter alarm is assumed to be $5.

LOADSHAPE

HVAC RES

Algorithm

CALCULATION OF SAVINGS

Electric energy savings are calculated by estimating the difference in power requirements to move air through the existing and new filter and multiplying by the anticipated operating hours of the blower during the heating season.

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = kWh_{heating} + kWh_{cooling}$$

$$kWh_{heating} = \%Heating * kW_{motor} * EFLH_{heat} * EI * (1 - Leakage) * ISR$$

$$kWh_{cooling} = \%AC * kW_{motor} * EFLH_{cool} * EI * (1 - Leakage) * ISR$$

~~$\Delta kWh = kWh_{heating} + kWh_{cooling}$~~

~~$kWh_{heating} = \%Heating * kW_{motor} * EFLH_{heat} * EI * Utility\ Adjustment * ISR$~~

~~$kWh_{cooling} = \%AC * kW_{motor} * EFLH_{cool} * EI * Utility\ Adjustment * ISR$~~

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[512] Many manufacturers suggest replacing filters more often than an annual basis, however this measure assumes that a filter will generally last one full heating season before it needs replacement.

[513] CPUC Support Tables: Effective Useful Life and Remaining Useful Life. Air Filter Alarm. Accessed on June 11, 2024. https://www.caetrm.com/cpuc/table/effusefullife/

[514] Assumes an average price of $1.08 for fiberglass and $9.41 for pleated, plus $6.25 in labor (based on 15 minutes, including portion of travel time, and $25 per hour, which is in line with the typical prevailing wage of a General Laborer, as per Annual Wage Order No. 23 documents published by the Missouri Department of Labor). Average filter costs sourced from "Air Filter Testing, Listing, and Labeling," Docket #12-AAER-2E prepared for the California Energy Commission, July 23, 2013.

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Where:

Factor	Term	School Value
%Heating	Fraction of participants with electric heating	Actual~~95.65%515~~
%AC	Fraction of participants with central cooling	Actual~~95.65%516~~
kW_{motor}	Average motor full load electric demand (kW) ~~– K- Kits~~	0.5[517]
	~~Average motor full load electric demand (kW) – MFLI~~	~~0.43~~
	~~Average motor full load electric demand (kW) – Other Programs~~	~~0.377[518]~~
$EFLH_{heat}$	Equivalent Full Load Hours (EFLH) Heating (hours/year) – SF or MF	1496[519]
	~~Equivalent Full Load Hours (EFLH) Heating (hours/year) - MFc (comprehensive envelope)~~	~~510[520]~~
$EFLH_{cool}$	Equivalent Full Load Hours (EFLH) Cooling (hours/year) - SF or MF	869[521]
	~~Equivalent Full Load Hours (EFLH) Cooling (hours/year) - MFc (comprehensive envelope)~~	~~632[522]~~
EI	Efficiency Improvement (%)	10~~5~~%[523]
Leakage	~~% Homes outside Service Territory – Kits~~	~~28%[524]~~
	% Homes outside Service Territory ~~– Other Programs~~	0~~28~~%~~[525]~~
ISR	~~In Service Rate – School Kits~~	~~Actual, or if unknown, assume 44%[526]~~
	~~In Service Rate – Appliance Recycling Program~~	~~Actual, or if unknown, assume 9%[527]~~
	In Service Rate ~~– MFIE Kits~~	Actual, or if unknown, assume 100%[528]
	~~In Service Rate – MFMR and Single Family Income-Eligible~~	~~Actual, or if unknown, assume 57.89%[529]~~
	~~In Service Rate – Other Programs~~	~~Actual~~

SUMMER COINCIDENT PEAK DEMAND SAVINGS

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

Where:

~~[515] Ameren Missouri Energy Efficient Kits Evaluation: PY2018.~~

~~[516] Ibid.~~

[517] Ameren Missouri EE Kits Evaluation PY2018, page 41, https://www.efis.psc.mo.gov/Document/Display/15870.

~~[518] Illinois TRM Version 12.0, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_3_Res_09222023_FINAL_clean.pdf, page 232. Typical blower motor capacity for gas furnace is ¼ to ¾ HP. Midpoint is ½ HP. ½ HP * 0.746 (kW/hp) = 0.377kW.~~

[519] Ameren Missouri EE Kits Evaluation PY2018, page 41, https://www.efis.psc.mo.gov/Document/Display/15870.

~~[520] Evaluation - Opinion Dynamics review PY2019. The recommended values are constructed based on weather conditions (heating degree days and cooling degree days) in select Missouri cities (St. Louis, Cape Girardeau, Kansas City), weighted by partial year 2019 installations.~~

[521] Ameren Missouri EE Kits Evaluation PY2018, page 41, https://www.efis.psc.mo.gov/Document/Display/15870.

~~[522] Evaluation - Opinion Dynamics review PY2019. The recommended values are constructed based on weather conditions (heating degree days and cooling degree days) in select Missouri cities (St. Louis, Cape Girardeau, Kansas City), weighted by partial year 2019 installations.~~

[523] Illinois TRM Version 12.0, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_3_Res_09222023_FINAL_clean.pdf, page 233. Based on Energy.gov website; "Maintaining Your Air Conditioner", which states that replacing a dirty air filter with a clean one can lower total air conditioner energy consumption by 5-15%. See https://www.energy.gov/energysaver/maintaining-your-air-conditioner; 'Maintaining Your Air Conditioner _ Department of Energy.pdf'.

~~[524] Ameren Missouri Energy Efficient Kits Evaluation: PY2019, https://www.efis.psc.mo.gov/Document/Display/15876, page 77.~~

~~[525] Ameren Missouri Energy Efficient Kits Evaluation: PY2019, https://www.efis.psc.mo.gov/Document/Display/15876, page 77.~~

~~[526] Ibid.~~

~~[527] Ameren Missouri Appliance Recycling Evaluation: PY2019, https://www.efis.psc.mo.gov/Document/Display/15876, page 95.~~

[528] Ameren Missouri EE Kits PY18 ~~Program Data~~Evaluation, https://www.efis.psc.mo.gov/Document/Display/15870, page 41.

~~[529] Ameren Missouri Community Savers Evaluation PY2018, https://www.efis.psc.mo.gov/Document/Display/36053, page 27.~~

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ΔkWh = Electric energy savings, as calculated above

CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor

= 0.0004660805

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~~ΔkWh = Energy Savings as calculated above~~

~~CF = 0.0004660805~~

NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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3.4.10 Packaged Terminal Air Conditioner (PTAC) and Packaged Terminal Heat Pump (PTHP)

DESCRIPTION

A PTAC is a packaged terminal air conditioner that cools and provides heat through an electric resistance heater (heat strip). A PTHP is a packaged terminal heat pump. A PTHP uses its compressor year-round to heat or cool. In warm weather, it efficiently captures heat from inside a space and pumps it outside for cooling. In cool weather, it captures heat from outdoor air and pumps it into a space, adding heat from electric heat strips as necessary to provide heat.

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

This measure characterizes:

1. TOS: the purchase and installation of a new efficient PTAC or PTHP.
2. EREP: For the early replacement baseline to apply, program participants or installation contractors must provide documentation asserting that the existing units operated when turned on—whether or not they provided cooling—and the existing unit brand name and model number must be documented; or, if the nameplate is not readable, a photograph of the unit in context and the nameplate specifically must be provided~~the early removal of an existing PTAC or PTHP from service, prior to its natural end of life, and replacement with a new efficient PTAC or PTHP unit~~. Savings are calculated between existing unit and efficient unit consumption during the remaining life of the existing unit, and between new baseline unit and efficient unit consumption for the remainder of the measure life. The measure is only valid for non-fuel switching installations – for example replacing a cooling only PTAC with a PTHP can currently not use the TRM.

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

DEFINITION OF EFFICIENT EQUIPMENT

In order for this characterization to apply, the efficient equipment is assumed to be PTACs or PTHPs that exceed baseline efficiencies.

DEFINITION OF BASELINE EQUIPMENT

TOS: the baseline condition is defined by the Code of Federal Regulations at 10 CFR 431.97(c), section §431.97.

EREP: the baseline is the existing PTAC or PTHP for the assumed remaining useful life of the unit and the new baseline as defined above for the remainder of the measure life.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 15 years.[530]

Remaining life of existing equipment is assumed to be 5 years.[531]

DEEMED MEASURE COST

TOS: The incremental capital cost for this equipment is estimated to be $84/ton.[532]

EREP: The measure cost is the full cost of removing the existing unit and installing a new one. The actual program cost should be used; if unknown, assume $1,047 per ton.[533]

The assumed deferred cost (after 5 years) of replacing existing equipment with new baseline unit is assumed to be $1,039 per ton.[534] This future cost should be discounted to present value using a 2.31% nominal societal discount rate, based on the ten year average (1/1/2014 – 12/31/2023) of the 10 year Treasury bond yield rates.[535] ~~This cost should be discounted to present value using the utilities' discount rate.~~

LOADSHAPE

Cooling RES
Heating RES

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[530] Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, Inc., June 2007, https://energizect.com/sites/default/files/documents/Measure%20Life%20Report%202007.pdf; 'Measure Life Report 2007.pdf', page 1-4.

[531] Standard assumption of one third of effective useful life.

[532] DEER 2008. This assumes that baseline shift from IECC 2012 to IECC 2015 carries the same incremental costs. Values should be verified during evaluation.

[533] Based on DCEO – IL PHA Efficient Living Program data.

[534] Based on subtracting TOS incremental cost from the DCEO data and incorporating inflation rate of 1.91%.

[535] 'Societal_Discount_Rate_Calculation_08082024.xlsx'.

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Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

Electric savings for PTACs and PTHPs should be calculated using the following algorithms

Time of sale:

$\Delta kWh = [((EFLH_{cool} * Capacity_{cool} * (1/SEER2_{base} - 1/SEER2_{ee})) / 1000) + ((EFLH_{heat} * Capacity_{heat} * (1/HSPF2_{base} - 1/HSFP2_{ee})) / 1{,}000)] * ISR$

~~$\Delta kWh = ((EFLH_{cool} * Capacity_{cool} * (1/SEER_{base} - 1/SEER_{ee})) / 1000) + ((EFLH_{heat} * Capacity_{heat} * (1/HSPF_{base} - 1/HSFP_{ee})) / 1000)$~~

Early replacement:[536]

ΔkWh for remaining life of existing unit:

$= [((EFLH_{cool} * Capacity_{cool} * (1/SEER2_{exist} - 1/SEER2_{ee})) / 1000) + ((EFLH_{heat} * Capacity_{heat} * (1/HSPF2_{exist} - 1/HSFP2_{ee})) / 1{,}000)] * ISR$

~~$= ((EFLH_{cool} * Capacity_{cool} * (1/SEER_{exist} - 1/SEER_{ee})) / 1000) + ((EFLH_{heat} * Capacity_{heat} * (1/HSPF_{exist} - 1/HSFP_{ee})) / 1000)$~~

ΔkWh for remaining measure life:

$=[((EFLH_{cool} * Capacity_{cool} * (1/SEER2_{base} - 1/SEER2_{ee})) / 1000) + ((EFLH_{heat} * Capacity_{heat} * (1/HSPF2_{base} - 1/HSFP2_{ee})) / 1{,}000)] * ISR$

~~$= ((EFLH_{cool} * Capacity_{cool} * (1/SEER_{base} - 1/SEER_{ee})) / 1000) + ((EFLH_{heat} * Capacity_{heat} * (1/HSPF_{base} - 1/HSFP_{ee})) / 1000)$~~

Where:

$Capacity_{heat}$ = Heating capacity of the unit in Btu/hr
= Actual

$EFLH_{heat}$ = Equivalent Full Load Hours for heating.
= Custom input if program or regional evaluation results are available, otherwise, per the following table:

Weather Basis (Ameren Missouri Average)	**$EFLH_{heat}$[537]**
SF or MF	1040
~~MFc (comprehensive envelope)~~	~~355~~

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[536] 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).

[537] Base values reported in *All-Electric Homes PY6 Metering Results: Multifamily HVAC Systems*, Cadmus, October 2015, Ameren. Illinois were adjusted to fit Missouri climate zones by a comparison of relative annual heating and cooling degree hours (base 65). See '3.4.8 EFLH 06022016.xlsx' for derivation. FLH values are based on metering of multifamily units that were used as the primary heating source to the whole home, and in buildings that had received weatherization improvements. A DMSHP installed in a single-family home may be used more sporadically, especially if the DMSHP serves only a room, and buildings that have not been weatherized may require longer hours. Additional evaluation is recommended to refine the EFLH assumptions for the general population.

~~Weather Basis (City based upon)~~	~~EFLH$_{heat}$[538]~~
~~St Louis~~	~~1,040~~

HSPF2$_{ee}$ = HSPF rating of new equipment ~~(kbtu/kwh)~~
= Actual installed

HSPF2$_{base}$ =Heating System Performance Factor of baseline unit (kBtu/kWh)

~~Equipment Type~~	~~HSPF$_{base}$ (manufacture date prior to 1/1/2017)~~	~~HSPF$_{base}$ (manufacture date on or after 1/1/2017)~~
~~PTHP (Heating mode) Standard Sized~~	~~3.7 – (0.052 x Capacity$_{cool}$/1000) x 3.41~~	
~~PTHP (Heating mode) Non-Standard Size~~	~~2.9 – (0.026 x Capacity$_{cool}$/1000) x 3.41~~	

Equipment Type	Unit Size	Federal Regulations Minimum Efficiency (HSPF)
PTHP (Heating mode)	Standard Sized	(3.7 – (0.052 * Capacity$_{heat}$ / 1,000)) * 3.41
PTHP (Heating mode)	Non-Standard Size*	(2.9 – (0.026 * Capacity$_{heat}$ / 1,000)) * 3.41

HSPF2$_{exist}$ = Actual HSPF rating of existing equipment ~~(kbtu/kwh)~~. If unknown, assume:

Existing Equipment Type	HSPF2$_{exist}$
Electric resistance heating (PTAC)	3.412[539]
PTHP	5.44[540]

Capacity$_{cool}$ = the cooling capacity of the ductless heat pump unit in Btu/hr.[541]
= Actual installed

SEER2$_{ee}$ = SEER rating of new equipment ~~(kbtu/kwh)~~
= Actual installed[542]

SEER2$_{base}$ = ~~Seasonal Energy Efficiency Ratio of~~SEER2 rating of the baseline unit (kBtu/kWh). When using the formulas in the table below, convert the baseline EER to SEER2 using the EER conversion formula.[543]

Equipment Type	Unit Size	Federal Regulations Minimum Efficiency (EER)
PTAC (Cooling mode)	Standard Sized	14.0 – (0.300 * Capacity$_{cool}$ / 1,000)
PTAC (Cooling mode)	Non-Standard Size*	10.9 – (0.213 * Capacity$_{cool}$ / 1,000)
PTHP (Cooling mode)	Standard Sized	14.0 – (0.300 * Capacity$_{cool}$ / 1,000)
PTHP (Cooling mode)	Non-Standard Size*	10.8 – (0.213 * Capacity$_{cool}$ / 1,000)

~~[538] Base values reported in *All-Electric Homes PY6 Metering Results: Multifamily HVAC Systems*, Cadmus, October 2015, Ameren. Illinois were adjusted to fit Missouri climate zones by a comparison of relative annual heating and cooling degree hours (base 65). See 3.4.8 EFLH 06022016.xlsx for derivation. FLH values are based on metering of multifamily units that were used as the primary heating source to the whole home, and in buildings that had received weatherization improvements. A DMSHP installed in a single-family home may be used more sporadically, especially if the DMSHP serves only a room, and buildings that have not been weatherized may require longer hours. Additional evaluation is recommended to refine the EFLH assumptions for the general population.~~

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

[540] This is estimated based on finding the average HSPF/SEER ratio from the AHRI directory data (using the least efficient models – SEER 12 and SEER 13) – 0.596 and applying to the average nameplate SEER rating of all early replacement qualifying equipment in Ameren PY2003-PY2004. This estimation methodology appears to provide a result within 10% of actual HSPF.

[541] 1 Ton = 12 kBtu/hr.

[542] ~~Note that i~~If only an EER2 rating is available, use the following conversion equation to estimate SEER2; SEER = (1.12 + (1.2544 - 0.08 * EER)$^{0.5}$) / 0.04. This is the observse of EER = (-0.02 * SEER^2) + (1.12 * SEER). ~~EER_base = (1.12 – √(1.2544 – 0.08 * EER)) / 0..~~ From Wassmer, M. (2003), "A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations," (Masters thesis), University of Colorado at Boulder.

[543] Ibid.

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~~Equipment Type~~	~~EER_{base} (manufacture date prior to 1/1/2017)~~	~~EER_{base} (manufacture date on or after 1/1/2017)~~
~~PTAC (Cooling mode) Standard Sized~~	~~13.8 – (0.3 x $Capacity_{cool}$/1000)~~	~~14.0 – (0.300 x $Capacity_{cool}$/1000)~~
~~PTAC (Cooling mode) Non-Standard Size~~	~~10.9 – (0.213 x $Capacity_{cool}$/1000)~~	
~~PTHP (Cooling mode) Standard Sized~~	~~14.0 – (0.300 x $Capacity_{cool}$/1000)~~	
~~PTHP (Cooling mode) Non-Standard Size~~	~~10.8 – (0.213 x $Capacity_{cool}$/1000)~~	

* Non-Standard Size apply only to units with existing sleeves less than 16 inches (406mm) in height and less than 42 inches (1067 mm) in width.

$SEER2_{exist}$ = Actual SEER rating of existing equipment ~~(kbtu/kwh)~~. If unknown, assume:

Existing Cooling System	$SEER2_{exist}$[544]
PTHP	~~7.2~~6.91
PTAC	6.~~8~~53

$EFLH_{cool}$ = Equivalent Full Load Hours for cooling.
= Custom input if program or regional evaluation results are available, otherwise, per the following table.[545]

Weather Basis (Ameren Missouri Average)~~Weather Basis (City based upon)~~	$EFLH_{cool}$
SF or MF~~St Louis~~	617
~~MFc (comprehensive envelope)~~	~~449~~

ISR = In-service rate. Actual, or if unknown, assume 100%[546]

SUMMER COINCIDENT PEAK DEMAND SAVINGS

Time of sale:

~~$\Delta kW = \Delta kWh_{cooling} * CF$~~

~~Where:~~

~~ΔkWh = Energy Savings as calculated above~~
~~CF = 0.0009474181~~

$\Delta kW = \Delta kWh_{Cooling} * CF$

Where:

$\Delta kWh_{Cooling}$ = Electric energy savings for cooling, calculated above

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[544] ASHP existing efficiency assumes degradation and is sourced from the Ameren Missouri Heating and Cooling Program Impact and Process Evaluation: Program Year 2015. CAC assumed to follow the same trend in degradation as the ASHP: 9.12 SEER nameplate to 7.2 (6.91 SEER2) operations SEER represents degradation to 78.9% of nameplate. 78.9% of 8.6 SEER CAC nameplate gives an operational SEER of 6.8 (6.53 SEER2)~~ASHP existing efficiency assumes degradation and is sourced from the Ameren Missouri Heating and Cooling Program Impact and Process Evaluation: Program Year 2015. CAC assumed to follow the same trend in degradation as the ASHP: 9.12 SEER nameplate to 7.2 operations SEER represents degradation to 78.9% of nameplate. 78.9% of 8.6 SEER CAC nameplate gives an operational SEER of 6.8~~.

[545] Evaluation - Opinion Dynamics review PY2019. The recommended values are constructed based on weather conditions (heating degree days and cooling degree days) in select Missouri cities (St. Louis, Cape Girardeau, Kansas City), weighted by partial year 2019 installations.

[546] Ameren Missouri HVAC Evaluation: PY2020, https://www.efis.psc.mo.gov/Document/Display/13831, page 53.

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CF = 0.0009474181

NATURAL GAS ENERGY SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE:

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3.4.11 Room Air Conditioner

DESCRIPTION

This measure relates to the purchase and installation of a room air conditioning unit that meets the ENERGY STAR® minimum qualifying efficiency specifications, in place of a baseline unit meeting minimum federal standard efficiency ratings presented below:[547]

~~Product Class (Btu/H)~~	~~Federal Standard CEERbase, with louvered sides, without reverse cycle[548]~~	~~Federal Standard CEERbase, without louvered sides, without reverse cycle~~	~~ENERGY STAR® CEERee, with louvered sides~~	~~ENERGY STAR® CEERee, without louvered sides~~
~~< 6,000~~	~~12.1~~	~~11.0~~	~~11.5~~	~~10.5~~
~~6,000 to 7,999~~			~~11.4~~	~~10.1~~
~~8,000 to 10,999~~	~~12.0~~	~~10.6~~		~~10.0~~
~~11,000 to 13,999~~		~~10.5~~	~~11.2~~	~~9.7~~
~~14,000 to 19,999~~	~~11.8~~	~~10.5~~	~~9.8~~	~~9.8~~
~~20,000-27,999~~	~~10.3~~	~~10.2~~		
~~>=28,000~~	~~9.9~~	~~10.3~~	~~9.5~~	

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~~Casement~~	~~Federal Standard CEERbase~~	~~ENERGY STAR® CEERee~~
~~Casement-only~~	~~10.5~~	~~10.0~~
~~Casement-slider~~	~~11.4~~	~~10.8~~

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~~Reverse Cycle - Product Class (Btu/H)~~	~~Federal Standard CEERbase, with louvered sides~~	~~Federal Standard CEERbase, without louvered sides[549]~~	~~ENERGY STAR® CEERee, with louvered sides[550]~~	~~ENERGY STAR® CEERee, without louvered sides~~
~~< 14,000~~	~~N/A~~	~~10.2~~	~~N/A~~	~~9.7~~
~~>= 14,000~~	~~N/A~~	~~9.6~~	~~N/A~~	~~9.1~~
~~< 20,000~~	~~10.8~~	~~N/A~~	~~10.3~~	~~N/A~~
~~>= 20,000~~	~~10.2~~	~~N/A~~	~~9.7~~	~~N/A~~

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Product Type and Class (Btu/hr)		Federal Standard with louvered sides (CEER)[551]	Federal Standard without louvered sides (CEER)	ENERGY STAR® v4.0 / CEE Tier 1 with louvered sides (CEER)[552]	ENERGY STAR® v4.0 / CEE Tier 1 without louvered sides (CEER)	CEE Tier 2 (CEER)[553]
Without Reverse Cycle	< 8,000	11.0	10.0	12.1	11.0	12.7
	8,000 to 10,999	10.9	9.6	12.0	10.6	12.5
	11,000 to 13,999	10.9	9.5	12.0	10.5	12.5
	14,000 to 19,999	10.7	9.3	11.8	10.2	12.3
	20,000 to 27,999	9.4	9.4	10.3	10.3	10.8
	>=28,000	9.0	9.4	9.9	10.3	10.4

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[547] Side louvers that extend from a room air conditioner model in order to position the unit in a window. A model without louvered sides is placed in a built-in wall sleeve and are commonly referred to as "through-the-wall" or "built-in" models.
Casement-only refers to a room air conditioner designed for mounting in a casement window of a specific size.
Casement-slider refers to a room air conditioner with an encased assembly designed for mounting in a sliding or casement window of a specific size. Reverse cycle refers to the heating function found in certain room air conditioner models. https://www.energystar.gov/products/heating_cooling/air_conditioning_room/key_product_criteria

[548] ~~Federal standard air conditioner baselines. https://ees.lbl.gov/product/room-air-conditioners.~~

[549] ~~Federal standard air conditioner baselines. https://ees.lbl.gov/product/room-air-conditioners.~~

[550] ~~EnergyStar® version 4.0 Room Air Conditioner Program Requirements. https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Version%204.0%20Room%20Air% 20Conditioners%20Program%20Requirements.pdf.~~

[551] See DOE's Appliance and Equipment Standards for Room AC;

[552] ENERGY STAR Version 4.0 Room Air Conditioners Program Requirements

[553] The Consortium for Energy Efficiency Super Efficient Home Appliance Initiative, Room Air Conditioner Specification, CEE Advanced Tier (CEER), effective January 31, 2017. Please see file 'CEE_ResApp_RoomAirConditionerSpecification_2017.pdf'. https://library.cee1.org/system/files/library/13069/CEE_ResApp_RoomAirConditionerSpecification_2017.pdf

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With Reverse Cycle	<14,000	9.8	9.3	10.8	10.2	12.5
	14,000 to 19,999	9.8	8.7	10.8	9.6	12.3
	>=20,000	9.3	8.7	10.2	9.6	10.4
Casement only		9.5		10.5		
Casement-Slider		10.4		11.4		

This measure was developed to be applicable to the following program type: TOS and EREP.

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

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the new room air conditioning unit must meet the ENERGY STAR® efficiency standards presented above.

DEFINITION OF BASELINE EQUIPMENT

For programs other than low-income programs, t~~T~~he baseline assumption is a new room air conditioning unit that meets the current minimum federal efficiency standards presented above.

For low income programs, for both Time of Sale and Early Replacement the baseline assumption is an inefficient unit either existing in the home or being purchased or acquired via the secondary market.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure life is assumed to be 12~~9~~ years.[554]

For low income programs, since the baseline unit is assumed to be purchased from the secondary market, it is assumed that the remaining life of the baseline unit is 6 years and would need to be replaced with another unit from the secondary market at that point.[555]

DEEMED MEASURE COST

For programs other than low-income programs, ~~The incremental cost for this measure is assumed to be \$20 for an ENERGY STAR® unit.[556]~~the incremental cost for this measure is assumed to be \$40 for a CEER Tier 1 or ENERGY STAR unit and \$100 for a CEE Tier 2 unit.[557]

For low income programs, the actual full cost of the ENERGY STAR® unit should be used. If unavailable assume \$300.[558] If a CEE Tier 2 unit is installed assume \$508.[559]

LOADSHAPE

Cooling RES

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = (FLH_{RoomAC} * Btuh * (1/CEER_{base} - 1/CEER_{ee})) / 1,000$$

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[554] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures~~ENERGY STAR® Room Air Conditioner Savings Calculator: http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=AC,~~ https://energizect.com/sites/default/files/documents/Measure%20Life%20Report%202007.pdf~~,~~; 'Measure Life Report 2007.pdf', page 1-3.

[555] Illinois TRM Version 12.0, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_3_Res_09222023_FINAL_clean.pdf, page 68.

~~[556] Illinois TRM Version 12.0, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_3_Res_09222023_FINAL_clean.pdf, page 69. Cost from RS Means 2018.~~

[557] Illinois TRM Version 12.0, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_3_Res_09222023_FINAL_clean.pdf, page 41. CEE Tier 1 cost based on field study conducted by Efficiency Vermont and Tier 2 based on professional judgement.

[558] Ibid.

[559] Consistent with Non IQ version of the measure.

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~~$\Delta kWh = \frac{\left(FLH_{RoomAC} * Btu/H * \left(\frac{1}{CEER_{base}} - \frac{1}{CEER_{ee}}\right)\right)}{1,000}$~~

Where:

FLH$_{RoomAC}$ = Full Load Hours of room air conditioning unit:

Weather Basis (City based upon)	Hours[560]
St Louis, MO	860 for primary use and 556 for secondary use

Btu/H = Size of unit
= Actual. If unknown assume 8,500 Btu/hr [561]
CEER$_{base}$ = Efficiency of baseline unit
= For programs other than low-income programs, a~~A~~s provided in tables above
= For low income programs, actual CEER of the existing unit; if unknown, assume 7.7[562]
CEER$_{ee}$ = Efficiency of ENERGY STAR® unit
= Actual. If unknown assume minimum qualifying standard as provided in tables above
ISR = Actual, or if unknown, reference values in the table below dependent on program type

Program Type	ISR
~~TOS[563]~~	~~9797%~~
SFIE[564]	98%

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$\Delta kW = \Delta kWh * CF$

Where:

ΔkWh = Electric energy savings, as calculated above
CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor
= 0.0009474181[565]
~~ΔkWh = Energy Savings as calculated above~~
~~CF = Summer Peak Coincidence Factor for measure~~
~~= 0.0009474181[566]~~

NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

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[560] Primary is based upon Ameren Missouri PY2013 CoolSavers Evaluation data, Secondary is based upon Ameren Missouri Efficient Products PY2016 Evaluation, https://www.efis.psc.mo.gov/Document/Display/17349, page 64.

[561] Based on maximum capacity average from the RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008, https://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/122_SPWG%20Room%20%20AC%20Evaluation%20FINALReport%20June%2023%20ver7.pdf~~.~~; '122_SPWG Room AC Evaluation FINALReport June 23 ver7.pdf'.

[562] Illinois TRM Version 12.0, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_3_Res_09222023_FINAL_clean.pdf, page 70.

~~[563] Ameren Missouri PY18 Participant SurveyEfficient Products Evaluation, https://www.efis.psc.mo.gov/Document/Display/15869, page 28.~~

[564] Ameren Missouri Efficient Products Evaluation PY2016, https://www.efis.psc.mo.gov/Document/Display/17349, page 63.

[565] Based on Ameren Missouri TRM Volume 1 - Appendix G: "Table 1 – Residential End Use Category Monthly Shapes and Coincident Peak Factors"~~Ameren Missouri 2016 loadshape~~ for residential cooling end-use.

~~[566] Based on Ameren Missouri 2016 loadshape for residential cooling end-use.~~

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Deemed O&M Cost Adjustment Calculation

N/A

Measure Code:

3.4.12 Ground Source Heat Pump

DESCRIPTION

A heat pump provides heating or cooling by moving heat between indoor and the ground.

This measure characterizes:

1. TOS: The installation of a new residential sized ground source heat pump. This could relate to the replacement of an existing unit at the end of its useful life, or the installation of a new system in a new home.
2. EREP: The early removal of functioning electric heating and cooling systems from service, prior to its natural end of life, and replacement with a new high efficiency ground source heat pump unit. To qualify as early replacement, the existing unit must be operational when replaced. If the SEER of the existing unit is known~~, and~~ the baseline SEER is the actual SEER value of the unit replaced, and if unknown use assumptions in the variable list below ($SEER2_{exist}$ and $HSPF2_{exist}$). If the operational status of the existing unit is unknown, use TOS assumptions.

