MEMORANDUM

TO: **TECHNICAL ADVISORY COMMITTEE**

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

SUBJECT: V12.0 ERRATA MEASURES EFFECTIVE 01/01/2024

DATE: 09/20/2024

Cc: CELIA JOHNSON, SAG

This memo documents errata changes to Version 12.0 of the Illinois Technical Reference Manual (TRM) that the Technical Advisory Committee (TAC) recommends be made effective 01/01/2024.

VEIC has provided a summary table below showing the errata measures and a brief summary of what was changed, followed by the v12.0 measures themselves.

TRM Policy Document, Section 3.2.1, states that,

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

It is our belief and understanding that the following measures have been determined to be consensus errata by the Program Administrators, Evaluators, and the entire TAC. The term 'errata' is used to describe these measures, and in accordance with the TRM Policy Document, the Evaluators may use this version of the measures during evaluation of the current program year (in addition to the measures currently in Version 12.0 of the TRM).

Summary of Errata Measures

Section	Measure Name	Measure Code	Brief Summary of Change	TAC Reviewed and Approved As of
4.1.11	Commercial LED Grow Lights	CI-AGE-GROW-V06-240101	Error discovered in calculation file of CFs where additional hour beyond peak period was being included.	6/19/2024
4.2.3	Commercial Steam Cooker	CI-FSE-STMC-V08-240101	Idle calculation needs to divide preheat time by 60 minutes per hour.	6/19/2024
4.2.18	Rack Oven - Double Oven	CI-FSE-RKOV-V04-240101	Fixed error in deemed savings calculation. Added Days variable to Algorithm section.	6/19/2024
4.2.22	Automatic Conveyor Broiler	CI-FSE-ACBL-V02-240101	Fixed error in preheat energy calculation.	6/19/2024
4.3.1	Water Heater	CI-HWE-STWH-V11-240101	Fixed error in large water heater fuel switch calculation.	6/19/2024
4.4.7	ENERGY STAR and CEE Tier 2 Room Air Conditioner	CI-HVC-ESRA-V04-240101	Update to ENERGY STAR and CEE Tier 2 specifications that came in to effect in October 2023.	6/19/2024
4.4.10	High Efficiency Boiler	CI-HVC-BOIL-V12-240101	Update to baseline after the 2023 Federal Standard update was vacated.	6/19/2024
4.4.51	Advanced Rooftop Controls with High Rotor Pole Switch Reluctance Motors	CI-HVC-HSRM-V05-240101	Addition of load factor and motor efficiency into the energy savings algorithm since study used is calculated on brake horsepower and not nominal horsepower.	6/19/2024
4.4.54	Process Heating Boiler	CI-HVC-PHBO-V04-240101	Update to baseline after the 2023 Federal Standard update was vacated.	6/19/2024
4.5.13	Occupancy Controlled Bi-Level Lighting Fixtures	CI-LTG-OCBL-V06-240101	Fixed CFbaseline to be 1.0 since pre condition is limited to fixtures on 8760.	6/19/2024
4.6.8	Refrigeration Economizers	CI-RFG-ECON-V08-240101	Fixed analysis error where condenser fan savings had not been appropriately adjusted to reflect Illinois climate.	6/19/2024
4.8.9	High Frequency Battery Chargers	CI-MSC-BACH-V03-240101	Fixed error in kW algorithm.	6/19/2024
4.8.25	Warm-Mix Asphalt Chemical Additives	CI-MSC-WMIX-V02-240101	Fixed error in SF table for Additives.	6/19/2024
5.1.2	ENERGY STAR Clothes Washer	RS-APL-ESCL-V12-240101	Fixed transcription error in electric v fuel DHW split for Peoples Gas unknown, and resultant all DU value.	11/15/2023
5.1.4	ENERGY STAR Dishwasher	RS-APL-ESDI-V10-240101	Fixed transcription error in electric v fuel DHW split for Peoples Gas unknown, and	11/15/2023

Section	Measure Name	Measure Code	Brief Summary of Change	TAC Reviewed and Approved As of
			resultant all DU value.	
5.1.7	ENERGY STAR and CEE Tier 2 Room Air Conditioner	RS-APL-ESRA-V11-240101	Update to ENERGY STAR and CEE Tier 2 specifications that came in to effect in October 2023.	6/19/2024
5.1.12	Ozone Laundry	RS-APL-OZNE-V06-240101	Fixed transcription error in electric v fuel DHW split for Peoples Gas unknown, and resultant all DU value.	11/15/2023
5.1.13	Income Qualified: ENERGY STAR and CEE Tier 2 Room Air Conditioner	RS-APL-IQRA-V05-240101	Update to ENERGY STAR and CEE Tier 2 specifications that came in to effect in October 2023.	6/19/2024
5.3.13	Residential Furnace Tune-Up	RS-HVC-FTUN-V08-240101	Typo fix in algorithm – 100,000 Btu per therm.	7/8/2024
5.3.20	Residential Energy Recovery Ventilator (ERV)	RS-HVC-ERVS-V03-240101	Removal of erroneous factor (24) in cooling equation.	8/19/2024
5.4.1	Domestic Hot Water Pipe Insulation	RS-HWE-PINS-V08-240101	Fixed transcription error in electric v fuel DHW split for Peoples Gas unknown, and resultant all DU value.	11/15/2023
5.4.4	Low Flow Faucet Aerators	RS-HWE-LFFA-V14-240101	Fixed transcription error in electric v fuel DHW split for Peoples Gas unknown, and resultant all DU value.	11/15/2023
5.4.5	Low Flow Showerheads	RS-HWE-LFSH-V13-240101	Fixed transcription error in electric v fuel DHW split for Peoples Gas unknown, and resultant all DU value.	11/15/2023
5.4.8	Thermostatic Restrictor Shower Valve	RS-HWE-TRVA-V08-240101	Fixed transcription error in electric v fuel DHW split for Peoples Gas unknown, and resultant all DU value.	11/15/2023
5.4.9	Shower Timer	RS-DHW-SHTM-V06-240101	Fixed transcription error in electric v fuel DHW split for Peoples Gas unknown, and resultant all DU value.	11/15/2023
5.6.8	High Performance Windows	RS-SHL-TTWI-V04-240101	Fixed transcription error in savings tables for single pane windows	11/15/2023

4.1.11 Commercial LED Grow Lights

DESCRIPTION

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

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

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

DEFINITION OF EFFICIENT EQUIPMENT

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

DEFINITION OF BASELINE EQUIPMENT

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

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

Crop Type	Baseline Technology Type	Baseline PPE (µmol/J)[2]	Baseline Fixture Wattage[3]
Flowering Crops (Tomatoes and Peppers)	High Pressure Sodium	1.7	1,100 W
Vegetative Growth	Metal Halide	1.25[4]	640 W
Microgreens[5]	T5 HO Fixture	1.0[6]	358 W
Propagation[7]	T5 HO Fixture	1.0[8]	234 W
Medical Cannabis – Flowering Stage	High Pressure Sodium	1.7	1,100 W
Medical Cannabis – Vegetative Stage	Metal Halide	1.25[9]	640 W
Medical Cannabis – Cloning, Seeding, and Propagation	T5 HO Fixture	1.0[10]	234W
Recreational Cannabis – Flowering Stage	HID/LED/Other	2.2[11]	850 W[12]
Recreational Cannabis – Vegetative Stage	HID/LED/Other	2.2[11]	640 W
Recreational Cannabis – Cloning, Seeding, and Propagation	T5/LED/Other	2.2[11]	234 W

Recreational cannabis cultivation facilities have a separate equipment definition due to Illinois legislation.[13] See cannabis cultivation code from "Cannabis Regulation and Tax Act," Illinois HB 1438:

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

[2] Erik Runkle and Bruce Bugbee "Plant Lighting Efficiency and Efficacy: µmols per joule". Accessed 4/21/2020.
[3] Jesse Remillard and Nick Collins, "Trends and Observations of Energy Use in the Cannabis Industry," ACEEE, accessed April 17, 2020. Baseline watts per square foot were taken by using typical fixture technology by crop type and dividing by 16 sqft per fixture (a 4'x4' area is a typical coverage amount for one grow light fixture).
[4] Jacob A. Nelson, Bruce Bugbee, "Economic Analysis of Greenhouse Lighting: Light Emitting Diodes vs. High Intensity Discharge Fixtures." Utah State University. Accessed 5/6/2020.
[5] Microgreens T5 fixture is based on a 6-lamp high output fixture, based on program experience.
[6] D.S. de Villiers, L.D. Albright, and R. Tuck, "Next Generation, Energy Efficient, Uniform Supplemental Lighting for Closed-System Plant Production." International Society for Horticultural Science. Accessed 4/8/2022.
[7] Propagation T5 fixture is based on a 4-lamp high output fixture, based on program experience.
[8] D.S. de Villiers, L.D. Albright, and R. Tuck, "Next Generation, Energy Efficient, Uniform Supplemental Lighting for Closed-System Plant Production." International Society for Horticultural Science. Accessed 4/8/2022.
[9] Jacob A. Nelson, Bruce Bugbee, "Economic Analysis of Greenhouse Lighting: Light Emitting Diodes vs. High Intensity Discharge Fixtures." Utah State University. Accessed 5/6/2020.
[10] D.S. de Villiers, L.D. Albright, and R. Tuck, "Next Generation, Energy Efficient, Uniform Supplemental Lighting for Closed-System Plant Production." International Society for Horticultural Science. Accessed 4/8/2022.
[11] Recreational cannabis baseline PPE requirement is either 36 W/sqft or 2.2 µmol/J and DLC listed. Per HB 1438.
[12] Recreational cannabis baseline wattage was back calculated using the medical cannabis – flowering stage wattage of 1,100 W and adjusted by the IL HB 1438 minimum fixture efficiency of 2.2 µm/J compared to the typical baseline of 1.7 µm/J.
[13] Illinois legislation Public Act 101-0027 the Cannabis Regulation and Tax Act, Article 20: Adult Use Cultivation Centers, (Section 20-15 (a) (23) a commitment to a technology standard for resource efficiency of the cultivation center facility (B) Lighting)

DEEMED LIFETIME OF EFFICIENT EQUIPMENT
The expected measure life is 9.5 years (average rated life of 50,000 hours).[14]

DEEMED MEASURE COST
LED Fixture Costs:[15]

≤ 250 Watts = $ 325.87 per fixture

> 250 Watts = $ 535.04 per fixture

LOADSHAPE
Loadshape C65 – Non-Residential Indoor Agriculture Vegetative Room

Loadshape C66 – Non-Residential Indoor Agriculture Flowering Room

COINCIDENCE FACTOR
Summer coincidence factor for vegetative and flowering rooms = 0.95

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS
PPF Equivalence Method:

$$\Delta kWh = \left[\left(\frac{PPF_{Total,i}}{PPE_{BL,i} \times 1000}\right) - kW_{ee,i}\right] \times Hours \times WHF_e$$

$$PPF_{Total,i} = PPF_{Fixture,i} \times Qty_i$$

Where:

$PPF_{Total,i}$ = Total Photosynthetically-active Photon Flux output of the installed efficient fixtures for a specific growth phase, i in units of µmol/s. Equal to the number of fixtures installed multiplied by the PPF output per fixture.

$PPE_{BL,i}$ = Photosynthetically-active Photon Flux Efficiency of the assumed baseline fixture for a specific growth phase, i in units of µmol/J. Can be found in the table above.

$PPF_{Fixture,i}$ = The Photosynthetically-active Photon Flux output of an individual fixture installed for a

[14] Based on 50,000 hours lifetime and 5,250 hours per year of use (average hours of use per year using flowering and vegetative rooms).
[15] Focus on Energy Evaluation Business Programs: Measure Life Study Final Report: August 25, 2009

specific growth phase, i in units of µmol/s.[16]

Qty_i = The installed quantity of efficient fixtures.

i = An indicator used to separate growth phases of products or different plants. "i" can be used to separate "Flowering" and "Vegetative", or different crop types, such as "Flowering Crops (tomatoes and peppers)" and "Microgreens".

1000 = Watts to kilowatts conversion factor

$kW_{ee,i}$ = Total power of the installed fixtures for a specific growth phase, i.

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

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

WHFe = 1.21[19] if cooling or unknown or 1.00 if none; waste heat factor for energy to account for cooling savings from efficient lighting in cooled buildings.

For example, a recreational cannabis growth facility is installing 100 efficient LED fixtures in their flowering spaces. Using the manufacturer and model number, the DLC Qualified Products List for horiculture lighting lists these fixtures as consuming 529W and having a Photosynthetic Photon Efficiency (PPE) of 3.3 µmol/J and producing 1,722 µmol/s. One hundred (100) fixtures at 529W each is a total lighting power of 52.9 kW. The baseline PPE is 2.2 µmol/J, as dictated by IL HB 1438. The total flux output and annual energy savings calculations are shown below.

$$PPF_{Total,i} = (1{,}722\ \mu mol/s) \times 100\ fixtures = 172{,}200\ \mu mol/s$$

[16] Individual fixture PPF can be sourced directly from the DLC horticulture qualified products list, Design Light Consortium – Horticultural Lighting, Testing and Reporting Requirements for LED-Based Horticultural Lighting, version 2.1, effective September 1, 2021.

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

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

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

$$\Delta kWh = \left[\left(\frac{172{,}200\ \frac{\mu mol}{s}}{2.2\ \frac{\mu mol}{J} \times 1000}\right) - (52.9\ kW)\right] \times 4{,}200\ hours \times 1.21$$

= 128,944 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = \left[\left(\frac{PPF_{Total,i}}{PPE_{BL,i} \times 1000}\right) - kW_{ee,i}\right] \times CF\ \times WHF_d$$

Where:

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

CF = 0.95 for vegetative crops and flowering crops

For example, a recreational cannabis growth facility is installing 100 efficient LED fixtures in their flowering spaces. Using the manufacturer and model number, the DLC Qualified Products List for horiculture lighting lists these fixtures as consuming 529W and having a Photosynthetic Photon Efficiency (PPE) of 3.3 µmol/J and producing 1,722 µmol/s. One hundred (100) fixtures at 529W each is a total lighting power of 52.9 kW. The baseline PPE is 2.2 µmol/J, as dictated by IL HB 1438. The total flux output and peak demand savings calculations are shown below.

$$PPF_{Total,i} = (1{,}722\ \mu mol/s) \times 100\ fixtures = 172{,}200\ \mu mol/s$$

$$\Delta kWh = \left[\left(\frac{172{,}200\ \frac{\mu mol}{s}}{2.2\ \frac{\mu mol}{J} \times 1000}\right) - (52.9\ kW)\right] \times 0.95 \times 1.22$$

= 29.41 kW

FOSSIL FUEL SAVINGS

N/A

WATER AND OTHER NON-ENERGY IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

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

MEASURE CODE: CI-AGE-GROW-V06-240101

REVIEW DEADLINE: 1/1/2024

4.2.3 Commercial Steam Cooker

DESCRIPTION

To qualify for this measure the installed equipment must be an ENERGY STAR® steamer in place of a standard steamer in a commercial kitchen. Savings are presented dependent on the pan capacity and corresponding idle rate at heavy load cooking capacity and if the steamer is gas or electric.

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

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed equipment must be as follows:

Gas	Electric
ENERGY STAR® qualified with 38% minimum cooking energy efficiency at heavy load (potato) cooking capacity for gas steam cookers.	ENERGY STAR® qualified with 50% minimum cooking energy efficiency at heavy load (potato) cooking capacity for electric steam cookers.

DEFINITION OF BASELINE EQUIPMENT

The baseline condition is assumed to be a non-ENERGY STAR® commercial steamer at end of life. It is assumed that the efficient equipment and baseline equipment have the same number of pans.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 12 years.[20]

DEEMED MEASURE COST

The incremental capital cost for this measure uses actual costs, otherwise use costs outlined below:[21]

Equipment Type	Baseline Equipment Cost	Efficient Equipment Cost	Incremental Cost
Electric	$5,444	$8,201	$2,758
Gas	$10,265	$12,324	$2,059

LOADSHAPE

Loadshape C01 – Commercial Electric Cooking

COINCIDENCE FACTOR

Summer Peak Coincidence Factor for measure is provided below for different building type:[22]

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

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

[21] Costs taken from California “SWFS005-03_Steamers_2022_Price_Updated”

[22] Values taken from Minnesota Technical Reference Manual (Version 2.2, effective May 2, 2018), ‘Electric Oven and Range’ measure and are based upon “Project on Restaurant Energy Performance-End-Use Monitoring and Analysis”, Appendixes I and II, Claar, et. al., May 1985.Unknown is an average of other location types

Location	CF
Full Service Expanded Menu	0.36
Cafeteria	0.39
Unknown	0.408

Algorithm

CALCULATION OF SAVINGS

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

ENERGY SAVINGS AND FOSSIL FUEL SAVINGS

Non Fuel Switch Measures

The algorithm below applies to ENERGY STAR electric steam cooker compared to baseline electric steam cooker:

$$\Delta kWh = (\Delta idle\ Energy + \Delta preheat\ Energy + \Delta cooking\ Energy) * Days$$

The algorithm below applies to ENERGY STAR gas steam cooker compared to baseline gas steam cooker:

$$\Delta therms = (\Delta idle\ Energy + \Delta preheat\ Energy + \Delta cooking\ Energy) * 1/100{,}000 * Days$$

Fuel Switch/Electrification Measures

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

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

$= [(Idle\ Energy_{GasBase} + Preheat\ Energy_{GasBase} + Cooking\ Energy_{GasBase}) * 1/1{,}000{,}000 * Days] –$

$[(Idle\ Energy_{ElecEE} + Preheat\ Energy_{ElecEE} + Cooking\ Energy_{ElecEE}) * 3412/1{,}000{,}000 * Days]$

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

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

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

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

Where:

ΔIdle Energy = $((((1- CSM_{\%Baseline})* IDLE_{BASE} + CSM_{\%Baseline} * PC_{BASE} * E_{FOOD} / EFF_{BASE}) * (HOURS_{day} – (F / PC_{Base}) – (PRE_{number} *PRE_{TimeBase} / 60))) - (((1- CSM_{\%ENERGYSTAR}) * IDLE_{ENERGYSTAR} + CSM_{\%ENERGYSTAR} * PC_{ENERGYSTAR} * E_{FOOD} / EFF_{ENERGYSTAR}) * (HOURS_{Day} - (F l/ PC_{ENERGYSTAR}) - (PRE_{number} * PRE_{TimeEE} / 60))))$

ΔPreheat Energy = $(PRE_{number} *(PRE_{heatEnergyBase} - PRE_{heatEnergyEE})$

ΔCooking Energy = $((1/ EFF_{BASE}) - (1/ EFF_{ENERGY\ STAR})) * F * E_{FOOD}$

Idle $Energy_{GasBase}$ = $((((1- CSM_{\%Baseline})* IDLE_{BASE} + CSM_{\%Baseline} * PC_{BASE} * E_{FOOD} / EFF_{BASE}) * (HOURS_{day} - (F / PC_{Base}) - (PRE_{number} *PRE_{TimeGasBase}/60)))$

Preheat $Energy_{GasBase}$ = $(PRE_{number} * Pre_{heatEnergyGasBase})$

Cooking $Energy_{GasBase}$ = (1/ EFFBASE) * F * E_{FOOD}

Idle $Energy_{ElecEE}$ = $(((1- CSM_{\%ENERGYSTAR}) * IDLE_{ENERGYSTAR} + CSM_{\%ENERGYSTAR} * PC_{ENERGY} * E_{FOOD} / EFF_{ENERGYSTAR}) * (HOURS_{Day} - (F / PC_{ENERGYSTAR}) - (PRE_{number} * PRE_{TimeElecEE}/60))))$

Preheat $Energy_{ElecEE}$ = $(PRE_{number} * Pre_{heatEnergyElecEE})$

Cooking $Energy_{ElecEE}$ = $(1/ EFF_{ENERGY\ STAR}) * F * E_{FOOD}$

Where:

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

= 90%[23]

$IDLE_{Base}$ = Idle Energy Rate of Base Steamer[24]

Number of Pans	$IDLE_{BASE}$ - Gas, Btu/hr	$IDLE_{BASE}$ - Electric, kw
3	11,000	1.0
4	14,667	1.33

[23]Food Service Technology Center 2011 Savings Calculator

[24]Food Service Technology Center 2011 Savings Calculator. Estimates for units with 10 pans taken from ENERGY STAR Commercial Food Service Savings Calculator.