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

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

DEFINITION OF EFFICIENT EQUIPMENT

A new residential sized ground source heat pump with specifications to be determined by program.

DEFINITION OF BASELINE EQUIPMENT

The baseline for the TOS measure is federal standard efficiency level as of: ~~3.3 COP and 14.1 EER when replacing an existing ground source heat pump,~~ 14.3 SEER2 and 7.5~~8.2~~ HSPF2 when replacing an existing air source heat pump or existing ground source heat pump, and 13.4 SEER2 and 3.41 HSPF2 when replacing a central air conditioner and electric resistance heating.

For the early replacement baseline to apply, program participants or installation contractors must provide documentation asserting that the existing units operated when turned on—whether or not they provided cooling—and the existing unit brand name and model number must be documented; or, if the nameplate is not readable, a photograph of the unit in context and the nameplate specifically must be provided. The baseline for the early replacement measure is the efficiency of the existing equipment for the assumed remaining useful life of the unit and the new baseline as defined above for the remainder of the measure life.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 25~~18~~ years.[567]

For early replacement, the remaining life of existing equipment is assumed to be 6 years for GSHP, ASHP and CAC and 25~~18~~ years for electric resistance.

DEEMED MEASURE COST

~~TOS:~~New Construction and Time of Sale: The actual installed cost of the Ground Source Heat Pump should be used (default of $3957 per ton),[568] minus the assumed installation cost of the baseline equipment ($6562 + $600 per ton for ASHP[569] or $2011 for a new baseline 80% AFUE furnace[570] and $3,338 for new baseline Central AC replacement [571]).

Early Replacement: The actual full installation cost of the Ground Source Heat Pump should be used (default of $3957 per ton).
The assumed deferred cost 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 and $3,670 for new baseline Central AC replacement.[572] This future cost should be discounted to present value using a 2.31% nominal societal discount rate, based on the ten year average (1/1/2014 – 12/31/2023) of the 10 year Treasury bond yield rates. [573]

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[567] Illinois TRM Version 12.0, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_3_Res_09222023_FINAL_clean.pdf, p. 166. System life of indoor components as per DOE estimate (see 'Geothermal Heat Pumps Department of Energy.htm'). The ground loop has a much longer life, but the compressor and other mechanical components are the same as an ASHP.

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

[569] Full install ASHP costs are based upon data provided by Ameren. See 'ASHP Costs_06242022'.

[570] See 'Technical Standard Document_APPENDIX_E.pdf'.

[571] See 'CAC Costs 09.02.2024.xlsx'.

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

[573] 'Societal_Discount_Rate_Calculation_08082024.xlsx'.

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~~The incremental capital cost for this measure is dependent on the efficiency and capacity of the new unit.~~~~[574]~~

~~Efficiency (EER)~~	~~Cost (including labor) per measure~~
~~GSHP - EER 23 - replace electric furnace / CAC~~	~~$4,717~~
~~GSHP EER 23 Replace at Fail GSHP~~	~~$3,200~~

~~EREP: The full install cost for this measure is the actual cost of removing the existing unit and installing the new one. If this is unknown, assume the following (note these costs are per ton of unit capacity):~~~~[575]~~

~~Efficiency (EER)~~	~~Cost (including labor) per measure~~
~~GSHP - EER 23 - replace electric furnace / CAC Early Replacement~~	~~$5,250~~
~~GSHP EER 23~~	~~$4,859~~

LOADSHAPE

Cooling RES
Heating RES

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

TOS:

$\Delta kWh = [((EFLH_{cool} * Capacity_{cool} * (1/EER2_{base} - 1/EER2_{ee}) / 1000) + ((EFLH_{heat} * Capacity_{heat} * (1/HSPF2_{base} - 1/HSFP2_{ee}) / 1000)] * ISR$

~~TOS:~~

~~$\Delta kWh = [((EFLH_{cool} * Capacity_{cool} * (1/EER_{base} - 1/EER_{ee})) / 1000) + ((EFLH_{heat} * Capacity_{heat} * (1/HSPF_{base} - 1/HSFP_{ee})) / 1000)] * ISR$~~

EREP:[576]

ΔkWh for remaining life of existing unit (1st 6 years for replacing an ASHP or GSHP, 18 years for replacing electric resistance):

$= [((EFLH_{cool} * Capacity_{cool} * (1/EER2_{exist} - 1/EER2_{ee}) / 1000) + ((EFLH_{heat} * Capacity_{heat} * (1/HSPF2_{exist} - 1/HSFP2_{ee}) / 1000)] * ISR$

~~$= [((EFLH_{cool} * Capacity_{cool} * (1/EER_{exist} - 1/EER_{ee})) / 1000) + ((EFLH_{heat} * Capacity_{heat} * (1/HSPF_{exist} - 1/HSFP_{ee})) / 1000)] * ISR$~~

ΔkWh for remaining measure life (next 12 years if replacing an ASHP or GSHP):

$= [((EFLH_{cool} * Capacity_{cool} * (1/EER2_{base} - 1/EER2_{ee}) / 1000) + ((EFLH_{heat} * Capacity_{heat} * (1/HSPF2_{base} - 1/HSFP2_{ee}) / 1000)] * ISR$

~~[574] Cost based upon Ameren Missouri MEEIA 2016-18 TRM effective January 1, 2018.~~

~~[575] Ibid.~~

[576] 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).

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~~$= [((EFLH_{cool} * Capacity_{cool} * (1/EER_{base} - 1/EER_{ee})) / 1000) + ((EFLH_{heat} * Capacity_{heat} * (1/HSPF_{base} - 1/HSFP_{ee})) / 1000)] * ISR$~~

Where:

$EFLH_{cool}$ = Equivalent full load hours of air conditioning:[577]

Weather Basis (City based upon)	$EFLH_{cool}$ (Hours)
St Louis, MO	869

$Capacity_{cool}$ = Cooling capacity of air source heat pump (Btu/hr)
= Actual (1 ton = 12,000Btu/hr)

$EER2_{exist}$ = Seasonal Energy Efficiency Ratio of existing unit (kBtu/kWh)
= Use actual SEER2[578] rating where it is possible to measure or reasonably estimate. If using rated efficiencies, derate the efficiency value based on the age of the existing equipment (up to a maximum of 30 years) to account for degradation over time.[579] If age is unknown, use 12 years.
= SEER2 * $(1-0.01)^{Age}$ ~~= Seasonal Energy Efficiency Ratio of existing cooling system (kBtu/kWh)~~

If rated efficiency is unknown, use defaults provided below, which should not be further adjusted to account for age-related degradation:~~= Use actual SEER rating where it is possible to measure or reasonably estimate. If using rated efficiencies, derate the efficiency value based on the age of the existing equipment (up to a maximum of 30 years) to account for degradation over time.[580] If age is unknown, use 12 years.~~

~~= EER * $(1-1.44\%)^{Age}$~~

Existing Cooling System	SEER2$_{exist}$ ~~[581]~~
Air Source Heat Pump	~~7.2~~6.91[582]
Ground Source Heat Pump	13.4[583]
Central AC	6.534
No central cooling[584]	Let '1/SEER2$_{exist}$' = 0

$EER2_{base}$ = Seasonal Energy Efficiency Ratio of baseline Air Source Heat Pump (kBtu/kWh)
= 14.3 if replacing air source heat pump or ground source heat pump; 13.4 if replacing central air conditioner~~[585]~~

$EER2_{ee}$ = Seasonal Energy Efficiency Ratio of efficient Air Source Heat Pump (kBtu/kWh)
= Actual

$EFLH_{heat}$ = Equivalent full load hours of heating

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[577] ~~Based on Full Load Hour assumptions (for St Louis and Kansas City) taken from the ENERGY STAR® calculator (http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_CAC.xls) and reduced by 28.5% based on the evaluation results in Ameren territory suggesting an appropriate EFLH of 869.The other climate region values are calculated using the relative climate normals cooling degree day ratios (at 65F set point).~~ PY2019 Evaluation Report, https://www.efis.psc.mo.gov/Document/Display/15876, page 30.

[578] Part load EER2 is paired with SEER2exist, consistent with the approach presented in section 3.4.2, Illinois TRM Version 12.0, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_3_Res_09222023_FINAL_clean.pdf, p. 508.

[579] Ibid., page 112. Justification for degradation factors can be found on page 14 of 'AIC HVAC Metering Study Memo FINAL 2_28_2018.docx'. Estimate efficiency as (Rated Efficiency * (1-0.01)^Equipment Age).

~~[580] Based on IL TRM V8.0, which bases justification for degradation factors on page 21 of 'AIC HVAC Metering Study Memo FINAL 2_28_2018'. Default of 12 years based on the remaining measure life of the equipment.~~

~~[581] ASHP existing efficiency assumes degradation and is sourced from the Ameren Missouri Heating and Cooling Program Impact and Process Evaluation: Program Year 2015. CAC assumed to follow the same trend in degradation as the ASHP: 9.12 SEER nameplate to 7.2 (6.91 SEER2) operations SEER represents degradation to 78.9% of nameplate. 78.9% of 8.6 SEER CAC nameplate gives an operational SEER of 6.8 (6.53 SEER2)Ameren Missouri HVAC Program Evaluation PY2018 - Operating would have the manufacturers recommendations of 10-12 EER and 2.4-2.8 COP. Use of 12 EER and 2.8 COP. is conservative.~~

[582] ASHP existing efficiency assumes degradation and is sourced from the Ameren Missouri Heating and Cooling Program Impact and Process Evaluation: Program Year 2015. CAC assumed to follow the same trend in degradation as the ASHP: 9.12 SEER nameplate to 7.2 (6.91 SEER2) operations SEER represents degradation to 78.9% of nameplate. 78.9% of 8.6 SEER CAC nameplate gives an operational SEER of 6.8 (6.53 SEER2).

[583] Illinois TRM Version 12.0, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_3_Res_09222023_FINAL_clean.pdf, page 169.

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

~~[585] Based on minimum federal standard effective 1/1/2015; http://www.gpo.gov/fdsys/pkg/CFR-2012-title10-vol3/pdf/CFR-2012-title10-vol3-sec430-32.pdf.~~

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= Dependent on location:[586]

Weather Basis (City based upon)	$EFLH_{heat}$ (Hours)
St Louis, MO	1496

$Capacity_{heat}$ = Heating Capacity of Air Source Heat Pump (Btu/hr)
= Actual (1 ton = 12,000Btu/hr)

$HSPF2_{exist}$ = Heating System Performance Factor of existing heating system (kBtu/kWh)

= Use actual HSPF2 rating where it is possible to measure or reasonably estimate. If using rated efficiencies, derate the efficiency value based on the age of the existing equipment (up to a maximum of 30 years) to account for degradation over time.[587] If age is unknown, use 12 years.
= $HSPF2 * (1-0.01)^{Age}$
~~= Heating System Performance Factor of existing heating system (kBtu/kWh)~~
= If rated efficiency is unknown, use defaults provided below, which should not be further adjusted to account for age-related degradation~~Use actual HSPF rating where it is possible to measure or reasonably estimate. If not available use~~:[588]

Existing Heating System	$HSPF2_{exist}$
Air Source Heat Pump	~~5.44~~~~[589]~~4.91
Ground Source Heat Pump	7.5
Electric Resistance	3.41~~[590]~~

$HSPF2_{base}$ = Heating System Performance Factor of baseline Air Source Heat Pump (kBtu/kWh)
= 7.5~~8.2~~ if replacing air source heat pump or ground source heat pump; 3.41 if replacing electric resistance heating~~[591]~~

$HSFP2_{ee}$ = Heating System Performance Factor of efficient Air Source Heat Pump (kBtu/kWh)

ISR = In-service rate. Actual, or if unknown, assume ~~In Service Rate =~~ 100%[592]

SUMMER COINCIDENT PEAK DEMAND SAVINGS

TOS:

$\Delta kW = \Delta kWh * CF$

Where:

ΔkWh = Electric energy savings, as calculated above
CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor
= 0.0009474181
~~ΔkWh = Energy Savings as calculated above~~
~~CF = 0.0009474181~~

NATURAL GAS SAVINGS

N/A

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[586] ~~Based on Full Load Hour assumptions (for St Louis and Kansas City) taken from the ENERGY STAR® calculator (http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_CAC.xls). The other weather basis values are calculated using the relative climate normals HDD data with a base temp ratio of 60°F.~~ PY2019 Residential Evaluation Report, https://www.efis.psc.mo.gov/Document/Display/15876, page 30.

[587] Illinois TRM Version 12.0, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_3_Res_09222023_FINAL_clean.pdf, page 112. Justification for degradation factors can be found on page 14 of 'AIC HVAC Metering Study Memo FINAL 2_28_2018.docx'. Estimate efficiency as (Rated Efficiency * (1-0.01)^Equipment Age).

[588] Illinois TRM Version 12.0, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_3_Res_09222023_FINAL_clean.pdf, page 171.

~~[589] This is estimated based on finding the average HSPF/SEER ratio from the AHRI directory data (using the least efficient models – SEER 12 and SEER 13) – 0.596, and applying to the average nameplate SEER rating of all early replacement qualifying equipment in Ameren PY2003-PY2004. This estimation methodology appears to provide a result within 10% of actual HSPF.~~

~~[590] Electric resistance has a COP of 1.0 which equals 1/0.293 = 3.41 HSPF.~~

~~[591] Based on minimum federal standard effective 1/1/2015; http://www.gpo.gov/fdsys/pkg/CFR-2012-title10-vol3/pdf/CFR-2012-title10-vol3-sec430-32.pdf.~~

[592] Ameren Missouri HVAC Evaluation: PY2020, https://www.efis.psc.mo.gov/Document/Display/13831, page 53.

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WATER IMPACT DESCRIPTIONS AND CALCULATION
N/A

DEEMED O&M COST ADJUSTMENT CALCULATION
N/A

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3.5 Lighting

3.5.1 LED Screw Based Omnidirectional Bulb

DESCRIPTION

This measure provides savings assumptions for LED screw-based omnidirectional (e.g., A-Type) lamps installed in a known location (i.e., residential and in-unit interior or exterior) or, if the implementation strategy does not allow for the installation location to be known (e.g., an upstream retail program or efficiency kit), an unknown residential location. For upstream programs, utilities should develop an assumption of the Residential v Commercial split and apply the relevant assumptions to each portion.

Federal legislation stemming from the Energy Independence and Security Act of 2007 (EISA) requires all general-purpose light bulbs between 40W and 100W to be approximately 30% more energy efficient than standard incandescent bulbs. Production of 100W, standard efficacy incandescent lamps ended in 2012, followed by restrictions on 75W lamps in 2013 and 60W and 40W lamps in 2014. The baseline for this measure has therefore become bulbs (improved incandescent or halogen) that meet the new standard.

A provision in the EISA regulations required that by January 1, 2020, all lamps meet efficiency criteria of at least 45 lumens per watt, in effect making the baseline equivalent to a current day CFL. In 2019, the Department of Energy issued a final determination and clarified that a) the EISA backstop provision had not been triggered and therefore b) the efficiency standard would not change in 2020. In May 2022, DOE reversed this decision by issuing a final rule that expanded the General Service Lamp (GSL) and General Service Incandescent Lamp (GSIL) definitions and reinstated the 45 lumen per watt backstop provision with phased enforcement between January 2023 and July 2023.[593]

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

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

DEFINITION OF EFFICIENT EQUIPMENT

In order for this measure to apply, new lamps must be ENERGY STAR® labeled based upon the ENERGY STAR® specification v2.0 which became effective on 1/2/2017~~ (https://www.energystar.gov/sites/default/files/Luminaires%20V2%200%20Final.pdf)~~.[594]

Qualification could also be based on the Design Light Consortium's qualified product list.[595]

DEFINITION OF BASELINE EQUIPMENT

In 2012, Federal legislation stemming from the Energy Independence and Security Act of 2007 (EISA) will require all general-purpose light bulbs between 40 watts and 100 watts to have ~30% increased efficiency, essentially phasing out standard incandescent technology. In 2012, the 100 w lamp standards apply; in 2013 the 75 w lamp standards will apply, followed by restrictions on the 60 w and 40 w lamps in 2014. Since measures installed under this TRM all occur after 2014, baseline equipment are the values after EISA. These are shown in the baseline table below.

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Additionally, an EISA backstop provision was included that would require replacement baseline lamps to meet an efficacy requirement of 45 lumens/watt or higher beginning on 1/1/2020. In December 2019, DOE issued a final determination for General Service Incandescent Lamps (GSILs), finding that this more stringent standard was not economically justified. However, in May 2022 DOE reversed this decision by issuing a Final rule for both the broadened General Service Lamp definition as well as the implementation of the 45 lumen per watt backstop. DOE stated that it will use its enforcement discretion to minimize impacts on the supply chain and effectively allow companies to continue the manufacture and import of noncompliant bulbs through the remainder of 2022, and allow retailers to continue selling them with limited enforcement until July 2023.

No savings are claimed for non-income qualified programs unless via direct install programs.

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~~Direct Install programs where it can be shown that the LED is replacing working inefficient lighting should continue to use the existing inefficient lighting as baseline and also assume a measure life of 2 yearsStarting August 1, 2023, the EISA backstop provision became effective, limiting the sale, manufacture, and import of non-compliant lamps. Therefore, the baseline condition for this measure is a reflection of the 2022 DOE final rule reinstating the 45 lumen per watt backstop provisions for all GSL and GSILs between 310 and 3,300 lumens. All other lamps, i.e., those below 310 lumens and above 3,300 lumens, the baseline condition is a reflection of products available in the market and standards agreed upon in practice.~~

~~Prior to August 1, 2023, the baseline condition for this measure is assumed to be an EISA-qualified halogen or CFL lamp~~.

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[593] DOE 87 FR 27439

[594] https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Lamps%20V2_0%20Revised%20AUG-2016.pdf; 'ENERGY STAR Lamps V2_0 Revised AUG-2016.pdf'.

[595] https://www.designlights.org/QPL.

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~~Direct Install programs where it can be shown that the LED is replacing working inefficient lighting should continue to use the existing inefficient lighting as baseline and also assume a measure life of 8 years.~~

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure life is assumed to be two years for Direct Install in non-income eligible populations and eight years for income eligible populations ~~The measure life is 19 years for residential applications and 6 years for non-residential applications~~.[596]

DEEMED MEASURE COST

The deemed measures cost for a LED screw based omnidirectional bulb is $1.45 per bulb.[597]

LOADSHAPE

Lighting RES
Lighting BUS

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = (Watt_{Base} - Watt_{EE}) * ISR * (1 - LKG) * Hours * WHF / 1{,}000$$

~~$\Delta kWh = \Delta kWh_{RES} + \Delta kWh_{NRES}$~~

~~$\Delta kWh_{RES} = (Watt_{Base} - Watt_{EE}) * \%RES * ISR * (1 - LKG) * Hours_{RES} * WHF_{RES} / 1{,}000$~~

~~$\Delta kWh_{NRES} = (Watt_{Base} - Watt_{EE}) * (1 - \%RES) * ISR * (1 - LKG) * Hours_{NRES} * WHF_{NRES} / 1{,}000$~~

Where:

$Watts_{Base}$ = Based on lumens of LED bulb installed. If lumens of LED bulb are unknown, refer to table below.
$Watts_{EE}$ = Actual wattage of LED purchased / installed - If unknown, use default provided below:[598]

Minimum Lumens	Maximum Lumens	LED Wattage (WattsEE)	Baseline (WattsBase)	Delta Watts (WattsEE)
310	399	4.0	25	21.0
400	749	6.6	29	22.4
750	899	9.6	43	33.4
900	1,399	13.1	53	39.9
1,400	1,999	16.0	72	56.0
2,000	2,999	21.8	150	128.2

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[596] Illinois TRM Version 12.0, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_3_Res_09222023_FINAL_clean.pdf, page 327~~Measure life is estimated based on the ratio of average equipment specifications for lifetime hours to the estimated annual operating hours. EULs of 19 years for residential and 6 years for non-residential are based on average rated lifetime for 2021 program measures (through 8/3/2021) divided by 995 hours for residential settings and by 3,351 for non-residential settings~~.

[597] Illinois TRM Version 12.0, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_3_Res_09222023_FINAL_clean.pdf, page 329~~Based on IL TRM V11.0, Section 5.5.8~~.

[598] Ibid., page 328~~Watts$_{EE}$ defaults are based upon the average available ENERGY STAR® product, accessed 06/18/2015. For any lumen range where there is no ENERGY STAR® product currently available, Watts$_{EE}$ is based upon the ENERGY STAR® minimum luminous efficacy (55Lm/W for lamps with rated wattages less than 15W and 65 Lm/W for lamps with rated wattages ≥ 15 watts) for the mid-point of the lumen range. See calculation at "cerified-light-bulbs-2015-06-18.xlsx." These assumptions should be reviewed regularly to ensure they represent the available product~~.

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Minimum Lumens	Maximum Lumens	LED Wattage (WattsEE)	Baseline (WattsBase)	Delta Watts (WattsEE)
3,000	3,299	28.9	200	171.1

~~%RES = percentage of bulbs sold to residential customers~~
~~= 100% for Online Store and 96% for Upstream Lighting, or 96% if unknown[599]~~

LKG = leakage rate (program bulbs installed outside Ameren Missouri's service area)
= Actual, or if unknown, assume 0%[600]

~~Program~~	~~Leakage~~	~~(1-Leakage)~~
~~Efficiency Kit (School)[601]~~	~~28%~~	~~72%~~
~~Efficiency Kit (MF)[602]~~	~~0%~~	~~100%~~
~~Appliance Recycling[603]~~	~~0%~~	~~100%~~
~~Low Income[604]~~	~~0%~~	~~100%~~
~~MFMR[605]~~	~~0%~~	~~100%~~

ISR = In S~~S~~ervice Rate, the percentage of units rebated that are actually in service. Actual, or if unknown, assume:

Program	Discounted In Service Rate (ISR)
~~Direct Install (MFLI)~~MFIE[606]	98.2%
~~Efficiency Kit (School)[607]~~	~~92%~~
SFIE and PAYS~~Efficiency Kit (MF)~~[608]	100%
~~Appliance Recycling[609]~~	~~88%~~
~~Low Income Kits~~	~~90%~~
~~Pay As You Save[610]~~	~~87%~~

Hours~~$_{RES}$~~ = Average hours of use per year for bulbs in residential homes. Use custom value or table below.
~~Hours$_{NRES}$ = Average hours of use per year for bulbs in non-residential buildings. Use custom value or table below.~~

Program	HOU Res
Residential	995.18[611]
~~Efficient Kits~~	~~995.18~~
Income Eligible RES	674.18[612]
~~MFMR~~	~~693.50[613]~~

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~~[599] Ameren Missouri Lighting Evaluation: PY2022. 96% is the weighted average for bulbs sold through the Online Store and Upstream Programs based on evaluation results and the distribution of bulbs in the PY2022 program.~~
[600] Assumed based on program delivery channels.
~~[601] Ameren Missouri Efficient Kits Impact and Process Evaluation: Program Year 2019 (Table 7-95), https://www.efis.psc.mo.gov/Document/Display/15877, page 149.~~
~~[602] Assumed based on program design.~~
~~[603] Ameren Missouri Appliance Recycling Evaluation PY2019 (Appendix Table 56), https://www.efis.psc.mo.gov/Document/Display/15876, page 93.~~
~~[604] Assumed based on program design.~~
~~[605] Ibid.~~
[606] Ameren Missouri Community Savers Evaluation: PY2018, . https://www.efis.psc.mo.gov/Document/Display/36053, page 17.
~~[607] Ameren Missouri Efficient Kits Impact and Process Evaluation: Program Year 2019 (Table 7-9), https://www.efis.psc.mo.gov/Document/Display/15877, page 153.~~
[608] Ameren Missouri Efficient Kits Impact and Process Evaluation: Program Year 2018, https://www.efis.psc.mo.gov/Document/Display/15870, page 38.
~~[609] Ameren Missouri Appliance Recycling Evaluation PY2019 (Table 9-9; cumulative value), https://www.efis.psc.mo.gov/Document/Display/15877, page 185.~~
~~[610] Ameren Missouri Pay As You Save (PAYS®) Evaluation: PY2022 Participant Survey~~
[611] Ameren Missouri Lighting Evaluation PY2018, https://www.efis.psc.mo.gov/Document/Display/15873, page 36.
[612] Ameren Missouri Community Savers Evaluation PY2018 workpapers- Weighted Avg. HOU from ADM workpapers.
~~[613] ADM 2017 Community Savers EM&V~~

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WHFe~~$_{RES}$~~ = Waste Heat Factor for energy to account for the impact from reducing waste heat from efficient lighting on electric cooling and heating loads in residential homes.
= 0.99 if unknown[614]

~~WHFe$_{NRES}$ = Waste Heat Factor for energy to account for the impact from reducing waste heat from efficient lighting on electric cooling and heating loads in non-residential spaces.~~

~~= If unknown assume 1.1 or 0.97 for Income Eligible.[615]~~

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WHFe$_{Heat}$ = Waste Heat Factor for energy to account for electric heating increase from reducing waste heat from efficient lighting (if fossil fuel heating, see calculation of heating penalty in that section).
= 1 - ((HF / ηHeat) * %ElecHeat).
= If unknown assume 0.88[616]

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[614] Ameren Missouri PY2014 Evaluation, https://www.efis.psc.mo.gov/Document/Display/14194, page 45.

~~[615] Ameren Missouri Community Savers Evaluation PY2018 workpapers. Weighted Avg. calculated from ADM workpapers.~~

[616] Calculated using defaults: 1-((0.53/1.57) * 0.35) = 0.88.

Where:

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

= 53%[617] for interior or unknown location

= 0% for exterior or unheated location

ηHeat$_{Electric}$ = Efficiency in COP of Heating equipment

= Actual - If not available, use:[618]

System Type	Age of Equipment	HSPF2 Estimate	ηHeat (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[619]	N/A	N/A	1.28

~~System Type~~	~~Age of Equipment~~	~~HSPF Estimate~~	~~ηHeat (COP Estimate)~~
~~Heat Pump~~	~~Before 2006~~	~~6.8~~	~~2.00~~
	~~2006-2014~~	~~7.7~~	~~2.26~~
	~~2015 and after~~	~~8.2~~	~~2.40~~
~~Resistance~~	~~N/A~~	~~N/A~~	~~1.00~~
~~Unknown~~	~~N/A~~	~~N/A~~	~~1.57[620]~~

%ElecHeat = Percentage of heating savings assumed to be electric

Heating fuel	%ElectricHeat
Electric	100%
Natural Gas	0%
Unknown	35%[621]

WHFe$_{Cool}$ = Waste Heat Factor for energy to account for cooling savings from reducing waste heat from efficient lighting

Bulb Location	WHFe$_{Cool}$
Building with cooling	1.12[622]
Building without cooling or exterior	1.0
Unknown	1.11[623]

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[617] This means that heating loads increase by 53% of the lighting savings. This is based on the average result from REMRate modeling of several different building configurations in Iowa (Des Moines, Mason City, and Burlington). These results were judged to be equally applicable to Missouri.

[618] These default system efficiencies are based on the applicable minimum federal standards. In 2006 and 2015, 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.

[619] Calculation assumes 35% Heat Pump and 65% Resistance, which is based upon data from Energy Information Administration, 2009 Residential Energy Consumption Survey, ~~,~~ https://www.eia.gov/consumption/residential/data/2009/hc/hc6.9.xls; 'hc6.9.xls'. 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.

~~[620] Calculation assumes 50% heat pump and 50% resistance, which is based upon data from Energy Information Administration, 2009 Residential Energy Consumption Survey, see "HC6.9 Space Heating in Midwest Region.xls." Average efficiency of heat pump is based on assumption 50% are units from before 2006 and 50% 2006-2014.~~

[621] Average (default) value of 35% electric space heating from 2009 Residential Energy Consumption Survey for Missouri. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area, then they should be used.

[622] The value is estimated at 1.12 (calculated as 1 + (0.34 / 2.8)), and it is based on cooling loads decreasing by 34% of the lighting savings (average result from REMRate modeling of several different building configurations in Iowa (Des Moines, Mason City, and Burlington)). The estimate also assumes typical cooling system operating efficiency of 2.8 COP (starting from standard assumption of SEER 10.5 central AC unit, converted to 9.5 EER using algorithm (-0.02 * SEER^2) + (1.12 * SEER) (from Wassmer, M. (2003); A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder), converted to COP = EER/3.412 = 2.8COP). Results of the Iowa study are assumed to be applicable to Missouri.

[623] The value is estimated at 1.11 (calculated as 1 + (0.91*(0.34 / 2.8)), which is based on assumption that 91% of homes have central cooling (based on 2009 Residential Energy Consumption Survey, https://www.eia.gov/consumption/residential/data/2009/hc/hc6.9.xls; 'hc6.9.xls') ~~(based on 2009 Residential Energy Consumption Survey, see "HC7.9 Air Conditioning in Midwest Region.xls", https://www.eia.gov/consumption/residential/data/2015/hc/php/hc7.9.php)~~.

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SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ΔkWh * CF

Where:

ΔkWh = Electric energy savings, as calculated above.
CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor
= 0.0001492529 for Lighting RES (Residential)

~~$\Delta kW = \Delta kWh * CF$~~

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~~Where:~~

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~~ΔkWh~~ ~~= Energy Savings as calculated above~~
~~CF~~ ~~= Summer peak coincidence demand (kW) to annual energy (kWh) factor~~
~~= 0.0001492529 for residential bulbs and 0.0001899635 for nonresidential bulbs~~

NATURAL GAS SAVINGS

Heating Penalty for Natural Gas heated homes:[624]

ΔTherms= -((Watts $_{Base}$ – Watts$_{EE}$) / 1,000 * ISR * Hours * HF * 0.03412) / ηHeat * %GasHeat

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~~$\Delta Therms = -\frac{\frac{Watts_{Base} - Watts_{EE}}{1,000} * ISR * Hours * HF * 0.03412}{\eta Heat} * \%GasHeat$~~

Where:

HF = Heating Factor or percentage of light savings that must now be heated
= 53%[625] for interior or unknown location
= 0% for exterior or unheated location
0.03412 =Converts kWh to therms
$\eta Heat_{Gas}$ = Efficiency of heating system
= 71%[626]
%GasHeat = Percentage of heating savings assumed to be n~~N~~atural g~~G~~as

Heating fuel	%GasHeat
Electric	0%
Natural Gas	100%
Unknown	65%[627]

MEASURE CODE:

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

[625] This means that heating loads increase by 53% of the lighting savings. This is based on the average result from REMRate modeling of several different building configurations in Iowa (Des Moines, Mason City, and Burlington). Results of the Iowa study are judged to be equally applicable to Missouri.

[626] This has been estimated assuming that natural gas central furnace heating is typical for Missouri residences (the predominant heating is gas furnace with 48% of Missouri homes (based on Energy Information Administration, 2009 Residential Energy Consumption Survey)). See reference ~~"HC6.9 Space Heating in Midwest Region.xls."~~; https://www.eia.gov/consumption/residential/data/2009/hc/hc6.9.xls; 'hc6.9.xls'. In 2000, 29% of furnaces purchased in Missouri 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, so units purchased 15 years ago provide a reasonable proxy for the current mix of furnaces in the state. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows: ((0.29*0.92) + (0.71*0.8)) * (1-0.15) = 0.71~~.~~.

[627] Average (default) value of 65% gas space heating from 2009 Residential Energy Consumption Survey for Missouri. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area, then they should be used.

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3.5.2 LED Specialty Lamp

DESCRIPTION

This measure provides savings assumptions for LED directional, decorative, and globe lamps when the LED is installed in a known location (i.e., residential and in-unit interior or exterior) or, if the implementation strategy does not allow for the installation location to be known (e.g., an upstream retail program or efficiency kit), an unknown residential location. For upstream programs, utilities should develop an assumption of the Residential v Nonresidential split and apply the relevant assumptions to each portion.

Federal legislation stemming from the Energy Independence and Security Act of 2007 (EISA) requires all general-purpose light bulbs between 40W and 100W to be approximately 30% more energy efficient than standard incandescent bulbs. Production of 100W, standard efficacy incandescent lamps ended in 2012, followed by restrictions on 75W lamps in 2013 and 60W and 40W lamps in 2014. The baseline for this measure has therefore become bulbs (improved incandescent or halogen) that meet the new standard.

A provision in the EISA regulations required that by January 1, 2020, all lamps meet efficiency criteria of at least 45 lumens per watt, in effect making the baseline equivalent to a current day CFL. In 2019, the Department of Energy issued a final determination and clarified that a) the EISA backstop provision had not been triggered and therefore b) the efficiency standard would not change in 2020. In May 2022, DOE reversed this decision by issuing a final rule that expanded the General Service Lamp (GSL) and General Service Incandescent Lamp (GSIL) definitions and reinstated the 45 lumen per watt backstop provision with phased enforcement between January 2023 and July 2023.[628]

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

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

DEFINITION OF EFFICIENT EQUIPMENT

In order for this characterization to apply, new lamps must be ENERGY STAR® labeled based upon the ENERGY STAR® specification v2.0 which became effective on 1/2/2017~~,)~~.[629] Qualification could also be based on the Design Light Consortium's qualified product list.[630]

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DEFINITION OF BASELINE EQUIPMENT

Starting August 1, 2023, the EISA backstop provision became effective, limiting the sale, manufacture, and import of non-compliant lamps. Therefore, the baseline condition for this measure is a reflection of the 2022 DOE final rule reinstating the 45 lumen per watt backstop provisions for all GSL and GSILs between 310 and 3,300 lumens. All other lamps, i.e., those below 310 lumens and above 3,300 lumens, the baseline condition is a reflection of products available in the market and standards agreed upon in practice.

No savings are claimed for non-income qualified programs unless via direct install programs.

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

Direct Install programs where it can be shown that the LED is replacing working inefficient lighting should continue to use the existing inefficient lighting as baseline and also assume a measure life of 8 years.~~Prior to August 1, 2023, the baseline condition for this measure is assumed to be an EISA-qualified halogen lamp.~~

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure life is assumed to be two years for Direct Install in non-income eligible populations and eight years for income eligible populations .[631]

~~The measure life is 19 years for residential applications and 6 years for non-residential applications.[632]~~

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[628] DOE 87 FR 27439.

[629] https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Lamps%20V2_0%20Revised%20AUG-2016.pdf; 'ENERGY STAR Lamps V2_0 Revised AUG-2016.pdf'.

[630] https://www.designlights.org/QPL.

[631] Illinois TRM Version 12.0, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_3_Res_09222023_FINAL_clean.pdf, page 311.

~~[632] Measure life is estimated based on the ratio of average equipment specifications for lifetime hours to the estimated annual operating hours. EULs of 19 years for residential and 6 years for non-residential are based on average rated lifetime for 2021 program measures (through 8/3/2021) divided by 995 hours for residential settings and by 3,351 for non-residential settings.~~

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DEEMED MEASURE COST

The deemed measures cost for a specialty LED is $1.66 per lamp.[633] ~~In the case of direct install programs or lighting included in efficient kits, the actual cost of the measure should be used.~~

LOADSHAPE

Lighting RES
Lighting BUS

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = (Watt_{Base} - Watt_{EE}) * ISR * (1 - LKG) * Hours * WHF / 1,000$$

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~~$\Delta kWh_{RES} = (Watt_{Base} - Watt_{EE}) * \%RES * ISR * (1 - LKG) * Hours_{RES} * WHF_{RES} /1,000$~~

~~$\Delta kWh_{NRES} = (Watt_{Base} - Watt_{EE}) * (1 - \%RES) * ISR * (1 - LKG) * Hours_{NRES} * Days * WHF_{NRES}/1,000$~~

Where:

$Watts_{Base}$ = Based on bulb type and lumens of LED bulb installed. See tables below.
$Watts_{EE}$ = Actual wattage of LED purchased / installed - If unknown, use default provided below:~~[634]~~

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~~Baseline and Efficienct Wattages through July 31, 2023, assuming a EISA-compliant halogen baseline~~

~~Bulb Type~~	~~Lower Lumen Range~~	~~Upper Lumen Range~~	~~$Watts_{Base}$~~	~~$Watts_{EE}$~~	~~Delta Watts~~
~~Directional~~	~~250~~	~~349~~	~~25~~	~~5.6~~	~~19.4~~
	~~350~~	~~399~~	~~35~~	~~6.3~~	~~28.7~~
	~~400~~	~~599~~	~~40~~	~~7.5~~	~~32.5~~
	~~600~~	~~749~~	~~60~~	~~9.7~~	~~50.3~~
	~~750~~	~~999~~	~~75~~	~~12.7~~	~~62.3~~
	~~1000~~	~~1250~~	~~100~~	~~16.2~~	~~83.8~~
~~Decorative~~	~~70~~	~~89~~	~~10~~	~~1.8~~	~~8.2~~
	~~90~~	~~149~~	~~15~~	~~2.7~~	~~12.3~~
	~~150~~	~~299~~	~~25~~	~~3.2~~	~~21.8~~
	~~300~~	~~499~~	~~40~~	~~4.7~~	~~35.3~~
	~~500~~	~~699~~	~~60~~	~~6.9~~	~~53.1~~
~~Globe~~	~~250~~	~~349~~	~~25~~	~~4.1~~	~~20.9~~
	~~350~~	~~499~~	~~40~~	~~5.9~~	~~34.1~~
	~~500~~	~~574~~	~~60~~	~~7.6~~	~~52.4~~
	~~575~~	~~649~~	~~75~~	~~13.6~~	~~61.4~~
	~~650~~	~~1099~~	~~100~~	~~17.5~~	~~82.5~~

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[633] Illinois TRM Version 12.0, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_3_Res_09222023_FINAL_clean.pdf, page 311~~Based on IL TRM V11.0, Section 5.5.6~~.

~~[634] $Watts_{EE}$ defaults are based upon the average available ENERGY STAR® product, accessed 06/18/2015. For any lumen range where there is no ENERGY STAR® product currently available, $Watts_{EE}$ is based upon the ENERGY STAR® minimum luminous efficacy (directional; 40Lm/W for lamps with rated wattages less than 20Wand 50 Lm/W for lamps with rated wattages ≥ 20 watts. decorative and globe; 45Lm/W for lamps with rated wattages less than 15W, 50lm/W for lamps ≥15 and <25W, 60 Lm/W for lamps with rated wattages ≥ 25 watts) for the mid-point of the lumen range. See calculation at "'cerified-light-bulbs-2015-06-18.xlsx'." These assumptions should be reviewed regularly to ensure they represent the available product.~~

~~Bulb Type~~	~~Lower Lumen Range~~	~~Upper Lumen Range~~	~~Watts$_{Base}$~~	~~Watts$_{EE}$~~	~~Delta Watts~~
	~~1100~~	~~1300~~	~~150~~	~~13.0~~	~~137.0~~

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

Bulb Type	Minimum Lumens	Maximum Lumens	LED Wattage (Watts$_{EE}$)	Baseline (Watts$_{Base}$)	Delta Watts (WattsEE)
Omni-Directional 3-Way	1,100	1,999	14.7	100	85.3
	2,000	2,700	22.6	150	127.4
Globe (medium and intermediate bases less than 750 lumens)	310	349	3.0	25	22
	350	499	4.7	40	35.3
	500	574	5.7	60	54.3
	575	649	6.5	75	68.5
	650	1,000	8.2	100	91.8
Globe (candelabra bases less than 1050 lumens)	310	349	3.5	25	21.5
	350	499	4.4	40	35.6
	500	574	5.5	60	54.5
Decorative (Shapes B, BA, C, CA, DC, F, G, medium and intermediate bases less than 750 lumens)	310	499	4.3	40	35.7
	500	800	5.8	60	54.2
Decorative (Shapes B, BA, C, CA, DC, F, G, candelabra bases less than 1050 lumens)	310	499	4.2	40	35.8
	500	650	5.5	60	54.5
Decorative (Shape ST)	310	499	6.5	40	33.5
	500	999	8.8	60	51.2
	1000	1500	10.0	100	90.0
Decorative (Shape S)	310	340	2.25	25	22.8

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

Directional R, BR, and ER lamp types:[635]

Bulb Type	Minimum Lumens	Maximum Lumens	LED Wattage (Watts$_{EE}$)	Baseline (Watts$_{Base}$)	Delta Watts (WattsEE)
Reflector lamp types with medium screw bases (PAR20, PAR30(S,L), PAR38, R40, etc.) w/ diameter >2.25" (*see exceptions below)	400	649	7.0	50	43
	650	899	10.7	75	64.3
	900	1,049	13.9	90	76.1
	1,050	1,199	13.8	100	86.2
	1,200	1,499	15.9	120	104.1
	1,500	1,999	18.9	150	131.1
	2,000	3,299	27.3	250	222.7

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

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Bulb Type	Minimum Lumens	Maximum Lumens	LED Wattage ($Watts_E$E)	Baseline ($Watts_{Base}$)	Delta Watts (WattsE E)
Reflector lamp types with medium screw bases (PAR16, R14, R16, etc.) w/ diameter <2.25" (*see exceptions below)	310	374	4.6	35	30.4
	375	600	6.4	50	43.6
*BR30, BR40, or ER40	650	949	9.3	65	55.7
	950	1,099	12.7	75	62.3
	1,100	1,399	14.4	85	70.6
	1,400	1,600	16.6	100	83.4
	1,601	1,800	22.2	120	97.8
*R20	450	524	6.0	40	34.0
	525	750	7.1	45	37.9
*MR16	310	324	3.8	20.0	16.2
	325	369	4.8	25.0	20.2
	370	400	4.9	25.0	20.1

For PAR, MR, and MRX Lamps Types:

For these highly focused directional lamp types, it is necessary to have Center Beam Candle Power (CBCP) and beam angle measurements to accurately estimate the equivalent baseline wattage. The formula below is based on the ENERGY STAR Center Beam Candle Power tool.[636] If CBCP and beam angle information are not available or if the equation below returns a negative value (or undefined), use the manufacturer's recommended baseline wattage equivalent.[637]

WattsBase = 375.1 – 4.355(D) – (227,800 – (937.9 * D) – (0.9903 * D^2) – (1,479 *BA) – (12.02 * D * BA) + (14.69 * (BA^2)) - 16,720 * ln(CBCP))^0.5

Where:

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

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

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

Additional EISA non-exempt bulb types:

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[636] See 'ESLampCenterBeamTool.xlsx'.

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

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Bulb Type	Minimum Lumens	Maximum Lumens	LED Wattage (Watts$_{EE}$)	Baseline (Watts$_{Base}$)	Delta Watts (WattsEE)
Dimmable Twist, Globe (less than 5" in diameter and > 749 lumens), candle (shapes B, BA, CA > 749 lumens), Candelabra Base Lamps (>1049 lumens), Intermediate Base Lamps (>749 lumens)	310	399	4.0	25	21.0
	400	749	6.6	29	22.4
	750	899	9.6	43	33.4
	900	1,399	13.1	53	39.9
	1,400	1,999	16.0	72	56.0

~~Baseline and Efficienct Wattages after August 1, 2023, under the EISA backstop provision of 45 lumens/watt~~

~~Bulb Type~~	~~Lower Lumen Range~~	~~Upper Lumen Range~~	~~Watts$_{Base}$~~	~~Watts$_{EE}$~~	~~Delta Watts~~
~~Directional~~	~~250~~	~~309~~	~~25~~	~~5.6~~	~~19.4~~
	~~310~~	~~399~~	~~7.9~~	~~6.3~~	~~1.6~~
	~~400~~	~~599~~	~~11.1~~	~~7.5~~	~~3.6~~
	~~600~~	~~749~~	~~15~~	~~9.7~~	~~5.3~~
	~~750~~	~~999~~	~~19.4~~	~~12.7~~	~~6.7~~
	~~1000~~	~~1250~~	~~25~~	~~16.2~~	~~8.8~~
~~Decorative~~	~~70~~	~~89~~	~~10~~	~~1.8~~	~~8.2~~
	~~90~~	~~149~~	~~15~~	~~2.7~~	~~12.3~~
	~~150~~	~~309~~	~~25~~	~~3.2~~	~~21.8~~
	~~310~~	~~499~~	~~40~~	~~4.7~~	~~35.3~~
	~~500~~	~~699~~	~~60~~	~~6.9~~	~~53.1~~
~~Globe~~	~~250~~	~~309~~	~~25~~	~~4.1~~	~~20.9~~
	~~310~~	~~499~~	~~9.0~~	~~5.9~~	~~3.1~~
	~~500~~	~~574~~	~~11.9~~	~~7.6~~	~~4.3~~
	~~575~~	~~649~~	~~13.6~~	~~13.6~~	~~0.0~~
	~~650~~	~~1099~~	~~19.4~~	~~17.5~~	~~1.9~~
	~~1100~~	~~1300~~	~~26.7~~	~~13.0~~	~~13.7~~

LKG = leakage rate (program bulbs installed outside Ameren Missouri's service area)
= Actual, or if unknown, assume 0%[638]

~~[639]~~ISR = In Service Rate, the percentage of units rebated that are actually in service. Actual, or if unknown, assume:

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[638] Assumed based on program delivery channels.

~~[639] Ameren Missouri Lighting Evaluation: PY2019. 3.98% is the weighted average for bulbs sold through the Online Store and Upstream Programs based on evaluation results and the distribution of bulbs in the PY19 program, https://www.efis.psc.mo.gov/Document/Display/15876, page 13 .~~

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Program	Discounted In Service Rate (ISR)
~~Direct Install (MFLI)~~MFIE[640]	98.2%
SFIE and~~,~~ PAYS~~Efficiency Kit (MF)~~[641]	100%
~~Low Income Kits~~	~~90%~~
~~Pay As You Save[642]~~	~~87%~~

~~[643]~~ Hours = Average hours of use per year for bulbs in residential homes. Custom, or if unknown assume 1,314[644] for exterior, or or if interior use table below.

Program	HOU Res
Residential	995.18[645]
~~Efficient Kits~~	~~995.18~~
Income Eligible RES	674.18[646]
~~MFMR~~	~~693.50[647]~~

WHFe = Waste Heat Factor for energy to account for the impact from reducing waste heat from efficient lighting on electric cooling and heating loads in residential homes.
= 0.99 if unknown[648]
$WHFe_{Heat}$ = Waste Heat Factor for energy to account for electric heating increase from reducing waste heat from efficient lighting (if fossil fuel heating, see calculation of heating penalty in that section).
= 1 - ((HF / ηHeat) * %ElecHeat).
= If unknown assume 0.88[649]

Where~~:~~

HF = Heating Factor or percentage of light savings that must now be heated
= 53%[650] for interior or unknown location
= 0% for exterior or unheated location
$ηHeat_{Electric}$ = Efficiency in COP of Heating equipment
= Actual - If not available, use:[651]

System Type	Age of Equipment	HSPF2 Estimate	ηHeat (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

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[640] Ameren Missouri Community Savers Evaluation: PY2018, . https://www.efis.psc.mo.gov/Document/Display/36053, page 17.
[641] Ameren Missouri Efficient Kits Impact and Process Evaluation: Program Year 2018, https://www.efis.psc.mo.gov/Document/Display/15870, page 38.
~~[642] Ameren Missouri Pay As You Save (PAYS®) Evaluation: PY2022 Participant Survey, https://www.efis.psc.mo.gov/Document/Display/17591, page 7.~~
~~[643] Ameren Missouri Efficient Kits Impact and Process Evaluation: Program Year 2018, https://www.efis.psc.mo.gov/Document/Display/15870, page 38.~~
[644] Ameren Missouri Lighting Impact and Process Evaluation: Program Year 2015. Average daily HOU for efficient bulbs is listed as 3.6 for outside bulbs and a weighted (by inventory) average of 1.99 for inside spaces. Unknown location is weighted average (by inventory) of all bulbs. See 'MO Lamp Hours.xlsx' for calculations.
[645] Ameren Missouri Lighting Evaluation PY2018, https://www.efis.psc.mo.gov/Document/Display/15873, page 36.
[646] Ameren Missouri Community Savers Evaluation PY2018 workpapers- Weighted Avg. HOU from ADM workpapers.
~~[647] ADM 2017 Community Savers EM&V, https://www.efis.psc.mo.gov/Document/Display/28281, page 3-4.~~
[648] Ameren Missouri PY2014 Evaluation, https://www.efis.psc.mo.gov/Document/Display/14194, page 45.
[649] Calculated using defaults: 1-((0.53/1.57) * 0.35) = 0.88.
[650] This means that heating loads increase by 53% of the lighting savings. This is based on the average result from REMRate modeling of several different building configurations in Iowa (Des Moines, Mason City, and Burlington). These results were judged to be equally applicable to Missouri.
[651] These default system efficiencies are based on the applicable minimum federal standards. In 2006 and 2015, 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.

Unknown[652]	N/A	N/A	1.28

%ElecHeat = Percentage of heating savings assumed to be electric

Heating fuel	%ElectricHeat
Electric	100%
Natural Gas	0%
Unknown	35%[653]

WHFe$_{Cool}$ = Waste Heat Factor for energy to account for cooling savings from reducing waste heat from efficient lighting

Bulb Location	WHFe$_{Cool}$
Building with cooling	1.12[654]
Building without cooling or exterior	1.0
Unknown	1.11[655]

~~%RES = percentage of bulbs sold to residential customers~~
~~= 100% for Online Store and 96% for Upstream Lighting or 96% if unknown[656]~~
~~ISR = In Service Rate, the percentage of units rebated that are actually in service – see table below~~
~~Hours$_{RES}$ = Average hours of use per year~~
~~= Custom, or if unknown assume 728[657] for interior or 1,314 for exterior, or 776 if location is not known.~~
~~Hours$_{NRES}$ = 3,351~~
~~WHFe$_{Heat}$ = Waste Heat Factor for energy to account for electric heating increase from reducing waste heat from efficient lighting (if fossil fuel heating – see calculation of heating penalty in that section).~~
~~= 1 – ((HF / ηHeat) * %ElecHeat)~~
~~If unknown assume 0.88[658]~~
~~HF = Heating Factor or percentage of light savings that must now be heated~~
~~= 53%[659] for interior or unknown location~~
~~= 0% for exterior or unheated location~~
~~ηHeat$_{Electric}$ = Efficiency in COP of Heating equipment~~
~~= Actual – If not available, use values in table below[660]~~
~~%ElecHeat = Percentage of heating savings assumed to be electric~~
~~WHFe$_{Cool}$ = Waste Heat Factor for energy to account for cooling savings from reducing waste heat from efficient lighting~~

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[652] Calculation assumes 35% Heat Pump and 65% Resistance, which is based upon data from Energy Information Administration, 2009 Residential Energy Consumption Survey, ~~,~~ https://www.eia.gov/consumption/residential/data/2009/hc/hc6.9.xls; 'hc6.9.xls'. 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.

[653] Average (default) value of 35% electric space heating from 2009 Residential Energy Consumption Survey for Missouri. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area, then they should be used.

[654] The value is estimated at 1.12 (calculated as 1 + (0.34 / 2.8)), and it is based on cooling loads decreasing by 34% of the lighting savings (average result from REMRate modeling of several different building configurations in Iowa (Des Moines, Mason City, and Burlington)). The estimate also assumes typical cooling system operating efficiency of 2.8 COP (starting from standard assumption of SEER 10.5 central AC unit, converted to 9.5 EER using algorithm (-0.02 * SEER^2) + (1.12 * SEER) (from Wassmer, M. (2003); A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder), converted to COP = EER/3.412 = 2.8COP). Results of the Iowa study are assumed to be applicable to Missouri.

[655] The value is estimated at 1.11 (calculated as 1 + (0.91*(0.34 / 2.8)), which is based on assumption that 91% of homes have central cooling (based on 2009 Residential Energy Consumption Survey, see https://www.eia.gov/consumption/residential/data/2009/hc/hc6.9.xls; 'hc6.9.xls')~~, https://www.eia.gov/consumption/residential/data/2015/hc/php/hc7.9.php.~~

~~[656] Ameren Missouri Lighting Evaluation: PY2022. 96% is the weighted average for bulbs sold through the Online Store and Upstream Programs based on evaluation results and the distribution of bulbs in the PY2022 program.~~

~~[657] Ameren Missouri Lighting Impact and Process Evaluation: Program Year 2015. Average daily HOU for efficient bulbs is listed as 3.6 for outside bulbs and a weighted (by inventory) average of 1.99 for inside spaces. Unknown location is weighted average (by inventory) of all bulbs. See 'MO Lamp Hours.xls' for calculations.~~

~~[658] Calculated using defaults: 1-((0.53/1.57) * 0.35) = 0.88.~~

~~[659] This means that heating loads increase by 53% of the lighting savings. This is based on the average result from REMRate modeling of several different building configurations in Iowa (Des Moines, Mason City, and Burlington). Results of the Iowa study were judged to be equally applicable to Missouri.~~

~~[660] These default system efficiencies are based on the applicable minimum federal standards. In 2006 and 2015 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.~~

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~~Program~~	~~Channel or Subgroup~~	~~Discounted In Service Rate (ISR)~~
~~Retail (Time of Sale)[661]~~	~~Overall Program Average~~	~~88.44%~~
	~~Online Store - Reflector~~	~~80.00%~~
	~~Online Store - Specialty~~	~~84.00%~~
	~~Upstream - Reflector~~	~~90.00%~~
	~~Upstream - Specialty~~	~~93.00%~~
~~Direct Install (MFLI)[662]~~		~~98.2%~~
~~Efficiency Kit (School)[663]~~		~~90%~~
~~Efficiency Kit (Multi-Family)[485]~~		~~100%~~
~~Pay As You Save[664]~~		~~87%~~

~~System Type~~	~~Age of Equipment~~	~~HSPF Estimate~~	~~ηHeat (COP Estimate)~~
~~Heat Pump~~	~~Before 2006~~	~~6.8~~	~~2.00~~
	~~2006-2014~~	~~7.7~~	~~2.26~~
	~~2015 and after~~	~~8.2~~	~~2.40~~
~~Resistance~~	~~N/A~~	~~N/A~~	~~1.00~~
~~Unknown~~	~~N/A~~	~~N/A~~	~~1.57~~ [665]

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~~Heating fuel~~	~~%ElectricHeat~~
~~Electric~~	~~100%~~
~~Natural Gas~~	~~0%~~
~~Unknown~~	~~35%[666]~~

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~~Bulb Location~~	~~$WHFe_{Cool}$~~
~~Building with cooling~~	~~1.12[667]~~
~~Building without cooling or exterior~~	~~1.0~~
~~Unknown~~	~~1.11[668]~~

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$\Delta kW = \Delta kWh * CF$

Where:

ΔkWh = Electric energy savings, as calculated above.

CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor

= 0.0001492529 for Lighting RES (Residential)

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~~$\Delta kW = \Delta kWh * CF$~~

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[661] ~~Ameren Missouri Lighting Evaluation: PY2019. 3.98% is the weighted average for bulbs sold through the Online Store and Upstream Programs based on evaluation results and the distribution of bulbs in the PY2019 program.~~

[662] ~~Ameren Missouri Community Savers Program Evaluation: PY2018.~~

[663] ~~Ameren Missouri Efficient Kits Impact and Process Evaluation: Program Year 2018.~~

[664] ~~Ameren Missouri Pay As You Save (PAYS®) Evaluation: PY2022 Participant Survey~~

[665] ~~Calculation assumes 50% heat pump and 50% resistance, which is based upon data from Energy Information Administration, 2009 Residential Energy Consumption Survey, see "HC6.9 Space Heating in Midwest Regionals." Average efficiency of heat pump is based on assumption 50% are units from before 2006 and 50% 2006-2014.~~

[666] ~~Average (default) value of 35% electric space heating from 2009 Residential Energy Consumption Survey for Missouri. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area, then they should be used.~~

[667] ~~The value is estimated at 1.12 (calculated as 1 + (0.34 / 2.8)), is based on cooling loads decreasing by 34% of the lighting savings (average result from REMRate modeling of several different building configurations in Iowa (Des Moines, Mason City, and Burlington)). The estimate also assumes typical cooling system operating efficiency of 2.8 COP (starting from standard assumption of SEER 10.5 central AC unit, converted to 9.5 EER using algorithm (-0.02 * SEER^2) + (1.12 * SEER) (from Wassmer, M. (2003); A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder), converted to COP = EER/3.412 = 2.8COP). Results of the Iowa study were assumed to be applicable to Missouri.~~

[668] ~~The value is estimated at 1.11 (calculated as 1 + (0.91*(0.34 / 2.8)). Based on assumption that 91% of homes have central cooling (based on 2009 Residential Energy Consumption Survey, see "HC7.9 Air Conditioning in Midwest Region.xls").~~

~~Where:~~

~~ΔkWh = Energy Savings as calculated above~~

~~CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor~~
~~= 0.0001492529 for Lighting RES (Residential)~~
~~= 0.0001899635 for Lighting BUS (Business)~~

NATURAL GAS SAVINGS

Heating Penalty for Natural Gas heated home~~:~~s[669]

~~$$\Delta Therms = -\frac{\frac{Watts_{Base} - Watts_{EE}}{1{,}000} * ISR * Hours * HF * 0.03412}{\eta Heat} * \%GasHeat$$~~

ΔTherms= -((Watts $_{Base}$ – Watts$_{EE}$) / 1,000 * ISR * Hours * HF * 0.03412) / ηHeat * %GasHeat

Where:

HF = Heating Factor or percentage of light savings that must be heated
= 53%[670] for interior or unknown location
= 0% for exterior or unheated location

0.03412 =Converts kWh to therms

ηHeat$_{Gas}$ = Efficiency of heating system
=71%[671]

%GasHeat = Percentage of homes with gas heat

Heating fuel	%GasHeat
Electric	0%
Gas	100%
Unknown	65%[672]

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

MEASURE CODE:

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

[670] This means that heating loads increase by 53% of the lighting savings. This is based on the average result from REMRate modeling of several different building configurations in Des Moines, Mason City, and Burlington, Iowa. Results of the Iowa study were judged to be equally applicable to Missouri.

[671] This has been estimated assuming that natural gas central furnace heating is typical for Missouri residences (the predominant heating is gas furnace with 48% of Missouri homes (based on Energy Information Administration, 2009 Residential Energy Consumption Survey)). See reference ~~"HC6.9 Space Heating in Midwest Region.xls."~~, https://www.eia.gov/consumption/residential/data/2009/hc/hc6.9.xls; 'hc6.9.xls'. In 2000, 29% of furnaces purchased in Missouri 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, so units purchased 15 years ago provide a reasonable proxy for the current mix of furnaces in the State. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows: ((0.29*0.92) + (0.71*0.8)) * (1-0.15) = 0.71~~.~~.

[672] Average (default) value of 65% gas space heating from 2009 Residential Energy Consumption Survey for Missouri. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area, then they should be used.

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3.5.3 LED Nightlights

DESCRIPTION

This measure describes savings from LED nightlights. This characterization assumes that the LED nightlight is installed in a residential location.

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

DEFINITION OF BASELINE EQUIPMENT

For this characterization to apply, the high-efficiency equipment must be a qualified LED nightlight.

DEFINITION OF BASELINE EQUIPMENT

The baseline condition is assumed to be an incandescent/halogen nightlight.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The estimated useful life of the is estimated is 8 years.[673]

DEEMED MEASURE COST

Where possible, the actual cost should be used and compared to the baseline cost. If the incremental cost is unknown, assume $3.35.[674]

LOADSHAPE

Lighting RES

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = ((WattsBase - WattsEE) / 1000) * ISR * (1-Leakage) * Hours * WHFe$$

Where:

$Watts_{base}$ = Actual wattage if known, if unknown, assume 7W.[675]
$Watts_{EE}$ = Actual wattage of LED purchased / installed.
ISR = In Service Rate or the percentage of nightlights rebated that get installed
Leakage = Adjustment to account for the percentage of program bulbs that move out.
= Actual, or if unknown, 0% for Online Store and 4% for Upstream Lighting or 3.98% if unknown [676]
Hours = Average hours of use per year
= 4,380[677]
LKG = leakage rate (program bulbs installed outside Ameren Missouri's service area)
= Actual, or if unknown, assume 0%[678]
ISR = In Service Rate, the percentage of units rebated that are actually in service. Actual, or if unknown, assume:

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[673] Southern California Edison Company, "LED, Electroluminescent & Fluorescent Night Lights", Work Paper WPSCRELG0029 Rev. 1, February 2009, p. 2. and p.3.