Number of Pans	$IDLE_{BASE}$ - Gas, Btu/hr	$IDLE_{BASE}$ - Electric, kw
5	18,333	1.67
6	22,000	2.0
10	18,000	1.2

PC_{Base} = Production Capacity of Base Steamer[25]

Number of Pans	PC_{BASE}, gas (lbs/hr)	PC_{BASE}, electric (lbs/hr)
3	65	70
4	87	93
5	108	117
6	130	140
10	233	233

E_{FOOD}= Amount of Energy Absorbed by the food during cooking known as ASTM Energy to Food (Btu/lb or kW/lb)

=105 Btu/lb (gas steamers) or 0.0308 (electric steamers) [26]

EFF_{BASE} =Heavy Load Cooking Efficiency for Base Steamer

=15% (gas steamers) or 26% (electric steamers) [27]

$HOURS_{day}$ = Average Daily Operation (hours)

Type of Food Service	Hoursday[28]
Fast Food, limited menu	4
Fast Food, expanded menu	5
Pizza	8
Full Service, limited menu	8
Full Service, expanded menu	7
Cafeteria	6
Unknown	6[29]
Custom	Varies

F = Food cooked per day (lbs/day)

[25]Production capacity per Food Service Technology Center 2011 Savings Calculator of 23.3333 lb/hr per pan for electric baseline steam cookers and 21.6667 lb/hr per pan for natural gas baseline steam cookers. ENERGY STAR® savings calculator uses 23.3 lb/hr per pan for both electric and natural gas baseline steamers. Estimates for units with 10 pans taken from ENERGY STAR Commercial Food Service Savings Calculator.

[26]ENERGY STAR Commercial Kitchen Equipment Savings Calculator, Steam Cooker Calculations

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

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

[29]Unknown is average of other locations

= custom or if unknown, use 100 lbs/day[30]

$CSM_{\%ENERGYSTAR}$ = ENERGY STAR Steamer's Time in Manual Steam Mode (% of time)[31]

= 0%

$IDLE_{ENERGYSTAR}$ = Idle Energy Rate of ENERGY STAR®[32]

=Actual, or

Number of Pans	$IDLE_{ENERGY\ STAR}$ – gas, (Btu/hr)	$IDLE_{ENERGY\ STAR}$ – electric, (kW)
3	6,250	0.40
4	8,333	0.53
5	10,417	0.67
6	12,500	0.80
10	12,500	0.80

$PC_{ENERGYSTAR}$ = Production Capacity of ENERGY STAR® Steamer[33]

=Actual, or

Number of Pans	PC_{ENERGY} - gas(lbs/hr)	PC_{ENERGY} – electric (lbs/hr)
3	55	50
4	73	67
5	92	83
6	110	100
10	200	167

$EFF_{ENERGYSTAR}$ = Heavy Load Cooking Efficiency for ENERGY STAR® Steamer(%)

=Actual, or 38% (gas steamer) or 50% (electric steamer) [34]

PRE_{number} = Number of preheats per day

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

[31]Reference information from the Food Service Technology Center siting that ENERGY STAR® steamers are not typically operated in constant steam mode, but rather are used in timed mode. Reference ENERGY STAR Commercial Kitchen Equipment Savings Calculator, Steam Cooker Calculation. Both baseline & efficient steamer mode values should be considered for users in Illinois market.

[32]Food Service Technology Center 2011 Savings Calculator. Estimates for units with 10 pans taken from ENERGY STAR Commercial Food Service Savings Calculator.

[33]Production capacity per Food Service Technology Center 2011 Savings Calculator of 18.3333 lb/hr per pan for gas ENERGY STAR® steam cookers and 16.6667 lb/hr per pan for electric ENERGY STAR® steam cookers. ENERGY STAR® savings calculator uses 16.7 lb/hr per pan for electric and 20 lb/hr for natural gas ENERGY STAR® steamers. Estimates for units with 10 pans taken from ENERGY STAR Commercial Food Service Savings Calculator.

[34]Reference Food Service Technology Center 2011 Savings Calculator values as used by Consortium for Energy Efficiency, Inc. for Tier 1A and Tier 1B qualified electric and natural gas steamer heavy cooking load energy efficiencies, as sourced from ENERGY STAR Program Requirements Product Specification for Commercial Steam Cookers, version 1.2, effective August 1, 2013.

=1[35] (if unknown, use 1)

$PRE_{heatEnergyBase}$ = Energy per preheat of Base Steamer[36]

Equipment Type	Preheat Energy
Electric	1.78 kWh
Gas	18,832.7 Btu

$PRE_{heatEnergyEE}$ = Energy per preheat of ENERGY STAR Steamer[37]

Equipment Type	Preheat Energy
Electric	1.67 kWh
Gas	10,293.9 Btu

$PRE_{TimeBase}$ =Preheat duration of Base Steamer[38]

Equipment Type	Preheat Time (minutes)
Electric	11.9
Gas	10.9

PRE_{TimeEE} = Preheat duration of ENERGY STAR Steamer[39]

Equipment Type	Preheat Time (minutes)
Electric	13.2
Gas	13.4

EFF_{BASE} =Heavy Load Cooking Efficiency for Base Steamer

=15% (gas steamer) or 26% (electric steamer) [40]

$EFF_{ENERGYSTAR}$ =Heavy Load Cooking Efficiency for ENERGY STAR® Steamer

=Actual, or 38% (gas steamer) or 50% (electric steamer) [41]

F = Food cooked per day (lbs/day)

= custom or if unknown, use 100 lbs/day[42]

E_{FOOD} = Amount of Energy Absorbed by the food during cooking known as ASTM Energy to

[35]Reference ENERGY STAR Commercial Kitchen Equipment Savings Calculator, Steam Cooker Calculations
[36] Reference ENERGY STAR Commercial Foodservice Savings Calculator, March 2021
[37] Ibid
[38] Ibid
[39] Ibid
[40] Reference Food Service Technology Center 2011 Savings Calculator values as used by Consortium for Energy Efficiency, Inc. for baseline electric and natural gas steamer heavy cooking load energy efficiencies.
[41] Ibid.
[42]Amount used by both Food Service Technology Center and ENERGY STAR® savings calculator

Food[43]

E_{FOOD} - gas(Btu/lb)	E_{FOOD} (kWh/lb)
105[44]	0.0308[45]

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

For example, for an ENERGY STAR gas steam cooker compared to baseline gas cooker: A 3 pan steamer in a full service restaurant

ΔSavings = (ΔIdle Energy + ΔPreheat Energy + ΔCooking Energy) * Days * 1/100.000

ΔIdle Energy = ((((1- 0.9)* 11000 + 0.9 * 65 * 105 /0.15)*(7 - (100 / 65)-(1*10.9/60))) - (((1-0) * 6250 + 0 * 55 * 105 / 0.38) * (7 - (100 / 55) - (1*13.4/60))))

= 191,028

ΔPreheat Energy = (1 *(18,832.7-10,293.9)

= 8,539

ΔCooking Energy = (((1/ 0.15) - (1/ 0.38)) * (100 lb/day * 105 btu/lb)))

= 42368

ΔTherms = (191,028 + 8,539 + 42368) * 365.25 *1/100,000

= 884 therms

For an ENERGY STAR electric steam cooker compared to baseline electric cooker: A 3 pan steamer in a cafeteria:

ΔSavings = (ΔIdle Energy + ΔPreheat Energy + ΔCooking Energy) * Days

ΔIdle Energy = ((((1- .9)* 1.0 + .9 * 70 * 0.0308 /0.26)*(6 - (100 / 70)-(1*11.9/60))) - (((1-0) * 0.4 + 0 * 50 * 0.0308 / 0.50) * (6 - (100 / 50) - (1*13.2/60))))

= 31.6

ΔPreheat Energy = (1 *(1.78 - 1.67))

= 0.1

ΔCooking Energy = (((1/ 0.26) - (1/ 0.5)) * (100 * 0.0308)))

= 5.7

ΔkWh = (31.6 + 0.1 + 5.7) * 365.25 days

= 13,660 kWh

[43]Reference ENERGY STAR Commercial Kitchen Equipment Savings Calculator, Steam Cooker Calculations.

[44]Ibid.

[45]Ibid.

For an ENERGY STAR electric steam cooker compared to baseline gas cooker: A 3 pan steamer in a cafeteria:

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

= [(Idle $Energy_{GasBase}$ + Preheat $Energy_{GasBase}$ + Cooking $Energy_{GasBase}$) * 1/1,000,000 * Days] –

[(Idle $Energy_{ElecEE}$ + Preheat $Energy_{ElecEE}$ + Cooking $Energy_{ElecEE}$) * 3412/1,000,000 * Days]

Idle $Energy_{GasBase}$ = ((((1- 0.9)* 11000 + 0.9 * 65 * 105 /0.15)*(6 - (100 / 65)-(1*10.9/60)))
= 187,432 Btu

Preheat $Energy_{GasBase}$ = (1 * 18,832)
= 18,832 Btu

Cooking $Energy_{GasBase}$ = (1/ 0.15) * (100 lb/day * 105 btu/lb)
= 70,000

Idle $Energy_{ElecEE}$ = (((1-0) * 0.4 + 0 * 50 * 0.0308 / 0.50) * (6 - (100 / 50) - (1*13.2/60))))
= 1.5 kWh

Preheat $Energy_{ElecEE}$ = (1 * 1.67)
= 1.67 kWh

Cooking $Energy_{ElecEE}$ = (1/ 0.5) * (100 * 0.0308)
= 6.16

SiteEnergySavings (MMBTUs) = [(187,432 + 18,832 + 70,000) * 1/1,000,000 * 365.25] – [(1.5 + 1.67 + 6.16) * 3412/1,000,000 * 365.25]
= 89.3 MMBtu

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

= 89.3 * 1,000,000/3412

= 26,172kWh

Secondary kWh Savings for Water Supply and Wastewater Treatment

The following savings should be included in the total savings for this measure, but should not be included in TRC tests to avoid double counting the economic benefit of water savings.

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

Where

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

=2,571[46]

For example, an electric 3 pan steamer with average efficiency in a full service – expanded menu restaurant

ΔWater (gallons) = (40 - 10) * 7 * 365.25

= 76,703 gallons

ΔkWh_{water} = 76,703/1,000,000*2,571

= 197 kWh

Summer Coincident Peak Demand Savings

This is only applicable to the electric steam cooker.

Non-fuel switch measures:

ΔkW = ((ΔIdle Energy + ΔPreheat Energy + ΔCooking Energy) /HOURSDay) * CF

$\Delta kW = - ((\text{Idle Energy}_{ElecEE} + \text{Preheat Energy}_{ElecEE} + \text{Cooking Energy}_{ElecEE}) / \text{HOURSDay}) * CF$

Where:

CF =Summer Peak Coincidence Factor for measure is provided below for different locations:[47]

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

Other values as defined above

[46] This factor include 2571 kWh/MG for water supply based on Illinois energy intensity data from a 2012 ISAWWA study. For more information please review Elevate Energy's 'IL TRM: Energy per Gallon Factor, May 2018 paper'. Note that the Commercial Steam Cooker does not discharge its water into the wastewater system so only the water supply factor is used here.

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

For example, for 3 pan electric steam cooker located in a cafeteria:

$\Delta kW = ((\Delta Idle\ Energy + \Delta Preheat\ Energy + \Delta Cooking\ Energy)/(HOURS_{Day} * Days)) * CF$

$= ((31.18 + 0.5 + 5.69)/6) * 0.39$

$= 2.43\ kW$

Fossil Fuel Savings

Calculation provided together with Electric Energy Savings above.

Water Impact Descriptions and Calculation

This is applicable to both gas and electric steam cookers.

$$\Delta Water\ (gallons) = (W_{BASE} - W_{ENERGYSTAR®}) * HOURS_{Day} * Days$$

Where

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

= 40[48]

$W_{ENERGYSTAR}$ = Water Consumption Rate of ENERGY STAR® Steamer look up[49]

=Actual, or

Equipment Type	gal/hr
Boilerless	1.69
Steam Generation	6.6

For example, a boilerless electric 3 pan steamer with in a full service restaurant

$\Delta Water\ (gallons) = (40 - 1.69) * 7 * 365.25$

$= 97{,}949$ gallons

Deemed O&M Cost Adjustment Calculation

N/A

Cost Effectiveness Screening and Load Reduction Forecasting when Fuel Switching

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

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

The inputs to cost effectiveness screening should reflect the actual impacts on the electric and fuel consumption at the customer meter and, for fuel switching measures, should therefore reflect the decrease in one fuel and increase in another, as opposed to the single savings value calculated in the "Electric and Fossil Fuel Energy Savings" section

[48] FSTC (2002). Commercial Cooking Appliance Technology Assessment. Chapter 8: Steamers.

[49] Average water consumption by equipment type calculated from the ENERGY STAR Qualified Products List, Accessed 06/02/2023.

above. Therefore in addition to the calculation of savings claimed, the following values should be used to assess the cost effectiveness of the measure.

ΔTherms = [Gas Cooking Consumption Replaced]

= [(Idle $Energy_{GasBase}$ + Preheat $Energy_{GasBase}$ + Cooking $Energy_{GasBase}$) * 1/100,000 * Days]

ΔkWh = [Electric Cooking Consumption Added]

= - [(Idle $Energy_{ElecEE}$ + Preheat $Energy_{ElecEE}$ + Cooking $Energy_{ElecEE}$) * Days]

MEASURE CODE: CI-FSE-STMC-V08-240101

REVIEW DEADLINE: 1/1/2028

4.2.18 Rack Oven - Double Oven

DESCRIPTION

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

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

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed equipment must be a new natural gas rack oven - double oven with a baking efficiency ≥ 56%.[50]

DEFINITION OF BASELINE EQUIPMENT

The baseline equipment is an existing natural gas rack oven – double oven with a baking efficiency <51%.[51]

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 12 years.[52]

DEEMED MEASURE COST

The incremental capital cost for this measure is $3,000.[53]

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

FOSSIL FUEL SAVINGS

Custom calculation below, otherwise use deemed value of 585 therms based on default values.[54]

[50] Based on average test data per ASTM F2093 used in California Foodservice Rack Oven Memo 09202019 Attachment supporting the CAeTRM.
[51] Ibid.
[52] Lifecycle determined from Food Service Technology Center Gas Rack Oven Life-Cycle Cost Calculator and from FSTC Oven Technology Assessment.
[53]See 'Arkansas Deemed TRM Table for GasFoodService.xls' from v3.0 Arkansas Technical Reference Manual.
[54] Assumptions derived from Food Service Technology Center Gas Rack Oven Life-Cycle Cost Calculator, FSTC Oven Technology Assessment, Section 7: Ovens, and from FSTC Gas Double Rack Oven Test Reports.

$$\Delta Therms = \Delta DailyPreheatEnergy + \ \Delta DailyIdleEnergy + \Delta DailyCookingEnergy) * Days/100{,}000$$

$$\Delta DailyPreheatEnergy = DailyPreheats * (PreheatEnergyBase - PreheatEnergyEE)$$

$$\Delta DailyIdleEnergy = (IdleRateBase * (Hours - \frac{LB}{PCBase} - \frac{DailyPreheats*PreheatTime}{60})) - (IdleRateEE * (Hours - \frac{LB}{PCEE} - \frac{DailyPreheats*PreheatTime}{60}))$$

$$\Delta DailyCookingEnergy = \left(\frac{LB * EFOOD}{EffBase}\right) - \left(\frac{LB * EFOOD}{EffEE}\right)$$

Where[55]:

DailyPreheats = Number of preheats per day

= Custom; or if unknown, 1

$PreheatEnergy_{EE}$ = Preheat energy of energy efficient rack oven – double oven

= Custom; or if unknown 65,758 Btu

$PreheatEnergy_{Base}$ = Preheat energy of baseline rack oven – double oven

= Custom; or if unknown 90,009 Btu

$IdleRate_{EE}$ =Idle rate of energy efficient rack oven – double oven

=Custom; or if unknown, 24,600 Btu/hr

$IdleRate_{Base}$ =Idle rate of baseline rack oven – double oven

=Custom; or if unknown, 36,909 Btu/hr

LB = Pounds of food cooked per day

= Custom; or if unknown, 1,200 lb/day

PC_{EE} = Production capacity of energy efficient rack oven – double oven

= Custom; or if unknown, 279 lbs/hour

PC_{Base} = Production capacity of baseline rack oven – double oven

= Custom; or if unknown, 272 lbs/hour

PreheatTime = Length of a single preheat

= Custom; or if unknown, 20 minutes

[55] Unless noted otherwise, assumptions consistent with Southern California Gas Company (SCG). 2019. "Reformulated baseline efficiencies and eligibility requirements for Commercial Rack Oven workpaper SWFS014-01." Memorandum submitted to Peter Biermayer (Energy Division) and Sue Haselhorst (Ex Ante Review Team). September 18.