[674] Average cost data provided in Stanley Mertz, "LED Nightlights Energy Efficiency Retail products programs", March 2018.

[675] Based on Stanley Mertz, "LED Nightlights Energy Efficiency Retail products programs", March 2018.

[676] Ameren Missouri Lighting Evaluation: PY2019. 3.98% is the weighted average for bulbs sold through the Online Store and Upstream Programs based on evaluation results and the distribution of bulbs in the PY19 program, https://www.efis.psc.mo.gov/Document/Display/15876, page 13 .

[677] Assumes nightlight is operating 12 hours per day, consistent with the 2016 Pennsylvania TRM.

[678] Assumed based on program delivery channels.

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Program	Discounted In Service Rate (ISR)
~~Direct Install (MFLI)~~MFIE [679]	98.2%
SFIE, PAYS~~Efficiency Kit (MF)~~[680]	100%
~~Low Income Kits~~	~~90%~~
~~Pay As You Save[681]~~	~~87%~~

WHFe = Waste Heat Factor for energy to account for the impact from reducing waste heat from efficient lighting on electric cooling and heating loads in residential homes.
= 0.99 if unknown[682]

$WHFe_{Heat}$ = Waste Heat Factor for energy to account for electric heating increase from reducing waste heat from efficient lighting (if fossil fuel heating, see calculation of heating penalty in that section).
= 1 - ((HF / ηHeat) * %ElecHeat).
= If unknown assume 0.88[683]

Where

HF = Heating Factor or percentage of light savings that must now be heated
= 53%[684] for interior location

$ηHeat_{Electric}$ = Efficiency in COP of Heating equipment
= Actual - If not available, use:[685]

System Type	Age of Equipment	HSPF2 Estimate	ηHeat (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[686]	N/A	N/A	1.28

%ElecHeat = Percentage of heating savings assumed to be electric

Heating fuel	%ElectricHeat
Electric	100%
Natural Gas	0%
Unknown	35%[687]

$WHFe_{Cool}$ = Waste Heat Factor for energy to account for cooling savings from reducing waste heat from efficient lighting

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[679] Ameren Missouri Community Savers Evaluation: PY2018, . https://www.efis.psc.mo.gov/Document/Display/36053, page 17.

[680] Ameren Missouri Efficient Kits Impact and Process Evaluation: Program Year 2018, https://www.efis.psc.mo.gov/Document/Display/15870, page 38.

~~[681] Ameren Missouri Pay As You Save (PAYS®) Evaluation, https://www.efis.psc.mo.gov/Document/Display/17591, page 7.~~

[682] Ameren Missouri PY2014 Evaluation, https://www.efis.psc.mo.gov/Document/Display/14194, page 45.

[683] Calculated using defaults: 1-((0.53/1.57) * 0.35) = 0.88.

[684] This means that heating loads increase by 53% of the lighting savings. This is based on the average result from REMRate modeling of several different building configurations in Iowa (Des Moines, Mason City, and Burlington). These results were judged to be equally applicable to Missouri.

[685] These default system efficiencies are based on the applicable minimum federal standards. In 2006 and 2015, 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.

[686] Calculation assumes 35% Heat Pump and 65% Resistance, which is based upon data from Energy Information Administration, 2009 Residential Energy Consumption Survey, ~~,~~ https://www.eia.gov/consumption/residential/data/2009/hc/hc6.9.xls; ‘hc6.9.xls’. 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.

[687] Average (default) value of 35% electric space heating from 2009 Residential Energy Consumption Survey for Missouri. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area, then they should be used.

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Bulb Location	$WHFe_{Cool}$
Building with cooling	1.12[688]
Building without cooling	1.0
Unknown	1.11[689]

SUMMER COINCIDENT PEAK DEMAND SAVINGS

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

Where:

ΔkWh = Electric energy savings, as calculated above.
CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor
= 0.0001492529 for Lighting RES (Residential)

NATURAL GAS SAVINGS

Heating Penalty for Natural Gas heated homes:[690]

$$\Delta Therms = -((Watts_{Base} - Watts_{EE}) / 1{,}000 * ISR * Hours * HF * 0.03412) / \eta Heat * \%GasHeat$$

Where:

HF = Heating Factor or percentage of light savings that must be heated
= 53%[691] for interior or unknown location
= 0% for exterior or unheated location
0.03412 =Converts kWh to therms
$\eta Heat_{Gas}$ = Efficiency of heating system
=71%[692]
%GasHeat = Percentage of homes with gas heat

Heating fuel	%GasHeat
Electric	0%
Gas	100%
Unknown	65%[693]

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

MEASURE CODE:

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[688] The value is estimated at 1.12 (calculated as 1 + (0.34 / 2.8)), and it is based on cooling loads decreasing by 34% of the lighting savings (average result from REMRate modeling of several different building configurations in Iowa (Des Moines, Mason City, and Burlington)). The estimate also assumes typical cooling system operating efficiency of 2.8 COP (starting from standard assumption of SEER 10.5 central AC unit, converted to 9.5 EER using algorithm $(-0.02 * SEER^2) + (1.12 * SEER)$ (from Wassmer, M. (2003); A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder), converted to COP = EER/3.412 = 2.8COP). Results of the Iowa study are assumed to be applicable to Missouri.

[689] The value is estimated at 1.11 (calculated as 1 + (0.91*(0.34 / 2.8)), which is based on assumption that 91% of homes have central cooling (based on 2009 Residential Energy Consumption Survey, see~~,~~ https://www.eia.gov/consumption/residential/data/2009/hc/hc6.9.xls; 'hc6.9.xls').

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

[691] This means that heating loads increase by 53% of the lighting savings. This is based on the average result from REMRate modeling of several different building configurations in Des Moines, Mason City, and Burlington, Iowa. Results of the Iowa study were judged to be equally applicable to Missouri.

[692] This has been estimated assuming that natural gas central furnace heating is typical for Missouri residences (the predominant heating is gas furnace with 48% of Missouri homes (based on Energy Information Administration, 2009 Residential Energy Consumption Survey)). See reference ~~,~~ https://www.eia.gov/consumption/residential/data/2009/hc/hc6.9.xls; 'hc6.9.xls'. In 2000, 29% of furnaces purchased in Missouri 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, so units purchased 15 years ago provide a reasonable proxy for the current mix of furnaces in the State. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows: ((0.29*0.92) + (0.71*0.8)) * (1-0.15) = 0.71.

[693] Average (default) value of 65% gas space heating from 2009 Residential Energy Consumption Survey for Missouri. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area, then they should be used.

~~Ultra-Efficient LED Lighting~~

~~DESCRIPTION~~

~~This characterization provides savings assumptions for a variety of ultra efficient LED screw based lamp types including omnidirectional and specialty (globe, decorative and downlights) types. This characterization assumes that the LED lamp is installed in a residential location.~~

~~This measure was developed to be applicable to the following program types: TOS and KITS.~~

~~DEFINITION OF EFFICIENT EQUIPMENT~~

~~In order for this characterization to apply, new lamps must exceed efficiency specifications defined in the Standard-Efficiency LED Baseline Wattage Tables below. Consult the tables to find the maximum wattage that can be considered ultra-efficient for each bulb type.~~

~~Actual lamp wattages of the efficient equipment should be used to determine savings.~~

~~DEFINITION OF BASELINE EQUIPMENT~~

~~See "Standard-Efficiency LED Baseline Wattage" tables below for specific baseline wattages by lamp type and lumen output.~~

~~DEEMED LIFETIME OF EFFICIENT EQUIPMENT~~

~~According to the ENERGY STAR Qualified Products list (accessed 6/16/2020), the average rated life for Omnidirectional lamps is approximately 20,000 hours, 17,000 hours for decorative and 25,000 for directional lamps .~~

~~DEEMED MEASURE COST~~

~~The actual ultra-efficient LED lamp cost should be used. For incremental cost, assume a baseline cost according to the following table[694]:~~

~~Bulb Type~~	~~Standard LED Baseline Cost~~
~~Omnidirectional~~	~~$2.70~~
~~Directional~~	~~$5.18~~
~~Decorative and Globe~~	~~$3.40~~

~~LOADSHAPE~~

~~Lighting RES~~
~~Lighting BUS~~

~~Algorithm~~

~~CALCULATION OF SAVINGS~~

~~ELECTRIC ENERGY SAVINGS~~

~~$\Delta kWh = (Watt_{Base} - Watt_{EE}) * ISR * (1 - LKG) * Hours * WHF / 1,000$~~

~~Where:~~

~~$Watts_{Base}$ = Input wattage of the existing or baseline system. Reference the "Standard-Efficiency LED Baseline Wattage" table for default values.[695]~~

~~$Watts_{EE}$ = Actual wattage of LED purchased / installed must be used.~~

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~~[694] Illinois TRM Version 12.0, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_3_Res_09222023_FINAL_clean.pdf, page 366. Baseline and LED lamp costs are based on field data collected by CLEAResult and provided by ComEd. See 'ComEd Pricing Projections 06302016.xlsx' for analysis. Given LED prices are expected to continue declining assumed costs should be reassessed on an annual basis and replaced with IL specific LED program information when available.~~

~~[695] Illinois TRM Version 12.0, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_3_Res_09222023_FINAL_clean.pdf, page 367. See file 'LED Lamp Updates 2021-06-09.xslx' for details on Guidehouse lamp wattage calculations based on equivalent baseline wattage and LED wattage of available ENERGY STAR product.~~

~~Standard-Efficiency LED Baseline Wattage Table: Omnidirectional~~

~~Minimum Lumens~~	~~Maximum Lumens~~	~~Standard LED Baseline Wattage (WattsBase)~~
~~120~~	~~399~~	~~4.0~~
~~400~~	~~749~~	~~6.6~~
~~750~~	~~899~~	~~9.6~~
~~900~~	~~1,399~~	~~13.1~~
~~1,400~~	~~1,999~~	~~16.0~~
~~2,000~~	~~2,999~~	~~21.8~~
~~3,000~~	~~3,299~~	~~28.9~~

~~Standard-Efficiency LED Baseline Wattage Table: Decorative Lamps~~

~~Bulb Type~~	~~Minimum Lumens~~	~~Maximum Lumens~~	~~Standard LED Baseline Wattage (Watts$_{Base}$)~~
~~Omni-Directional~~	~~1,100~~	~~1,999~~	~~14.7~~
~~3-Way~~	~~2,000~~	~~2,700~~	~~22.6~~
~~Globe (medium and intermediate bases less than 750 lumens)~~	~~310~~	~~349~~	~~3.0~~
	~~350~~	~~499~~	~~4.7~~
	~~500~~	~~574~~	~~5.7~~
	~~575~~	~~649~~	~~6.5~~
	~~650~~	~~1,000~~	~~8.2~~
~~Globe (candelabra bases less than 1050 lumens)~~	~~310~~	~~349~~	~~3.5~~
	~~350~~	~~499~~	~~4.4~~
	~~500~~	~~574~~	~~5.5~~
~~Decorative (Shapes B, BA, C, CA, DC, F, G, medium and intermediate bases less than 750 lumens)~~	~~310~~	~~499~~	~~4.3~~
	~~500~~	~~800~~	~~5.8~~
~~Decorative (Shapes B, BA, C, CA, DC, F, G, candelabra bases less than 1050 lumens)~~	~~310~~	~~499~~	~~4.2~~
	~~500~~	~~650~~	~~5.5~~
~~Decorative (Shape ST)~~	~~310~~	~~499~~	~~6.5~~
	~~500~~	~~999~~	~~8.8~~
	~~1000~~	~~1500~~	~~10.0~~
~~Decorative – (Shape S)~~	~~310~~	~~340~~	~~2.25~~

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~~Standard-Efficiency LED Baseline Wattage Table: Directional Lamps~~

~~Bulb Type~~	~~Minimum Lumens~~	~~Maximum Lumens~~	~~Standard LED Baseline Wattage (Watts$_{Base}$)~~
~~Reflector lamp types with medium screw bases (PAR20, PAR30(S,L), PAR38, R40, etc.) w/ diameter >2.25"~~	~~400~~	~~649~~	~~7.0~~
	~~650~~	~~899~~	~~10.7~~
	~~900~~	~~1,049~~	~~13.9~~
	~~1,050~~	~~1,199~~	~~13.8~~
	~~1,200~~	~~1,499~~	~~15.9~~
	~~1,500~~	~~1,999~~	~~18.9~~
	~~2,000~~	~~3,299~~	~~27.3~~
~~Reflector lamp types with medium screw bases (PAR16, R14, R16, etc.) w/ diameter <2.25"~~	~~310~~	~~374~~	~~4.6~~
	~~375~~	~~600~~	~~6.4~~
~~BR30, BR40, or ER40~~	~~650~~	~~949~~	~~9.3~~
	~~950~~	~~1,099~~	~~12.7~~
	~~1,100~~	~~1,399~~	~~14.4~~
	~~1,400~~	~~1,600~~	~~16.6~~
	~~1,601~~	~~1,800~~	~~22.2~~
~~R20~~	~~450~~	~~524~~	~~6.0~~
	~~525~~	~~750~~	~~7.1~~
~~MR16~~	~~310~~	~~324~~	~~3.8~~
	~~325~~	~~369~~	~~4.8~~
	~~370~~	~~400~~	~~4.9~~

~~Standard-Efficiency LED Baseline Wattage Table: Additional EISA non-exempt bulb types~~

~~Bulb Type~~	~~Minimum Lumens~~	~~Maximum Lumens~~	~~Standard LED Baseline Wattage (Watts$_{Base}$)~~
~~Dimmable Twist, Globe (less than 5" in diameter and > 749 lumens), candle (shapes B, BA, CA > 749 lumens), Candelabra Base Lamps (>1049 lumens), Intermediate Base Lamps (>749 lumens)~~	~~310~~	~~399~~	~~4.0~~
	~~400~~	~~749~~	~~6.6~~
	~~750~~	~~899~~	~~9.6~~
	~~900~~	~~1,399~~	~~13.1~~
	~~1,400~~	~~1,999~~	~~16.0~~

~~LKG = leakage rate (program bulbs installed outside Ameren Missouri's service area)~~
~~= Actual, or if unknown, assume 0%[696]~~

~~ISR = In Service Rate, the percentage of units rebated that are actually in service. Actual, or if unknown, assume:~~

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~~[696] Assumed based on program delivery channels.~~

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~~Program~~	~~Discounted In Service Rate (ISR)~~
~~Direct Install (MFLI)~~ [697]	~~98.2%~~
~~Efficiency Kit (MF)~~[698]	~~100%~~
~~Low Income Kits~~	~~90%~~
~~Pay As You Save~~[699]	~~87%~~

~~Hours = Average hours of use per year for bulbs in residential homes. Custom, or if unknown assume 1,314~~[700] ~~for exterior, or or if interior use table below.~~

~~Program~~	~~HOU Res~~
~~Residential~~	~~995.18~~[701]
~~Efficient Kits~~	~~995.18~~
~~Income Eligible RES~~	~~674.18~~[702]
~~MFMR~~	~~693.50~~[703]

~~WHFe = Waste Heat Factor for energy to account for the impact from reducing waste heat from efficient lighting on electric cooling and heating loads in residential homes.~~

~~= 0.99 if unknown~~[704]

~~WHFe~~$_{Heat}$ ~~= Waste Heat Factor for energy to account for electric heating increase from reducing waste heat from efficient lighting (if fossil fuel heating, see calculation of heating penalty in that section).~~

~~= 1 - ((HF / ηHeat) * %ElecHeat).~~

~~= If unknown assume 0.88~~[705]

~~Where~~

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

~~= 53%~~[706] ~~for interior or unknown location~~

~~= 0% for exterior or unheated location~~

~~ηHeat~~$_{Electric}$ ~~= Efficiency in COP of Heating equipment~~

~~= Actual - If not available, use:~~[707]

~~System Type~~	~~Age of Equipment~~	~~HSPF2 Estimate~~	~~ηHeat (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~~[708]	~~N/A~~	~~N/A~~	~~1.28~~

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[697] ~~Ameren Missouri Community Savers Evaluation: PY2018, . https://www.efis.psc.mo.gov/Document/Display/36053, page 17.~~

[698] ~~Ameren Missouri Efficient Kits Impact and Process Evaluation: Program Year 2018, https://www.efis.psc.mo.gov/Document/Display/15870, page 38.~~

[699] ~~Ameren Missouri Pay As You Save (PAYS®) Evaluation, https://www.efis.psc.mo.gov/Document/Display/17591, page 7.~~

[700] ~~Ameren Missouri Lighting Impact and Process Evaluation: Program Year 2015. Average daily HOU for efficient bulbs is listed as 3.6 for outside bulbs and a weighted (by inventory) average of 1.99 for inside spaces. Unknown location is weighted average (by inventory) of all bulbs. See 'MO Lamp Hours.xlsx' for calculations.~~

[701] ~~Ameren Missouri Lighting Evaluation PY2018, https://www.efis.psc.mo.gov/Document/Display/15873, page 36.~~

[702] ~~Ameren Missouri Community Savers Evaluation PY2018 workpapers- Weighted Avg. HOU from ADM workpapers.~~

[703] ~~ADM 2017 Community Savers EM&V, https://www.efis.psc.mo.gov/Document/Display/28281, page 3-4.~~

[704] ~~Ameren Missouri PY2014 Evaluation, https://www.efis.psc.mo.gov/Document/Display/14194, page 45.~~

[705] ~~Calculated using defaults: 1-((0.53/1.57) * 0.35) = 0.88.~~

[706] ~~This means that heating loads increase by 53% of the lighting savings. This is based on the average result from REMRate modeling of several different building configurations in Iowa (Des Moines, Mason City, and Burlington). These results were judged to be equally applicable to Missouri.~~

[707] ~~These default system efficiencies are based on the applicable minimum federal standards. In 2006 and 2015, 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.~~

[708] ~~Calculation assumes 35% Heat Pump and 65% Resistance, which is based upon data from Energy Information Administration, 2009 Residential Energy Consumption Survey, https://www.eia.gov/consumption/residential/data/2009/hc/hc6.9.xls; 'hc6.9.xls'. 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.~~

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~~%ElecHeat = Percentage of heating savings assumed to be electric~~

~~Heating fuel~~	~~%ElectricHeat~~
~~Electric~~	~~100%~~
~~Natural Gas~~	~~0%~~
~~Unknown~~	~~35%[709]~~

~~$WHFe_{Cool}$ = Waste Heat Factor for energy to account for cooling savings from reducing waste heat from efficient lighting~~

~~Bulb Location~~	~~$WHFe_{Cool}$~~
~~Building with cooling~~	~~1.12[710]~~
~~Building without cooling or exterior~~	~~1.0~~
~~Unknown~~	~~1.11[711]~~

~~SUMMER COINCIDENT PEAK DEMAND SAVINGS~~

~~$\Delta kW = \Delta kWh * CF$~~

~~Where:~~

~~ΔkWh = Electric energy savings, as calculated above.~~
~~CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor~~
~~= 0.0001492529 for Lighting RES (Residential)~~

~~NATURAL GAS SAVINGS~~

~~Heating Penalty for Natural Gas heated homes[712]~~

~~$\Delta Therms = ((Watts\_{Base} - Watts_{EE}) / 1{,}000 * ISR * Hours * HF * 0.03412) / \eta Heat * \%GasHeat$~~

~~Where:~~

~~HF = Heating Factor or percentage of light savings that must be heated~~
~~= 53%[713] for interior or unknown location~~
~~= 0% for exterior or unheated location~~
~~0.03412 =Converts kWh to therms~~
~~$\eta Heat_{Gas}$ = Efficiency of heating system~~
~~=71%[714]~~
~~%GasHeat = Percentage of homes with gas heat~~

~~[709] Average (default) value of 35% electric space heating from 2009 Residential Energy Consumption Survey for Missouri. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area, then they should be used.~~

~~[710] The value is estimated at 1.12 (calculated as 1 + (0.34 / 2.8)), and it is based on cooling loads decreasing by 34% of the lighting savings (average result from REMRate modeling of several different building configurations in Iowa (Des Moines, Mason City, and Burlington)). The estimate also assumes typical cooling system operating efficiency of 2.8 COP (starting from standard assumption of SEER 10.5 central AC unit, converted to 9.5 EER using algorithm (-0.02 * $SEER^2$) + (1.12 * SEER) (from Wassmer, M. (2003); A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder), converted to COP = EER/3.412 = 2.8COP). Results of the Iowa study are assumed to be applicable to Missouri.~~

~~[711] The value is estimated at 1.11 (calculated as 1 + (0.91*(0.34 / 2.8)), which is based on assumption that 91% of homes have central cooling (based on 2009 Residential Energy Consumption Survey, see https://www.eia.gov/consumption/residential/data/2009/hc/hc6.9.xls; 'hc6.9.xls').~~

~~[712] Negative value because this is an increase in heating consumption due to the efficient lighting.~~

~~[713] This means that heating loads increase by 53% of the lighting savings. This is based on the average result from REMRate modeling of several different building configurations in Des Moines, Mason City, and Burlington, Iowa. Results of the Iowa study were judged to be equally applicable to Missouri.~~

~~[714] This has been estimated assuming that natural gas central furnace heating is typical for Missouri residences (the predominant heating is gas furnace with 48% of Missouri homes (based on Energy Information Administration, 2009 Residential Energy Consumption Survey)). See reference https://www.eia.gov/consumption/residential/data/2009/hc/hc6.9.xls; 'hc6.9.xls'. In 2000, 29% of furnaces purchased in Missouri 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, so units purchased 15 years ago provide a reasonable proxy for the current mix of furnaces in the State. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows: ((0.29*0.92) + (0.71*0.8)) * (1-0.15) = 0.71.~~

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~~Heating fuel~~	~~%GasHeat~~
~~Electric~~	~~0%~~
~~Gas~~	~~100%~~
~~Unknown~~	~~65%~~[715]

~~WATER IMPACT DESCRIPTIONS AND CALCULATION~~

~~N/A~~

~~MEASURE CODE:~~

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[715] ~~Average (default) value of 65% gas space heating from 2009 Residential Energy Consumption Survey for Missouri. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area, then they should be used.~~

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~~3.6 Motors~~

~~3.6.1 High Efficiency Pool Pumps~~

~~DESCRIPTION~~

~~Residential outdoor pool pumps can be single speed, two/multi speed or variable speed. A federal standard (82 FR 5650) effective July 19, 2021 effectively requires pool pumps to be at least two speed.~~

~~Single speed pumps are often oversized, and run frequently at constant flow regardless of load. Single speed pool pumps require that the motor be sized for the task that requires the highest speed. As such, energy is wasted performing low speed tasks at high speed. Two- speed and variable speed pool pumps reduce speed when less flow is required, such as when filtering is needed but not cleaning, and have timers that encourage programming for fewer on-hours. Variable speed pool pumps use advanced motor technologies to achieve efficiency ratings of 90% while the average single speed pump will have efficiency ratings between 30% and 70%.[716] This measure is the characterization of the purchasing and installing of a new ENERGY STAR variable speed residential pool pump motor in place of a new baseline pump meeting the federal standard for Time of Sale and New Construction, or the early replacement of a standard single speed motor of equivalent horsepower.~~

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

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

~~DEFINITION OF EFFICIENT EQUIPMENT~~

~~The high efficiency equipment is an ENERGY STAR® variable speed residential pool pump for in-ground pools.~~

~~DEFINITION OF BASELINE EQUIPMENT~~

~~For TOS and NC, the baseline equipment is a two speed residential pool pump meeting the Federal Standard, effective July 19, 2021 provided below:~~

~~Size Class~~	~~Baseline (Effective 7/19/2021)~~
~~Extra Small (hhp ≤ 0.13)~~	~~WEF ≥ 5.55~~
~~Small (hhp > 0.13 and < 0.711)~~	~~WEF ≥ -1.30 x ln (hhp) + 2.90~~
~~Standard Size (hhp ≥ 0.711)~~	~~WEF ≥ -2.30 x ln (hhp) + 6.59~~

~~For early replacement, the baseline is the existing single speed residential pool pump.~~

~~DEEMED LIFETIME OF EFFICIENT EQUIPMENT~~

~~The estimated useful life for a two speed or variable speed pool pump is 10 years.~~[717]

~~DEEMED MEASURE COST~~

~~For TOS and NC, the incremental cost is estimated $314 for a variable speed motor.~~[718]

~~For early replacement, the actual cost of the measure should be used; if actual is unknown, use $549.~~[719]

~~LOADSHAPE~~

~~Pool Spa RES~~

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[716] ~~U.S. DOE, 2012. Measure Guideline: Replacing Single-Speed Pool Pumps with Variable Speed Pumps for Energy Savings. Report No. DOE/GO-102012-3534.~~

[717] ~~The CEE Efficient Residential Swimming Pool Initiative (p. 18) indicates that the average motor life for pools in use year-round is 5-7 years. For pools in use for less than a third of the year, the expected lifetime is higher, so a 10-year assumption is selected. This assumption is consistent with DEER 2014 and the ENERGY STAR® Pool Pump Calculator, https://www.energystar.gov/productfinder/downloads/Pool_Pump_Calculator_2020.05.05_FINAL.xlsx (https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fwww.energystar.gov%2Fproductfinder%2Fdownloads%2FPool_Pump_Calculator_2020.05.05_FINAL.xlsx&wdOrigin=BROWSELINK) assumptionsThe CEE Efficient Residential Swimming Pool Initiative, p18, indicates that the average motor life for pools in use year round is 5-7 years. For pools in use for under a third of a year, you would expect the lifetime to be higher so 10 years is selected as an assumption. This is consistent with DEER, 2014 and the ENERGY STAR® Pool Pump Calculator assumptions.~~

[718] ~~Illinois TRM Version 12.0, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_3_Res_09222023_FINAL_clean.pdf, page 408. ENERGY STAR® Pool Pump Calculator, using the difference between the two speed pool pump and variable speed pool pump incremental costs.~~

[719] ~~ENERGY STAR® Pool Pump Calculator, estimated cost for a variable speed pool pump., https://www.energystar.gov/productfinder/downloads/Pool_Pump_Calculator_2020.05.05_FINAL.xlsx (https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fwww.energystar.gov%2Fproductfinder%2Fdownloads%2FPool_Pump_Calculator_2020.05.05_FINAL.xlsx&wdOrigin=BROWSELINK).~~

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~~Algorithm~~

~~CALCULATION OF ENERGY SAVINGS~~

~~Electric Energy Savings~~[720]

~~For TOS and NC:~~

~~ΔkWh = (Gallons * Turnovers * (1/(WEF$_{base}$ – 1/WEF$_{ee}$) * Days) / 1,000 * ISR~~

~~For Early Replacement:~~

~~ΔkWh = (Gallons * Turnovers * (1/EF$_{exist}$ – 1/WEF$_{ee}$) * Days) / 1,000 * ISR~~

~~For TOS and NC:~~

~~$$\Delta kWh = \left(Gallons * Turnovers * \left(\frac{1}{WEF_{base}} - \frac{1}{WEF_{ee}}\right) * Days\right)/1{,}000 * ISR$$~~

~~For Early Replacement:~~

~~$$\Delta kWh = \left(Gallons * Turnovers * \left(\frac{1}{EF_{exist}} - \frac{1}{WEF_{ee}}\right) * Days\right)/1{,}000 * ISR$$~~

~~Where:~~

~~Gallons = Capacity of the pool. Use actual, or if unknown assume 22,000.~~[721]
~~Turnovers = Desired number of pool water turnovers per day~~
~~= 2~~[722]
~~WEF$_{base}$ = Weighted Energy Factor of baseline pump (gal/Wh)~~
~~= Actual, or if unknown, assume 4.6~~[723]
~~WEF$_{ee}$ = Weighted Energy Factor of installed ENERGY STAR pump (gal/Wh)~~
~~= Actual, or if unknown, assume 6.31~~[724]
~~EF$_{exist}$ = Energy Factor of existing single speed pump (gal/Wh)~~
~~= Actual, or if unknown, assume 2.3~~[725]
~~Days = Days per year of operation~~
~~= 121.62~~[726]
~~1,000 = Conversion factor from Wh to kWh~~
~~ISR = In Service Rate~~[727]
~~= Actual, or if unknown 100%~~[728] ~~for the Efficiency Products Program.~~

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[720] ~~Ibid. The methodology followed is consistent with the most recent version of the 2020 ENERGY STAR calculator (Pool_Pump_Calculator_2020.05.05_FINAL.xlsx), however this has not been updated to account for the new federal standard, https://www.energystar.gov/productfinder/downloads/Pool_Pump_Calculator_2020.05.05_FINAL.xlsx.~~

[721] ~~Ibid. Consistent with assumption in the 2020 ENERGY STAR calculator (Pool_Pump_Calculator_2020.05.05_FINAL.xlsx), https://www.energystar.gov/productfinder/downloads/Pool_Pump_Calculator_2020.05.05_FINAL.xlsx.~~

[722] ~~Ibid.~~

[723] ~~Ibid. Consistent with IL-TRM V10.0 assumption, which is based Based oon applying the federal standard specifications to the average Curve-C rated hydraulic horsepower (hhp) from the ENERGY STAR Qualified Products List, accessed 3/31/2021.~~

[724] ~~Ibid. Consistent with IL-TRM V10.0 assumption, which is Bbased on applying the ENERGY STAR specifications to the average Curve-C rated hydraulic horsepower (hhp) from the ENERGY STAR Qualified Products List, accessed 3/31/2021.~~

[725] ~~Ibid. Consistent with assumption in the 2020 ENERGY STAR calculator, assuming 1.5 HP pump ('Pool_Pump_Calculator_2020.05.05_FINAL.xlsx'), https://www.energystar.gov/productfinder/downloads/Pool_Pump_Calculator_2020.05.05_FINAL.xlsx.~~

[726] ~~Ibid. Consistent with assumption in the 2020 ENERGY STAR calculator ('Pool_Pump_Calculator_2020.05.05_FINAL.xlsx'), https://www.energystar.gov/productfinder/downloads/Pool_Pump_Calculator_2020.05.05_FINAL.xlsx.~~

[727] ~~Ameren Missouri Efficient Products Evaluation PY2019 (Table 6-9)Ameren Missouri Efficient Products Evaluation: PY2019, https://www.efis.psc.mo.gov/Document/Display/15876, page 67.~~

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[728] ~~Ibid. Consistent with assumption in the 2020 ENERGY STAR calculator, assuming 1.5 HP pump ('Pool_Pump_Calculator_2020.05.05_FINAL.xlsx'), https://www.energystar.gov/productfinder/downloads/Pool_Pump_Calculator_2020.05.05_FINAL.xlsx.~~

~~Summer Coincident Peak Demand Savings~~

~~ΔkW = ΔkWh * CF~~

~~Where:~~

~~ΔkWh = Electric energy savings, as calculated above.~~
~~CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor~~~~$\Delta kW = \Delta kWh * CF$~~

~~= 0.0002354459Where:~~

~~ΔkWh = Energy Savings as calculated above~~
~~CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor~~
~~= 0.0002354459~~

~~Natural Gas Savings~~

~~N/A~~

~~Water Impact Descriptions and Calculation~~

~~N/A~~

~~Deemed O&M Cost Adjustment Calculation~~

~~N/A~~

~~Measure Code:~~

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~~3.7~~3.6 Building Shell

3.7.1 Air Sealing

DESCRIPTION

Thermal shell air leaks are sealed through strategic use and location of air-tight materials. An estimate of savings is provided in two ways. It is highly recommended that leaks be detected and pre- and post-sealing leakage rates measured with the assistance of a blower-door by qualified/certified inspectors.[729] Where this occurs, an algorithm is provided to estimate the site-specific savings. Where test in/test out has not occurred, a ~~conservative deemed~~prescriptive savings assumption is provided.

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

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

DEFINITION OF EFFICIENT EQUIPMENT

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

DEFINITION OF BASELINE EQUIPMENT

The existing air leakage should be determined through approved and appropriate test methods using a blower door. The baseline condition of a building upon first inspection significantly affects the opportunity for cost-effective energy savings through air sealing.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 20~~15~~ years.[730]

DEEMED MEASURE COST

The actual capital cost for this measure should be used.

LOADSHAPE

Building Shell RES

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

Methodology 1: Test In / Test Out Approach

$$\Delta kWh = \Delta kWh_{cooling} + \Delta kWh_{heating}$$

~~$\Delta kWh = \Delta kWh\_cooling + \Delta kWh\_heating$~~

If the home has central cooling, the electric energy saved in annual cooling due to the air sealing is:~~Where:~~

$\Delta kWh_{cooling}$ ~~ΔkWh_cooling~~ $= (((CFM50_{Pre} - CFM50_{Post}) / N_{cool}) * 60 * 24 * CDD * DUA * 0.018 * LM) / ((1,000 * \eta Cool))$

~~= If central cooling, reduction in annual cooling requirement due to air sealing~~

Where:

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[729] Refer to the Energy Conservatory Blower Door Manual for more information on testing methodologies.

[730] Illinois TRM Version 12.0, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_3_Res_09222023_FINAL_clean.pdf, page 375. As recommended in Navigant ComEd Effective Useful Life Research Report, 'ComEd Effective Useful Life Research Report.pdf', May 2018~~Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007~~.

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~~$= \frac{\left(\frac{CFM50_{Pre} - CFM50_{Post}}{N_{cool}}\right) * 60 * 24 * CDD * DUA * 0.018 * LM}{(1000 * \eta Cool)}$~~

$CFM50_{Pre}$ = Infiltration at 50 Pascals as measured by blower door before air sealing
= Actual[731]

$CFM50_{Post}$ = Infiltration at 50 Pascals as measured by blower door after air sealing
= Actual

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[731] Because the pre- and post-sealing blower door test will occur on different days, there is a potential for the wind and temperature conditions on the two days to affect the readings. There are methodologies to account for these effects. For wind – first, if possible, avoid testing in high wind, place blower door on downwind side, take a pre-test baseline house pressure reading, adjust house pressure readings by subtracting the baseline reading, and use the time averaging feature on the digital gauge, etc. Corrections for air density due to temperature swings can be accounted for with air density correction factors. Refer to the Energy Conservatory Blower Door Manual for more information.

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N_{cool} = Conversion factor from leakage at 50 Pascal to leakage at natural conditions
=Dependent on number of stories:[732]

Weather Basis (City based upon)	N_cool (by # of stories)			
	1	1.5	2	3
St Louis, MO	34.9	30.9	28.3	25.1

60 * 24 = Converts cubic feet per minute to cubic feet per day
CDD = Cooling Degree Days:[733]

Weather Basis (City based upon)	CDD 65
St Louis, MO	1,646

DUA = Discretionary Use Adjustment (reflects the fact that people do not always operate their AC when conditions may call for it)
= 0.75[734]
0.018 = Specific heat capacity of air (Btu/ft^3*°F)
1000 = Converts Btu to kBtu
ηCool = Efficiency (SEER2) of air conditioning equipment (kBtu/kWh)
= Actual (where it is possible to measure or reasonably estimate) - if unknown, assume the following: [735]

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

~~following:~~~~[736]~~

~~Age of Equipment~~	~~SEER Estimate~~
~~Before 2006~~	~~10~~
~~2006 - 2014~~	~~13~~
~~Central AC After 1/1/2015~~	~~13~~
~~Heat Pump After 1/1/2015~~	~~14~~

LM = Latent multiplier to account for latent cooling demand: [737]

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[732] N-factor is used to convert 50-pascal blower door air flows to natural air flows and is dependent on geographic location and # of stories. These were developed by applying the LBNL infiltration model (see LBNL paper 21040, *Exegisis of Proposed ASHRAE Standard 119: Air Leakage Performance for Detached Single-Family Residential Buildings*; Sherman, 1986; page v-vi, Appendix page 7-9, https://eta-publications.lbl.gov/sites/default/files/exegesis_of_proposed_ashrae_std_119.pdf~~)~~; ‘exegesis_of_proposed_ashrae_std_119.pdf’) to the reported wind speeds and outdoor temperatures provided by the NRDC 30-year climate normals. For more information see Bruce Harley, CLEAResult ‘~~“~~Infiltration Factor Calculations Methodology-20151123.docx~~Infiltration Factor Calculations Methodology.doc~~’~~”~~ and calculation worksheets.

[733] Based on climate normals data with a base temperature of 65°F.

[734] This factor's source: Energy Center of Wisconsin, May 2008 metering study; “Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research,” ‘Energy Center of WI Central AC in WI 2008.pdf’, p. 31.

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

~~[736] These default system efficiencies are based on the applicable minimum federal standards. In 2006 the federal standard for central AC was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate.~~

[737] The LM is used to convert the sensible cooling savings calculated to a value representing sensible and latent cooling loads. The values are derived from the methodology outlined in Infiltration Factor Calculation Methodology by Bruce Harley, Senior Manager, Applied Building Science, CLEAResult 11/18/2015 and is based upon an 8760 analysis of sensible and total heat loads using hourly climate data (see ‘Infiltration Factor Calculations Methodology-20151123.docx’).

Weather Basis (City based upon)	LM
St Louis, MO	3.0

If the home is heated with electric heat (resistance or heat pump), the electric energy saved in annual heating due to the air sealing is:

$\Delta kWh_{HeatingElectricGas}$ ~~ΔkWh_heating~~ = $(((CFM50_{Pre} - CFM50_{Post}) / N_{heat}) * 60 * 24 * HDD * 0.018) / (\eta Heat * 3,412)$
~~= If electric heat (resistance or heat pump), reduction in annual electric heating due to air sealing~~
Where:

~~$= \frac{\frac{(CFM50_{Pre} - CFM50_{Post})}{N\_heat} * 60 * 24 * HDD * 0.018}{(\eta Heat * 3,412)}$~~

N_{heat}~~N_heat~~ = Conversion factor from leakage at 50 Pascal to leakage at natural conditions
= Based on building height:[738]

Weather Basis (City based upon)	N_heat (by # of stories)			
	1	1.5	2	3
St Louis, MO	24.0	21.3	19.5	17.3

HDD = Heating Degree Days

Weather Basis (City based upon)	HDD 65
St Louis, MO	4,486

ηHeat = Efficiency of heating system
= Actual - if not available refer to default table below:[739]

~~System Type~~	~~Age of Equipment~~	~~HSPF Estimate~~	~~ηHeat (Effective COP Estimate) (HSPF/3.412)*0.85~~
~~Heat Pump~~	~~Before 2006~~	~~6.8~~	~~1.7~~
	~~2006 - 2014~~	~~7.7~~	~~1.92~~
	~~2015 and after~~	~~8.2~~	~~2.04~~
~~Resistance~~	~~N/A~~	~~N/A~~	~~1~~

System Type	Age of Equipment	HSPF2 Estimate	ηHeat (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[740]	N/A	N/A	1.28

3412 = Converts Btu to kWh

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[738] N-factor is used to convert 50-pascal blower door air flows to natural air flows and is dependent on geographic location and # of stories. These were developed by applying the LBNL infiltration model (see LBNL paper 21040, *Exegisis of Proposed ASHRAE Standard 119: Air Leakage Performance for Detached Single-Family Residential Buildings*; Sherman, 1986; page v-vi, Appendix page 7-9~~)~~, https://eta-publications.lbl.gov/sites/default/files/exegesis_of_proposed_ashrae_std_119.pdf) to the reported wind speeds and outdoor temperatures provided by the NRDC 30 year climate normals. For more information see Bruce Harley, CLEAResult "Infiltration Factor Calculations Methodology.doc" and calculation worksheets.

[739] 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.

[740] Calculation assumes 35% Heat Pump and 65% Resistance, which is based upon data from Energy Information Administration, 2009 Residential Energy Consumption Survey, ~~,~~ https://www.eia.gov/consumption/residential/data/2009/hc/hc6.9.xls; 'hc6.9.xls'. 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.

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~~Conservative Deemed Approach~~

~~$\Delta kWh = SavingsPerUnit * SqFt$~~

~~Where:~~

~~SavingsPerUnit = Annual savings per square foot, dependent on heating / cooling equipment~~[741]

~~Building Type~~	~~HVAC System~~	~~SavingsPerUnit (kWh/ft)~~
~~Manufactured~~	~~Central Air Conditioner~~	~~0.062~~
~~Multifamily~~	~~Central Air Conditioner~~	~~0.043~~
~~Single Family~~	~~Central Air Conditioner~~	~~0.050~~
~~Manufactured~~	~~Electric Furnace/Resistance Space Heat~~	~~0.413~~
~~Multifamily~~	~~Electric Furnace/Resistance Space Heat~~	~~0.285~~
~~Single Family~~	~~Electric Furnace/Resistance Space Heat~~	~~0.308~~
~~Manufactured~~	~~Air Source Heat Pump~~	~~0.391~~
~~Multifamily~~	~~Air Source Heat Pump~~	~~0.251~~
~~Single Family~~	~~Air Source Heat Pump~~	~~0.308~~
~~Manufactured~~	~~Air Source Heat Pump - Cooling~~	~~0.062~~
~~Multifamily~~	~~Air Source Heat Pump - Cooling~~	~~0.043~~
~~Single Family~~	~~Air Source Heat Pump - Cooling~~	~~0.050~~
~~Manufactured~~	~~Air Source Heat Pump - Heating~~	~~0.329~~
~~Multifamily~~	~~Air Source Heat Pump - Heating~~	~~0.208~~
~~Single Family~~	~~Air Source Heat Pump - Heating~~	~~0.257~~

~~SqFt = Building conditioned square footage~~
~~= Actual~~

---

[741] ~~The values in the table represent estimates of savings from a 15% improvement in air leakage. The values are half those provided by Cadmus for the Iowa Joint Assessment, based on building simulations performed. While 30% savings are certainly achievable, this represents a thorough job in both the attic and basements and could not be verified without testing. The conservative 15% estimate is more appropriate for a deemed estimate. These values should be re-evaluated if EM&V values provide support for a higher deemed estimate.~~

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If the building is heated with a gas furnace, there will be some electric savings in heating the building attributed to air sealing since the furnace fans will run less.

~~Additional Fan savings~~

$\Delta kWh_{HeatingGas}$ ~~$\Delta kWh\_heating$~~ = $\Delta Therms * F_e * 29.3$~~If gas *furnace* heat, kWh savings for reduction in fan run time~~

Where:

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

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

= 3.14%[742]

29.3 = kWh per therm

Methodology 2: Prescriptive Infiltration Reduction Measures[743]

Savings shall only be calculated via Methodology 2 if a blower door test is not conducted.

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

If the home has central cooling, the electric energy saved in annual cooling due to the air sealing is:

$\Delta kWh_{cooling} = (\Delta kWh_{cool\_gasket} * n_{gasket} + \Delta kWh_{cool\_sweep} * n_{sweep} + \Delta kWh_{cool\_sealing} * lf_{sealing} + \Delta kWh_{cool\_wx} * lf_{wx}) * ADJ_{RxAirsealing}$

If the home is heated with electric heat (resistance or heat pump), the electric energy saved in annual heating due to the air sealing is:

$\Delta kWh_{heatingelectric} = (\Delta kWh_{heat\_gasket} * n_{gasket} + \Delta kWh_{heat\_sweep} * n_{sweep} + \Delta kWh_{heat\_sealing} * lf_{sealing} + \Delta kWh_{heat\_wx} * lf_{wx}) * \%ElectricHeat * ADJ_{RxAirsealing}$

Where:

n_{gasket} = Number of gaskets installed

n_{sweep} = Number of sweeps installed

$lf_{sealing}$ = Linear feet of caulking, sealing, or polyethylene tape

lf_{wx} = Linear feet of window weatherstripping or door weatherstripping

Measure	**Savings Variable Names**	**ΔkWhheat/Unit**			**ΔkWhcool/Unit**	
		Electric Resistance	**Heat Pump**	**Electric Heat Type Unknown[744]**	**With Cooling**	**Unknown Cooling**
Outlet Gasket	ΔkWh_{cool_gasket} ΔkWh_{heat_gasket}	7.19	3.59	5.9	1.63	1.07
Door Sweep	ΔkWh_{cool_sweep} ΔkWh_{heat_sweep}	138.2	69.1	114.0	6.39	4.22

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

[743] Illinois TRM Version 12.0, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_3_Res_09222023_FINAL_clean.pdf, page 382. Prescriptive savings are based upon “Evaluation of the Weatherization Residential Assistance Partnership and Helps Programs (WRAP/Helps).” Middletown, CT: KEMA, 2010. Accessed July 30, 2015, and adjusted for relative HDD of Bridgeport/Hartford CT with the applicable weather data. Cooling savings derived using savings assumptions pulled from ASHRAE, 2001 AHSRAE Handbook – Fundamentals, Chapter 26, Table 1. Effective Air Leakage Areas (Low-Rise Residential Applications Only). See ‘Air Sealing Prescriptive Savings 07.06.2024.xlsx’ for more information.

[744] Calculation assumes 35% Heat Pump and 65% Resistance, which is based upon data from Energy Information Administration, 2009 Residential Energy Consumption Survey, ~~,~~ https://www.eia.gov/consumption/residential/data/2009/hc/hc6.9.xls; ‘hc6.9.xls’.

Caulking/Sealing/Polyethylene Tape	$\Delta kWh_{cool\_sealing}$	7.91	3.95	6.5	0.17	0.11
	$\Delta kWh_{heat\_sealing}$					
Window or door weatherstripping	ΔkWh_{cool_wx}	9.19	4.59	7.6	0.16	0.11
	ΔkWh_{heat_wx}					

%ElectricHeat = Percentage of homes with electric heat

Heating fuel	%ElectricHeat
Electric	100%
Natural Gas	0%
Unknown	35%[745]

$ADJ_{RxAirsealing}$ = Adjustment for air sealing savings to account for prescriptive estimates overclaiming savings[746]
= 80%

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ΔkWh * CF

Where:

ΔkWh = Electric energy savings, as calculated above.
CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor~~ΔkW = ΔkWh * CF~~

= 0.0004660805[747]~~Where:~~
~~ΔkWh = Energy Savings as calculated above~~
~~CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor~~
~~= 0.0004660805[748]~~

NATURAL GAS SAVINGS

Methodology 1: Test In / Test Out Approach
If natural gas heating:

$\Delta Therms$ = $(((CFM50_{Pre} - CFM50_{Post}) / N_{heat}) * 60 * 24 * HDD * 0.018) / (\eta Heat * 100{,}000)$

~~$\Delta Therms = \frac{\frac{(CFM50_{Pre} - CFM50_{Post})}{N\_heat} * 60 * 24 * HDD * 0.018}{(\eta Heat * 100{,}000)}$~~

Where:
N_heat = Conversion factor from leakage at 50 Pascal to leakage at natural conditions
= Based on building height:[749]

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[745] Average (default) value of 35% electric space heating from 2009 Residential Energy Consumption Survey for Missouri. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area, then they should be used.

[746] Illinois TRM Version 12.0, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_3_Res_09222023_FINAL_clean.pdf, p. 384.Though we do not have a specific evaluation to point to, modeled savings have often been found to overclaim. Further VEIC reviewed these deemed estimates and consider them to likely be a high estimate. As such an 80% adjustment is applied, and this could be further refined with future evaluations.

[747] Based on Ameren Missouri TRM Volume 1 - Appendix G: "Table 1 – Residential End Use Category Monthly Shapes and Coincident Peak Factors"~~Ameren Missouri 2016 loadshape~~ for residential HVAC end-use.

[748] ~~Based on Ameren Missouri 2016 loadshape for residential HVAC end-use.~~

[749] N-factor is used to convert 50-pascal blower door air flows to natural air flows and is dependent on geographic location and # of stories. These were developed by applying the LBNL infiltration model (see LBNL paper 21040, *Exegisis of Proposed ASHRAE Standard 119: Air Leakage Performance for Detached Single-Family Residential Buildings*; Sherman, 1986; page v-vi, Appendix page 7-9, https://eta-publications.lbl.gov/sites/default/files/exegesis_of_proposed_ashrae_std_119.pdf) to the reported wind speeds and outdoor temperatures provided by the NRDC 30-year climate normals. For more information see Bruce Harley, CLEAResult "Infiltration Factor Calculations Methodology.doc" and calculation worksheets.

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Field Code Changed

Weather Basis (City based upon)	N_heat (by # of stories)			
	1	1.5	2	3
St Louis, MO	24.0	21.3	19.5	17.3

HDD = Heating Degree Days

Weather Basis (City based upon)	HDD 65
St Louis, MO	4,486

ηHeat = Efficiency of heating system
= Equipment efficiency * distribution efficiency
= Actual[750] - if not available, use 71%[751]

Other factors as defined above

Methodology 2: Prescriptive Infiltration Reduction Measures[752]

Savings shall only be calculated via Methodology 2 if a blower door test is not conducted.
~~Conservative Deemed Approach~~
If the home is heated with electric heat (resistance or heat pump), the electric energy saved in annual heating due to the air sealing is:

$$\Delta Therms = (\Delta Therms_{gasket} * n_{gasket} + \Delta Therms_{sweep} * n_{sweep} + \Delta Therms_{sealing} * lf_{sealing} + \Delta Therms_{wx} * lf_{wx}) * (1 – \%ElectricHeat) * ADJ_{RxAirsealing}$$

Where:

Measure	Savings Variable Names	ΔTherms/Unit
Outlet Gasket	$\Delta Therms_{gasket}$	0.34
Door Sweep	$\Delta Therms_{sweep}$	6.46
Caulking/Sealing/Polyethylene Tape	$\Delta Therms_{sealing}$	0.37
Window or door weatherstripping	$\Delta Therms_{wx}$	0.43

Other factors as defined above

~~$\Delta kWh = SavingsPerUnit * SqFt$~~

~~Where:~~

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[750] Ideally, the system efficiency should be obtained either by recording the AFUE of the unit, or performing a steady state efficiency test. The distribution efficiency can be estimated via a visual inspection and by referring to a look up table such as that provided by the Building Performance Institute~~ – (http://www.bpi.org/files/pdf/DistributionEfficiencyTable-BlueSheet.pdf~~ (https://www.bpi.org/__cms/docs/Guidance%20on%20Estimating%20Distribution%20Efficiency.pdf; 'Guidance on Estimating Distribution Efficiency.pdf'~~https://www.bpi.org/__cms/docs/Guidance%20on%20Estimating%20Distribution%20Efficiency.pdf~~)~~ -~~ or by performing duct blaster testing.

[751] This has been estimated assuming that natural gas central furnace heating is typical for Missouri residences (the predominant heating is gas furnace with 48% of Missouri homes (based on Energy Information Administration, 2009 Residential Energy Consumption Survey). In 2000, 29% of furnaces purchased in Missouri 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, so units purchased 16 years ago provide a reasonable proxy for the current mix of furnaces in the State. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows: ((0.29*0.92) + (0.71*0.8)) * (1-0.15) = 0.71.

[752] Illinois TRM Version 12.0, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_3_Res_09222023_FINAL_clean.pdf, page 382. Prescriptive savings are based upon "Evaluation of the Weatherization Residential Assistance Partnership and Helps Programs (WRAP/Helps)." Middletown, CT: KEMA, 2010. Accessed July 30, 2015, and adjusted for relative HDD of Bridgeport/Hartford CT with the applicable weather data. Cooling savings derived using savings assumptions pulled from ASHRAE, 2001 AHSRAE Handbook – Fundamentals, Chapter 26, Table 1. Effective Air Leakage Areas (Low-Rise Residential Applications Only). See 'Air Sealing Prescriptive Savings 07.06.2024.xlsx' for more information.

~~SavingsPerUnit = Annual savings per square foot, dependent on heating / cooling equipment~~~~[753]~~

~~Building Type~~	~~HVAC System~~	~~SavingsPerUnit (Therms/ft)~~
~~Manufactured~~	~~Gas Boiler~~	~~0.022~~
~~Multifamily~~	~~Gas Boiler~~	~~0.018~~
~~Single Family~~	~~Gas Boiler~~	~~0.016~~
~~Manufactured~~	~~Gas Furnace~~	~~0.017~~
~~Multifamily~~	~~Gas Furnace~~	~~0.012~~
~~Single Family~~	~~Gas Furnace~~	~~0.013~~

~~SqFt = Building square footage~~

~~= Actual~~

Water Impact Descriptions and Calculation

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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~~[753] The values in the table represent estimates of savings from a 15% improvement in air leakage. The values are half those provided by Cadmus for the Iowa Joint Assessment, based on building simulations performed. While 30% savings are certainly achievable, this represents a thorough job in both the attic and basements and could not be verified without testing. The conservative 15% estimate is more appropriate for a deemed estimate. These values should be re-evaluated if EM&V values provide support for a higher deemed estimate.~~

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3.7.2 Ceiling Insulation

DESCRIPTION

This measure describes savings from adding insulation to the attic/ceiling. This measure requires a member of the implementation staff evaluating the pre- and post-project R-values and to measure surface areas. The efficiency of the heating and cooling equipment in the home should also be evaluated if possible.

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

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

DEFINITION OF EFFICIENT EQUIPMENT

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.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 30~~25~~ years.[754]

DEEMED MEASURE COST

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

LOADSHAPE

Building Shell RES

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

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~~$\Delta kWh = \Delta kWh_{cooling} + \Delta kWh_{heating}$~~

ΔkWh = $\Delta kWh_{cooling} + \Delta kWh_{heating}$

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If the home has central cooling, the electric energy saved in annual cooling due to the ceiling insulation is:

~~Where~~

$\Delta kWh_{cooling}$ ~~=~~ = $((1/R_{Old} - 1/R_{Attic}) * A_{attic} * (1 – FramingFactor_{Attic}) * CDD * 24 * DUA * ADJ_{AtticCool}) / (1{,}000 * \eta Cool)$

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~~If central cooling, reduction in annual cooling requirement due to insulation~~

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Where

~~$$= \frac{\left(\frac{1}{R_{Old}} - \frac{1}{R_{Attic}}\right) * A_{attic} * (1 - FramingFactor_{Attic}) * CDD * 24 * DUA}{(1000 * \eta Cool)}$$~~

R_{Attic} = R-value of new attic assembly including all layers between inside air and outside air (ft^2.°F.h/Btu)
R_{Old} = R-value value of existing assembly and any existing insulation
(Minimum of R-5 for uninsulated assemblies[755])
A_{Attic} = Total area of insulated ceiling/attic (ft^2)

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[754] Illinois TRM Version 12.0, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_3_Res_09222023_FINAL_clean.pdf, page 421. As recommended in Guidehouse 'EMV Group A, Deliverable 16 EUL Research – Residential Insulation' (see https://pda.energydataweb.com/api/view/2518/CPUC%20Insulation%20EUL%20Draft%20Report%2006292021.pdf; 'CPUC Insulation EUL Draft Report 06292021.pdf'), prepared for California Public Utilities Commission, June 2021.~~Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007~~

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

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FramingFactor$_{Attic}$= Adjustment to account for area of framing
= 7%[756]

CDD = Cooling Degree Days:[757]

Weather Basis (City based upon)	CDD 65
St Louis, MO	1,646

24 = Converts days to hours

DUA = Discretionary Use Adjustment (reflects the fact that people do not always operate their AC when conditions may call for it)
= 0.75[758]

1000 = Converts Btu to kBtu

ηCool = Seasonal energy efficiency ratio of cooling system (kBtu/kWh)
= Actual (where it is possible to measure or reasonably estimate) – i~~—i~~f unknown, assume the following: [759]

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	12.4

~~following:[760]~~

~~Age of Equipment~~	~~ηCool Estimate~~
~~Before 2006~~	~~10~~
~~2006 - 2014~~	~~13~~
~~Central AC after 1/1/2015~~	~~13~~
~~Heat Pump after 1/1/2015~~	~~14~~

ADJ$_{AtticCool}$ = Adjustment to cooling savings to account for to account for inaccuracies in engineering algorithms.
= 114%[761]

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If the home is heated with electric heat (resistance or heat pump), the electric energy saved in annual heating due to the ceiling insulation is:

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[756] ASHRAE, 2001, "Characterization of Framing Factors for New Low-Rise Residential Building Envelopes (904-RP)," '2001 - ASHRAE - Characterization of Framing Factors.pdf', Table 7.1

[757] Based on climate normals data with a base temp of 65°F.

[758] This factor's source: Energy Center of Wisconsin, May 2008 metering study; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research," 'Energy Center of WI Central AC in WI 2008.pdf', p. 31~~This factor's source: Energy Center of Wisconsin, May 2008 metering study; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research," p31~~.

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

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~~[760] These default system efficiencies are based on the applicable minimum federal standards. In 2006 the federal standard for central AC was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate.~~

[761] Illinois TRM Version 12.0, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_3_Res_09222023_FINAL_clean.pdf, page 424. As demonstrated in air sealing and insulation research by Navigant, see Navigant (2018). ComEd and Nicor Gas Air Sealing and Insulation Research Report. Presented to Commonwealth Edison Company and Nicor Gas Company. Adjustment factor was derived from a consumption data regression analysis with an experimental design that does not require further net savings adjustment for non-income eligible populations. 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.

$\Delta kWh_{HeatingElectric}$ ~~$kWh_{\_heating}$~~ = ((1/R_{Old} - 1/R_{Attic})* A_{attic}* (1 – $FramingFactor_{Attic}$) * HDD * 24 * $ADJ_{AtticHeat}$) / (3,412 * ηHeat)

~~If electric heat (resistance or heat pump), reduction in annual electric heating due to insulation~~

Where:

~~$= \frac{\left(\frac{1}{R_{Old}} - \frac{1}{R_{Attic}}\right) * A_{Attic} * (1 - FramingFactor_{Attic}) * HDD * 24 * ADJAttic}{(\eta Heat * 3{,}412)}$~~

HDD = Heating Degree Days

Weather Basis (City based upon)	HDD 65
St Louis, MO	4,486

ηHeat = Efficiency of heating system

= Actual - if not available, refer to default table below:[762]

~~System Type~~	~~Age of Equipment~~	~~HSPF Estimate~~	~~ηHeat (Effective COP Estimate) (HSPF/3.412)*0.85~~
~~Heat Pump~~	~~Before 2006~~	~~6.8~~	~~1.7~~
	~~2006 - 2014~~	~~7.7~~	~~1.9~~
	~~2015 and after~~	~~8.2~~	~~2.0~~
~~Resistance~~	~~N/A~~	~~N/A~~	~~1.0~~

System Type	Age of Equipment	HSPF2 Estimate	ηHeat (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[763]	N/A	N/A	1.28

3,412 = Converts Btu to kWh

$ADJ_{AtticHeat}$ = Adjustment ~~for attic insulation~~to heating savings to account for to account for inaccuracies in engineering algorithms~~prescriptive engineering algorithms consistently overclaiming savings~~.

= 63~~74~~%[764]

If the home is heated with electric heat (resistance or heat pump), the electric energy saved in annual heating due to the ceiling insulation is:

$\Delta kWh_{HeatingElectricGas}$ ~~ΔkWh_heating~~ = ΔTherms * F_e * 29.3

~~If gas *furnace* heat, kWh savings for reduction in fan run time~~

~~= ΔTherms * F_e * 29.3~~

Where:

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

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[762] 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.

[763] Calculation assumes 35% Heat Pump and 65% Resistance, which is based upon data from Energy Information Administration, 2009 Residential Energy Consumption Survey, ~~;~~ https://www.eia.gov/consumption/residential/data/2009/hc/hc6.9.xls; 'hc6.9.xls'. 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.

[764] Illinois TRM Version 12.0, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_3_Res_09222023_FINAL_clean.pdf, page 425. As demonstrated in air sealing and insulation research by Navigant, Navigant (2018). ComEd and Nicor Gas Air Sealing and Insulation Research Report. Presented to Commonwealth Edison Company and Nicor Gas Company. 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~~Based upon comparing algorithm derived savings estimate and evaluated bill analysis estimate in the following 2012 Massachusetts report: "Home Energy Services Impact Evaluation," August 2012. See "Insulation ADJ calculations.xls" for details or calculation~~.