60 = Conversion of minutes to hour

EFOOD = ASTM energy to food ratio, the energy absorbed by food during cooking

= 235 Btu/lb

Eff_{EE} = Cooking efficiency of energy efficient rack oven – double oven

= Custom; or if unknown, use 56%

Eff_{Base} = Cooking efficiency of baseline rack oven – double oven

= Custom; or if unknown, 51%

Days = 365[56]

Hours = Average daily hours of operation

= Custom; or if unknown, use 12 hours[57]

100,000 = Btu to therms conversion factor

WATER IMPACT DESCRIPTIONS AND CALCULATION
N/A

DEEMED O&M COST ADJUSTMENT CALCULATION
N/A

MEASURE CODE CI-FSE-RKOV-V04-240101

REVIEW DEADLINE: 1/1/2028

[56] Consistent with the ENERGY STAR Commercial Food Service Equipment Calculator, updated March 2024

[57] Typical operating hours based on oven operating schedule of 12 hours per day provided in FSTC Gas Double Rack Oven Test Reports on various double rack ovens.

4.2.22 Automatic Conveyor Broiler

DESCRIPTION

This measure applies to natural gas fired energy efficient automatic conveyor broiler installed in a commercial kitchen. Conveyor broilers are one of the most energy intensive appliances in a commercial kitchen and energy efficient automatic conveyor broilers have potential to save energy while providing similar capacities and reducing the heat load in a kitchen[58].

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

DEFINITION OF EFFICIENT EQUIPMENT

To be eligible for rebates, the energy efficient natural gas fired automatic conveyor broiler must have a catalyst and an input rate less than 80 kBtu/hr or a dual stage or modulating valve with a capability of throttling the input rate below 80 kBtu/hr[59].

Natural gas fired energy efficient automatic conveyor broilers equipped with electric bun grills and/or electric heating/warming elements are eligible for electric energy savings.

DEFINITION OF BASELINE EQUIPMENT

The base case is defined as natural gas fired automatic conveyor broiler capable of maintaining a temperature above 600ºF and an idle rate greater than the energy efficient replacement.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 12 years[60].

DEEMED MEASURE COST

The incremental capital cost varies based on the conveyor width[61]:

Conveyor Width (in)	IMC
18in	$2,523
26in	$3,146
30in	$3,659

LOADSHAPE

N/A

COINCIDENCE FACTOR

Summer Peak Coincidence Factor for measure is 0.90[62].

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[58] "California eTRM: Automatic Conveyor Broiler, Commercial", July 29th ,2021 https://www.caetrm.com/measure/SWFS017/02/

[59] "California eTRM: Automatic Conveyor Broiler, Commercial", July 29th ,2021 as well as "New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs: Conveyor Broiler", August 30th , 2021, Page 410.

[60] "California eTRM: Automatic Conveyor Broiler, Commercial", July 29th ,2021 https://www.caetrm.com/measure/SWFS017/02/

[61] Ibid.

[62] "California eTRM: Automatic Conveyor Broiler, Commercial", July 29th ,2021 https://www.caetrm.com/measure/SWFS017/02/

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS

Natural gas fired energy efficient automatic conveyor broilers equipped with electric bun grills and/or electric heating/warming elements are eligible for electric energy savings.

$\Delta kWh = kWH_{base} - kWh_{eff}$

$kWh = Electrical_{IDLE}(kW) * Hours_{DAY} * Days$

Where:

$Electrical_{IDLE}(kW)$ = Electrical Idle Energy Rate. See table below[63]. If known, use actual.

Conveyor Width (in)	Baseline Idle Energy Rate (kW)	EE Idle Energy Rate (kW)
<20in	1.84	0.20
20in -26in	1.35	0.37
>26in	4.80	1.15

$Hours_{DAY}$ = Daily Operating Hours. See table below. If known, use actual.

Location	$Hours_{DAY}$
Smaller restaurants; 2nd broiler in 24-hr restaurant	8 hours[64]
24 hour restaurant	23 hours[65]

Days = Days per year of operation

= Actual, default =

Location	Days
Smaller restaurants; 2nd broiler in 24-hr restaurant	312 days[66]
24 hour restaurant	363 days[67]

SUMMER COINCIDENT PEAK DEMAND SAVINGS

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

Where:

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63 Ibid.

64 Assumptions derived from Food Service Technology Center Gas Broiler Life-Cycle Cost Calculator and from FSTC Broiler Technology Assessment, Section 4: Broilers.

65 "California eTRM: Automatic Conveyor Broiler, Commercial", July 29th ,2021 https://www.caetrm.com/measure/SWFS017/02/

66 Typical annual operating time from FSTC Broiler Technology Assessment, Table 4.3.

67 "California eTRM: Automatic Conveyor Broiler, Commercial", July 29th ,2021 https://www.caetrm.com/measure/SWFS017/02/

ΔkWh = Annual kWh savings from measure as calculated above.

$AnnualHours = Hours_{DAY} * Days$

= Actual. If unknown, use values listed above.

CF = Summer Peak Coincidence Factor

= 0.90

FOSSIL FUEL SAVINGS

ΔTherms = ΔIdle Energy + ΔPreheat Energy + ΔCooking Energy

$\Delta Idle\ Energy = (Idle\ Energy_{Base} - Idle\ Energy_{EE})/100{,}000$

$Idle\ Energy_{Base} = (Hours_{DAY} – (LB/PC_{Base}) – (PRE_{TimeBase}/60))* IDLE_{Base}$

$Idle\ Energy_{EE} = (Hours_{DAY} – (LB/PC_{EE}) – (PRE_{TimeEE}/60))* IDLE_{EE}$

Where:

LB = pounds of food cooked per day (lb/day)

PC = Production capacity (lbs/hr)

PRE_{TIME} = Preheat time (min/day)

IDLE = Idle energy rate (Btu/hr)

If known, use actual values, otherwise see table below:[68]

Conveyor Width (in)	LB (lb/day)		PC (Lbs/hr)		PreTIME (Min)		IDLE (Btu/hr)	
	Base	EE	Base	EE	Base	EE	Base	EE
<20in	75		29	21	10	29	54,500	28,000
20in - 26in	150		48	42	8	16	78,120	47,960
>26in	110		90	86	22	12	104,000	57,000

$\Delta Preheat\ Energy = (PRE_{ENERGYBase} - PRE_{ENERGYEff})/100{,}000$

Where:

PRE_{ENERGY} = Preheat energy (Btu)

$\Delta Cooking\ Energy = (Cooking\ Energy_{base} - Cooking\ Energy_{Eff})/100{,}000$

[68] "California eTRM: Automatic Conveyor Broiler, Commercial", July 29th ,2021 https://www.caetrm.com/measure/SWFS017/02/

$$\text{Cooking Energy}_{base} = (LB/PC_{Base}) * \text{Cooking}_{RateBase}$$

$$\text{Cooking Energy}_{EE} = (LB/PC_{EE}) * \text{Cooking}_{RateEE}$$

$\text{Cooking}_{RateBase}$ = Baseline Cooking energy rate (Btu/hr)

Cooking_{RateEE} = Efficient Cooking energy rate (Btu/hr)

If known, use actual values, otherwise see table below:[69]

Conveyor Width (in)	Pre_{ENERGY} (Btu)		$Cooking_{Rate}$ (Btu/hr)	
	Base	EE	Base	EE
<20in	11,500	13,500	55,000	28,500
20in - 26in	14,130	14,214	78,240	50,938
>26in	42,500	13,500	111,210	67,117

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

DEEMED O&M COST ADJUSTMENT CALCULATION
N/A

MEASURE CODE: CI-FSE-ACBL-V02-240101

REVIEW DEADLINE: 1/1/2026

[69] "California eTRM: Automatic Conveyor Broiler, Commercial", July 29th ,2021 https://www.caetrm.com/measure/SWFS017/02/

4.3.1 Water Heater

DESCRIPTION

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

Tankless water heaters function similar to standard hot water heaters except they do not have a storage tank. When there is a call for hot water, the water is heated instantaneously as it passes through the heating element and then proceeds to the user or appliance calling for hot water. Tankless water heaters achieve savings by eliminating the standby losses that occur in stand-alone or tank-type water heaters and by being more efficient than the baseline storage hot water heater.

Heat pump water heaters use electricity to move heat from one place to another instead of generating heat directly and can allow for additional energy savings. Savings are presented dependent on the heating system installed in the home due to the impact of the heat pump water heater on the heating loads.

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

DEFINITION OF EFFICIENT EQUIPMENT

The minimum specifications of the high efficiency equipment should be defined by the programs.

DEFINITION OF BASELINE EQUIPMENT

Time of Sale: The baseline condition is assumed to be a new standard water heater of same type as the existing unit being replaced, meeting the Federal Standard for ≤75,000 Btuh units and IECC 2021 for all others. If existing type is unknown, assume same water heater type as the efficient unit.

For Residential-sized >55 gallon HPWH tanks, the baseline should assume the same capacity and use the appropriate standard listed below, unless it can be confirmed that the existing tank being replaced was <55 gallon (and the larger tank is only being used to achieve greater efficiency of the heat pump cycle and prevent the unit from going in to resistance mode), in which case the existing unit capacity and the <55 gallon algorithms should be used.

New Construction: The baseline condition is a new standard water heater of the same type as the efficient, meeting the IECC code level in place at the time the building permit was issued. As code requirements and adoption can differ from municipality to municipality, the user should verify which version of code is applicable given these constraints. Note, IECC 2021 is expected to become effective statewide in 2023. IECC 2018 is the requisite code for any projects with permitting dates spanning July 1, 2019 to the IECC 2021 effective date. Prior to July 1, 2019, IECC 2015 is the applicable code.

Note the same draw pattern (very small, low, medium and high draw) should be used for both baseline and efficient units. Definitions of draw pattern are provided below.

Equipment Type	Sub Category	Draw Pattern	Federal Standard – Uniform Energy Factor[70]
Residential Gas Storage Water Heaters ≤75,000 Btu/h	≤55 gallon tanks	Very small	UEF = 0.3456 – (0.0020 * Rated Storage Volume in Gallons)
		Low	UEF = 0.5982 – (0.0019 * Rated Storage Volume in Gallons)
		Medium	UEF = 0.6483 – (0.0017 * Rated Storage Volume in Gallons)
		High	UEF = 0.6920 – (0.0013 * Rated Storage Volume in Gallons)

[70] 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.

Equipment Type	Sub Category	Draw Pattern	Federal Standard – Uniform Energy Factor[70]
	>55 gallon and ≤100 gallon tanks	Very small	UEF = 0.6470 – (0.0006 * Rated Storage Volume in Gallons)
		Low	UEF = 0.7689 – (0.0005 * Rated Storage Volume in Gallons)
		Medium	UEF = 0.7897 – (0.0004 * Rated Storage Volume in Gallons)
		High	UEF = 0.8072 – (0.0003 * Rated Storage Volume in Gallons)
Residential-duty Commercial High Capacity Storage Gas-Fired Storage Water Heaters > 75,000 Btu/h	≤120 gallon tanks	Very small	UEF = 0.2674 – (0.0009 * Rated Storage Volume in Gallons)
		Low	UEF = 0.5362 – (0.0012 * Rated Storage Volume in Gallons)
		Medium	UEF = 0.6002 – (0.0011 * Rated Storage Volume in Gallons)
		High	UEF = 0.6597 – (0.0009 * Rated Storage Volume in Gallons)
Commercial Gas Storage Water Heaters >75,000 Btu/h and ≤155,000 Btu/h	>120 gallon tanks	All	80% $E_{thermal}$, Standby Losses = (Q /800 + 110√Rated Storage Volume in Gallons)
Commercial Gas Storage Water Heaters >155,000 Btu/h			
Residential Gas Instantaneous Water Heaters ≤ 200,000 Btu/h	≤2 gal	Very low	UEF = 0.80
		All other	UEF = 0.81
Commercial Gas Instantaneous Water Heaters > 200,000 Btu/h	<10 gal	All	80% $E_{thermal}$
	≥10 gal	All	80% $E_{thermal}$
Residential Electric Storage Water Heaters ≤ 75,000 Btu/h	≤55 gallon tanks	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)
	>55 gallon and ≤120 gallon tanks [71]	Very small	UEF = 1.9236 – (0.0011 * Rated Storage Volume in Gallons)
		Low	UEF = 2.0440 – (0.0011 * Rated Storage Volume in Gallons)
		Medium	UEF = 2.1171 – (0.0011 * Rated Storage Volume in Gallons)
		High	UEF = 2.2418 – (0.0011 * Rated Storage Volume in Gallons)
Residential Electric Instantaneous Water Heaters	≤12kW and ≤2 gal	All other	UEF = 0.91
		High	UEF = 0.92
Residential-duty Commercial Electric Instantaneous Water Heaters	> 12kW and ≤58.6 kW and ≤2 gal	All	UEF = 0.80

Residential-duty Commercial Water Heaters meet the following criteria:

- Is not designed to provide outlet hot water at temperatures greater than 180 °F; and
- If electric, must use a single-phase external power supply; and
- Gas-fired Storage Water Heater with a rated input no greater than 105 kBtu/h and a DOE Rated Storage volume no greater than 120 gallons.
- Electric Instantaneous with a rated input no greater than 58.6 kW and a DOE Rated Storage volume no greater than 2 gallons.

Draw patterns are based on first hour rating (gallons) for storage tanks and maximum flow (GPM) for instantaneous

[71] It is assumed that tanks <75,000Btu/h and >55 gallons will not be eligible measures due to the high baseline.

as shown below:[72]

Storage Water Heater Draw Pattern	
Draw Pattern	**First Hour Rating (gallons)**
Very Small	≥ 0 and < 18
Low	≥ 18 and < 51
Medium	≥ 51 and < 75
High	≥ 75

Instantaneous Water Heater Draw Pattern	
Draw Pattern	**Max GPM**
Very Small	≥ 0 and < 1.7
Low	≥ 1.7 and < 2.8
Medium	≥ 2.8 and < 4
High	≥ 4

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 15 years for storage[73] and heat pump units[74], 5 years for electric tankless,[75] and 20 years for gas tankless.[76]

DEEMED MEASURE COST

The full install cost and incremental cost assumptions are provided below. Actual costs should be used where available:

Gas storage water heaters:[77]

Equipment Type	Category	Install Cost	Incremental Cost
Gas Storage Water Heaters ≤ 75,000 Btu/h, ≤55 Gallons	Baseline	$616	N/A
	Efficient	$1,055	$440
Gas Storage Water Heaters > 75,000 Btu/h	0.80 Et	$4,886	N/A
	0.83 Et	$5,106	$220
	0.84 Et	$5,299	$413
	0.85 Et	$5,415	$529
	0.86 Et	$5,532	$646
	0.87 Et	$5,648	$762
	0.88 Et	$5,765	$879
	0.89 Et	$5,882	$996
	0.90 Et	$6,021	$1,135

72 Definitions provided in 10 CFR 430, Subpart B, Appendix E, Section 5.4.1.
73 DEER 08, EUL_Summary_10-1-08.xls.
74 As recommended in Navigant 'ComEd Effective Useful Life Research Report', May 2018.
75 Ohio Technical Reference Manual 8/2/2010 referencing CenterPoint Energy-Triennial CIP/DSM Plan 2010-2012 Report; Additional reference stating >20 years is soured from the US DOE Energy Savers for Tankless or Demand-Type Water Heaters.
76 Ibid.
77 Cost information is based upon data from "2010-2012 WA017 Ex Ante Measure Cost Study Draft Report", Itron, February 28, 2014. See "NR HW Heater_WA017_MCS Results Matrix - Volume I.xls" for more information.

For electric water heaters, the incremental capital cost for this measure is assumed to be:[78]

Tank Size	Incremental Cost
50 gallons	$1050
80 gallons	$1050
100 gallons	$1950

The incremental capital cost for an electric tankless heater this measure is assumed to be:[79]

Output (gpm) at delta T 70	Incremental Cost
5	$1050
10	$1050
15	$1950

The incremental capital cost for a gas fired tankless heater is assumed to be[80]:

Output (gpm) at delta T 70	Incremental Cost
5.0	$1,500
10.0	$1,500
15.0	$2,400

For a heat pump water heater, the incremental installation cost (including labor) should be used. Defaults are provided below.[81] Actual efficient costs can also be used although care should be taken as installation costs can vary For a heat pump water heater, the incremental installation cost (including labor) should be used. Defaults are provided below.[82] Actual efficient costs can also be used although care should be taken as installation costs can vary significantly due to complexities of a particular site.

Capacity	Efficiency Range	Baseline Installed Cost	Efficient Installed Cost	Incremental Installed Cost
≤55 gallons	<2.6 UEF	$1,032	$2,062	$1,030
	≥2.6 UEF	$1,032	$2,231	$1,199
>55 gallons	<2.6 UEF	$1,319	$2,432	$1,113
	≥2.6 UEF	$1,319	$3,116	$1,797

[78] Act on Energy Commercial Technical Reference Manual, Table 9.6.1-4
[79] Act on Energy Technical Reference Manual, Table 9.6.2-3
[80] Act on Energy Commercial Technical Reference Manual, Table 9.6.3-4. Please see file 'Ameren C and I TRM.pdf' for further details.
[81] Costs for <2.6 UEF are based upon averages from the NEEP Phase 3 Incremental Cost Study. The assumption for higher efficiency tanks is based upon averaged from NEEP Phase 4 Incremental Cost Study. See 'HPWH Cost Estimation.xls' for more information.
[82] Costs for <2.6 UEF are based upon averages from the NEEP Phase 3 Incremental Cost Study. The assumption for higher efficiency tanks is based upon averaged from NEEP Phase 4 Incremental Cost Study. See 'HPWH Cost Estimation.xls' for more information.