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= 3.14%[765]

29.3 = kWh per therm

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

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SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ΔkWh * CF

Where:

ΔkWh = Electric energy savings, as calculated above.
CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor~~$\Delta kW = \Delta kWh * CF$~~
~~Where:~~
~~CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor~~

= 0. 0004660805[766]

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NATURAL GAS SAVINGS

Methodology 1:

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ΔTherms (if Natural Gas heating)

$= ((1/R_{Old} - 1/R_{Attic}) * A_{attic} * (1 – FramingFactor_{Attic}) * HDD * 24 * ADJ_{AtticHeat}) / (100{,}000 * \eta Heat)$

~~$= \frac{\left(\frac{1}{R_{old}} - \frac{1}{R_{attic}}\right) * A_{Attic} * (1 - FramingFactor_{Attic}) * HDD * 24 * ADJAttic}{(\eta Heat * 100{,}000)}$~~

Where:
HDD = Heating Degree Days

Weather Basis (City based upon)	HDD 65
St Louis, MO	4,486

ηHeat = Efficiency of heating system
= Equipment efficiency * distribution efficiency
= Actual.[767] If unknown, assume 71%.[768]
100,000 = Converts Btu to therms
Other factors as defined above.

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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[766] Based on Ameren Missouri TRM Volume 1 - Appendix G: "Table 1 – Residential End Use Category Monthly Shapes and Coincident Peak Factors"~~Ameren Missouri 2016 loadshape~~ for residential HVAC end-use.

[767] Ideally, the system efficiency should be obtained either by recording the AFUE of the unit, or performing a steady state efficiency test. The distribution efficiency can be estimated via a visual inspection and by referring to a look up table such as that provided by the Building Performance Institute ~~–~~ (https://www.bpi.org/__cms/docs/Guidance%20on%20Estimating%20Distribution%20Efficiency.pdf; ‘Guidance on Estimating Distribution Efficiency.pdf’)~~https://www.bpi.org/__cms/docs/Guidance%20on%20Estimating%20Distribution%20Efficiency.pdf (http://www.bpi.org/files/pdf/DistributionEfficiencyTable-BlueSheet.pdf)~~ or by performing duct blaster testing.

[768] This has been estimated assuming that natural gas central furnace heating is typical for Missouri residences (the predominant heating is gas furnace with 48% of Missouri homes based on Energy Information Administration, 2009 Residential Energy Consumption Survey). In 2000, 29% of furnaces purchased in Missouri 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, so units purchased 16 years ago provide a reasonable proxy for the current mix of furnaces in the State. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows: ((0.29*0.92) + (0.71*0.8)) * (1-0.15) = 0.71.

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MEASURE CODE:

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3.7.3 Duct Insulation

DESCRIPTION

This measure describes evaluating the savings associated with performing duct insulation on the distribution system of homes with central cooling and/or a ducted heating system. While insulating ducts in conditioned space can help with control and comfort, energy savings are largely limited to insulating ducts in unconditioned space where the heat loss is to outside the thermal envelope. Therefore, for this measure to be applicable, at least 30% of ducts should be within unconditioned space (e.g., attic with floor insulation, vented crawlspace, unheated garages. Basements should be considered conditioned space).

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

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

DEFINITION OF EFFICIENT EQUIPMENT

The efficient condition is insulated duct work throughout the unconditioned space in the home.

DEFINITION OF BASELINE EQUIPMENT

The baseline condition is existing duct work with at least 30% of the ducts within the unconditioned space in the home.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 20 years.[769]

DEEMED MEASURE COST

The actual duct insulation measure cost should be used.

LOADSHAPE

HVAC RES

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

Electric energy savings is calculated as the sum of energy saved when cooling the home and energy saved when heating the home.

$\Delta kWh = \Delta kWh\_cooling + \Delta kWh\_heating$

~~$\Delta kWh = \Delta kWh_{Cooling} + \Delta kWh_{Heating}$~~

If the home has central cooling, the electric energy saved in annual cooling due to the added insulation is:

$\Delta kWh_{Cooling} = (1/R_{existing} - 1/R_{new}) * Area * EFLH_{cool} * \Delta T_{AVG,cooling}) / (1,000 * SEER2)$

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~~$\Delta kWh_{Cooling} = \frac{\left(\frac{1}{R_{existing}} - \frac{1}{R_{new}}\right) * Area * EFLH_{cool} * \Delta T_{AVG,cooling}}{(1,000 * SEER)}$~~

Where:

$R_{existing}$ = Duct heat loss coefficient with existing insulation ((hr-^{0}F-ft^2)/Btu)

= Actual

R_{new} = Duct heat loss coefficient with new insulation (hr-^{0}F-ft^2)/Btu)

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[769] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, https://energizect.com/sites/default/files/documents/Measure%20Life%20Report%202007.pdf; 'Measure Life Report 2007.pdf', page 1-3. ~~Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007, https://energizect.com/sites/default/files/documents/Measure%20Life%20Report%202007.pdf, page 1-3.~~

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= Actual

Area = Area of the duct surface exposed to the unconditioned space that has been insulated (ft^2)

$EFLH_{cool}$ = Equivalent Full Load Cooling Hours:

Weather Basis (Ameren Missouri Average)	EFLHcool (Hours)
SF or MF	869[770]
~~MFc (comprehensive envelope)~~	~~632[771]~~

$\Delta T_{AVG,cooling}$ = Average temperature difference (^{0}F) during cooling season between outdoor air temperature and assumed 60^{0}F duct supply air temperature[772]

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Weather Basis (City based upon)	$OA_{AVG,cooling}$ [°F][773]	$\Delta T_{AVG,cooling}$ [°F]
St Louis, MO	80.8	20.8

1,000 = Converts Btu to kBtu

SEER2 = Seasonal Energy Efficiency Ratio of Air Conditioning equipment (kBtu/kWh)~~Efficiency in SEER of air conditioning equipment~~

= Actual - If not available, assume the following: [774]

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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

~~use:[775]~~

~~Equipment Type~~	~~Age of Equipment~~	~~SEER Estimate~~
~~Central AC~~	~~Before 2006~~	~~10~~
	~~After 2006~~	~~13~~
~~Heat Pump~~	~~Before 2006~~	~~10~~
	~~2006-2014~~	~~13~~
	~~2015 on~~	~~14~~

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[770] ~~Based on Full Load Hour assumptions (for St Louis and Kansas City) taken from the ENERGY STAR® calculator (http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_CAC.xls) and reduced by 28.5% based on the evaluation results in Ameren territory suggesting an appropriate EFLH of 869.The other weather basis values are calculated using the relative climate normals cooling degree day ratios (at 65F set point).~~PY2019 Residential Evaluation Report, https://www.efis.psc.mo.gov/Document/Display/15876, page 30.

~~[771] Evaluation - Opinion Dynamics review PY2019. The recommended values are constructed based on weather conditions (heating degree days and cooling degree days) in select Missouri cities (St. Louis, Cape Girardeau, Kansas City), weighted by partial year 2019 installations.~~

[772] Leaving coil air temperatures are typically about 55ºF. Therefore, 60ºF is used as an average temperature, recognizing that some heat transfer occurs between the ductwork and the environment it passes through.

[773] National Solar Radiation Data Base -- 1991- 2005 Update: Typical Meteorological Year 3 https://doe2.com/Download/Weather/TMY3/ ~~http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/by_state_and_city.html~~. Heating season defined as September 17th through April 13th, cooling season defined as May 20 through August 15th. For cooling season, temperatures from 8AM to 8PM were used to establish average temperatures as this is when cooling systems are expected to be loaded.

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

~~[775] These default system efficiencies are based on the applicable minimum federal standards. In 2006 the federal standard for central AC was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate.~~

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If the home is heated with electric heat (resistance or heat pump), the electric energy saved in annual heating due to the added insulation is:

$\Delta kWh_{HeatingElectric} = (1/R_{existing} - 1/R_{new}) * Area * EFLH_{heat} * \Delta T_{AVG,heating}) / (3,412 * COP)$

~~$$\Delta kWh_{HeatingElectric} = \frac{\left(\frac{1}{R_{existing}} - \frac{1}{R_{new}}\right) * Area * EFLH_{heat} * \Delta T_{AVG,heating}}{(3,412 * COP)}$$~~

Where:

EFLHheat = Equivalent Full Load Heating Hours:[776]

Weather Basis (Ameren Missouri Average)	EFLHheat (Hours)
SF or MF	1,496
~~MFc (comprehensive envelope)~~	~~509~~

$\Delta T_{AVG,heating}$ = Average temperature difference (⁰F) during heating season between outdoor air temperature and assumed 115⁰F duct supply temperature[777]

Weather Basis (City based upon)	$OA_{AVG,heating}$ [°F][778]	$\Delta T_{AVG,heating}$ [°F]
St Louis, MO	43.2	71.8

3,412 = Converts Btu to kWh

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COP = Efficiency in COP of heating equipment
= Actual - if not available, use:~~[779]~~

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System Type	Age of Equipment	HSPF2 Estimate	ηHeat (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[780]	N/A	N/A	1.28

~~System Type~~	~~Age of Equipment~~	~~HSPF Estimate~~	~~COP (Effective COP Estimate) (HSPF/3.412)*0.85~~
~~Heat Pump~~	~~Before 2006~~	~~6.8~~	~~1.7~~
	~~2006 - 2014~~	~~7.7~~	~~1.92~~
	~~2015 on~~	~~8.2~~	~~2.04~~
~~Resistance~~	~~N/A~~	~~N/A~~	~~1~~

If the building is heated with a gas furnace, there will be some electric savings in heating the building attributed to extra insulation since the furnace fans will run less.

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[776] Evaluation - Opinion Dynamics review PY2019. The recommended values are constructed based on weather conditions (heating degree days and cooling degree days) in select Missouri cities (St. Louis, Cape Girardeau, Kansas City), weighted by partial year 2019 installations.

[777] Forced air supply temperatures are typically 130⁰F. 115⁰F is used as an average temperature, recognizing that some heat transfer occurs between the ductwork and the environment it passes through.

[778] National Solar Radiation Data Base -- 1991- 2005 Update: Typical Meteorological Year 3 https://doe2.com/Download/Weather/TMY3/ ~~http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/by_state_and_city.html~~. Heating season defined as September 17 through April 13, cooling season defined as May 20 through August 15. For cooling season, temperatures from 8AM to 8PM were used to establish average temperatures as this is when cooling systems are expected to be loaded.

~~[779] 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.~~

[780] Calculation assumes 35% Heat Pump and 65% Resistance, which is based upon data from Energy Information Administration, 2009 Residential Energy Consumption Survey, ~~,~~ https://www.eia.gov/consumption/residential/data/2009/hc/hc6.9.xls; 'hc6.9.xls'. 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.

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$\Delta kWh_{HeatingGas}$ = ΔTherms * Fe * 29.3

~~$\Delta kWhHeating_{Gas} = (\Delta Therms * Fe * 29.3)$~~

Where:

ΔTherms = Therm savings as calculated in Natural Gas Savings

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

= 3.14%[781]

29.3 = Converts therms to kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$\Delta kW = \Delta kWh_{Cooling} * CF$

Where:

$\Delta kWh_{Cooling}$ = Electric energy savings for cooling, calculated above

CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor~~$\Delta kW = \Delta kWh * CF$~~

~~Where:~~

~~ΔkWhCooling = Electric energy savings for cooling, calculated above~~

~~CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor~~

= 0.0004660805

NATURAL GAS SAVINGS

If home uses a gas heating system, the savings resulting from the insulation is calculated with the following formula.

ΔTherms = $(1/R_{existing} - 1/R_{new}) * Area * EFLH_{heat} * \Delta T_{AVG,heating}) / (100,000 * \eta HeatGas)$

~~$$\Delta Therms = \frac{\left(\frac{1}{R_{existing}} - \frac{1}{R_{new}}\right) * Area * EFLHheat * \Delta T_{AVG,heating}}{(100,000 * \eta Heat)}$$~~

Where: ηHeatGas equals 71%[782] and a~~A~~ll factors as defined above.

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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

[782] This has been estimated assuming that natural gas central furnace heating is typical for Missouri residences (the predominant heating is gas furnace with 48% of Missouri homes (based on Energy Information Administration, 2009 Residential Energy Consumption Survey). In 2000, 29% of furnaces purchased in Missouri 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, so units purchased 16 years ago provide a reasonable proxy for the current mix of furnaces in the State. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows: ((0.29*0.92) + (0.71*0.8)) * (1-0.15) = 0.71.

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3.7.4 Floor Insulation

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 "Foundation Sidewall 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 type: RF.

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

DEFINITION OF EFFICIENT EQUIPMENT

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~~25~~ years.[783]

DEEMED MEASURE COST

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

LOADSHAPE

Building Shell RES

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

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

~~$\Delta kWh = (\Delta kWh\_cooling + \Delta kWh\_heating)$~~

$\Delta kWh = \Delta kWh_{cooling} + \Delta kWh_{heating}$

If the home has central cooling, the electric energy saved in annual cooling due to the floor insulation is:

~~Where:~~

ΔkWh_cooling = ~~If central cooling, reduction in annual cooling requirement due to insulation~~$((1/R_{Old} - 1/(R_{Added} + R_{Old})) * Area * (1 – FramingFactor_{Floor}) * CDD * 24 * DUA * ADJ_{FloorCool}) / (1,000 * \eta Cool)$

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Where:

~~$$= \frac{\left(\frac{1}{R_{Old}} - \frac{1}{(R_{Added} + R_{Old})}\right) * Area * (1 - Framing\ Factor) * CDD * 24 * DUA}{(1000 * \eta Cool)}$$~~

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[783] Illinois TRM Version 12.0, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_3_Res_09222023_FINAL_clean.pdf, page 402. As recommended in Guidehouse 'EMV Group A, Deliverable 16 EUL Research – Residential Insulation' (see https://pda.energydataweb.com/api/view/2518/CPUC%20Insulation%20EUL%20Draft%20Report%2006292021.pdf; 'CPUC Insulation EUL Draft Report 06292021.pdf'), prepared for California Public Utilities Commission, June 2021~~Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007~~.

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R_{Old} = R-value value of floor before insulation, assuming 3/4” plywood subfloor and carpet with pad
= Actual. I~~ – i~~f unknown, assume 3.53~~96~~[784]
R_{Added} = R-value of additional spray foam, rigid foam, or cavity insulation.
Area = Total floor area to be insulated
$FramingFactor_{Floor}$ ~~Framing Factor~~ = Adjustment to account for area of framing
= 12%[785]
24 = Converts hours to days
CDD = Cooling Degree Days

Weather Basis (City based upon)	Unconditioned Space
	CDD 75 [786]
St Louis, MO	762

DUA = Discretionary Use Adjustment (reflects the fact that people do not always operate their AC when conditions call for it).
= 0.75[787]
1000 = Converts Btu to kBtu
ηCool = Seasonal energy efficiency ratio of cooling system (kBtu/kWh)
= Actual (where it is possible to measure or reasonably estimate). If unknown, assume the following: [788]~~[789]~~

Age of Equipment	ηCool Estimate
Before 2006	9.5~~10~~
2006 - 2014	12.4~~13~~
Central AC After 1/1/2015	12.4~~13~~
Heat Pump After 1/1/2015	13.3~~14~~

$ADJ_{FloorCool}$ = Adjustment to cooling savings to account for to account for inaccuracies in engineering algorithms.
= 75%[790]

If the home is heated with electric heat (resistance or heat pump), the electric energy saved in annual heating due to the floor insulation is:

$\Delta kWh_{HeatingElectric}$ ~~ΔkWh_heating~~ = ~~If electric heat (resistance or heat pump), reduction in annual electric heating due to insulation~~$((1/R_{Old} - 1/(R_{Added} + R_{Old})) * Area * (1 – FramingFactor_{Floor}) * HDD * 24 * ADJ_{FloorHeat}) / (3,412 * \eta Heat)$

Where:

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[784] Ibid., page 404. Based on 2005 ASHRAE Handbook – Fundamentals: assuming ¾” subfloor, ½” carpet with rubber pad, and accounting for a still air film above and below: 0.68 + 0.94 + 1.23 + 0.68 = 3.53~~Based on 2005 ASHRAE Handbook – Fundamentals: assuming 2x8 joists, 16” OC, ¾” subfloor, ½” carpet with rubber pad, and accounting for a still air film above and below: 1/ [(0.85 cavity share of area / (0.68 + 0.94 + 1.23 + 0.68)) + (0.15 framing share / (0.68 + 7.5” * 1.25 R/in + 0.94 + 1.23 + 0.68))] = 3.96~~.

[785] ASHRAE, 2001, “Characterization of Framing Factors for New Low-Rise Residential Building Envelopes (904-RP),” ‘2001 - ASHRAE - Characterization of Framing Factors.pdf’, Table 7.1.

[786] The base temperature should be the outdoor temperature at which the desired indoor temperature stays constant in balance with heat loss or gain to the outside and internal gains. Since unconditioned basements are allowed to swing in temperature, are ground coupled, and are usually cool, they have a bigger delta between the two (heating and cooling) base temperatures. 75F for cooling and 50F for heating are used based on professional judgment. Five-year average cooling degree days with 75F base temp are provided from DegreeDays.net because the 30 year climate normals from NCDC are not available at base temps above 72F.

[787] This factor's source: Energy Center of Wisconsin, May 2008 metering study; “Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research,” ‘Energy Center of WI Central AC in WI 2008.pdf’, p. 31~~Energy Center of Wisconsin, May 2008 metering study; “Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research,” p31~~.

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

~~[789] These default system efficiencies are based on the applicable minimum federal standards. In 2006 the federal standard for central AC was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate.~~

[790] Illinois TRM Version 12.0, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_3_Res_09222023_FINAL_clean.pdf, page 405. As demonstrated in two years of metering evaluation by Opinion Dynamics, see Memo “Results for AIC PY6 HPwES Billing Analysis” (‘Memo on Ameren HPwES Billing Analysis FINAL 2015-03-06.pdf’), dated February 20, 2015. 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.

~~$= \frac{\left(\frac{1}{R_{Old}} - \frac{1}{(R_{Added} + R_{Old})}\right) * Area * (1 - Framing\ Factor) * HDD * 24 * ADJ_{Floor}}{(\eta Heat * 3{,}412)}$~~

HDD = Heating Degree Days:

Weather Basis Zone (City based upon)	Unconditioned Space
	HDD 50 [791]
St Louis, MO	1,911

ηHeat = Efficiency of heating system
= Actual -- if not available, refer to default table below:~~[792]~~

System Type	Age of Equipment	HSPF2 Estimate	ηHeat (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[793]	N/A	N/A	1.28

~~System Type~~	~~Age of Equipment~~	~~HSPF Estimate~~	~~ηHeat (Effective COP Estimate) (HSPF/3.412)*0.85~~
~~Heat Pump~~	~~Before 2006~~	~~6.8~~	~~1.7~~
	~~2006 - 2014~~	~~7.7~~	~~1.9~~
	~~2015 and after~~	~~8.2~~	~~2.0~~
~~Resistance~~	~~N/A~~	~~N/A~~	~~1.0~~

$ADJ_{FloorHeat}$ = Adjustment to heating savings to account for to account for inaccuracies in engineering algorithms~~Adjustment for floor insulation to account for prescriptive engineering algorithms overclaiming savings~~.
= 63~~88~~%[794]

If the home is heated with electric heat (resistance or heat pump), the electric energy saved in annual heating due to the floor insulation is:

$\Delta kWh_{HeatingElectricGas}$ = ΔTherms * F_e * 29.3

Where:

~~Other factors as defined above~~

~~ΔkWh_heating = If gas *furnace* heat, kWh savings for reduction in fan run time~~
~~= ΔTherms * F_e * 29.3~~

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

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[791] The base temperature should be the outdoor temperature at which the desired indoor temperature stays constant in balance with heat loss or gain to the outside and internal gains. Since unconditioned basements are allowed to swing in temperature, are ground coupled, and are usually cool, they have a bigger delta between the two (heating and cooling) base temperatures. 75F for cooling and 50F for heating are used based on professional judgment. National Climatic Data Center, calculated from 1981-2010 climate normals.

~~[792] 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.~~

[793] Calculation assumes 35% Heat Pump and 65% Resistance, which is based upon data from Energy Information Administration, 2009 Residential Energy Consumption Survey, ~~,~~ https://www.eia.gov/consumption/residential/data/2009/hc/hc6.9.xls; 'hc6.9.xls'. 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.

[794] Illinois TRM Version 12.0, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_3_Res_09222023_FINAL_clean.pdf, page 406. As demonstrated in two years of metering evaluation by Opinion Dynamics, see Memo "Results for AIC PY6 HPwES Billing Analysis" ('Memo on Ameren HPwES Billing Analysis FINAL 2015-03-06.pdf'), dated February 20, 2015. 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~~Based upon comparing algorithm-derived savings estimate and evaluated bill analysis estimate in the following 2012 Massachusetts report: "Home Energy Services Impact Evaluation," August 2012. See "Insulation ADJ calculations.xls" for details or calculation. Note that basement wall is used as a proxy for crawlspace ceiling~~.

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= 3.14%[795]
29.3 = kWh per therm

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$\Delta kW = \Delta kWh * CF$

Where:

ΔkWh = Electric energy savings, as calculated above.
CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor~~$\Delta kW = \Delta kWh * CF$~~
~~Where:~~
~~CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor~~

= 0. 0004660805[796]

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NATURAL GAS SAVINGS

ΔTherms (if Natural Gas heating)

$= ((1/R\_{Old} - 1/(R_{Added} + R_{Old})) * Area * (1 – FramingFactor_{Floor}) * HDD * 24 * ADJ_{FloorHeat}) / (100{,}000 * \eta Heat)$

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~~$= \frac{\left(\frac{1}{R_{Old}} - \frac{1}{(R_{Added} + R_{Old})}\right) * Area * (1 - Framing\ Factor) * HDD * 24 * ADJ_{Floor}}{(\eta Heat * 100{,}000)}$~~

Where
ηHeat = Efficiency of heating system
= Equipment efficiency * distribution efficiency
= Actual[797] - If not available, use 71%[798]
100,000 = Converts Btu to therms
Other factors as defined above.

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE:

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

[796] Based on Ameren Missouri TRM Volume 1 - Appendix G: "Table 1 – Residential End Use Category Monthly Shapes and Coincident Peak Factors"~~Ameren Missouri 2016 loadshape~~ for residential building shell end-use.

[797] Ideally, the system efficiency should be obtained either by recording the AFUE of the unit, or performing a steady state efficiency test. The distribution efficiency can be estimated via a visual inspection and by referring to a look up table such as that provided by the Building Performance Institute (https://www.bpi.org/__cms/docs/Guidance%20on%20Estimating%20Distribution%20Efficiency.pdf; ‘Guidance on Estimating Distribution Efficiency.pdf’) ~~- https://www.bpi.org/__cms/docs/Guidance%20on%20Estimating%20Distribution%20Efficiency.pdf (http://www.bpi.org/files/pdf/DistributionEfficiencyTable-BlueSheet.pdf~~ or by performing duct blaster testing.

[798] This has been estimated assuming that natural gas central furnace heating is typical for Missouri residences (the predominant heating is gas furnace with 48% of Missouri homes (based on Energy Information Administration, 2009 Residential Energy Consumption Survey). In 2000, 29% of furnaces purchased in Missouri 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, so units purchased 16 years ago provide a reasonable proxy for the current mix of furnaces in the State. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows: ((0.29*0.92) + (0.71*0.8)) * (1-0.15) = 0.71.

~~3.7.5 Foundation Sidewall Insulation (Retired, effective 1/1/2025)~~[799]

~~Description~~
~~Insulation is added to a basement or crawl space. Insulation added above ground in conditioned space is modeled the same as wall insulation. Below ground insulation is adjusted with an approximation of the thermal resistance of the ground. Insulation in unconditioned spaces is modeled by reducing the degree days to reflect the smaller but non-zero contribution to heating and cooling load. Cooling savings only consider above grade insulation, as below grade has little temperature difference during the cooling season.~~

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

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

~~Definition of Efficient Equipment~~
~~The requirements for participation in the program will be defined by the utilities.~~

~~Definition of Baseline Equipment~~
~~The existing condition will be evaluated by implementation staff or a participating contractor and is likely to be no basement wall or ceiling insulation.~~

~~DEEMED LIFETIME OF EFFICIENT EQUIPMENTT~~

~~The expected measure life is assumed to be 3025 years.~~[800]

~~Deemed Measure Cost~~
~~The actual installed cost for this measure should be used in screening.~~

~~Loadshape~~
~~Building Shell RES~~

~~Algorithm~~

~~Calculation of Savings~~

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

$$\Delta kWh = (\Delta kWh\_cooling + \Delta kWh\_heating)$$

~~ΔkWh = ΔkWh~~$_{cooling}$ ~~+ ΔkWh~~$_{heating}$

~~If the home has central cooling, the electric energy saved in annual cooling due to the insulation is:~~

~~ΔkWh~~$_{cooling}$ ~~= ((1/R~~$_{OldAG}$ ~~– 1/(R~~$_{Added}$~~+R~~$_{OldAG}$~~)) * L_~~$_{BWT}$ ~~* H_~~$_{BWAG}$ ~~* (1 – FramingFactor~~$_{Basement}$~~) * CDD * 24 * DUA * ADJ~~$_{BasementCool}$~~) / (1,000 * ηCool)~~

~~Where:~~
~~ΔkWh_cooling = If central cooling, reduction in annual cooling requirement due to Insulation~~
~~Where:~~

$$= \frac{\left(\frac{1}{R_{OldAG}} - \frac{1}{(R_{Added} + R_{OldAG})}\right) * L_{BWT} * H_{BWAG} * (1 - FF) * CDD * 24 * DUA}{(1{,}000 * \eta Cool)}$$

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[799] ~~"Retire" indicates that the measure is not anticipated to be offered through an Ameren Missouri-administered demand-side program during the period of TRM effectiveness.~~
[800] ~~Illinois TRM Version 12.0, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_3_Res_09222023_FINAL_clean.pdf, page 392. As recommended in Guidehouse 'EMV Group A, Deliverable 16 EUL Research – Residential Insulation' (see https://pda.energydataweb.com/api/view/2518/CPUC%20Insulation%20EUL%20Draft%20Report%2006292021.pdf; 'CPUC Insulation EUL Draft Report 06292021.pdf'), prepared for California Public Utilities Commission, June 2021Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007.~~

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~~R_{Added} = R-value of additional spray foam, rigid foam, or cavity insulation.~~
~~R_{OldAG} = R-value value of foundation wall above grade.~~
~~= Actual, if unknown assume 1.0[801]~~
~~L_{BWT} = Length (Basement Wall Total) of basement wall around the entire insulated perimeter (ft)~~
~~H_{BWAG} = Height (Basement Wall Above Grade) of insulated basement wall above grade (ft)~~
~~$FramingFactor_{Basement}$ FF = Framing Factor, an adjustment to account for area of framing when cavity insulation is used~~
~~= 0% if spray foam or external rigid foam~~
~~= 25% if studs and cavity insulation[802]~~
~~24 = Converts hours to days~~
~~CDD = Cooling Degree Days~~
~~= Dependent whether basement is conditioned:~~

~~Weather Basis (City based upon)~~	~~Conditioned Space~~ ~~CDD 65 [803]~~	~~Unconditioned Space~~ ~~CDD 75 [804]~~
~~St Louis, MO~~	~~1,646~~	~~762~~

~~DUA = Discretionary Use Adjustment (reflects the fact that people do not always operate their AC when conditions may call for it).~~
~~= 0.75[805]~~
~~1,000 = Converts Btu to kBtu~~
~~ηCool = Seasonal energy efficiency ratio of cooling system (kBtu/kWh)~~
~~= Actual (where it is possible to measure or reasonably estimate). If unknown assume the following: [806]~~

~~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~~

~~following:[807]~~

~~Age of Equipment~~	~~ηCool Estimate~~
~~Before 2006~~	~~10~~
~~2006 - 2014~~	~~13~~
~~Central AC After 1/1/2015~~	~~13~~
~~Heat Pump After 1/1/2015~~	~~14~~

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[801] ~~ORNL Builders Foundation Handbook, crawl space data from Table 5-5: Initial Effective R-values for Uninsulated Foundation System and Adjacent Soil, 1991, http://www.ornl.gov/sci/roofs+walls/foundation/ORNL_CON-295.pdf https://foundationhandbook.ornl.gov/handbook/.~~

[802] ~~ASHRAE, 2001, "Characterization of Framing Factors for New Low-Rise Residential Building Envelopes (904-RP)," '2001 – ASHRAE – Characterization of Framing Factors.pdf', Table 7.1~~

[803] ~~National Climatic Data Center, calculated from 1981-2010 climate normals with a base temp of 65°F.~~

[804] ~~The base temperature should be the outdoor temperature at which the desired indoor temperature stays constant, in balance with heat loss or gain to the outside and internal gains. Since unconditioned basements are allowed to swing in temperature, are ground coupled, and are usually cool, they have a bigger delta between the two (heating and cooling) base temperatures. 75F for cooling and 50F for heating are used based on professional judgment. Five year average cooling degree days with 75F base temp are provided from DegreeDys.net because the 30 year climate normals from NCDC are not available at base temps above 72F.~~

[805] ~~This factor's source: Energy Center of Wisconsin, May 2008 metering study; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research," 'Energy Center of WI Central AC in WI 2008.pdf', p. 31This factor's source is: Energy Center of Wisconsin, May 2008 metering study; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research," p31.~~

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

[807] ~~These default system efficiencies are based on the applicable minimum federal standards. In 2006 the federal standard for central AC was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate.~~

~~$ADJ_{BasementCool}$ = Adjustment to cooling savings to account for to account for inaccuracies in engineering algorithms.~~

~~= 75%[808]~~

~~If the home is heated with electric heat (resistance or heat pump), the electric energy saved in annual heating due to the insulation is:~~

~~$\Delta kWh_{HeatingElectric}$ ΔkWh_heating = If electric heat (resistance or heat pump), reduction in annual electric heating due to insulation= ((((1/R_{OldAG} – 1/(R_{Added} + R_{OldAG})) * L_{BWT} * H_{BWAG} * (1 – FF)) + ((1/R_{OldBG} – 1/(R_{Added} + R_{OldBG}))* L_{BWT} * (H_{BWT} – H_{BWAG}) * (1 – FrameingFactor$_{Basement}$))) * HDD * 24 * DUA * $ADJ_{BasementHeat}$) / (3,412 * ηHeat)~~