LOADSHAPE

For electric hot water heaters, use Loadshape C02 - Commercial Electric DHW.

COINCIDENCE FACTOR

The coincidence factor is assumed to be 0.925.[83]

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY AND FOSSIL FUEL SAVINGS

Non Fuel Switch Measures

Electric energy savings are calculated for electric water heaters per the equations given below.

Electric units ≤12 kW:

$$\Delta kWh = \frac{(T_{out} - T_{in}) \ * \ HotWaterUse_{Gallon} * \gamma Water * 1 * \left(\frac{1}{UEF_{elecbase}} - \frac{1}{UEF_{Eff}}\right)}{3412}$$

$$+HPWHWasteHeat_{cool} - \ HPWHWasteHeat_{heat}$$

Electric units > 12kW:

$$\Delta kWh = \frac{\left((T_{out} - T_{air}) * V * \gamma Water * 1 * \left(\frac{SL_{elecbase} - \ SL_{eff}}{100}\right)\right) * 8766}{3412}$$

Natural gas energy savings are calculated for natural gas storage water heaters per the equations given below.

$$\Delta Therms = \frac{(T_{out} - T_{in}) \ * \ HotWaterUse_{Gallon} * \gamma Water * 1 * \left(\frac{1}{UEF_{gasbase}} - \frac{1}{UEF_{Eff}}\right)}{100{,}000}$$

$$- \ HPWHWasteHeat_{GasHeat}$$

Additional Standby Loss Savings

Gas Storage Water Heaters >75,000 Btu/h can claim additional savings due to lower standby losses.

$$\Delta Therms_{Standby} = \frac{(SL_{gasbase} - SL_{eff}) * 8766}{100{,}000}$$

[83] Coincidence factor based on Average W in peak period/Max W from Itron eShape data for Missouri, calibrated to Illinois loads.

Fuel Switch/Electrification Measures:

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

Electric units ≤12 kW:

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

$$= \left[\frac{(T_{out}-T_{in}) * HotWaterUse_{Gallon} * \gamma Water * 1 * \left(\frac{1}{UEF_{gasbase}}\right)}{1{,}000{,}000}\right] - \left[\frac{(T_{out}-T_{in}) * HotWaterUse_{Gallon} * \gamma Water * 1 * \left(\frac{1}{UEF_{Eff}}\right)}{1{,}000{,}000} + HPWHWasteHeat_{cool} - HPWHWasteHeat_{heat}\right]$$

Electric units > 12kW and gas units >75,000 Btu/h:

SiteEnergySavings (MMBTUs) = [GasConsumptionReplaced] – [ElectricConsumptionAdded] + ($HPWHWasteHeat_{cool}$ * 0.003412) – ($HPWHWasteHeat_{heat}$ * ConversionToMMBtu)

$$[GasConsumptionReplaced] = \left[\frac{(T_{out}-T_{in}) * HotWaterUse_{Gallon} * \gamma Water * 1 * \left(\frac{1}{UEF_{gasbase}}\right)}{1{,}000{,}000} + \frac{(SL_{gasbase} * 8766)}{1{,}000{,}000}\right]$$

$$[ElectricConsumptionAdded] = \left[\frac{(T_{out}-T_{in}) * HotWaterUse_{Gallon} * \gamma Water * 1 * \left(\frac{1}{UEF_{Eff}}\right)}{1{,}000{,}000} + \frac{\left((T_{out}-T_{air}) * V * \gamma Water * 1 * \left(\frac{SL_{eff}}{100}\right)\right) * 8766}{1{,}000{,}000}\right]$$

$$HPWHWasteHeat_{cool} = \left[\frac{\left((T_{OUT}-T_{IN}) * HotWaterUse_{Gallon} * \gamma Water * 1 * \left(1-\frac{1}{UEF_{Eff}}\right)\right) * LF * 25\% * LM}{COP_{COOL} * 3412}\right] * Cool$$

$HPWHWasteHeat_{heat}$ =

$$\text{If Electric Heat} = \left[\frac{\left((T_{OUT}-T_{IN}) * HotWaterUse_{Gallon} * \gamma Water * 1 * \left(1-\frac{1}{UEF_{Eff}}\right)\right) * LF * 35\%}{COP_{HEAT} * 3412}\right] * ElectricHeat$$

If Gas Heat $= \left[\frac{\left((T_{OUT} - T_{IN}) * HotWaterUse_{Gallon} * \gamma Water * 1 * \left(1 - \frac{1}{UEF_{Eff}}\right) \right) * \mathrm{LF} * 35\%}{100{,}000 * \eta Heat} \right] * (1 - \mathrm{ElectricHeat})$

ConversionToMMBtu =

If Electric Heat = 0.003412 kWh/MMBtu

If Gas Heat = 0.1 Therms/MMBtu

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

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

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

Where:

T_{OUT} = Tank temperature

= 125°F

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

= 50.7°F [84]

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

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

1. Consumption per usable storage tank capacity

   = Capacity * Consumption/cap

   Where:

   Capacity = Usable capacity of hot water storage tank in gallons

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

= Actual

Consumption/cap = Estimate of consumption per gallon of usable tank capacity, based on building type:[85]

Building Type[86]	Consumption/Cap
Convenience	528
Education	568
Grocery	528
Health	788
Large Office	511
Large Retail	528
Lodging	715
Other Commercial	341
Restaurant	622
Small Office	511
Small Retail	528
Warehouse	341
Nursing	672
Multi-Family	894
Unknown	555[87]

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

Where:

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

= Actual

Consumption/1,000 sq.ft. = Estimate of DHW consumption per 1,000 sq.ft. based on building type:[88]

Building Type[89]	Consumption/1,000 sq.ft.
Convenience	4,594

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

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

[87] From a historical average of all Ameren Illinois commercial & industrial water heater applications from 2013-2022

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

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

Building Type[89]	Consumption/1,000 sq.ft.
Education	7,285
Grocery	697
Health	24,540
Large Office	1,818
Large Retail	1,354
Lodging	29,548
Other Commercial	3,941
Restaurant	44,439
Small Office	1,540
Small Retail	6,111
Warehouse	1,239
Nursing	30,503
Multi-Family	15,434

γWater = Specific weight capacity of water (lb/gal)

= 8.33 lbs/gal

1 = Specific heat of water (Btu/lb.°F)

$UEF_{elecbase}$ = Rated efficiency of baseline water heater expressed as Uniform Energy Factor (UEF);

Note the same draw pattern (very small, low, medium and high draw) should be used for both baseline and efficient units.

Equipment Type	Sub Category	Draw Pattern	Federal Standard – Uniform Energy Factor[90]
Residential Electric Storage Water Heaters ≤ 75,000 Btu/h	≤55 gallon tanks	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)
	>55 gallon and ≤120 gallon tanks [91]	Very small	UEF = 1.9236 – (0.0011 * Rated Storage Volume in Gallons)
		Low	UEF = 2.0440 – (0.0011 * Rated Storage Volume in Gallons)
		Medium	UEF = 2.1171 – (0.0011 * Rated Storage Volume in Gallons)
		High	UEF = 2.2418 – (0.0011 * Rated Storage Volume in Gallons)
Residential Electric Instantaneous Water Heaters	≤12kW and ≤2 gal	All other	UEF = 0.91
		High	UEF = 0.92
Residential-duty Commercial Electric Instantaneous Water Heaters	> 12kW and ≤58.6 kW and ≤2 gal	All	UEF = 0.80

Draw patterns are based on first hour rating (gallons) for storage tanks and maximum flow (GPM) for instantaneous as shown below:[92]

[90] 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.

[91] It is assumed that tanks <75,000Btu/h and >55 gallons will not be eligible measures due to the high baseline.

[92] Definitions provided in 10 CFR 430, Subpart B, Appendix E, Section 5.4.1.

Storage Water Heater Draw Pattern	
Draw Pattern	**First Hour Rating (gallons)**
Very Small	≥ 0 and < 18
Low	≥ 18 and < 51
Medium	≥ 51 and < 75
High	≥ 75

Instantaneous Water Heater Draw Pattern	
Draw Pattern	**Max GPM**
Very Small	≥ 0 and < 1.7
Low	≥ 1.7 and < 2.8
Medium	≥ 2.8 and < 4
High	≥ 4

UEF_{eff} = Rated efficiency of efficient water heater expressed as Uniform Energy Factor (UEF)

= Actual

3412 = Converts Btu to kWh

$HPWHWasteheat_{cool}$ = Heat Pump Water Heater Only - Cooling savings from conversion of heat in building to water heat[93]

$$= \left[\frac{\left((T_{OUT} - T_{IN}) * \ HotWaterUse_{Gallon} * \gamma Water * 1 * \left(1 - \frac{1}{UEF_{Eff}}\right) \right) * \ LF \ * \ 25\% \ * LM}{COP_{COOL} * 3412} \right] * Cool$$

Where:

LF = Location Factor

= 1.0 for HPWH installation in a conditioned space

= 0.5 for HPWH installation in an unknown location[94]

= 0.0 for installation in an unconditioned space

25% = Portion of reduced waste heat that results in cooling savings[95]

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[93] This algorithm calculates the heat removed from the air by subtracting the HPWH electric consumption from the total water heating energy delivered. This is then adjusted to account for location of the HP unit and the coincidence of the waste heat with cooling requirements, the efficiency of the central cooling, and latent cooling demands.

[94] Note unconditioned means a space that is not intentionally heated via furnace vents or boiler radiators. The presence of and/or leakage from a heating system in a space doesn't in itself imply the space is conditioned.

[95] This is estimated based on the percentage of lighting savings that result in reduced cooling loads (lighting is used as a proxy for hot water heating since load shapes suggest their seasonal usage patterns are similar). This is based on the WHFe for unknown non-residential buildings (1.08) and assuming an average cooling COP of 3.08 (1.08 = 1 + 0.246/3.08).

COP_{COOL} = COP of Central Air Conditioner

= Actual - If unknown, assume 3.08 (10.5 SEER / 3.412)

LM = Latent multiplier to account for latent cooling demand

= 1.33 [96]

Cool = 1 if building has central cooling, 0 if not cooled

$HPWHWasteheat_{Heat}$ = Heat Pump Water Heater Only - Heating cost from conversion of heat in building to water heat (dependent on heating fuel)

$$= \left(\frac{\left((T_{OUT} - T_{IN}) * HotWaterUse_{Gallon} * \gamma Water * 1 * \left(1 - \frac{1}{UEF_{Eff}}\right) \right) * \text{LF} * 35\%}{\text{COP}_{\text{HEAT}} * 3412} \right) * \text{ElectricHeat}$$

Where:

35% = Portion of reduced waste heat that results in increased heating load[97]

COP_{HEAT} = COP of electric heating system

= Actual system efficiency including duct loss - If not available, use:[98]

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 on	8.2	2.04
Resistance	N/A	N/A	1

ElectricHeat = 1 if building is electrically heated, 0 if not

[96] A sensible heat ratio (SHR) of 0.75 corresponds to a latent multiplier of 4/3 or 1.33. SHR of 0.75 for typical split system from page 10 of "Controlling Indoor Humidity Using Variable-Speed Compressors and Blowers" by M. A. Andrade and C. W. Bullard, 1999: www.ideals.illinois.edu/bitstream/handle/2142/11894/TR151.pdf

[97] This is estimated based on the percentage of lighting savings that result in increased heating loads (lighting is used as a proxy for hot water heating since load shapes suggest their seasonal usage patterns are similar). The WHFh for unknown non-residential buildings is 35%.

[98] 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.

For example, for a 50 gallon, 95% UEF storage unit installed in a 1500 ft^2 restaurant:

ΔkWh = ((125 – 50.7) * ((1,500/1,000) * 44,439) * 8.33 * 1 * (1/0.88 - 1/0.95))/3412 + 0 + 0

= 1012 kWh

Electric units > 12kW:

T_{air} = Ambient Air Temperature

= 70°F

V = Rated tank volume in gallons

= Actual

$SL_{elecbase}$ = Standby loss of electric baseline unit (%/hr)

= 0.30 + 27/V

SL_{eff} = Nameplate standby loss of new water heater, in BTU/h

8766 = Hours per year

For example, >12kW, 100 gallon storage unit with rated standby loss of 0.5 %/hr:

SLbase = 0.3 + (27 / 100)

= 0.57%/hr

ΔkWh = (((125 – 70) * 100 * 8.33 * 1 * (0.57- 0.5)/100) * 8766)/3412

= 82.4 kWh

Gas units:

100,000 = Converts Btu to Therms

$EF_{gasbase}$ = Rated efficiency of baseline water heater (expressed as Uniform Energy Factor (UEF) or Thermal Efficiency as provided below).

Note the same draw pattern (very small, low, medium and high draw) should be used for both baseline and efficient units.

Equipment Type	Sub Category	Draw Pattern	Federal Standard – Uniform Energy Factor[99]
Residential Gas Storage Water Heaters ≤75,000 Btu/h	≤55 gallon tanks	Very small	UEF = 0.3456 – (0.0020 * Rated Storage Volume in Gallons)
		Low	UEF = 0.5982 – (0.0019 * Rated Storage Volume in Gallons)
		Medium	UEF = 0.6483 – (0.0017 * Rated Storage Volume in Gallons)
		High	UEF = 0.6920 – (0.0013 * Rated Storage Volume in Gallons)
	>55 gallon and ≤100	Very small	UEF = 0.6470 – (0.0006 * Rated Storage Volume in Gallons)

[99] 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.

Equipment Type	Sub Category	Draw Pattern	Federal Standard – Uniform Energy Factor[99]
	gallon tanks	Low	UEF = 0.7689 – (0.0005 * Rated Storage Volume in Gallons)
		Medium	UEF = 0.7897 – (0.0004 * Rated Storage Volume in Gallons)
		High	UEF = 0.8072 – (0.0003 * Rated Storage Volume in Gallons)
Residential-duty Commercial High Capacity Storage Gas-Fired Storage Water Heaters > 75,000 Btu/h	≤120 gallon tanks	Very small	UEF = 0.2674 – (0.0009 * Rated Storage Volume in Gallons)
		Low	UEF = 0.5362 – (0.0012 * Rated Storage Volume in Gallons)
		Medium	UEF = 0.6002 – (0.0011 * Rated Storage Volume in Gallons)
		High	UEF = 0.6597 – (0.0009 * Rated Storage Volume in Gallons)
Commercial Gas Storage Water Heaters >75,000 Btu/h and ≤155,000 Btu/h	>120 gallon tanks	All	80% $E_{thermal}$, Standby Losses = (Q /800 + 110√Rated Storage Volume in Gallons)
Commercial Gas Storage Water Heaters >155,000 Btu/h			
Residential Gas Instantaneous Water Heaters ≤ 200,000 Btu/h	≤2 gal	Very low	UEF = 0.80
		All other	UEF = 0.81
Commercial Gas Instantaneous Water Heaters > 200,000 Btu/h	<10 gal	All	80% $E_{thermal}$
	≥10 gal	All	78% $E_{thermal}$

Draw patterns are based on first hour rating (gallons) for storage tanks and maximum flow (GPM) for instantaneous as shown below:[100]

Storage Water Heater Draw Pattern	
Draw Pattern	**First Hour Rating (gallons)**
Very Small	≥ 0 and < 18
Low	≥ 18 and < 51
Medium	≥ 51 and < 75
High	≥ 75

Instantaneous Water Heater Draw Pattern	
Draw Pattern	**Max GPM**
Very Small	≥ 0 and < 1.7
Low	≥ 1.7 and < 2.8
Medium	≥ 2.8 and < 4

$HPWHWasteHeat_{GasHeat}$ = Heat Pump Water Heater Only - Heating cost from conversion of heat in building to water heat (dependent on heating fuel)

[100] Definitions provided in 10 CFR 430, Subpart B, Appendix E, Section 5.4.1.

$$= \left(\frac{\left((T_{OUT} - T_{IN}) * HotWaterUse_{Gallon} * \gamma Water * 1 * \left(1 - \frac{1}{UEF_{Eff}}\right) \right) * \mathrm{LF} * 35\%}{100{,}000 * \eta Heat} \right) * (1 - \mathrm{ElectricHeat})$$

ηHeat = Heating system efficiency including duct loss

= Actual

Where:

$SL_{gasbase}$ = Standby loss of gas baseline unit (Btu/h)

$= Q/800 + 110\sqrt{V}$

Q = Nameplate input rating in Btu/h

V = Rated volume in gallons

SL_{eff} = Nameplate standby loss of new water heater, in Btu/h

8766 = Hours per year

For example, for a 200,000 Btu/h, 150 gallon, 90% UEF storage unit with rated standby loss of 1029 BTU/h installed in a 1500 ft^2 restaurant:

ΔTherms = ((125 – 50.7) * ((1,500/1,000) * 44,439) * 8.33 * 1 * (1/0.8 - 1/0.9))/100,000

= 57.3 Therms

$\Delta Therms_{Standby}$ = (((200000/800 + 110 * √150) – 1029) * 8766)/100,000

= 49.8 Therms

ΔThermsTotal = 57.3 + 49.8

= 107.1 Therms

Fuel switch example, a 160,000 Btu/h, 120 gallon, 80% UEF storage unit with rated standby loss of 1405 BTU/h installed in a 1500 ft^2 restaurant (with gas heat 85% AFUE and cooling) is replaced with a 120 gallon HPWH with medium draw (UEF = 2.1171 – (0.0011 * 100) = 2.0) and standby loss rate of 0.5%/hr installed in a unknown location.

GasConsumptionReplaced = (((125 – 50.7) * ((1,500/1,000) * 44,439) * 8.33 * 1 * 1/0.8)/1,000,000) + ((1405 * 8766)/1,000,000)

= 63.8 MMBtu

ElectricConsumptionAdded = (((125 – 50.7) * ((1,500/1,000) * 44,439) * 8.33 * 1 * 1/2.0)/1,000,000) + ((((125 – 50.7) * 120 * 8.33 * 1 * 0.5/100) * 8766)/1,000,000)

= 23.9 MMBtu

$HPWHWasteHeat_{cool}$ = ((125 – 50.7) * ((1,500/1,000) * 44,439) * 8.33 * 1 * (1 - 1/2.0) * 0.5 * 0.25 * 1.33) / (3.08 * 3412 * 1)

= 326 kWh

HPWHWasteHeatGasHeat = ((125 – 50.7) * ((1,500/1,000) * 44,439) * 8.33 * 1 * (1 - 1/2.0) * 0.5 * 0.35) / (100,000 * 0.85 * 1)

= 42 Therms

SiteEnergySavings (MMBTUs) = 63.8 – 23.9 + (326 * 0.003412) – (42 * 0.1)

= 36.8 MMBtu

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = \frac{\Delta kWh}{Hours} * CF$$

Where:

Hours = Full load hours of water heater

= 6461 [101]

CF = Summer Peak Coincidence Factor for measure

= 0.925 [102]

For example, >12kW, 100 gallon storage unit with rated standby loss of 0.5 %/hr:

ΔkW = 82.4 / 6,461 * 0.925

= 0.0118 kW

FOSSIL FUEL SAVINGS

Calculation provided together with Electric Energy Savings above.

[101] Full load hours assumption based on Wh/Max W Ratio from Itron eShape data for Missouri, calibrated to Illinois loads.

[102] Coincidence factor based on Average W in peak period/Max W from Itron eShape data for Missouri, calibrated to Illinois loads.

DEEMED O&M COST ADJUSTMENT CALCULATION

The deemed O&M cost adjustment for a tankless heaters is $100.[103]

COST EFFECTIVENESS SCREENING AND LOAD REDUCTION FORECASTING WHEN FUEL SWITCHING

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

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

The inputs to cost effectiveness screening should reflect the actual impacts on the electric and fuel consumption at the customer meter and, for fuel switching measures, should therefore reflect the decrease in one fuel and increase in another, as opposed to the single savings value calculated in the "Electric and Fossil Fuel Energy Savings" section above. Therefore in addition to the calculation of savings claimed, the following values should be used to assess the cost effectiveness of the measure.

Electric units ≤12 kW:

ΔTherms = [GasConsumptionReplaced]

$$= \left[\frac{(T_{out} - T_{in}) \ * \ HotWaterUse_{Gallon} * \gamma Water * 1 * \left(\frac{1}{UEF_{gasbase}}\right)}{100{,}000}\right]$$

ΔkWh = [ElectricConsumptionAdded]

$$= -\left[\frac{(T_{out} - T_{in}) \ * \ HotWaterUse_{Gallon} * \gamma Water * 1 * \left(\frac{1}{UEF_{Eff}}\right)}{3{,}412} + HPWHWasteHeat_{cool} - HPWHWasteHeat_{heat}\right]$$

Electric units > 12kW and gas units >75,000 Btu/h:

ΔTherms = [GasConsumptionReplaced]

103 Water heaters (WH) require annual maintenance. There are different levels of effort for annual maintenance depending if the unit is gas or electric, tanked or tankless. Electric and gas tank water heater manufacturers recommend an annual tank drain to clear sediments. Also recommended are "periodic" inspections by qualified service professionals of operating controls, heating element and wiring for electric WHs and thermostat, burner, relief valve internal flue-way and venting systems for gas WHs. Tankless WH require annual maintenance by licensed professionals to clean control compartments, burners, venting system and heat exchangers. This information is from WH manufacturer product brochures including GE, Rennai, Rheem, Takagi and Kenmore. References for incremental O&M costs were not found. Therefore the incremental cost of the additional annual maintenance for tankless WH is estimated at $100.

$$= \left[\frac{(T_{out} - T_{in}) \ * \ HotWaterUse_{Gallon} * \gamma Water * 1 * \left(\frac{1}{UEF_{gasbase}}\right)}{100{,}000} + \frac{(SL_{gasbase} * 8766)}{100{,}000}\right] - (\text{HPWHWasteHeat}_{heat(gas)})$$

ΔkWh = [ElectricConsumptionAdded]

$$= -\left[\frac{(T_{out} - T_{in}) \ * \ HotWaterUse_{Gallon} * \gamma Water * 1 * \left(\frac{1}{UEF_{Eff}}\right)}{1{,}000{,}000} + \frac{\left((T_{out} - T_{air}) * V * \gamma Water * 1 * \left(\frac{SL_{eff}}{100}\right)\right) * 8766}{1{,}000{,}000} + (\text{HPWHWasteHeat}_{cool} \ * \ 0.003412) - (\text{HPWHWasteHeat}_{heat(electric)})\right]$$

MEASURE CODE: CI-HWE-STWH-V11-240101

REVIEW DEADLINE: 1/1/2027

4.4.7 ENERGY STAR and CEE Tier 2 Room Air Conditioner

DESCRIPTION

This measure relates to the purchase and installation of a room air conditioning unit that meets either the ENERGY STAR or CEE Tier 2 minimum qualifying efficiency specifications, in place of a baseline unit meeting minimum Federal Standard efficiency ratings presented below:[104]

<table>
<tr><th>Product Class (Btu/H)</th><th>Federal Standard CEER, with louvered sides</th><th>Federal Standard CEER, without louvered sides</th><th>ENERGY STAR CEER, with louvered sides</th><th>ENERGY STAR CEER, without louvered sides</th><th>CEE Tier 2 CEER</th></tr>
<tr><td>< 6,000</td><td rowspan="2">11.0</td><td rowspan="2">10.0</td><td>13.1</td><td rowspan="2">12.8</td><td rowspan="2">14.85</td></tr>
<tr><td>6,000 - 7,999</td><td>13.7</td></tr>
<tr><td>8,000 to 10,999</td><td rowspan="2">10.9</td><td>9.6</td><td rowspan="2">14.7</td><td>13.0</td><td rowspan="2">14.72</td></tr>
<tr><td>11,000 to 13,999</td><td>9.5</td><td>12.8</td></tr>
<tr><td>14,000 to 19,999</td><td>10.7</td><td>9.3</td><td>14.4</td><td>12.6</td><td>14.45</td></tr>
<tr><td>20,000 to 27,999</td><td>9.4</td><td rowspan="2">9.4</td><td>12.7</td><td rowspan="2">12.7</td><td>12.69</td></tr>
<tr><td>>= 28,000</td><td>9.0</td><td>12.2</td><td>12.15</td></tr>
</table>

Casement	Federal Standard (CEER)	ENERGY STAR (CEER)
Casement-only	9.5	12.8
Casement-slider	10.4	14.0

Reverse Cycle - Product Class (Btu/H)	Federal Standard CEER, with louvered sides	Federal Standard CEER, without louvered sides	ENERGY STAR CEER, with louvered sides	ENERGY STAR CEER, without louvered sides
< 14,000	N/A	9.3	N/A	12.6
>= 14,000	N/A	8.7	N/A	11.7
< 20,000	9.8	N/A	13.2	N/A
>= 20,000	9.3	N/A	12.6	N/A

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

[104] Federal Baselines defined by Code of Federal Regulations §430.32(d). ENERGY STAR specification defined by Version 5.0 Room Air Conditioners. CEE specification defined by Room Air Conditioner Specification effective May 17, 2022.
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.

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the new room air conditioning unit must meet the ENERGY STAR efficiency standards presented above.

DEFINITION OF BASELINE EQUIPMENT

The baseline assumption is a new room air conditioning unit that meets the current minimum federal efficiency standards presented above.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure life is assumed to be 12 years. [105]

DEEMED MEASURE COST

The incremental cost for this measure is assumed to be $40 for an ENERGY STAR unit and $261 for a CEE Tier 2 unit.[106]

LOADSHAPE

Loadshape C03 - Commercial Cooling

COINCIDENCE FACTOR

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

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

= 91.3% [107]

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

= 47.8% [108]

Algorithm

CALCULATION OF SAVINGS

ENERGY SAVINGS

$$\Delta kWh = (FLH_{RoomAC} * Btu/h * (1/CEER_{base} - 1/CEER_{ee}))/1000$$

Where:

[105] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007.

[106] ENERGY STAR cost based on field study conducted by Efficiency Vermont and Tier 2 based on Efficiency Vermont's characterization of the NEEP Mid-Atlantic TRM's (version 9.0, October 2019) incremental cost analysis. See 'room-ac-cost-analysis-10.2023.xlsx.'

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

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

FLH_{RoomAC} = Full Load Hours of room air conditioning unit

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

Btu/h = Input capacity of unit

= Actual. If unknown assume 8,500 Btu/hr [109]

$CEER_{base}$ = Combined Energy Efficiency Ratio of baseline unit

= As provided in tables above

$CEER_{ee}$ = Combined Energy Efficiency Ratio of ENERGY STAR or CEE Super Efficient unit

= Actual. If unknown assume minimum qualifying standard as provided in tables above

For example, for an 8,500 Btu/h capacity ENERGY STAR unit, with louvered sides, in an unknown location in Rockford:

$\Delta kWH_{ENERGY\ STAR}$ = (1133 * 8500 * (1/10.9 – 1/14.7)) / 1000

= 228.4 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = Btu/h * ((1/CEER_{base} - 1/CEER_{ee}))/1000) * CF$$

Where:

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

= 91.3% [110]

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

= 47.8%[111]

Other variable as defined above

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

$\Delta kW_{ENERGY\ STAR}$ = ((8500 * (1/10.9 – 1/14.7)) / 1000) * 0.913

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

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

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

= 0.184 kW

FOSSIL FUEL SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-ESRA-V04-240101

REVIEW DEADLINE: 1/1/2026

4.4.10 High Efficiency Boiler

DESCRIPTION

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

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

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed equipment must be a boiler used 80% or more for space heating, not process, and boiler AFUE, E_T (thermal efficiency), or E_C (combustion efficiency) rating must be rated greater than or equal to 85% for hot water boilers and 83% for steam boilers.

DEFINITION OF BASELINE EQUIPMENT

Dependent on when the unit is installed and whether the unit is hot water or steam. The baseline efficiency source is the Energy Independence and Security Act of 2007 with technical amendments from Federal Register, volume 81, Number 10, January 15, 2016 for boilers <300,000 and Federal Register, volume 74, Number 139, July 22, 2009 for boilers ≥300,000 Btu/hr.[112]

For boilers <300,000 Btu/hr the technical amendments include the recent compliance dates for gas-fired hot water and steam boilers manufactured on or after January 15, 2021.[113]

> Note, for natural draft steam boilers, as IECC 2021, Illinois state energy code that is expected to become effective statewide in 2024, exceeds the minimum federal efficiency standards, it was replaced in favor of the more aggressive thermal efficiency values in the table below. For new construction applications where the permitting date is prior to the state's adoption of IECC 2021, it is recommended to use the applicable edition of IECC corresponding to that timeline. As code requirements and adoption can differ from municipality to municipality, the user should verify which version of code is applicable given these constraints.
>
> Each gas-fired commercial packaged boiler must meet the applicable energy conservation standard levels detailed in the table below.

Boiler baseline efficiency standards

Boiler Type	Efficiency
Hot Water Boiler < 300,000 Btu/h	84% AFUE
Hot Water Boiler ≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h	80% E_T
Hot Water Boiler > 2,500,000 Btu/h	82% E_C
Steam Boiler < 300,000 Btu/h	82% AFUE
Steam Boiler ≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h	79% E_T
Steam Boiler ≥ 2,500,000 Btu/h	79% E_T

[112] Energy Conservation Standards for Commercial Boilers, Code of Federal Regulations, 10 CFR 431.87

[113] Code of Federal Regulations, effective January 15, 2021 (10 CFR 432(e)(3)).

DEEMED LIFETIME OF EFFICIENT EQUIPMENT
The expected measure life is assumed to be 25 years.[114]

DEEMED MEASURE COST
The measure cost for this technology is tiered based on the boiler type and combustion efficiencies. As installation costs for the base case and the measure case units are assumed to be the same, labor costs are not specified for this measure.

Incremental and Gross Measure costs for Space Heating Boilers

Boiler Type	Incremental Measure Cost ($/KBtu)[115]	Full Installed Measure Cost ($/KBtu)[116]
Hot Water Boiler ≥85% E_C and <90% E_C	$2.17	$12.94
Hot Water Boiler ≥90% E_C	$12.17	$22.95
Steam Boiler ≥83% E_C and <85% E_C	$4.35	$19.24
Modular Steam Boiler Arrays (≥85% E_C)[117]	Custom	

LOADSHAPE
N/A

COINCIDENCE FACTOR
N/A

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS
N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS
N/A

FOSSIL FUEL SAVINGS

$$\Delta Therms = EFLH * Capacity * ((Efficiency_{EE} - Efficiency_{Base}) / Efficiency_{Base}) / 100{,}000$$

Where:

EFLH = Equivalent Full Load Hours for heating in Existing Buildings or New Construction are provided in section 4.4 HVAC End Use

Capacity = Nominal Heating Input Capacity Boiler Size (Btu/hr) for efficient unit not existing unit

= custom Boiler input capacity in Btu/hr

[114] Consistent with DOE assumption determined through a literature review in Appendix 8-F of the Department of Energy Commercial Technical Support Document.
[115] Ibid.
[116] Ibid.
[117] Miura Modular Boilers, https://s29958.pcdn.co/wp-content/uploads/2019/03/LXBrochure2016.pdf

$Efficiency_{Base}$ = Baseline Boiler Efficiency Rating, dependant on year and boiler type

Hot water boiler baseline:

Boiler Capacity and Distribution Type	Efficiency
Hot Water <300,000 Btu/hr[118]	84% AFUE
Hot Water ≥300,000 & ≤2,500,000 Btu/hr[119]	80% E_T
Hot Water Boiler > 2,500,000[120]	82% E_C

Steam boiler baseline:

Boiler Capacity and Distribution Type	Efficiency
Steam <300,000 Btu/hr[121]	82% AFUE
Steam Boiler ≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h [122]	79% E_T
Steam - natural draft ≥300,000 & ≤2,500,000 Btu/hr	79% TE[123]
Steam Boiler >2,500,000 Btu/h	79% E_T
Steam - natural draft >2,500,000 Btu/hr	79% E_T [124]

$Efficiency_{EE}$ = Efficent Boiler Efficiency Rating

=actual value, specified to one significant digit (i.e., 95.7%)

> **For example**, a 150,000 btu/hr water boiler meeting AFUE 90% is installed in Rockford at a high rise office building , in the year 2022
>
> ΔTherms = 2,089* 150,000 * (0.90-0.840)/0.840) / 100,000 Btu/Therm
>
> = 224 Therms

WATER IMPACT DESCRIPTIONS AND CALCULATION
N/A

DEEMED O&M COST ADJUSTMENT CALCULATION
N/A

MEASURE CODE: CI-HVC-BOIL-V12-240101

REVIEW DEADLINE: 1/1/2027

[118] Code of Federal Regulations, effective January 15, 2021 (10 CFR 432(e)(3)).
[119] Thermal Efficiency. Code of Federal Regulations, effective March 2, 2012 (10 CFR 431.87).
[120] Combustion Efficiency. Code of Federal Regulations, effective March 2, 2012 (10 CFR 431.87).
[121] Code of Federal Regulations, effective January 15, 2021 (10 CFR 432(e)(3)).
[122] Code of Federal Regulations, effective March 2, 2012 (10 CFR 431.87). Includes efficiency requirements for all steam boilers ≥ 300,000 Btu/hr.
[123] IECC 2021
[124] IECC 2021

4.4.51 Advanced Rooftop Controls with High Rotor Pole Switch Reluctance Motors

DESCRIPTION

A High Rotor Pole Switch Reluctance Motor (HRSRM) is a type of brushless DC electric motor that runs by reluctance torque. Unlike other DC motor types, power is delivered to windings in the stator rather than the rotor. This simplifies the mechanical design; power does not need to be delivered to a moving part, but requires a switching system through software control to deliver power to the different windings. Electronic devices can precisely time switch, facilitating HRSRM configurations.

In applications on rooftop units (RTUs), the HRSRM motor is comparable or more efficient than an RTU equipped with a variable speed drive supply fan. It results in fan-energy savings and can also include cooling savings if coupled with compressor or ventilation control, compared to a baseline scenario of constant-volume, constant-ventilation operation that is typical of single-zone, packaged HVAC units.

Fan energy savings come from the new integrated motor controls that allow for higher efficiency at varying loads and is achieved in all applications. Cooling savings can also be added from the effective use of variable speed or multi-stage cooling.

The markets that can be served by HRSRM motors are those which utilize RTUs, including but not limited to:

1 Fast-Service Restaurant
2 Full-Service Restaurant
3 Small Office
4 Stand-Alone Retail
5 Strip Mall
6 Warehouse

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

DEFINITION OF EFFICIENT EQUIPMENT

The efficient equipment is a single-zone, packaged HVAC unit with an existing functional integrated economizer that has been fitted with a HRSRM supply-fan and integrated speed control. This applies to both retrofit and new construction, and early replacement applications.