~~$= \frac{\left(\left(\left(\frac{1}{R_{OldAG}} - \frac{1}{(R_{Added} + R_{OldAG})}\right) * L_{BWT} * H_{BWAG} * (1 - FF)\right) + \left(\left(\frac{1}{R_{OldBG}} - \frac{1}{(R_{Added} + R_{OldBG})}\right) * L_{BWT} * (H_{BWT} - H_{BWAG}) * (1 - FF)\right) * HDD * 24 * DUA * ADJ_{Basement}\right)}{(3{,}412 * \eta Heat)}$~~

~~Where~~L

~~R_{OldBG} = R-value value of foundation wall below grade (including thermal resistance of the earth)[809]~~
~~= dependent on depth of foundation (H_basement_wall_total – H_basement_wall_AG):~~
~~= Actual R-value of wall plus average earth R-value by depth in table below~~
~~For example, for an area that extends 5 feet below grade, an R-value of 7.46 would be selected and added to the existing insulation R-value.~~

~~Below Grade R-value~~									
~~Depth below grade (ft)~~	~~0~~	~~1~~	~~2~~	~~3~~	~~4~~	~~5~~	~~6~~	~~7~~	~~8~~
~~Earth R-value (°F-ft^2-h/Btu)~~	~~2.44~~	~~4.50~~	~~6.30~~	~~8.40~~	~~10.44~~	~~12.66~~	~~14.49~~	~~17.00~~	~~20.00~~
~~Average Earth R-value (°F-ft2-h/Btu)~~	~~2.44~~	~~3.47~~	~~4.41~~	~~5.41~~	~~6.42~~	~~7.46~~	~~8.46~~	~~9.53~~	~~10.69~~
~~Total BG R-value (earth + R-1.0 foundation) default~~	~~3.44~~	~~4.47~~	~~5.41~~	~~6.41~~	~~7.42~~	~~8.46~~	~~9.46~~	~~10.53~~	~~11.69~~

~~H_{BWT} = Total height of basement wall (ft)~~
~~HDD = Heating Degree Days~~
~~= dependent on whether basement is conditioned:~~

~~Weather Basis (City based upon)~~	~~Conditioned Space HDD 65~~ [810]	~~Unconditioned Space HDD 50~~ [811]
~~St Louis, MO~~	~~4,486~~	~~1,911~~

~~ηHeat = Efficiency of heating system~~

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~~[808] Illinois TRM Version 12.0, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_3_Res_09222023_FINAL_clean.pdf, page 395. As demonstrated in two years of metering evaluation by Opinion Dynamics, see Memo "Results for AIC PY6 HPwES Billing Analysis" ('Memo on Ameren HPwES Billing Analysis FINAL 2015-03-06.pdf'), dated February 20, 2015. 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.~~

~~[809] Adapted from Table 1, page 24.4, of the 1977 ASHRAE Fundamentals Handbook.~~

~~[810] National Climatic Data Center, calculated from 1981-2010 climate normals with a base temp of 60°F, consistent with the findings of Belzer and Cort, Pacific Northwest. National Laboratory in "Statistical Analysis of Historical State-Level Residential Energy Consumption Trends," 2004.~~

~~[811] The base temperature should be the outdoor temperature at which the desired indoor temperature stays constant in balance with heat loss or gain to the outside and internal gains. Since unconditioned basements are allowed to swing in temperature, are ground coupled, and are usually cool, they have a bigger delta between the two (heating and cooling) base temperatures. 75F for cooling and 50F for heating are used based on professional judgment. National Climatic Data Center, calculated from 1981-2010 climate normals.~~

~~= Actual. If not available refer to default table below:~~[812]

~~System Type~~	~~Age of Equipment~~	~~HSPF2 Estimate~~	~~ηHeat (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~~[813]	~~N/A~~	~~N/A~~	~~1.28~~

~~System Type~~	~~Age of Equipment~~	~~HSPF Estimate~~	~~ηHeat (Effective COP Estimate) (HSPF/3.412)*0.85~~
~~Heat Pump~~	~~Before 2006~~	~~6.8~~	~~1.7~~
	~~2006 - 2014~~	~~7.7~~	~~1.9~~
	~~2015 and after~~	~~8.2~~	~~2.0~~
~~Resistance~~	~~N/A~~	~~N/A~~	~~1.0~~

~~ADJ$_{BasementHeat}$ ADJ$_{Basement}$ = Adjustment for basement wall insulation to account for prescriptive engineering algorithms overclaiming savings.~~

~~= 6388%~~[814]

~~If the home is heated with electric heat (resistance or heat pump), the electric energy saved in annual heating due to the insulation is:~~

~~ΔkWh$_{HeatingElectricGas}$ = ΔTherms * F$_e$ * 29.3~~

~~ΔkWh_heating = If gas *furnace* heat, kWh savings for reduction in fan run time~~

~~Where:~~

~~= ΔTherms * F$_e$ * 29.3~~

~~F$_e$ = Furnace fan energy consumption as a percentage of annual fuel consumption~~

~~= 3.14%~~[815]

~~29.3 = kWh per therm~~

~~Summer Coincident Peak Demand~~

~~ΔkW = ΔkWh * CF~~

~~Where:~~

~~$\Delta kW = \Delta kWh * CF$~~

~~Where:~~

~~CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor~~

~~= 0. 0004660805~~[816]

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[812] ~~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.~~

[813] ~~Calculation assumes 35% Heat Pump and 65% Resistance, which is based upon data from Energy Information Administration, 2009 Residential Energy Consumption Survey, , https://www.eia.gov/consumption/residential/data/2009/hc/hc6.9.xls; 'hc6.9.xls'. 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.~~

[814] ~~Illinois TRM Version 12.0, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_3_Res_09222023_FINAL_clean.pdf, page 397. 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 valuesBased upon comparing algorithm derived savings estimate and evaluated bill analysis estimate in the following 2012 Massachusetts report: "Home Energy Services Impact Evaluation," August 2012. See "Insulation ADJ calculations.xls" for details or calculation.~~

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

[816] ~~Based on Ameren Missouri TRM Volume 1 – Appendix G: "Table 1 – Residential End Use Category Monthly Shapes and Coincident Peak Factors"Ameren Missouri 2016 loadshape for residential building shell end-use.~~

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~~Natural Gas Savings~~
~~If Natural Gas heating:~~

~~ΔTherms = ((((1/R_{OldAG} – 1/(R_{Added} + R_{OldAG})) * L_{BWT} * H_{BWAG} * (1 – FramingFactor$_{Basement}$)) + ((1/R_{OldBG} – 1/(R_{Added} + R_{OldBG}))* L_{BWT}* (H_{BWT} – H_{BWAG}) * (1 – FramingFactor$_{Basement}$))) * HDD * 24 * DUA * ADJ$_{BasementHeat}$) / (100,000 * ηHeat)~~

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$$= \frac{\left(\left(\left(\frac{1}{R_{OldAG}} - \frac{1}{(R_{Added} + R_{OldAG})}\right) * L_{BWT} * H_{BWAG} * (1 - FF)\right) + \left(\left(\frac{1}{R_{OldBG}} - \frac{1}{(R_{Added} + R_{OldBG})}\right) * L_{BWT} * (H_{BWT} - H_{BWAG}) * (1 - FF)\right)\right) * HDD * 24 * ADJ_{Basement}}{(100,000 * \eta Heat)}$$

~~Where~~

~~ηHeat = Efficiency of heating system~~
~~= Equipment efficiency * distribution efficiency~~
~~= Actual[817] – If not available, use 71%[818]~~
~~100,000 = Converts Btu to therms~~
~~Other factors as defined above~~

~~Water Impact Descriptions and Calculation~~
~~N/A~~

~~Deemed O&M Cost Adjustment Calculation~~
~~N/A~~

~~Measure Code:~~

~~[817] Ideally, the system efficiency should be obtained either by recording the AFUE of the unit or performing a steady state efficiency test. The distribution efficiency can be estimated via a visual inspection and by referring to a look up table such as that provided by the Building Performance Institute (https://www.bpi.org/__cms/docs/Guidance%20on%20Estimating%20Distribution%20Efficiency.pdf; 'Guidance on Estimating Distribution Efficiency.pdf') https://www.bpi.org/__cms/docs/Guidance%20on%20Estimating%20Distribution%20Efficiency.pdf (http://www.bpi.org/files/pdf/DistributionEfficiencyTable-BlueSheet.pdf – or by performing duct blaster testing.~~

~~[818] This has been estimated assuming that natural gas central furnace heating is typical for Missouri residences (the predominant heating is gas furnace with 48% of Missouri homes (based on Energy Information Administration, 2009 Residential Energy Consumption Survey). In 2000, 29% of furnaces purchased in Missouri 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, so units purchased 16 years ago provide a reasonable proxy for the current mix of furnaces in the State. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows: ((0.29*0.92) + (0.71*0.8)) * (1-0.15) = 0.71.~~

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~~3.7.6 Storm Windows~~

~~DESCRIPTION~~

~~Storm windows installed on either the interior or exterior of existing window assemblies can reduce both heating and cooling loads by reducing infiltration and solar heat gain and improving insulation properties. Glass options for storm windows can include traditional clear glazing as well as low-emissivity (Low-E) glazing. Low-E glass is formed by adding an ultra-thin layer of metal to clear glass. The metallic oxide (pyrolytic) coating is applied when the glass is in its molten state, and the coating becomes a permanent and extremely durable part of the glass. This coating is also known as "hard coat" Low-E. Low-E glass is designed to redirect heat back towards the source, effectively providing higher insulating properties and lower solar heat gain as compared to traditional clear glass. This characterization captures the savings associated with installing storm windows to an existing window assembly (retrofit).~~

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

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

~~DEFINITION OF EFFICIENT EQUIPMENT~~

~~An interior or exterior storm window installed according to manufacturer specifications.~~

~~DEFINITION OF BASELINE EQUIPMENT~~

~~The existing window assembly.~~

~~DEEMED LIFETIME OF EFFICIENT EQUIPMENT~~

~~20 years~~[819]

~~DEEMED MEASURE COST~~

~~The actual capital cost for this measure should be used when available and include both material and labor costs. If unavailable, the cost for a low-e storm window can be assumed as $7.85/ft^2 of window area (material cost) plus $30 per window for installation expenses.~~[792576] ~~For clear glazing, cost can be assumed as $6.72/ft^2 of window area (material cost) plus $30 per window for installation expenses.~~[820]

~~LOADSHAPE~~

~~Building Shell RES~~

~~Algorithm~~

~~CALCULATION OF SAVINGS~~

~~The following reference tables show savings factors (kBtu/ft^2) for both heating and cooling loads for each of the seven weather zones defined by the TRM.~~[821] ~~They are used with savings equations listed in the electric energy and gas savings sections to produce savings estimates. If storm windows are left installed year-round, both heating and cooling savings may be claimed. If they are installed seasonally, only heating savings should be claimed. Savings are dependent on location, storm window location (interior or exterior), glazing type (clear or Low-E) and existing window assembly type.~~

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[819] ~~Task ET-WIN-PNNL-FY13-01_5.3: Database of Low-E Storm Window Energy Performance across U.S. Climate Zones. KA Cort and TD Culp, 'Culp ET Task 5_3_PNNL-22865_Final2.pdf', September 2013. Prepared for the U.S. Department of Energy by Pacific Northwest National Laboratory. PNNL-22864.~~

[820] ~~A comparison of Low-E to clear glazed storm windows available at large national retail outlets showed the average incremental cost for Low-E glazing to be $1.13/ft^2. Installation costs are identical.~~

[821] ~~Missouri TRM 2017, https://dnr.mo.gov/document-search/missouri-technical-reference-manual-2017-volume-3-residential-measures, p. 193. Savings factors are based on simulation results, St. Louis, MO, weather basis, documented in "Storm Windows Savings.xlsx."~~

~~St Louis, MO~~

~~Heating Savings Factors (SavingsFactor~~$_{heat}$~~):~~

~~Savings in kBtu/ft²~~		~~Base Window Assembly~~			
		~~SINGLE PANE, DOUBLE HUNG~~	~~DOUBLE PANE, DOUBLE HUNG~~	~~SINGLE PANE, FIXED~~	~~DOUBLE PANE, FIXED~~
~~Storm Window Type~~	~~CLEAR EXTERIOR~~	~~47.7~~	~~13.3~~	~~48.5~~	~~12.3~~
	~~CLEAR INTERIOR~~	~~49.8~~	~~17.9~~	~~49.0~~	~~14.2~~
	~~LOW-E EXTERIOR~~	~~51.5~~	~~13.3~~	~~53.2~~	~~19.3~~
	~~LOW-E INTERIOR~~	~~57.7~~	~~20.3~~	~~55.9~~	~~17.5~~

~~Cooling Savings Factors (SavingsFactor~~$_{cool}$~~):~~

~~Savings in kBtu/ft²~~		~~Base Window Assembly~~			
		~~SINGLE PANE, DOUBLE HUNG~~	~~DOUBLE PANE, DOUBLE HUNG~~	~~SINGLE PANE, FIXED~~	~~DOUBLE PANE, FIXED~~
~~Storm Window Type~~	~~CLEAR EXTERIOR~~	~~23.0~~	~~10.5~~	~~22.5~~	~~9.6~~
	~~CLEAR INTERIOR~~	~~23.9~~	~~10.7~~	~~24.4~~	~~9.8~~
	~~LOW-E EXTERIOR~~	~~29.5~~	~~15.4~~	~~29.3~~	~~9.3~~
	~~LOW-E INTERIOR~~	~~28.8~~	~~14.2~~	~~29.0~~	~~13.4~~

~~ELECTRIC ENERGY SAVINGS~~

$$\cancel{\Delta kWh = \Delta kWh_{cooling} + \Delta kWh_{heating}}$$

~~ΔkWh = ΔkWh~~$_{cooling}$ ~~+ ΔkWh~~$_{heating}$

~~Where:~~

~~ΔkWh~~$_{cooling}$ ~~= If storm windows are left installed during the cooling season and the home has central cooling, the reduction in annual cooling requirement due to air sealing~~

~~= ΣSavingsFactor~~$_{cool}$ ~~*A / ηCool~~

$$\cancel{= \frac{\Sigma_{cool} * A}{\eta Cool}}$$

~~Σ~~$_{cool}$ ~~= Savings factor for cooling, as tabulated above.~~

~~A = Area (square footage) of storm windows installed.~~

~~ηCool = Efficiency (SEER2) of Air Conditioning equipment (kBtu/kWh)~~

~~= Actual (where it is possible to measure or reasonably estimate) – If unknown, assume the following:~~ [822]

~~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~~

~~[822] These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Central AC was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate. Note all ratings have been converted to SEER2 equivalents – since the new rating better reflects the actual efficiency of the units.~~

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~~following:~~[823]

~~Age of Equipment~~	~~SEER Estimate~~
~~Before 2006~~	~~10~~
~~2006 - 2014~~	~~13~~
~~Central AC After 1/1/2015~~	~~13~~
~~Heat Pump After 1/1/2015~~	~~14~~

~~$\Delta kWh_{heating}$ = If electric heat (resistance or heat pump), reduction in annual electric heating due to air sealing~~

~~$= \Sigma SavingsFactor_{heat} * A / \eta Heat * 3.412$~~

$$= \frac{\Sigma_{heat} * A}{\eta Heat * 3.412}$$

~~Σ_{heat} = Savings factor for heating, as tabulated above.~~

~~ηHeat = Efficiency of heating system~~

~~= Actual - If not available refer to default table below:~~[824]

~~System Type~~	~~Age of Equipment~~	~~HSPF2 Estimate~~	~~ηHeat (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~~[825]	~~N/A~~	~~N/A~~	~~1.28~~

~~System Type~~	~~Age of Equipment~~	~~HSPF Estimate~~	~~ηHeat (Effective COP Estimate) (HSPF/3.412)*0.85~~
~~Heat Pump~~	~~Before 2006~~	~~6.8~~	~~1.7~~
	~~2006 - 2014~~	~~7.7~~	~~1.92~~
	~~2015 and after~~	~~8.2~~	~~2.04~~
~~Resistance~~	~~N/A~~	~~N/A~~	~~1~~

~~3.412 = Converts kBtu to kWh~~

~~SUMMER COINCIDENT PEAK DEMAND SAVINGS~~

~~$\Delta kW = \Delta kWh_{Cooling} * CF$~~

~~Where:~~

~~[823] These default system efficiencies are based on the applicable minimum federal standards. In 2006 the federal standard for central AC was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate.~~

~~[824] 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.~~

~~[825] Calculation assumes 35% Heat Pump and 65% Resistance, which is based upon data from Energy Information Administration, 2009 Residential Energy Consumption Survey, ; https://www.eia.gov/consumption/residential/data/2009/hc/hc6.9.xls; 'hc6.9.xls'. 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.~~

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~~ΔkWh$_{Cooling}$ = Electric energy savings for cooling, calculated above~~
~~CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor~~~~$\Delta kW = \Delta kWh * CF$~~
~~Where:~~
~~ΔkWh_cooling = As calculated above.~~
~~CF = Summer System Peak Coincidence Factor for Cooling~~
~~= 0. 0004660805[826]~~

~~Natural Gas Savings~~

~~If Natural Gas heating:~~

~~ΔTherms = Σ$_{heat}$ *A / ηHeat * 100~~

~~$\Delta Therms = \frac{\Sigma_{heat} * A}{\eta Heat * 100}$~~

~~Where:~~
~~ηHeat = Efficiency of heating system~~
~~= Equipment efficiency * distribution efficiency~~
~~= Actual[827] – If not available, use 71%[828]~~
~~100 = Converts kBtu to therms~~
~~Other factors as defined above~~

~~Water Impact Descriptions and Calculation~~

~~N/A~~

~~Deemed O&M Cost Adjustment Calculation~~

~~N/A~~

~~Measure Code:~~

~~[826] Based on Ameren Missouri TRM Volume 1 - Appendix G: "Table 1 – Residential End Use Category Monthly Shapes and Coincident Peak Factors" Ameren Missouri 2016 loadshape for residential building shell end-use.~~
~~[827] Ideally, the system efficiency should be obtained either by recording the AFUE of the unit or performing a steady state efficiency test. The distribution efficiency can be estimated via a visual inspection and by referring to a look up table such as that provided by the Building Performance Institute (https://www.bpi.org/__cms/docs/Guidance%20on%20Estimating%20Distribution%20Efficiency.pdf; 'Guidance on Estimating Distribution Efficiency.pdf') https://www.bpi.org/__cms/docs/Guidance%20on%20Estimating%20Distribution%20Efficiency.pdf (http://www.bpi.org/files/pdf/DistributionEfficiencyTable-BlueSheet.pdf – or by performing duct blaster testing.~~
~~[828] This has been estimated assuming that natural gas central furnace heating is typical for Missouri residences (the predominant heating is gas furnace with 48% of Missouri homes (based on Energy Information Administration, 2009 Residential Energy Consumption Survey). In 2000, 29% of furnaces purchased in Missouri 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, so units purchased 16 years ago provide a reasonable proxy for the current mix of furnaces in the State. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows: ((0.29*0.92) + (0.71*0.8)) * (1-0.15) = 0.71.~~

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~~3.7.7 Kneewall and Sillbox Insulation (Retired, effective 1/1/2025)~~[829]

~~Description~~

~~This measure describes savings from adding insulation (for example, blown cellulose, spray foam) to wall cavities (this includes kneewall and sillbox areas). This measure requires a member of the implementation staff evaluating the pre- and post-project R-values and to measure surface areas. The efficiency of the heating and cooling equipment in the home should also be evaluated if possible.~~

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

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

~~Definition of Efficient Equipment~~

~~The requirements for participation in the program will be defined by the utilities.~~

~~Definition of Baseline Equipment~~

~~The existing condition will be evaluated by implementation staff or a participating contractor and is likely to be empty wall cavities.~~

~~Deemed Lifetime of Efficient Equipment~~

~~The expected measure life is assumed to be 3025 years.~~[830]

~~Deemed Measure Cost~~

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

~~Loadshape~~

~~Building Shell RES~~

~~Algorithm~~

~~Calculation of Savings~~

~~Electric Energy Savings~~

~~ΔkWh = ΔkWh~~ $_{cooling}$ ~~+ ΔkWh~~ $_{heating}$

$$\Delta kWh = \Delta kWh_{cooling} + \Delta kWh_{heating}$$

~~If the home has central cooling, the electric energy saved in annual cooling due to the wall insulation is:~~

~~ΔkWh~~ $_{cooling}$ ~~Where~~

~~ΔkWh~~ $_{cooling}$ ~~= If central cooling, reduction in annual cooling requirement due to insulation= ((1/R~~ $_{Old}$ ~~− 1/R~~ $_{Wall}$ ~~) * A~~ $_{Wall}$ ~~* (1 − FramingFactor~~ $_{Wall}$ ~~) * CDD * 24 * DUA *ADJ~~ $_{WallCool}$ ~~) / (1,000 * ηCool)~~

~~Where:~~

$$= \frac{\left(\frac{1}{R_{Old}} - \frac{1}{R_{Wall}}\right) * A_{Wall} * (1 - FramingFactor_{Wall}) * CDD * 24 * DUA}{(1,000 * \eta Cool)}$$

~~R~~ $_{Wall}$ ~~= R-value of new wall assembly including all layers between inside air and outside air (ft².°F.h/Btu)~~

~~R~~ $_{Old}$ ~~= R-value value of existing assembly and any existing insulation (ft².°F.h/Btu)~~
~~(Minimum of R-5 for uninsulated assemblies~~[831]~~)~~

---

[829] ~~"Retire" indicates that the measure is not anticipated to be offered through an Ameren Missouri-administered demand-side program during the period of TRM effectiveness.~~

[830] ~~Illinois TRM Version 12.0, https://www.ilsag.info/wp-content/uploads/IL_TRM_Effective_010124_v12.0_Vol_3_Res_09222023_FINAL_clean.pdf, page 411. As recommended in Guidehouse 'EMV Group A, Deliverable 16 EUL Research – Residential Insulation' (see https://pda.energydataweb.com/api/view/2518/CPUC%20Insulation%20EUL%20Draft%20Report%2006292021.pdf; 'CPUC Insulation EUL Draft Report 06292021.pdf'), prepared for California Public Utilities Commission, June 2021Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007.~~

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

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~~A_{Wall} = Net area of insulated wall (ft^2)~~
~~$FramingFactor_{Wall}$ = Adjustment to account for area of framing~~
~~= 25%[832]~~
~~CDD = Cooling Degree Days:[833]~~

~~Weather Basis (City based upon)~~	~~CDD 65~~
~~St Louis, MO~~	~~1,646~~

~~24 = Converts days to hours~~
~~DUA = Discretionary Use Adjustment (reflects the fact that people do not always operate their AC when conditions may call for it)~~
~~= 0.75[834]~~
~~1,000 = Converts Btu to kBtu~~
~~ηCool = Seasonal Energy Efficiency Ratio of cooling system (kBtu/kWh)~~
~~= Actual (where it is possible to measure or reasonably estimate)) iIf unknown, assume the following: [835]~~

~~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~~

~~following:[836]~~

~~Age of Equipment~~	~~ηCool Estimate~~
~~Before 2006~~	~~10~~
~~2006 - 2014~~	~~13~~
~~Central AC after 1/1/2015~~	~~13~~
~~Heat Pump after 1/1/2015~~	~~14~~

~~$ADJ_{WallCool}$ = Adjustment for wall insulation to account for prescriptive engineering algorithms consistently overclaiming savings~~
~~= 63%[837]~~

~~If the home is heated with electric heat (resistance or heat pump), the electric energy saved in annual heating due to the wall insulation is:~~

---

[832] ~~ASHRAE, 2001, "Characterization of Framing Factors for New Low-Rise Residential Building Envelopes (904-RP)," '2001 - ASHRAE - Characterization of Framing Factors for New Low-Rise Residential Building Envelopes.pdf', Table 7.1.~~

[833] ~~National Climatic Data Center, calculated from 1981-2010 climate normals with a base temperature of 65°F.~~

[834] ~~This factor's source: Energy Center of Wisconsin, May 2008 metering study; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research," 'Energy Center of WI Central AC in WI 2008.pdf', p. 31This factor's source is: Energy Center of Wisconsin, May 2008 metering study; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research," p31.~~

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

[836] ~~These default system efficiencies are based on the applicable minimum federal standards. In 2006 the federal standard for central AC was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate.~~

[837] ~~Illinois TRM Version 12.0, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_3_Res_09222023_FINAL_clean.pdf, page 414. As demonstrated in two years of metering evaluation by Opinion Dynamics, see Memo "Results for AIC PY6 HPwES Billing Analysis" ('Memo on Ameren HPwES Billing Analysis FINAL 2015-03-06.pdf'), dated February 20, 2015. 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.~~

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~~$\Delta kWh_{HeatingElectric}$~~ $kWh_{heating}$ ~~= If electric heat (resistance or heat pump), reduction in annual electric heating due to insulation~~~~((1/R_{Old} – 1/R_{Wall}) * A_{Wall} * (1 – FramingFactor$_{Wall}$) * HDD * 24 * ADJ$_{WallHeat}$) / (3,412 * ηHeat)~~

~~Where:~~

~~$= \frac{\left(\frac{1}{R_{Old}} - \frac{1}{R_{Wall}}\right) * A_{Wall} * (1 - FramingFactor_{Wall}) * HDD * 24 * ADJWall}{(\eta Heat * 3{,}412)}$~~

~~HDD = Heating Degree Days:~~[838]

~~Weather Basis (City based upon)~~	~~HDD 65~~
~~St Louis, MO~~	~~4,486~~

~~ηHeat = Efficiency of heating system~~
~~= Actual - If not available, refer to default table below:~~[839]

~~System Type~~	~~Age of Equipment~~	~~HSPF2 Estimate~~	~~ηHeat (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~~[840]	~~N/A~~	~~N/A~~	~~1.28~~

~~System Type~~	~~Age of Equipment~~	~~HSPF Estimate~~	~~ηHeat (Effective COP Estimate) (HSPF/3.412)*0.85~~
~~Heat Pump~~	~~Before 2006~~	~~6.8~~	~~1.7~~
	~~2006 - 2014~~	~~7.7~~	~~1.9~~
	~~2015 and after~~	~~8.2~~	~~2.0~~
~~Resistance~~	~~N/A~~	~~N/A~~	~~1.0~~

~~3412 = Converts Btu to kWh~~
~~ADJ$_{WallHeat}$ = Adjustment for wall insulation to account for prescriptive engineering algorithms consistently overclaiming savings~~
~~= 63%~~[841]

~~If the home is heated with electric heat (resistance or heat pump), the electric energy saved in annual heating due to the wall insulation is:~~

~~$\Delta kWh_{HeatingElectricGas}$~~ ~~$\Delta kWh_{heating}$~~ ~~= If gas *furnace* heat, kWh savings for reduction in fan run time~~
~~= ΔTherms * F_e * 29.3~~

~~Where:~~

~~F_e = Furnace fan energy consumption as a percentage of annual fuel consumption~~

---

[838] ~~National Climatic Data Center, calculated from 1981-2010 climate normals with a base temp of 60°F, consistent with the findings of Belzer and Cort, Pacific Northwest National Laboratory in "Statistical Analysis of Historical State-Level Residential Energy Consumption Trends," 2004.~~

[839] ~~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.~~

[840] ~~Calculation assumes 35% Heat Pump and 65% Resistance, which is based upon data from Energy Information Administration, 2009 Residential Energy Consumption Survey, , https://www.eia.gov/consumption/residential/data/2009/hc/hc6.9.xls; 'hc6.9.xls'. 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.~~

[841] ~~Illinois TRM Version 12.0, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_3_Res_09222023_FINAL_clean.pdf, page 415. 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~~~~Based upon comparing algorithm derived savings estimate and evaluated bill analysis estimate in the following 2012 Massachusetts report: "Home Energy Services Impact Evaluation," August 2012. See "Insulation ADJ calculations.xls" for details or calculation.~~

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~~= 3.14%~~[842]

~~29.3 = kWh per therm~~

~~Summer Coincident Peak Demand Savings~~

~~$\Delta kW = \Delta kWh * CF$~~

~~Where:~~

~~ΔkWh = Electric energy savings, as calculated above.~~
~~CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor~~~~$\Delta kW = \Delta kWh * CF$~~
~~Where:~~
~~CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor~~

~~= 0. 0004660805~~[843]

~~Natural Gas Savings~~

~~ΔTherms (if Natural Gas heating)~~

~~= ((1/R_{Old} – 1/R_{Wall}) * A_{Wall} * (1 – $FramingFactor_{Wall}$) * HDD * 24 * $ADJ_{WallHeat}$) / (100,000 * ηHeat)~~

~~$= \frac{\left(\frac{1}{R_{old}} - \frac{1}{R_{wall}}\right) * A_{wall} * (1 - FramingFactor_{wall}) * HDD * 24 * ADJWall}{(\eta Heat * 100{,}000)}$~~

~~Where:~~
~~HDD = Heating Degree Days:~~[844]

~~Weather Basis (City based upon)~~	~~HDD 65~~
~~St Louis, MO~~	~~4,486~~

~~ηHeat = Efficiency of heating system~~
~~= Equipment efficiency * distribution efficiency~~
~~= Actual~~[845] ~~– If not available, use 71%~~[846]
~~100,000 = Converts Btu to therms~~
~~Other factors as defined above~~

~~Water Impact Descriptions and Calculation~~
~~N/A~~

~~Deemed O&M Cost Adjustment Calculation~~
~~N/A~~

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

[843] ~~Based on Ameren Missouri TRM Volume 1 - Appendix G: "Table 1 – Residential End Use Category Monthly Shapes and Coincident Peak Factors"Ameren Missouri 2016 loadshape for residential building shell end-use.~~

[844] ~~National Climatic Data Center, calculated from 1981-2010 climate normals with a base temp of 65°F, consistent with the findings of Belzer and Cort, Pacific Northwest National Laboratory in "Statistical Analysis of Historical State-Level Residential Energy Consumption Trends," 2004.~~

[845] ~~Ideally, the system efficiency should be obtained either by recording the AFUE of the unit, or performing a steady state efficiency test. The distribution efficiency can be estimated via a visual inspection and by referring to a look up table such as that provided by the Building Performance Institute (https://www.bpi.org/__cms/docs/Guidance%20on%20Estimating%20Distribution%20Efficiency.pdf; 'Guidance on Estimating Distribution Efficiency.pdf') https://www.bpi.org/__cms/docs/Guidance%20on%20Estimating%20Distribution%20Efficiency.pdf (http://www.bpi.org/files/pdf/DistributionEfficiencyTable-BlueSheet.pdf or by performing duct blaster testing.~~

[846] ~~This has been estimated assuming that natural gas central furnace heating is typical for Missouri residences (the predominant heating is gas furnace with 48% of Missouri homes (based on Energy Information Administration, 2009 Residential Energy Consumption Survey). In 2000, 29% of furnaces purchased in Missouri 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, so units purchased 16 years ago provide a reasonable proxy for the current mix of furnaces in the State. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows: ((0.29*0.92) + (0.71*0.8)) * (1-0.15) = 0.71.~~

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~~Measure Code:~~

3.7.5 Cool Roof

Description

Cool (high albedo) roofing materials reduce the overall heat load on a home by reflecting more of the incident solar radiation, thus decreasing the total heat energy absorbed into the building system. This reduction in heat load provides space cooling energy savings during the cooling season but can increase heating energy use during the winter. Therefore, cool roofs are most beneficial in warmer climates and may not be recommended for homes where the primary heat source is electric resistance.