DEFINITION OF BASELINE EQUIPMENT

The baseline equipment is a single-zone, packaged HVAC unit (with an existing functional integrated economizer) that lacks demand-controlled ventilation controls and lacks supply-fan speed control via a variable-frequency drive.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 12 years based on the HRSRM life.[125]

DEEMED MEASURE COST

Actual measure costs should be used if available. If costs are not available, the deemed measure cost below can be used. Material cost is based on the horsepower (hp) of the supply fan used in the RTU. Retrofit represents the full cost of the installation. New construction and early replacement represent the incremental cost of the motor itself on a new unit.[126]

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[125] Based on life cycle of a switch reluctance motor from P. Andrada, B. Blanque, E. Martınez, J.I. Perat, J.A. Sanchez, and M. Torrent, “Environmental and life cycle cost analysis of one switched reluctance motor drive and two inverter-fed induction motor drives,” IET Electric Power Applications (2010): page 8.
[126] Based on cost data from Turntide on HRSRM motors, https://turntide.com

Deemed Measure Cost Details

Type	HP	Material Cost	Labor Hours	Labor Rate	Deemed Cost
Retrofit	1	$1,554.75	3	$96.67	$1,844.76
Retrofit	1.5	$1,580.75	3	$96.67	$1,870.76
Retrofit	2	$1,644.75	3	$96.67	$1,934.76
Retrofit	5	$1,758.75	3	$96.67	$2,048.76
Retrofit	7.5	$2,417.75	3	$96.67	$2,707.76
Retrofit	10	$2,587.75	3	$96.67	$2,877.76
New Construction/Early Replacement	1	$932.85	-	-	$932.85
New Construction/Early Replacement	1.5	$948.45	-	-	$948.45
New Construction/Early Replacement	2	$986.85	-	-	$986.85
New Construction/Early Replacement	5	$1,055.25	-	-	$1,055.25
New Construction/Early Replacement	7.5	$1,450.65	-	-	$1,450.65
New Construction/Early Replacement	10	$1,552.65	-	-	$1,552.65

LOADSHAPE

Commercial ventilation C23

COINCIDENCE FACTOR

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

= 91.3%[127]

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

= 47.8%[128]

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

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

Algorithm

CALCULATION OF ENERGY SAVINGS

Six different building types were selected for study. OpenStudio measures were used to generate ASHRAE 90.1-2013 code-compliant DOE prototype baseline models for each building type. The total conditioned area, the number of conditioned zones, and the peak cooling demand for each building are summarized in the following table.[129]

Selected DOE Prototype Buildings

Building Type	Small Office	Stand-Alone Retail	Warehouse	Strip Mall	Fast-Service Restaurant	Full-Service Restaurant
Conditioned Area (ft2)	5,502	24,692	52,045	22,500	2,501	5,502
Number of Conditioned Zones	5	4	3	10	2	2
Total Fan Break Horsepower (BHP)	3.5	25	5	23	7	11
Design Cooling Load (Ton)	8.5	65	13	69	20	33

In order to achieve savings, the RTU control options consist of following modes:

1. Ventilation Mode:
   a. Outdoor air is at a minimum for building type
   b. Fan speed set to 40%
   c. Heating and cooling coils are off
2. Economizer Mode
   a. Outdoor air rate was set from 40% and increased as needed to satisfy indoor air temperature
   b. When outdoor air could no longer satisfy cooling, cooling mode was staged on
3. Mechanical Cooling Mode
   a. Outdoor air is at a minimum for building type
   b. Compressors (if multiple or variable) were staged/modulated to meet setpoint temperature of the space
   c. Supply fan set to 100%
4. Heating mode
   a. Outdoor air is at a minimum for building type
   b. Heating coil staged as necessary
   c. Supply fan set to 100%

The models produced a percentage energy savings based on using a HRSRM fan and varying compressor types. Retrofit savings include fan only. For new construction and early replacement, savings are based on compressor type and energy efficiency of the unit. These RTU control options are reflected in the table below. As a correction to these entries, a second set of single two-stage compressor RTU fan options are also reflected in the *Energy Savings Type: ESF_Fan* entry in the table below[130] and are characterized by the following speed settings:

1. Ventilation Mode:
   a. Outdoor air is at a minimum for building type
   b. Supply fan set to 40%

[129] Korbaga Woldekidan, Daniel Studer, and Ramin Faramarzi, "Performance Evaluation of Three RTU Energy Efficiency Technologies," 2019.

[130] Lick, A., A. Cardiel, J. Zhou, S. Hackel, S. Pigg, and K. Gries. "Switched-Reluctance Motor Field Evaluation Final Report." Slipstream project report for the ComEd Energy Efficiency Program. March 25, 2022. https://comedemergingtech.com/project/srm-field-evaluation

c. Heating and cooling coils are off

2. Economizer Mode:
    a. No change compared to existing RTU settings
3. Mechanical Cooling Mode (Stage 1):
    a. Outdoor air is at a minimum for building type
    b. Compressor stage 1 ON
    c. Supply fan set to 75%
4. Mechanical Cooling Mode (Stage 2):
    a. Outdoor air is at a minimum for building type
    b. Compressor stage 1 & 2 ON
    c. Supply fan set to 90%
5. Heating Mode:
    a. Outdoor air is at a minimum for building type
    b. Heating coil staged as necessary
    c. Supply fan set to 90%

ELECTRIC ENERGY SAVINGS

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

$$\Delta kWH = (kBtu/hr) * (1/ SEER_{exist}) * EFLH * ESF\_Cooling + 0.746 * FanHP * (LF/\eta_{motor}) * RunHours * ESF\_Fan$$

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

$$\Delta kWH = (kBtu/hr) * (1/IEER_{exist}) * EFLH * ESF\_Cooling + 0.746 * FanHP * (LF/\eta_{motor}) * RunHours * ESF\_Fan$$

Where:

kBtu/hr = capacity of the cooling equipment in kBtu per hour (1 ton of cooling capacity equals 12 kBtu/hr)

$SEER_{exist}$ = Seasonal Energy Efficiency Ratio of the existing equipment

= Actual. Or assume Code base in place at the original time of existing unit installation. IECC 2018 (effective July 1, 2019 to until IECC 2021 effective date) and IECC 2021 (expected to become effective statewide in 2024) provided below for referenced. As code requirements and adoption can differ from municipality to municipality, the user should verify which version of code is applicable given these constraints.

$IEER_{exist}$ = Integrated Energy Efficiency Ratio of the existing equipment

= Actual. Or assume Code base in place at the original time of existing unit installation. IECC 2018 (effective July 1, 2019 to until IECC 2021 effective date) and IECC 2021 (is expected to become effective statewide in 2024) provided below for reference. As code requirements and adoption can differ from municipality to municipality, the user should verify which version of code is applicable given these constraints.

EFLH = Equivalent Full Load Hours for cooling in Existing Buildings or New Construction are provided in Illinois TRM version 8.0 section 4.4 HVAC End Use

ESF_Cooling = Energy savings factor for cooling as found in **Error! Reference source not found.**[131]

ESF_Fan = Energy savings factor for cooling as found in table below[132]

Energy Savings Factors

Energy Savings Type	Retrofit Type	HRSRM on Single Stage Compressor	HRSRM on Single Two Stage Compressor	HRSRM on Variable Speed Compressor
ESF_Cooling[133]	New Construction/Early Replacement	0%	0%	0%
ESF_Cooling[134]	Supply Fan Retrofit Only	0.0%	0.0%	0.0%
ESF_Fan[134]	New Construction/Early Replacement	46.6%	61.0%	64.8%
ESF_Fan[134]	Supply Fan Retrofit Only	46.6%	61.0%	64.8%

FanHP = Horsepower of fan in RTU

= Actual

LF = Load Factor; Motor Load at Fan Design CFM (Default = 65%)[135]

η_{motor} = Installed nominal/nameplate motor efficiency

Default motor is a NEMA Premium efficiency, ODP, 4-pole/1800 RPM fan motor

NEMA Premium Efficiency Motors Default Efficiencies[136]

Size HP	Open Drip Proof (ODP)			Totally Enclosed Fan-Cooled (TEFC)		
	# of Poles			# of Poles		
	6	4	2	6	4	2
	Speed (RPM)			Speed (RPM)		
	1200	1800 Default	3600	1200	1800	3600
1	0.825	0.855	0.770	0.825	0.855	0.770
1.5	0.865	0.865	0.840	0.875	0.865	0.840
2	0.875	0.865	0.855	0.885	0.865	0.855
3	0.885	0.895	0.855	0.895	0.895	0.865

[131] Average cooling savings for all building types from paper entitled “Performance Evaluation of Three RTU Energy Efficiency Technologies”, NREL and ComEd, December 2020. Savings averaged by RTU compressor type.

[132] Based on forthcoming ComEd Field Study (final results TBD)

[133] Energy savings in this row only are due to control of the RTU that goes beyond solely fan motor replacement and utilizes additional control like ventilation or compressor control. Measures should incorporate additional control to claim savings here. See related footnotes for details.

[134] The numbers in the “HRSRM on Single Two Stage Compressor” column are based on the field study “Switched-Reluctance Motor Field Evaluation Final Report”, Prepared for ComEd by Slipstream, March 25, 2022. The numbers in the other two columns are based on the field study and the simulation study “Performance Evaluation of Three RTU Energy Efficiency Technologies”, NREL and ComEd, December 2020.

[135] Lawrence Berkeley National Laboratory, and Resource Dynamics Corporation. (2008). “Improving Motor and Drive System Performance; A Sourcebook for Industry”. U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy. Golden, CO: National Renewable Energy Laboratory.

[136] Douglass, J. (2005). Induction Motor Efficiency Standards. Washington State University and the Northwest Energy Efficiency Alliance, Extension Energy Program, Olympia, WA, October 2005.

Size HP	Open Drip Proof (ODP)			Totally Enclosed Fan-Cooled (TEFC)		
	# of Poles			# of Poles		
	6	4	2	6	4	2
	Speed (RPM)			Speed (RPM)		
	1200	1800 Default	3600	1200	1800	3600
5	0.895	0.895	0.865	0.895	0.895	0.885
7.5	0.902	0.910	0.885	0.910	0.917	0.895
10	0.917	0.917	0.895	0.910	0.917	0.902
15	0.917	0.930	0.902	0.917	0.924	0.910
20	0.924	0.930	0.910	0.917	0.930	0.910
25	0.930	0.936	0.917	0.930	0.936	0.917
30	0.936	0.941	0.917	0.930	0.936	0.917
40	0.941	0.941	0.924	0.941	0.941	0.924
50	0.941	0.945	0.930	0.941	0.945	0.930
60	0.945	0.950	0.936	0.945	0.950	0.936
75	0.945	0.950	0.936	0.945	0.954	0.936
100	0.950	0.954	0.936	0.950	0.954	0.941
125	0.950	0.954	0.941	0.950	0.954	0.950
150	0.954	0.958	0.941	0.958	0.958	0.950
200	0.954	0.958	0.950	0.958	0.962	0.954
250	0.954	0.958	0.950	0.958	0.962	0.958
300	0.954	0.958	0.954	0.958	0.962	0.958
350	0.954	0.958	0.954	0.958	0.962	0.958
400	0.958	0.958	0.958	0.958	0.962	0.958
450	0.962	0.962	0.958	0.958	0.962	0.958
500	0.962	0.962	0.958	0.958	0.962	0.958

RunHours = Annual operating hours for fan motor based on building type

= Default hours are provided for HVAC applications which vary by HVAC application and building type in the following table.[137] When available, actual hours should be used.

Building Type	Total Fan Run Hours	Model Source
Assembly	7,235	eQuest
Assisted Living	8,760	eQuest
Auto Dealership	7,451	OpenStudio
College	4,836	OpenStudio
Convenience Store	7,004	eQuest
Drug Store	7,156	OpenStudio
Elementary School	3,765	OpenStudio
Emergency Services	8,760	OpenStudio
Garage	7,357	eQuest
Grocery	8,543	OpenStudio
Healthcare Clinic	4,314	OpenStudio
High School	3,460	OpenStudio
Manufacturing Facility	8,706	eQuest

[137] Hours per year are estimated using the eQuest or OpenStudio models as the total number of hours the fans are operating for heating, cooling, and ventilation for each building type.

Building Type	Total Fan Run Hours	Model Source
MF – High Rise	8,760	OpenStudio
MF – Mid Rise	8,760	OpenStudio
Hotel/Motel – Guest	2,409	OpenStudio
Hotel/Motel – Common	8,683	OpenStudio
Movie Theater	7,505	eQuest
Office – Low Rise	6,345	OpenStudio
Office – Mid Rise	3,440	OpenStudio
Religious Building	7,380	eQuest
Restaurant	7,302	OpenStudio
Retail – Department Store	7,155	OpenStudio
Retail – Strip Mall	6,921	OpenStudio
Warehouse	6,832	OpenStudio
Unknown	6,241	n/a

2018 IECC Minimum Efficiency Requirements

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

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

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

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

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

2021 IECC Minimum Efficiency Requirements

TABLE C403.3.2(1)
ELECTRICALLY OPERATED UNITARY AIR CONDITIONERS AND CONDENSING UNITS—MINIMUM EFFICIENCY REQUIREMENTS[c, d]

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

TABLE C403.3.2(1)—continued
ELECTRICALLY OPERATED UNITARY AIR CONDITIONERS AND CONDENSING UNITS—MINIMUM EFFICIENCY REQUIREMENTS[c, d]

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

TABLE C403.3.2(1)—continued
ELECTRICALLY OPERATED UNITARY AIR CONDITIONERS AND CONDENSING UNITS—MINIMUM EFFICIENCY REQUIREMENTS[c, d]

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

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = [(kBtu/hr) * (1/EER_{exist}) * ESF\_Cooling + 0.746 * FanHP * (LF/\eta_{motor}) * ESF\_Fan] * CF$$

Where:

EER_{exist} = Energy Efficiency Ratio of the existing equipment (assume the following conversion from SEER to EER for calculation of peak savings: EER = (-0.02 * SEER2) + (1.12 * SEER))

= Actual, or assume Code base in place at the original time of existing unit installation

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

= 91.3%

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

= 47.8%

FOSSIL FUEL SAVINGS

N/A

Water and Other Non-Energy Impact Descriptions and Calculation
N/A

Deemed O&M Cost Adjustment Calculation
N/A

Measure Code: CI-HVC-HSRM-V05-240101

Review Deadline: 1/1/2028

4.4.54 Process Heating Boiler

DESCRIPTION

A process boiler is a pressure vessel that transfers heat to water for industrial process applications. Process boilers can be configured as an integrated packaged boiler or as modular instantaneous boiler arrays. This measure is applicable to boilers which serve process loads in a facility.

Modular instantaneous boilers are a recent addition to the industrial/commercial market aimed at addressing some of the drawbacks of conventional large boiler systems. They achieve high efficiencies by using multiple smaller sized modules to meet the minimum demand. They allow each boiler to operate at or close to full rated load most of the time, with reduced standby losses. The boiler design is a low water mass pressure vessel that produces steam at operating pressure rapidly then shuts off the combustion system once the demand requirement is met, thereby saving fuel.

Traditional packaged boiler systems are designed to provide the entire steam load of the facility using one or two boilers. Typically, the boiler horsepower is sized for the maximum steam load required at any facility. However, the average steam load of any facility is only 30 to 40 percent of this, and the average load on the boiler system is low. Therefore, they are not able to achieve these high efficiencies.[138]

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

DEFINITION OF EFFICIENT EQUIPMENT

The efficient case is the replacement of a non-residential standard efficiency process boiler for process loads with a high-efficiency process boiler exceeding the energy conservation standards outlined below. The efficient unit may either be a conventional packaged boiler or a modular boiler array system. Non-residential commercial boilers are defined as having an input rating greater than 300,000 Btu/h.

DEFINITION OF BASELINE EQUIPMENT

For Time of Sale and New Construction:
Gas-fired boilers, termed as commercial packaged boilers, manufactured after March 12, 2012 must comply with the standards defined in the Code of Federal Regulations, 10 CFR 431.87.[139]

Note, for natural draft steam boilers, as IECC 2021, Illinois state energy code, expected to become effective statewide in 2024, exceeds the minimum federal efficiency standards, it was replaced in favor of the more aggressive thermal efficiency values in the table below. For new construction applications where the permitting date is prior to the state's adoption of IECC 2021 it is recommended to use the applicable edition of IECC corresponding to that timeline. As code requirements and adoption can differ from municipality to municipality, the user should verify which version of code is applicable given these constraints.

Boiler baseline efficiency standards

Boiler Type	Efficiency[140]
Hot Water Boiler ≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h	80% E_T
Hot Water Boiler > 2,500,000 Btu/h and ≤10,000,000 Btu/h	82% E_C

[138] Modular boiler arrays have greater combustion efficiencies as compared to traditional steam boilers. This has been verified via a field study done by Nicor Gas ETP. The study covered an industrial manufacturing facility with (10) modular process steam boiler systems; the effective efficiency was found to be in line with the rated manufacturer efficiency of 87%.

[139] Boilers ≥ 300,000 Btu/hr, Code of Federal Regulations, 10 CFR 431.87, Table 1 – Commercial Packaged Boiler Energy Conservation Standards.

[140] Ibid.

Boiler Type	Efficiency[140]
Hot Water Boiler >10,000,000 Btu/h	82% E_C
Steam Boiler ≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h	79% E_T
Steam Boiler ≥ 2,500,000 Btu/h and ≤10,000,000 Btu/h	79% E_T
Steam Boiler > 10,000,000 Btu/h	79% E_T

where E_T means "thermal efficiency" and E_C means "combustion efficiency" as defined in 10 CFR 431.82.

For early replacement: The efficiency of the existing equipment should be used for the assumed remaining useful life of the equipment and a new baseline equipment as described above for the remainder of the measure life.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 25 years.[141]

For EREP, the remaining useful life of the existing equipment is assumed to be 1/3rd of EUL (25/3) or 8 years.

DEEMED MEASURE COST

The measure cost for this technology is tiered based on the boiler type and combustion efficiencies. As installation costs for the base case and the measure case units are assumed to be the same, labor costs are not specified for this measure.

Incremental and Gross Measure costs for Process Boilers

Boiler Type	Incremental Measure Cost ($/Kbtu)[142]	Full Measure Cost ($/Kbtu)[143]
Hot Water Boiler ≥85% E_C and <90% E_C	$2.17	$12.94
Hot Water Boiler ≥90% E_C	$12.17	$22.95
Steam Boiler ≥83% E_C and <85% E_C	$4.35	$19.24
Modular Steam Boiler Arrays (≥85% E_C)[144]	Custom	

A deferred baseline replacement cost, consistent with the delta between the full measure cost and incremental cost above should be assumed after the remaining useful life of the existing equipment.

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

141 https://www.govinfo.gov/content/pkg/FR-2020-01-10/pdf/2019-26356.pdf.
142 California ETRM measure "Process Boiler", https://www.caetrm.com/measure/SWWH008/01/ , accessed April 16, 2021..
143 Ibid.
144 Miura Modular Boilers, https://s29958.pcdn.co/wp-content/uploads/2019/03/LXBrochure2016.pdf

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS
N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS
N/A

FOSSIL FUEL SAVINGS
For first 8 years:

$$\Delta Therms = 8{,}766 * Capacity\ *\ UF * \left(\frac{Efficiency_{EE}}{Efficiency_{Exist}} - 1\right) * \frac{1}{100{,}000}$$

For remaining 17 years:

$$\Delta Therms = 8{,}766 * Capacity * \ UF * \left(\frac{Efficiency_{EE}}{Efficiency_{Base}} - 1\right) * \frac{1}{100{,}000}$$

Where:

8,766 = Annual Operating hours for Process Boilers

The assumed hours of operation are based on continual plant operation. Variation in plant operating hours is accounted for in the utilization factor. While the boiler may operate during the entire year, it may not be operating at its full rated load.

Capacity = Nominal heating input capacity boiler size for high-efficiency unit (Btu/hr)

UF = Utilization Factor

= Custom or if unknown 41.9%[145]

$Efficiency_{Exist}$ = Existing boiler efficiency rating,

= Actual

$Efficiency_{Base}$ = Baseline boiler efficiency rating, dependent on year and boiler type or use actual operating efficiencies for early replacements. See table in "Definition of Baseline Equipment."