This measure is only applicable to existing buildings constructed before 2016 that have not undergone roof improvements since 2016.

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

Definition of Efficient Equipment

The efficient condition is cool (high albedo) ~~asphalt shingle~~roofing material. Although, the ENERGY STAR cool roof rating was discontinued, the minimum thresholds are listed for the required minimum solar reflectance and thermal emittance by the roof slope. The *Cool Roof Rating Council* provides ratings at https://coolroofs.org/directory/roof.~~ at 0.30[847].~~

Roof Slope/Pitch	Solar Reflectance 1 Year	Solar Reflectance 3 Year	Thermal Emittance
Low slope/≤2:12 pitch	≥0.65	≥0.5	≥0.75
Steep slope/>2:12 pitch	≥0.25	≥0.15	≥0.75

Definition of Baseline Equipment

The baseline condition is assumed to be a~~a~~ conventional asphalt shingle roof of albedo 0.142. ~~All residential buildings with asphalt shingles and metal roofing products are,~~For other existing roofing materials, the reflectance and emittance values can be sourced, with savings determined by the calculators built by the Oak Ridge National Laboratory for low slope[848] and steep slope[849] roofs.

- ~~Steep slopes, typically 5:12, with a roof area to footprint area ratio of 13/12 (~1.08).~~
- ~~Other types of roofs are essentially horizontal, with roof area equal to footprint area.~~

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 15 years.[850]

Deemed Measure Cost

The actual implementation cost for applying cool (high albedo) roof should be used.

Loadshape

Building Shell RES

Algorithm

Calculation of Savings

Mid-America Regional Council (MARC), in partnership with Lawrence Berkeley National Laboratory (LBNL), commissioned Leidos to study building energy consumption. The study area was a nine-county region identified by MARC. A whole-building energy modeling tool was used to evaluate urban heat island (UHI) countermeasure strategies for several common residential building categories based on models developed by the U.S. Department of Energy (DOE). Residential buildings were adapted to the Kansas City region to model changes in building energy consumption.

~~[847] Heat Island Mitigation Assessment and Policy Development for the Kansas City Region, LBNL, https://www.marc.org/sites/default/files/2022-05/HeatIslandMitigationAssessmentandPolicy.pdf; 'HeatIslandMitigationAssessmentandPolicy.pdf'.~~

[848] Oak Ridge National Laboratory, Low slop roof savings calculator, https://web.ornl.gov/sci/buildings/tools/cool-roof/

[849] Oak Ridge National Laboratory, Steep slope roof savings calculator, https://web.ornl.gov/sci/buildings/tools/SteepSlopeCalc/

[850] DEER READI (Remote Ex-Ante Database Interface). http://www.deeresources.com/index.php/component/users/?view=login.

The LBNL study modeled four vintages of residential single and multi-family buildings. They are categorized as

Vintage Group	Year of construction	Adjusted Distribution %
Pre-1980	up to 1979	59%
Post-1980	1980-1999	25%
IECC 2006	2000-2009	13%
IECC 2012	2010-2015	3%

ELECTRIC ENERGY SAVINGS

ΔkWh = ~~SavingsFactor~~Cooling Savings * SF / 1,000 * HeatingFactor

Where:

~~SavingsFactor~~Cooling Savings = Dependent on home vintage and type (single family vs. multi-family): [851]

Vintage Group	kWh/1000 ft^2 ~~(SavingsFactor)~~Cooling Savings	
	Single Family	Multi-Family
Up to 1979	136.0	114.0
1980-1999	73.9	58.1
2000-2009	33.3	24.9
2010-2015	23.9	19.5

SF = Area of cool roof in square feet.

HeatingFactor =0[852] for Electric Resistance heating

=0.42[853] for Heat Pump heating

=1.0 for non-electric heating

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ΔkWh * CF

Where:

ΔkWh = Electric energy savings, as calculated above.

CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor

= 0. 0004660805[854]

NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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[851] The annual site energy savings by roof area for each of the residential prototypes from the installation of cool roofs instead of conventional roofs (scenario RR-2 in Leidos 2015b). Leidos. (2015b) Energy savings of high albedo roofs for the Kansas City Area. Leidos report commissioned by the Mid-America Regional Council. September 2015.

[852] Average reduction in savings due to electric heat, calculated with the ORNL Cool Roof calculator. Local file: "Residential Cool Roofs.xlsx"

[853] Ibid.~~BID~~

[854] Based on Ameren Missouri TRM Volume 1 - Appendix G: "Table 1 – Residential End Use Category Monthly Shapes and Coincident Peak Factors" ~~Ameren Missouri 2016 loadshape~~ for residential building shell end-use.

~~Residential New Construction~~

~~DESCRIPTION~~

~~This protocol documents the energy savings attributed to improvements in the construction of residential buildings compared to the baseline of a building that is minimally compliant with specified code requirements. It applies to attached or detached single family homes and multifamily residential buildings with individual meters, residential-grade HVAC and water heating equipment, and fewer than 4 stories.~~

~~DEFINITION OF EFFICIENT EQUIPMENT~~

~~Efficient equipment refers to all components and systems in the residential new construction that meet or exceed the energy efficiency standards set by RESNET accredited software or Passive House accreditation software. This includes high-performance insulation, windows, HVAC systems, and appliances designed to reduce energy consumption.~~

~~DEFINITION OF BASELINE EQUIPMENT~~

~~Baseline equipment represents the minimum code-compliant components and systems in residential new construction based on the current state-adopted International Energy Conservation Code (IECC) 2015 standards. This includes standard insulation, windows, HVAC systems, and appliances as defined by the IECC for energy modeling comparison.~~

~~DEEMED LIFETIME OF EFFICIENT EQUIPMENT~~

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

~~DEEMED MEASURE COST~~

~~Custom~~

~~LOADSHAPE~~

~~Cooling RES~~
~~Miscellaneous RES (applicable to non-cooling savings)~~

~~Algorithm~~

~~CALCULATION OF SAVINGS~~

~~Energy and peak demand savings for Residential New Construction programs will be calculated by comparing outputs of energy models of the as-designed unit or building to a minimally code-compliant baseline unit or building. The characteristics of the baseline unit or building thermal envelope and/or system characteristics shall be based on the current state-adopted International Energy Conservation Code (IECC) 2015.[855]~~

~~Modeled energy and peak demand savings shall be produced by a RESNET accredited software program[856] or the Passive House accreditation software packages (Passive House Planning Package[857] and WUFI Passive[858]), though both Passive House tools require the user to separately model the code baseline reference design to calculate energy and demand savings.~~

~~For multifamily buildings, savings may be calculated by modeling the building's individual units using any approved software. Savings may also be calculated for the entire building using Passive House accreditation software, or under RESNET multifamily sampling protocols.[859]~~

~~Baseline insulation and fenestration requirements by component for buildings less than 4 stories (equivalent U-factors)[860]:~~

~~[855] International Code Council, Inc. (2015). 2015 International Energy Conservation Code. Retrieved from International Code Council: https://codes.iccsafe.org/content/IECC2015?site_type=public~~

~~[856] See the RESNET National Registry of Accredited Rating Software Programs for a complete listing: http://www.resnet.us/professional/programs/energy_rating_software~~

~~[857] http://www.passivehouseacademy.com/index.php/shop-us~~

~~[858] http://www.phius.org/software-resources/wufi-passive-and-other-modeling-tools/wufi-passive-3-0~~

~~[859] At the time of publication, RESNET standards for multifamily inspection and sampling were still under development, though they are expected to be adopted before this TRM takes effect. See http://conference2018.resnet.us/data/energymeetings/presentations/How%20Standards%20are%20Evolving%20to%20Better%20Address%20Multifamily%20Ratings%20.pdf~~

~~[860] 2015 International Energy Conservation Code Table R402.1.4 Equivalent U-Factors presents the R-Value requirements of Table R402.1.2 in an equivalent U-Factor format. Users may choose to follow Table R402.1.2 instead. 2015 IECC supersedes this table in case of discrepancy. Additional requirements per §R402 of 2015 IECC must be followed even if not listed here. https://codes.iccsafe.org/content/IECC2015/chapter-4-re-residential-energy-efficiency~~

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~~Building Element~~	~~IECC Climate Zone 4A~~
~~Fenestration U-Factor~~	~~0.35~~
~~Skylight U-Factor~~	~~0.55~~
~~Ceiling U-Factor~~	~~0.026~~
~~Frame Wall U-Factor~~	~~0.06~~
~~Mass Wall U-Factor~~	~~0.098~~
~~Floor~~	~~0.047~~
~~Basement Wall~~	~~0.059~~
~~Slab~~	~~10, 2 ft~~
~~Crawl Space Wall~~	~~0.065~~

~~Residential new construction baseline building values for building less than 4 stories:~~

~~Data Point~~	~~Value~~
~~Air Infiltration Rate~~	~~5.0 ACH for the whole house~~[861]
~~Duct Leakage~~	~~4 CFM~~$_{25}$ ~~(4 cubic feet per minute per 100 square feet of conditioned space when tested at 25 pascals)~~[862]
~~Duct Insulation~~	~~Supply and return ducts in attics shall be insulated to a minimum of R-8 where ≥3” in diameter and a minimum of R-6 where <3” in diameter. All other ducts not located completely inside the building thermal envelope shall be insulated to a minimum of R-6 where ≥3” in diameter and a minimum of R-4.2 where <3” in diameter.~~[863]
~~Duct Location~~	~~50% in conditioned space, 50% unconditioned space~~
~~Mechanical Ventilation~~	~~A continuous whole-house ventilation system with efficiency of 2.8 CFM/Watt and airflow defined by Table M1507.3.3(1) of 2015 IRC~~[864]
~~Lighting~~	~~-~~
~~Appliances~~	~~Use baseline values as defined in applicable TRM measure for each appliance.~~
~~Thermostat Setback~~	~~Maintain zone temperature down to 55 °F (13 °C) or up to 85 °F (29 °C)~~ [865]
~~Temperature Set Points~~	~~Heating: 70°F; Cooling: 78°F~~[866]
~~ASHP, GSHP, PTHP Heating and Cooling Efficiency~~	~~See New Construction values in applicable TRM measure for each systen.~~
~~Electric Water Heating~~	~~See volume and load dependent values in TRM section 3.3.4.~~

~~ELECTRIC ENERGY SAVINGS~~

~~Energy savings will be calculated from the software output using the following algorithm:~~

~~*Energy savings of the qualified unit/building (kWh/yr)*~~

~~$\Delta kWh = (kWh\_base_{cooling} - kW\_ee_{cooling}) + (kWh\_base_{noncooling} - kW\_ee_{noncooling})$~~

---

[861] ~~2015 International Energy Conservation Code §R401-R404. https://codes.iccsafe.org/content/IECC2015/chapter-4-re-residential-energy-efficiency~~

[862] ~~Ibid.~~

[863] ~~Ibid.~~

[864] ~~2015 International Residential Code, Table M1507.3.3(1): Continuous Whole-House Mechanical Ventilation System Airflow Rate Requirements. https://codes.iccsafe.org/content/IRC2015/chapter-15-exhaust-systems~~

[865] ~~2015 International Energy Conservation Code §R401-R404. https://codes.iccsafe.org/content/IECC2015/chapter-4-re-residential-energy-efficiency~~

[866] ~~Ibid.~~

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~~Where:~~

~~$kWh\_base_{cooling}$ = Modeled annual cooling electric energy use of baseline home~~
~~$kW\_ee_{cooling}$ = Modeled annual cooling electric energy use of as-built home~~
~~$kWh\_base_{noncooling}$ = Modeled annual non-cooling electric energy use of baseline home~~
~~$kW\_ee_{noncooling}$ = Modeled annual non-cooling electric energy use of as-built home~~

~~Summer Coincident Peak Demand Savings~~

~~$\Delta kW = \Delta kWh_{Cooling} * CF$~~

~~Where:~~

~~$\Delta kWh_{Cooling}$ = Electric energy savings for cooling, calculated above~~
~~CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor~~
~~= 0.0009474181~~

~~Natural Gas Savings~~

~~N/A~~

~~Water Impact Descriptions and Calculation~~

~~N/A~~

~~Deemed O&M Cost Adjustment Calculation~~

~~N/A~~

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~~3.8 Miscellaneous~~

~~3.8.1 Home Energy Report (Retired, effective 1/1/2025)~~ [867]

~~Description~~
~~These behavior/feedback programs send energy use reports to participating residential electric or gas customers in order to change customers' energy use behavior. Energy savings are evaluated by ex post billing analysis comparing consumption before and after (or with and without) program intervention and require M&V methods that include customer specific energy usage regression analysis and randomized controlled trial (RCT) experimental designs, among others (see national protocols developed under the sponsorship of the US Department of Energy~~[868]~~). As such, calculation of savings achieved by the program for the year is treated as a custom protocol.~~

~~Given that actual monitored energy use is needed, as an ex-post input for these custom calculations, estimates of program savings are used for program planning and goal setting at the beginning of the program cycles. Estimated, or ex ante, values are based on previous actual program performance developed through forecasting analysis from the program implementer, or taken from actual savings values from comparable programs delivered by other program administrators.~~

~~HER Program Estimated (Ex Ante) Savings Values~~

~~Utility Program~~	~~Year~~	~~Gross Electric Energy Savings (kWh/home)~~	~~Gross Demand Savings (kW/home)~~ [A]
~~Ameren Missouri Home Energy Report~~	~~1~~	~~140.37~~ [B]	~~0.065422~~
	~~2~~	~~112.29~~	~~0.052337~~
	~~3~~	~~89.83~~	~~0.041870~~
	~~4~~	~~71.87~~	~~0.033496~~
	~~5~~	~~57.49~~	~~0.026797~~

[A] ~~Demand savings are calculated as the product of the gross electric energy savings and the kW factor for the Building Shell RES end use.~~
[B] ~~Value is based on the Ameren Missouri Home Energy Report Evaluation PY2021. First year annual energy savings are calculated as PY2021 HER Program Adjusted Net Annual Savings / Number of Customers Treated.~~

~~Definition of Efficient Case~~
~~The efficient case is a customer who receives a Home Energy Report.~~

~~Definition of Baseline Case~~
~~The baseline case is a customer who does not receive a Home Energy Report.~~

~~Deemed Lifetime of Program Savings~~
~~Year one savings represent ex post savings for the final year of treatment. Years two through five represent savings decay from the evaluated savings in year one. Once home energy reports cease, the savings persist for four additional years, with 20% savings decay each year. With this decay rate, second year savings are 80% of savings from the final year of treatment; third year savings are 64% of savings from the final year of treatment (80% of second year savings); fourth year savings are 51.2% of savings from the final year of treatment (80% of third year savings); fifth year savings are 40.96% of savings from the final year of treatment (80% of fourth year savings); and no savings persist beyond the fifth year.~~[869]

~~Deemed Measure Cost~~
~~It is assumed that most behavior changes in residential settings can be accomplished with homeowner labor only and without investment in new equipment. Therefore, without evidence to the contrary, measure costs in such residential programs focused on motivating changes in customer behavior may be defined as $0.~~

~~Loadshape~~
~~Building Shell RES~~

~~Water Impact Descriptions and Calculation~~
~~N/A~~

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[867] ~~"Retire" indicates that the measure is not anticipated to be offered through an Ameren Missouri-administered demand-side program during the period of TRM effectiveness.~~
[868] ~~Evaluation, Measurement, and Verification (EM&V) of Residential Behavior-Based Energy Efficiency Programs: Issues and Recommendations; SEEAction (State and Local Energy Efficiency Action Network- EPA/DOE), 2012; The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures; Residential Behavior Protocol, NREL/ DOE, 2015.~~
[869] ~~Opinion Dynamics, MEMO: Recommendation for Ameren Missouri HER Program Persistence and EUL; August 2021.~~

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~~Deemed O&M Cost Adjustment Calculation~~
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~~3.9~~3.7 Residential Demand Response

3.9.1 **Residential Demand Response ~~Baseline~~ Analysis Approach**

DESCRIPTION

For residential demand response measures, the energy and demand impacts of residential demand response events will be analyzed using AMI interval data. The baseline for measuring impacts will be established by creating a control group of non-participant customers with similar energy usage patterns and weather conditions. This control group will be used to estimate what energy usage would have been in the absence of a demand response event.

The analysis will include weather normalization to ensure that the baseline reflects the weather conditions experienced during the event. Demand reduction will be calculated as the difference between the weather-normalized baseline and the actual energy use during the event period.

If AMI data is not available for all participants, results will be extrapolated to represent the broader participant population.

~~Residential demand response: For demand and energy savings associated with calling a demand response event, program participants will be randomly partitioned into two groups. In this scenario, on an event day, participants in one group receive a signal to initiate activity on the thermostat (treatment group), while the other group of participants would not receive this signal (control group). Demand impacts will be estimated from the average of the hours over all event periods. Energy savings impacts will be estimated from comparing the 24 hours of the control group for each event day to the 24 hours of actual kWh consumption for each event day. However, if it is not practical or plausible to use this approach (such as everyone is dispatched), other quasi experimental design approaches may be used.~~

3.9.2 Demand Response Advanced Thermostat

DESCRIPTION

This measure characterizes the demand savings achieved by managing customer energy loads during peak periods through a residential demand response (DR) program. It also characterizes the energy savings resulting from load shaping strategies employed during non-peak hours to reduce overall usage. Savings impacts will be evaluated using ex-post analysis, primarily leveraging AMI interval data to compare energy consumption with and without program intervention.

The evaluation approach includes establishing a control group through propensity score matching with non-participant customers who have similar energy usage patterns and weather conditions. The analysis involves weather normalization to ensure accurate baseline estimations. The savings impacts will be determined by comparing the treatment group's energy use during DR events to the weather-normalized baseline~~This measure characterizes the energy and demand savings for an advanced thermostat enrolled in the Residential Demand Response (DR) Program. The program controls customer energy loads and also reduces energy usage by utilizing a continuous load shaping strategy during non-peak hours. Savings impacts are evaluated by ex post analysis comparing demand and consumption with and without program intervention, utilizing field data which may be available through advanced thermostats' 2-way communication ability. The program will require M&V methods that include customer-specific energy usage regression analysis and randomized controlled trial (RCT) experimental designs, among others. As such, calculation of both demand and energy savings achieved by the program for the year are treated as a custom protocol~~.

~~Given that actual monitored field data is needed as ex post inputs for these custom calculations, estimates of program savings based on previous year evaluation results are used for program planning and goal setting at the beginning of the program cycles.~~

As advanced thermostats evolve, some models include embedded optimization routines that can independently achieve energy savings. The program, however, will only attribute savings to the incremental impact of “program-driven optimization”—those savings achieved through the program’s influence in activating or enhancing the thermostat's optimization features. Energy savings that result from default or non-program-driven optimization will not be attributed to the program~~As advanced thermostats mature, some models include embedded optimization routines that achieve energy savings. The program differentiates between thermostats with “program driven optimization,” which achieve savings through program influence to operate optional optimization, and without “program-driven optimization,” which achieve no energy savings due to either the default optimization baseline or no optimization routine employed~~.

Due to the custom nature of the evaluation, ex-post demand and energy savings calculations will be based on the specific conditions and data available each year, with previous year results informing program planning and goal setting for subsequent cycles.

~~Demand Response Smart Thermostat Deemed Savings Estimates for 2019-21 Planning~~

~~Utility Program~~	~~Gross Electric Savings (*Annual*) (kWh/thermostat)~~	~~Gross Demand Savings (*Event*) (kW/thermostat)~~	
~~Demand Response Advanced Thermostat – with Program-Driven Optimization~~	~~97.49~~[870]	~~0.94~~[871]	

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[870] ~~Average energy savings per device based on Ameren Missouri PY20232 evaluation. See Ameren Missouri Program Year 20232 Annual EM&V Report, Volume 4: Demand Response Portfolio Report, Table 20, https://www.efis.psc.mo.gov/Document/Display/7866771922. Comparison of Savings from Emerson Optimization Using Telemetry and AMI Data Pathways.~~

[871] ~~Average demand impact per device based on Ameren Missouri PY20232 evaluation. See Ameren Missouri Program Year 20232 Annual EM&V Report, Volume 4: Demand Response Portfolio Report, Table 187. Residential DR Program: Event Day Energy Savings by Device Manufacturer for the number of devices and Table 143. Residential DR Program: Resource Capability Impacts for the per account kW impacts and number of accounts. https://www.efis.psc.mo.gov/Document/Display/786677 Table 13. Residential DR Program: Resource Capability Impacts for the number of devices and Appendix Table 3 Residential DR Program: Resource Capability Impacts for the AMI per account kW impacts and number of accounts.~~

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~~Demand Response Advanced Thermostat – without Program-Driven Optimization~~	~~0.00~~	~~0.94[872]~~	

This measure was developed to be applicable to the following program type: -DR.

DEFINITION OF EFFICIENT CASE

The efficient case is a customer who participates in the DR program, where the thermostat is under the control of the program. In this case, energy consumption is directly influenced by program-driven strategies, including load shaping during non-peak hours and demand reduction during peak periods~~The efficient case is a customer who participated in the DR program~~.

DEFINITION OF BASELINE CASE

The baseline case is a customer who is not participating in the DR program and whose thermostat operates independently of program-driven strategies. The baseline for measuring impacts will be established by creating a control group of non-participant customers with similar energy usage patterns and weather conditions. This control group will be used to estimate what energy usage would have been in the absence of a demand response event. The analysis will include weather normalization to ensure that the baseline reflects the weather conditions experienced during the event. If AMI data is not available for all participants, results will be extrapolated to represent the broader participant population~~The baseline case is a customer who is not participating in the DR program and who has installed a thermostat with default enabled capability – or the capability to automatically – establish a schedule of temperature set points according to driving device inputs above and beyond basic time and temperature data of conventional programmable thermostats. This category of products and services is broad and rapidly advancing with regard to their capability, usability, and sophistication, but at a minimum the baseline customer must have installed a thermostat capable of two-way communication and exceed the typical performance of manual and conventional programmable thermostats through the automatic or default capabilities described above~~.

DEEMED LIFETIME OF PROGRAM SAVINGS

The expected measure life is assumed to be 1 year.

DEEMED MEASURE COST

It is assumed that program-controlled changes in residential settings are accomplished without homeowner investment in new equipment. Therefore, without evidence to the contrary, measure costs in such residential programs focused on program controlled changes in customer behavior may be defined as $0.

LOADSHAPE

HVAC RES (for optimization routines that save energy during the cooling and heating seasons)
Cooling RES (for optimization routines that save energy only during the cooling season)
Heating RES (for optimization routines that save energy only during the heating season)

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

3.9.3 Demand Response Water Heater Switch

DESCRIPTION

This measure characterizes the demand savings achieved by controlling residential water heater loads during peak periods through a demand response (DR) program. Savings impacts will be evaluated using ex-post analysis, primarily leveraging AMI interval data to compare energy consumption during peak periods with and without program intervention.

The evaluation approach includes establishing a control group through propensity score matching with non-participant customers who have similar energy usage patterns and weather conditions. The analysis involves weather normalization to ensure accurate baseline estimations. The demand savings impacts will be determined by comparing the treatment group's energy use during DR events to the weather-normalized baseline.

~~[872] Ibid.~~

Due to the custom nature of the evaluation, ex-post demand savings calculations will be based on the specific conditions and data available each year, with previous year results informing program planning and goal setting for subsequent cycles.

This measure was developed to be applicable to the following program type: DR.

DEFINITION OF EFFICIENT CASE

The efficient case is a customer who participates in the DR program, where the water heater is under the control of the program. In this case, demand reduction is directly influenced by program-driven strategies during peak periods.

DEFINITION OF BASELINE CASE

The baseline case is a customer who is not participating in the DR program and whose water heater operates independently of program-driven strategies. The baseline for measuring impacts will be established by creating a control group of non-participant customers with similar energy usage patterns and weather conditions. This control group will be used to estimate what demand would have been in the absence of a demand response event. The analysis will include weather normalization to ensure that the baseline reflects the weather conditions experienced during the event. If AMI data is not available for all participants, results will be extrapolated to represent the broader participant population.

DEEMED LIFETIME OF PROGRAM SAVINGS

The expected measure life is assumed to be 1 year.

DEEMED MEASURE COST

The incremental cost of the water heater switch is $149.00.

LOADSHAPE

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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~~3.9.4 Demand Response Electric Vehicle Charger~~

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~~Description~~

~~This measure characterizes the demand savings achieved by controlling residential electric vehicle (EV) charger loads during peak periods through a demand response (DR) program. Savings impacts will be evaluated using ex-post analysis, primarily leveraging AMI interval data to compare energy consumption during peak periods with and without program intervention.~~

~~The evaluation approach includes establishing a control group through propensity score matching with non-participant customers who have similar energy usage patterns and weather conditions. The analysis involves weather normalization to ensure accurate baseline estimations. The demand savings impacts will be determined by comparing the treatment group's energy use during DR events to the weather-normalized baseline.~~

~~Due to the custom nature of the evaluation, ex-post demand savings calculations will be based on the specific conditions and data available each year, with previous year results informing program planning and goal setting for subsequent cycles.~~

~~This measure was developed to be applicable to the following program type: DR.~~

~~Definition of Efficient Case~~

~~The efficient case is a customer who participates in the DR program, where the EV charger is under the control of the program. In this case, demand reduction is directly influenced by program-driven strategies during peak periods.~~

~~Definition of Baseline Case~~

~~The baseline case is a customer who is not participating in the DR program and whose EV charger operates independently of program-driven strategies. The baseline for measuring impacts will be established by creating a control group of non-participant customers with similar energy usage patterns and weather conditions. This control group will be used to estimate what demand would have been in the absence of a demand response event. The analysis will include weather normalization to ensure that the baseline reflects the weather conditions experienced during the event. If AMI data is not available for all participants, results will be extrapolated to represent the broader participant population.~~

~~Deemed Lifetime of Program Savings~~

~~The expected measure life is assumed to be 1 year.~~

~~Deemed Measure Cost~~

~~Since customers do not need to invest in new equipment or incur additional expenses to participate in the program, the deemed measure cost is $0.~~

~~Loadshape~~

~~N/A~~

~~Water Impact Descriptions and Calculation~~

~~N/A~~

~~Deemed O&M Cost Adjustment Calculation~~

~~N/A~~

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~~3.9.5 Behavioral Demand Response~~

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~~Description~~

~~This measure characterizes the demand savings achieved through a behavioral demand response (DR) program, where participating customers are notified of peak energy use events and encouraged to reduce their energy consumption during these periods. Customers self-manage their energy use in response to notifications, which may be delivered via email, text message, or other communication channels. The program relies on customer action to achieve load reduction during DR events.~~

~~Savings impacts will be evaluated using ex-post analysis, primarily leveraging AMI interval data to compare energy consumption during peak periods with and without program participation. The effectiveness of customer actions in response to DR notifications will be assessed to determine the overall demand savings.~~

~~The evaluation approach includes establishing a control group through propensity score matching with non-participant customers who have similar energy usage patterns and weather conditions. The analysis involves weather normalization to ensure accurate baseline estimations. Demand savings impacts will be determined by comparing the energy use of participants during DR events to the weather-normalized baseline derived from the control group.~~

~~Due to the custom nature of the evaluation, ex-post demand savings calculations will be based on the specific conditions and data available each year, with previous year results informing program planning and goal setting for subsequent cycles.~~

~~This measure was developed to be applicable to the following program type: DR.~~

~~Definition of Efficient Case~~

~~The efficient case is a customer who receives notification of behavioral DR program peak energy use events. In this case, demand reduction is directly influenced by the customer's actions in response to program-driven notifications.~~

~~Definition of Baseline Case~~

~~The baseline case is a customer who does not receive notification of behavioral DR program peak energy use events. The baseline for measuring impacts will be established by creating a control group of non-participant customers with similar energy usage patterns and weather conditions. This control group will be used to estimate what demand would have been in the absence of a behavioral DR event notification. The analysis will include weather normalization to ensure that the baseline reflects the weather conditions experienced during the event. If AMI data is not available for all participants, results will be extrapolated to represent the broader participant population.~~

~~Deemed Lifetime of Program Savings~~

~~The expected measure life is assumed to be 1 year.~~

~~Deemed Measure Cost~~

~~Since customers do not need to invest in new equipment or incur additional expenses to participate in the program, the deemed measure cost is $0.~~

~~Loadshape~~

~~N/A~~

~~Water Impact Descriptions and Calculation~~

~~N/A~~

~~Deemed O&M Cost Adjustment Calculation~~

~~N/A~~

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