$Efficiency_{EE}$ = Efficient boiler efficiency rating for packaged or modular boiler system

= Actual value, specified to one significant digit (i.e., 95.7%)

[145] Illinois TRM v9.0,measure 4.4.3 Process Boiler Tune-up, "Work Paper – Tune up for Boilers serving Space Heating and Process Load by Resource Solutions Group, January 2012".

100,000 = Constant to convert from Btu to therm

For example, an 800,000 Btu/hr gas-fired process steam boiler with a thermal efficiency rating of 87% is installed replacing a similar sized natural draft steam boiler with baseline efficiency of 79%.

ΔTherms = 8,766 * 800,000 * 0.419 * (0.870 – 0.790)/0.790 / 100,000

= 2,976 therms

WATER AND OTHER NON-ENERGY IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-PHBO-V04-240101

REVIEW DEADLINE: 1/1/2027

4.5.13 Occupancy Controlled Bi-Level Lighting Fixtures

DESCRIPTION

This measure relates to replacing existing uncontrolled continuous lighting fixtures with new bi-level lighting fixtures. This measure can only relate to replacement in an existing building, since multi-level switching is required in the Commercial new construction building energy code (IECC 2012/2015/2018/2021). This measure is limited to 24/7 operation.

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

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

DEFINITION OF EFFICIENT EQUIPMENT

In order for this characterization to apply, the efficient system is assumed to be an occupancy controlled lighting fixture operating 24/7, that reduces light level during unoccupied periods.

DEFINITION OF BASELINE EQUIPMENT

The baseline equipment is assumed to be an uncontrolled lighting system on continuously, e.g. in stairwells and corridors for health and safety reasons.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life for all lighting controls is assumed to be 10 years.[146]

DEEMED MEASURE COST

When available, the actual cost of the measure shall be used. When not available, the assumed measure cost is $274.[147]

LOADSHAPE

Loadshape C06 - Commercial Indoor Lighting
Loadshape C07 - Grocery/Conv. Store Indoor Lighting
Loadshape C08 - Hospital Indoor Lighting
Loadshape C09 - Office Indoor Lighting
Loadshape C10 - Restaurant Indoor Lighting
Loadshape C11 - Retail Indoor Lighting
Loadshape C12 - Warehouse Indoor Lighting
Loadshape C13 - K-12 School Indoor Lighting
Loadshape C14 - Indust. 1-shift (8/5) (e.g., comp. air, lights)
Loadshape C15 - Indust. 2-shift (16/5) (e.g., comp. air, lights)
Loadshape C16 - Indust. 3-shift (24/5) (e.g., comp. air, lights)
Loadshape C17 - Indust. 4-shift (24/7) (e.g., comp. air, lights)
Loadshape C18 - Industrial Indoor Lighting
Loadshape C19 - Industrial Outdoor Lighting
Loadshape C20 - Commercial Outdoor Lighting

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[146] Consistent with Lighting Controls measure.
[147] Consistent with the Multi-level Fixture measure with reference to Goldberg et al, State of Wisconsin Public Service Commission of Wisconsin, Focus on Energy Evaluation, Business Programs: Incremental Cost Study, KEMA, October 28, 2009. Also consistent with field experience of about $250 per fixture and $25 install labor.

COINCIDENCE FACTOR

The summer peak coincidence factor for this measure is dependent on the location type. Values are provided for each building type in the reference section below.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = (KW_{Baseline} - (KW_{Controlled} * (1 - ESF))) * Hours * WHF_e$$

Where:

$KW_{Baseline}$ = Total baseline lighting load of the existing/baseline fixture

= Actual

Note that if the existing fixture is only being retrofit with bi-level occupancy controls and not being replaced $KW_{Baseline}$ will equal $KW_{Controlled}$.

$KW_{Controlled}$ = Total contolled lighting load at full light output of the new bi-level fixture

= Actual

Hours = Number of hours lighting is on. This measure is limited to 24/7 operation.

= 8,766

ESF = Energy Savings factor (represents the percentage reduction to the $KW_{Controlled}$ due to the occupancy control).

= % Standby Mode * (1 - % Full Light at Standby Mode)

% Standby Mode = Represents the percentage of the time the fixture is operating in standby (i.e. low-wattage) mode.

% Full Light at Standby Mode = Represents the assumed wattage consumption during standby mode relative to the full wattage consumption. Can be achieved either through dimming or a stepped control strategy.

= Dependent on application. If participant provided or metered data is available for both or either of these inputs a custom savings factor should be calculated. If not defaults are provided below:

Application	% Standby Mode	% Full Light at Standby Mode	Energy Savings Factor (ESF)
Stairwells	78.5%[148]	50%	39.3%
		33%	52.6%

[148] Average found from the four buildings in the State of California Energy Commission Lighting Research Program Bi-Level Stairwell Fixture Performance Final Report, October 2005.

Application	% Standby Mode	% Full Light at Standby Mode	Energy Savings Factor (ESF)
		10%	70.7%
		5%	74.6%
Corridors	50.0%[149]	50%	25.0%
		33%	33.5%
		10%	45.0%
		5%	47.5%
Other 24/7 Space Type	50.0%[150]	50%	25.0%
		33%	33.5%
		10%	45.0%
		5%	47.5%

WHF_e = Waste heat factor for energy to account for cooling energy savings from efficient lighting is provided in the Reference Table in Section 4.5 for each building type. If building is un-cooled, the value is 1.0.

HEATING PENALTY

If electrically heated building:

$$\Delta kWh_{heatpenalty}{}^{151} = (KW_{Baseline} - (KW_{Controlled} * (1 - ESF))) * Hours * -IFkWh$$

Where:

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

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = (KW_{Baseline} - (KW_{Controlled} * (1 - ESF))) * WHF_d * (CF_{baseline} - CF_{os})$$

Where:

WHF_d = Waste Heat Factor for Demand to account for cooling savings from efficient lighting in cooled buildings is provided in the Reference Table in Section 4.5. If the building is un-cooled WHFd is 1.

$CF_{baseline}$ = Baseline Summer Peak Coincidence Factor for the lighting system without Occupancy Sensors installed.

= 1.0 (due to 24/7 operation)

CF_{os} = Retrofit Summer Peak Coincidence Factor the lighting system with Occupancy Sensors installed.

---

149 Value determined from the Pacific Gas and Electric Company: Bi-Level Lighting Control Credits study for Interior Corridors of Hotels, Motels and High Rise Residential, June 2002.

150 Conservative estimate.

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

= 0.15 regardless of building type.[152]

NATURAL GAS HEATING PENALTY

If natural gas heating:

$$\Delta therms = (KW_{Baseline} - (KW_{Controlled} * (1 - ESF))) * Hours * - IFTherms$$

Where:

IFTherms = Lighting-HVAC Integration Factor for gas heating impacts; this factor represents the increased gas space heating requirements due to the reduction of waste heat rejected by the efficient lighting and provided in the Reference Table in Section 4.5 by buidling type.

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-LTG-OCBL-V06-240101

REVIEW DEADLINE: 1/1/2030

[152] Coincidence Factor Study Residential and Commercial Industrial Lighting Measures, RLW Analytics, Spring 2007. Note, the connected load used in the calculation of the CF for occupancy sensor lights includes the average ESF.

4.6.8 Refrigeration Economizers

DESCRIPTION

This measure applies to commercial walk in refrigeration systems and includes two components, outside air economizers and evaporator fan controllers. Economizers save energy by bringing in outside air when weather conditions allow, rather than operating the compressor. Walk-in refrigeration systems evaporator fans run almost all the time; 24 hrs/day, 365 days/yr. This is because they must run constantly to provide cooling when the compressor is running, and to provide air circulation when the compressor is not running. However, evaporator fans are a very inefficient method of providing air circulation. Installing an evaporator fan control system will turn off evaporator fans while the compressor is not running, and instead turn on an energy-efficient 35 watt fan to provide air circulation, resulting in significant energy savings. This measure allows for economizer systems with evaporator fan controls plus a circulation fan and without a circulation fan.

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

If applied to other program types, the measure savings should be verified. IECC code requires economizers in certain instances and therefore projects relying on code baseline definitions must verify eligibility.

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure an economizer is installed on a walk in refrigeration system.

DEFINITION OF BASELINE EQUIPMENT

The baseline condition is a walk-in refrigeration system without an economizer.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The estimated life of this measure is 15 years.[153]

DEEMED MEASURE COST

Installation costs can vary considerably depending on system size (larger systems may require multiple economizer units), physical site layouts (locating economizer intakes and ductwork), and controls elected. Therefore, actual site-specific costs should be used.

LOADSHAPE

Loadshape C22 - Commercial Refrigeration

COINCIDENCE FACTOR

The summer peak coincidence factor for this measure is assumed to be 0%.[154]

Algorithm

[153] Estimated life from DEER Work Paper PGE3PREF126.

[154] The economizer is only assumed to run when the outside temperature is below 33F (a 38°F cooler setpoint and 5 degree economizer deadband). Therefore savings will not coincide with the summer peak period.

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS

Electric energy savings is calculated dependent on whether evaporator fans controls are installed.

With Fan Control Installed

ΔkWh = [HP * kWhCond] + [((kWEvap * nFans) – kWCirc) * Hours * DCComp * BF] – [kWEcon * DCEcon * Hours]

Without Fan Control Installed

ΔkWh = [HP * kWhCond] – [kWEcon * DCEcon * Hours]

Where:

HP = Horsepower of Compressor

= actual installed

kWhCond = Condensing unit savings, kWh/HP[155]

Climate Zone (City based upon)	Hermetic / Semi-Hermetic	Scroll	Discus
1 (Rockford)	494	434	410
2 (Chicago/O'Hare)	423	372	352
3 (Springfield)	321	282	267
4 (Belleview)	230	202	191
5 (Marion)	136	119	113

Hours = Number of annual hours that economizer operates [156]

Region (city)	Hours
1 (Rockford)	2,033
2 (Chicago/O'Hare)	1,806
3 (Springfield)	1,350
4 (Belleview)	1,112
5 (Marion)	752

DCComp = Duty cycle of the compressor

= 50% [157]

[155] Savings table uses Economizer Calc_Revised052024.xls. Assume 5HP compressor size used to develop kWh/Hp value. No floating head pressure controls and compressor is located outdoors. Bin Data for IL zones uses TMYx data.

[156] In the source TRM (VT) this value was 2,996 hrs based on 38° F cooler setpoint, Burlington VT weather data, and 5 degree economizer deadband. The IL numbers were calculated by using weather bin data for each location (number of hours < 38F at each location is the Hours value) from TMYx data.

[157] A 50% duty cycle is assumed based on examination of duty cycle assumptions from refrigeration suppliers (35%-65%),

kWEvap = Connected load kW of each evaporator fan

= If known, actual installed. Otherwise assume 0.126 kW[158]

kWCirc = Connected load kW of the circulating fan

= If known, actual installed. Otherwise assume 0.035 kW[159]

nFans = Number of evaporator fans

= actual number of evaporator fans

DCEcon = Duty cycle of the economizer fan on days that are cool enough for the economizer to be working

= If known, actual installed. Otherwise assume 63%[160]

BF = Bonus factor for reduced cooling load from reduction of waste heat generation as a result of running the evaporator fan less

= 1.3[161]

kWEcon = Connected load kW of the economizer fan

= If known, actual installed. Otherwise assume 0.227 kW.[162]

For example, adding an outdoor air economizer and fan controls in Rockford to a 5 hp hermetic compressor walk in refrigeration unit with 3 evaporator fans would save:

ΔkWh = [hp * kWhCond] + [((kWEvap * nFans) – kWCirc) * Hours * DCComp * BF] – [kWEcon * DCEcon * Hours]

= [5 * 494] + [((0.126 * 3) – 0.035) * 2033 *0.5 * 1.3] – [0.227 * 0.63 * 2033]

= 2633 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ΔkWh / Hours * CF

Cooltrol (35%-65%), Natural Cool (70%), Pacific Gas & Electric (58%). Also, manufacturers typically size equipment with a built-in 67% duty factor and contractors typically add another 25% safety factor, which results in a 50% overall duty factor.

[158] Based on a weighted average of 80% shaded pole motors at 175 watts and 20% PSC motors at 84 watts. Motor wattage and efficiency values referenced from Oak Ridge National Laboratory, “Permanent Magnet Synchronous Motors for Commercial Refrigeration: Final Report", 2019. Table 1, page xiv; Table 24, page 57.

[159] Wattage of fan used by Freeaire and Cooltrol. This fan is used to circulate air in the cooler when the evaporator fan is turned off. As such, it is not used when fan control is not present.

[160] Average of two manufacturer estimates of 50% and 75%.

[161] Bonus factor (1+ 1/3.5) assumes COP of 3.5, based on the average of standard reciprocating and discus compressor efficiencies with a Saturated Suction Temperature of 20°F and a condensing temperature of 90°F.

[162] The 227 watts for an economizer is calculated from the average of three manufacturers: Freeaire (186 Watts), Cooltrol (285 Watts), and Natural Cool (218 Watts).

Where:

CF = Summer Peak Coincidence Factor for the measure

= 0 [163]

FOSSIL FUEL SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-RFG-ECON-V08-240101

REVIEW DEADLINE: 1/1/2028

[163] The economizer is only assumed to run when the outside temperature is below 33F (a 38°F cooler setpoint and 5 degree economizer deadband). Therefore savings will not coincide with the summer peak period.

4.8.9 High Frequency Battery Chargers

DESCRIPTION

This measure applies to industrial high frequency battery chargers, used for industrial equipment such as fork lifts, replacing existing SCR (silicon controlled rectifier) or ferroresonant charging technology. High frequency battery chargers have a greater system efficiency.

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

DEFINITION OF EFFICIENT EQUIPMENT

High frequency battery charger systems with minimum Power Conversion Efficiency of 90% and a minimum 8-hour shift operation five days per week.

DEFINITION OF BASELINE EQUIPMENT

SCR or ferroresonant battery charger systems with minimum 8-hour shift operation five days per week.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

15 years[164]

DEEMED MEASURE COST

The deemed incremental measure cost is $400.[165]

LOADSHAPE

Loadshape C14 - Indust. 1-shift (8/5) (e.g., comp. air, lights)
Loadshape C15 - Indust. 2-shift (16/5) (e.g., comp. air, lights)
Loadshape C16 - Indust. 3-shift (24/5) (e.g., comp. air, lights)
Loadshape C17 - Indust. 4-shift (24/7) (e.g., comp. air, lights)

COINCIDENCE FACTOR

The coincidence factor is assumed to be 0.0 for 1 and 2-shift operation and 1.0 for 3 and 4-shift operation.[166]

Algorithm

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = (CAP * DOD) * CHG * (CR_B / PC_B - CR_{EE} / PC_{EE})$$

Where:

CAP = Capacity of Battery

= Use actual battery capacity, otherwise use a default value of 35 kWh[167]

[164] Suzanne Foster Porter et al., "Analysis of Standards Options for Battery Charger Systems", (PG&E, 2010), 45.
[165] Franklin Energy, Field Study of Industrial High Frequency Battery Chargers (2017), pg 9. Weighted average applied between FR and SCR market split.
[166] Emerging Technologies Program Application Assessment Report #0808, Industrial Battery Charger Energy Savings Opportunities, Pacific Gas & Electric. May 29, 2009.
[167] Jacob V. Renquist, Brian Dickman, and Thomas H. Bradley, :"Economic Comparison of fuel cell powered forklifts to battery powered forklifts", International Journal of Hydrogen Energy Volume 37, Issue 17, (2012): 2.

DOD = Depth of Discharge

= Use actual depth of discharge, otherwise use a default value of 80%.[168]

CHG = Number of Charges per year

= Use actual number of annual charges, if unknown use values below based on the type of operations[169]

Standard Operations	Number of Charges per year
1-shift (8 hrs/day – 5 days/week)	520
2-shift (16 hrs/day – 5 days/week)	1040
3-shift (24 hrs/day – 5 days/week)	1560
4-shift (24 hrs/day – 7 days/week)	2184

CR_B = Baseline Charge Return Factor

= 1.2485[170]

PC_B = Baseline Power Conversion Efficiency

= 0.84[171]

CR_{EE} = Efficient Charge Return Factor

= 1.107[172]

PC_{EE} = Efficient Power Conversion Efficiency

= 0.89[173]

Default savings using defaults provided above are provided below:

Standard Operations	ΔkWh
1-shift (8 hrs/day – 5 days/week)	3,531
2-shift (16 hrs/day – 5 days/week)	7,061
3-shift (24 hrs/day – 5 days/week)	10,592
4-shift (24 hrs/day – 7 days/week)	14,829

[168] Ryan Matley, "Measuring Energy Efficiency Improvements in Industrial Battery Chargers", (ESL-IE-09-05-32, Energy Technology Conference, New Orleans, LA, May 12-15, 2009), 4.

[169] Number of charges is derived from the following reference and adjusted to the hours and days of the different types of shift operations. These values are based on an estimated 2-charge per 8-hour workday. See reference file Ryan Matley, "Measuring Energy Efficiency Improvements in Industrial Battery Chargers", (ESL-IE-09-05-32, Energy Technology Conference, New Orleans, LA, May 12-15, 2009), 4.

[170] Ecos Consulting, "Emerging Technologies Program Application Assessment Report #0808" (2009), pg. 8

[171] Ibid.

[172] Ibid.

[173] Ibid.

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = (PF_{EE} * PC_{EE} – PF_B * PC_B) * Volts_{DC} * Amps_{DC} / 1000 * CF$$

Where:

PF_B = Power factor of baseline charger

= 0.9095[174]

PF_{EE} = Power factor of high frequency charger

= 0.9370[175]

$Volts_{DC}$ = Actual DC rated voltage of charger (assumed baseline charger is replaced with same rated high frequency unit)

= Use actual battery DC voltage rating, otherwise use a default value of 48 volts.[176]

$Amps_{DC}$ = Actual DC rated amperage of charger (assumed baseline charger is replaced with same rated high frequency unit)

= Use actual battery DC ampere rating, otherwise use a default value of 81 amps.[177]

1,000 = watt to kilowatt conversion factor

CF = Summer Coincident Peak Factor for this measure

= 0.0 (for 1 and 2-shift operation)[178]

= 1.0 (for 3 and 4-shift operation)[179]

Other variables as provided above.

Default savings using defaults provided above are provided below:

Standard Operations	ΔkW
1-shift (8 hrs/day – 5 days/week)	0
2-shift (16 hrs/day – 5 days/week)	0
3-shift (24 hrs/day – 5 days/week)	0.2720
4-shift (24 hrs/day – 7 days/week)	0.2720

[174] Ibid.
[175] Ibid.
[176] Voltage rating based on the assumption of 35kWh battery with a normalized average amp-hour capacity of 760 Ah charged over a 7.5 hour charge cycle. Pacific Gas & Electric, "Emerging Technologies Program Application Assessment Report #0808", Industrial Battery Charger Energy Savings Opportunities. May 29, 2009. Page 8, Table 3.
[177] Ampere rating based on the assumption of 35kWh battery with a normalized average amp-hour capacity of 760 Ah charged over a 7.5 hour charge cycle. Pacific Gas & Electric, "Emerging Technologies Program Application Assessment Report #0808", Industrial Battery Charger Energy Savings Opportunities. May 29, 2009. Page 8, Table 3.
[178] Emerging Technologies Program Application Assessment Report #0808, Industrial Battery Charger Energy Savings Opportunities, Pacific Gas & Electric. May 29, 2009.
[179] Ibid.

Fossil Fuel Savings

N/A

Water Impact Descriptions and Calculation

N/A

Deemed O&M Cost Adjustment Calculation

N/A

Measure Code: CI-MSC-BACH-V03-240101

Review Deadline: 1/1/2030

4.8.25 Warm-Mix Asphalt Chemical Additives

Description

Warm-Mix Asphalt (WMA) is the name for a variety of technologies that allow for production and placement of asphalt at temperatures lower than traditional Hot-Mix Asphalt (HMA). The production temperature of WMA is typically 25°F to 90°F below that of HMA, resulting in reduced energy consumption. The actual temperature reduction depends upon the warm mix technology used. Currently, there are three categories of WMA technologies: asphalt foaming technologies, organic additives, and chemical additives.

The asphalt foaming technologies include a variety of processes to foam asphalt, including water-injecting systems, damp aggregate, or the addition of a hydrophilic material such as a zeolite. In the asphalt plant, the water turns to steam, disperses throughout the asphalt, and expands the binder, providing a corresponding temporary increase in volume and fluids content, similar in effect to increasing the binder content. Chemical additives often include surfactants that aid in coating and lubrication of the asphalt binder in the mixture. Lastly, organic additives are typically special types of waxes that cause a decrease in binder viscosity above the melting point of the wax.

In additional to energy savings, using WMA in place of HMA reduces greenhouse gas emissions and provides multiple non-energy benefits, such as beter compaction, cool-weather paving, longer haul distances, and improved working conditions for the paving crew (reduction of fumes and odors). Warm-mix chemical additives allow for the mixing and placement of asphalt at temperatures lower than traditional HMA while maintaining similar strength, durability, and performance characteristics.

This measure is applicable to the industrial market with the end user in the transporation sector. WMA can be used in any climate, as the lower mix temperature allows WMA to be used in cooler ambient conditions than traditional HMA.

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

Definition of Efficient Equipment

The efficient case is WMA. WMA is generally produced at temperatures ranging from 25°F to 90°F lower than HMA.[180]

General WMA technologies can be categorized as chemical additives, organic additives, and water-based foaming methods. Chemical additives reduce the internal friction between aggregate particles and thin films of binders when subjected to high shear rates during mixing and high shear stress during compaction. In contrast, the other two WMA methods rely on reduction of binder viscosity.

Definition of Baseline Equipment

The baseline case is traditional HMA. HMA is traditionally mixed between 280°F and 320°F.[181]

Deemed Lifetime of Efficient Equipment

The measure life is 1 year. Savings occur during production, and last only as long as the production runs. Since savings and costs scale to tons of asphalt production, a 1-year measure life appropriately tracks lifecycle savings.

[180] West, R.C., M.C. Rodezno, G. Julian, B.D. Prowell, B. Frank, L.V. Osborn, & A.J. Kriech (2014). "NCHRP Report 779:Field Performance of Warm-Mix Asphalt Technologies. Transportation Research Board of the National Academies", Washington, D.C. doi:10.17226/22272.

[181] West, R.C., M.C. Rodezno, G. Julian, B.D. Prowell, B. Frank, L.V. Osborn, & A.J. Kriech (2014). "NCHRP Report 779:Field Performance of Warm-Mix Asphalt Technologies. Transportation Research Board of the National Academies", Washington, D.C. doi:10.17226/22272.

DEEMED MEASURE COST

The costs of WMA depend primarily on the type of WMA technology that is used. Of the WMA technology options, water-injection asphalt foaming typically have the lowest cost per ton. Water injection WMA technologies have a lower incremental cost at around $0.08 per ton.[182]

Compared to other WMA technologies, additive based WMA technologies increase the mix costs by $2.50 per ton[183] due to the cost of chemicals and freight costs.

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF ENERGY SAVINGS

Energy savings are dependent on multiple factors that primarily affect the production of WMA. The following factors have been identified as the primary contributors to energy consumption:

- Mixing drum temperature
- Additive type

ELECTRIC ENERGY SAVINGS

N/A.

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A.

FOSSIL FUEL SAVINGS

Average temperature reduction achieved by plants that reduce mix production temperature when using WMA must be determined to estimate reductions in energy consumption. In practice, WMA production temperatures when using water-injection foaming technologies are typically about 25°F lower than those for hot mix asphalt (HMA) using the same mix design. WMA produced with additives tends to have substantially lower mixing temperatures. For the purpose of estimating energy savings, a temperature difference of 50°F is assumed for additive-type WMA compared to HMA using the same mix design.

$$therms_{savings} = tons \times SF$$

Where:

tons = Tons of asphalt produced

[182] West, R.C., M.C. Rodezno, G. Julian, B.D. Prowell, B. Frank, L.V. Osborn, & A.J. Kriech (2014). "NCHRP Report 779:Field Performance of Warm-Mix Asphalt Technologies. Transportation Research Board of the National Academies", Washington, D.C. doi:10.17226/22272.

[183] West, R.C., M.C. Rodezno, G. Julian, B.D. Prowell, B. Frank, L.V. Osborn, & A.J. Kriech (2014). "NCHRP Report 779:Field Performance of Warm-Mix Asphalt Technologies. Transportation Research Board of the National Academies", Washington, D.C. doi:10.17226/22272.

SF = WMA production savings factor (therms/ton)

= See Table for SF for Water Injection Foaming and Additives

Energy Savings by mixing temperature reduction

WMA Production Technology	[A] Energy Savings [184] (therms/Δ°F/ton)	[B] Temperature Reduction (°F)	[C] = [A]*[B] SF (therms/ton)
Water Injection Foaming	0.011	25	0.275
Additives	0.011	50	0.55
Custom Documented	0.011	Custom	Calculated

Example:

A plant producing 1,000 ton ashphalt everyday now decides to adopt additives for energy savings and non energy benefits. The savings for that plant will be computed:

Savings = 1,000 tons * 0.55 (therms/ton)

= 550 therms saved.

Water and Other Non-Energy Impact Descriptions and Calculation

In addition to reduced energy consumption, reduction in production temperatures results in reduced greenhouse gas emissions from the combustion process and any emissions from the mixed asphalt. The reduction of emissions, fumes, and odors results in a healthier work environment for production operators, truck drivers, and application workers. The lower temperature mix also allows for an extended paving season, night paving, and longer hauling distances for the WMA in comparison to HMA with faster application times.

Deemed O&M Cost Adjustment Calculation

N/A

Measure Code: CI-MSC-WMIX-V02-240101

Review Deadline: 1/1/2030

[184] 1100 Btu/Δ°F/ton from: West, R.C., M.C. Rodezno, G. Julian, B.D. Prowell, B. Frank, L.V. Osborn, & A.J. Kriech (2014). "NCHRP Report 779:Field Performance of Warm-Mix Asphalt Technologies. Transportation Research Board of the National Academies", Washington, D.C. doi:10.17226/22272, converted to 0.011 Therms/Δ°F/ton by dividing by 100,000 Btu/therm.

5.1.2 ENERGY STAR Clothes Washers

DESCRIPTION

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

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

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

DEFINITION OF EFFICIENT EQUIPMENT

Clothes washer must meet the ENERGY STAR, ENERGY STAR Most Efficient/CEE Tier 2 or CEE Advanced Tier minimum qualifications, 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.[185]

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	

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 14 years[186]

DEEMED MEASURE COST

The incremental cost for an ENERGY STAR unit for a non-IQ participant is assumed to be $87, for an ENERGY STAR Most Efficient/CEE Tier 2 unit it is $85 and for a CEE Advanced Tier it is $99.[187]

For an IQ participant the incremental cost is assumed to be $214, for an ENERGY STAR Most Efficient/CEE Tier 2 unit it is $212 and for a CEE Advanced Tier it is $227.[188]

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185 DOE Energy Conservation Standards for Clothes Washers, Appliance and Equipment Standard, 10 CFR Part 430.32(g)

186 Based on DOE Life-Cycle Cost and Payback Period Excel-based analytical tool.

187 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..

188 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.xls” for information.

Deemed O&M Cost Adjustments

N/A

Loadshape

Loadshape R01 - Residential Clothes Washer

Coincidence Factor

The coincidence factor for this measure is 3.8%.[189]

Algorithm

Calculation of Savings

Electric Energy Savings

Calculate clothes washer savings based on the Integrated Modified Energy Factor (IMEF).

The Integrated Modified Energy Factor (IMEF) includes unit operation, standby, water heating, and drying energy use: *"IMEF is the quotient of the capacity of the clothes container, C, divided by the total clothes washer energy consumption per cycle, with such energy consumption expressed as the sum of the machine electrical energy consumption, M, the hot water energy consumption, E, the energy required for removal of the remaining moisture in the wash load, D, and the combined low-power mode energy consumption"* .[190]

The hot water and dryer savings calculated here assumes electric DHW and Dryer (this will be separated in Step 2).

IMEFsavings[191] = Capacity * (IQAdj/IMEFbase - 1/IMEFeff) * Ncycles

Where

Capacity = Clothes Washer capacity (cubic feet)

= Actual. If capacity is unknown assume 3.55 cubic feet [192]

IQAdj = Baseline consumption adjustment for IQ program participants to account for a portion of participants who would have utilized the secondary market.[193]

= 1.28 if IQ (for PY 2024 - note this value will be updated to 1.02 in 2025 to account for the Federal Standard shift that occurred in 2015), 1.0 if non-IQ

---

[189] Calculated from Itron eShapes, 8760 hourly data by end use for Missouri, as provided by Ameren.

[190] **Definition provided on the ENERGY STAR website.**

[191] **IMEFsavings represents total kWh only when water heating and drying are 100% electric.**

[192] **Based on the average clothes washer volume of all units that pass the new Federal Standard on the California Energy Commission (CEC) database of Clothes Washer products accessed on 04/21/2022**. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area then that should be used.

[193] It is assumed that a second-hand unit is on average 1/3 of a measure's EUL years old (9 years). The baseline consumption of a unit meeting the pre 03/2015 Federal Standard was increased by an estimate of 0.4% * 9 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. For 2025 on, the post 03/2015 Federal Standard is utilized. 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.xls" for information.

IMEFbase = Integrated Modified Energy Factor of baseline unit

= 1.71[194]

IMEFeff = Integrated Modified Energy Factor of efficient unit

= Actual. If unknown assume average values provided below.

Ncycles = Number of Cycles per year

= 295[195]

IMEFsavings is provided below based on deemed values:[196]

Efficiency Level	IMEF	IMEF Savings (kWh)
Federal Standard	1.75	0.0
ENERGY STAR	2.21	139.6
ENERGY STAR Most Efficient/CEE Tier 2	2.92	254.8
CEE Advanced Tier	3.10	275.6

Break out savings calculated in Step 1 for electric DHW and electric dryer

ΔkWh = [Capacity * 1/IMEFbase * Ncycles * (%CWbase + (%DHWbase * %Electric_DHW) + (%Dryerbase * %Electric_Dryer))] - [Capacity * 1/IMEFeff * Ncycles * (%CWeff + (%DHWeff * %Electric_DHW) + (%Dryereff * %Electric_Dryer))]

Where:

%CW = Percentage of total energy consumption for Clothes Washer operation (different for baseline and efficient unit – see table below)

%DHW = Percentage of total energy consumption used for water heating (different for baseline and efficient unit – see table below)

%Dryer = Percentage of total energy consumption for dryer operation (different for baseline and efficient unit – see table below)

[194] 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 (products accessed on 04/21/2022).

[195] Weighted average of clothes washer cycles per year (based on 2009 Residential Energy Consumption Survey (RECS) national sample survey of housing appliances section, state of Illinois. 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.

[196] IMEF values are the weighted average of the new ENERGY STAR specifications. Weighting is based upon the relative top v front loading percentage of available ENERGY STAR and CEE Tier 2 products in the CEC database. See "IL TRM_CW Analysis_06202019.xlsx" for the calculation.

	Percentage of Total Energy Consumption[197]		
	%CW	%DHW	%Dryer
Baseline	6.7%	15.8%	77.5%
ENERGY STAR	6.6%	13.0%	80.4%
ENERGY STAR Most Efficient/CEE Tier 2	8.2%	8.8%	82.9%
CEE Advanced Tier	8.9%	7.0%	84.1%

%Electric_DHW = Percentage of DHW savings assumed to be electric

= 100 % for Electric

= 0 % for Fossil Fuel

= If unknown[198], use the following table:

	Location				
Utility	**Single Family**	**Single Family Low Income**	**Multi Family**	**Multi Family Low Income**	**Unknown**
Ameren[199]	24%	25%	40%	43%	28%
ComEd[200]	8%		11%		9%
People's Gas[201]	23%	26%	49%	50%	37%
Northshore Gas[202]	20%				
Nicor Gas[203]	20%				
All DUs					23%

Note: If a measure is supported by a gas and electric utility, utilize the assumptions above for the gas utility

%Electric_Dryer = Percentage of dryer savings assumed to be electric

[197] 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 calculation.

[198] Based on the average % electricity used for water heating in Unknown residential structure types across all utilities covered by the IL program. Residence types include: SF, SF LI, MF & MF LI. Utilities included: Ameren, ComEd, People's Gas, Northshore Gas & Nicor. Please see subsequent table and citations for specific sources.

[199] Provided by AEG from the 2020 Market Potential Study completed for AIC, as well as AIC Income Qualified Initiative: 2021 Participant Survey Results Memo (February 1, 2022) p. 17.

[200] Commonwealth Edison Residential Baseline Study (2020). p.4.4 & 4.19; Section 4-7 Water Heating. Prepared by Itron.

[201] Residential Appliance Saturation Survey of natural gas for space heating and water heating (2021). Note, Multifamily customers have a residential billing rate code and responded on the survey that they live in an apartment or condominium in a building that has either 2-4 or 5+ units.

[202] Ibid.

[203] Comparable service area & customers to NSG, therefore using their survey data.

Dryer fuel	%Electric_Dryer
Electric	100%
Natural Gas	0%
Unknown	69%[204]

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

	ΔkWH – Non IQ Participants								
	Electric DHW Electric Dryer	Gas DHW Electric Dryer	Electric DHW Gas Dryer	Gas DHW Gas Dryer	Electric DHW Unknown Dryer	Gas DHW Unknown Dryer	Unknown DHW Electric Dryer	Unknown DHW Gas Dryer	Unknown DHW Unknown Dryer
ENERGY STAR	139.6	104.3	45.3	10.1	110.3	75.1	114.2	19.9	85.0
ENERGY STAR Most Efficient/CEE Tier 2	254.8	189.4	77.1	11.7	199.7	134.4	207.7	30.0	152.7
CEE Advanced Tier	275.6	202.3	84.5	11.1	210.8	154.5	235.1	26.0	170.3

	ΔkWH –IQ Participants (2024)								
	Electric DHW Electric Dryer	Gas DHW Electric Dryer	Electric DHW Gas Dryer	Gas DHW Gas Dryer	Electric DHW Unknown Dryer	Gas DHW Unknown Dryer	Unknown DHW Electric Dryer	Unknown DHW Gas Dryer	Unknown DHW Unknown Dryer
ENERGY STAR	309.7	231.4	100.5	22.4	244.7	166.6	253.3	44.1	188.6
ENERGY STAR Most Efficient/CEE Tier 2	424.3	315.4	128.4	19.5	332.5	223.8	345.9	50.0	254.3
CEE Advanced Tier	445.0	326.7	136.4	17.9	340.4	249.5	379.6	42.0	275.0

	ΔkWH –IQ Participants (2025 on)								
	Electric DHW Electric Dryer	Gas DHW Electric Dryer	Electric DHW Gas Dryer	Gas DHW Gas Dryer	Electric DHW Unknown Dryer	Gas DHW Unknown Dryer	Unknown DHW Electric Dryer	Unknown DHW Gas Dryer	Unknown DHW Unknown Dryer
ENERGY STAR	153.3	114.5	49.7	11.1	121.1	82.5	125.4	21.9	93.3
ENERGY STAR Most Efficient/CEE Tier 2	268.4	199.5	81.2	12.3	210.4	141.6	218.8	31.6	160.9
CEE Advanced Tier	289.2	212.3	88.7	11.6	221.2	162.1	246.7	27.3	178.7

<u>Secondary kWh Savings for Water Supply and Wastewater Treatment</u>

The following savings should be included in the total savings for this measure but should not be included in TRC tests to avoid double counting the economic benefit of water savings.

$$\Delta kWh_{water} = \Delta Water\ (gallons) / 1{,}000{,}000 * E_{water\ total}$$

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

Where

ΔWater (gallons) = Water saved, in gallons – as calculated below.

$E_{water\ total}$ = IL Total Water Energy Factor (kWh/Million Gallons)

=5,010[205]

Using defaults provided:

ENERGY STAR ΔkWh_{water} = 1,595/1,000,000 * 5,010

= 8.0 kWh [13.6 kWh for IQ (2024), 8.5 kWh for IQ (2025 on)]

ENERGY STAR Most Efficient/CEE Tier 2 ΔkWh_{water} = 2,500/1,000,000 * 5,010

= 12.5 kWh [18.2 kWh for IQ (2024), 13.1 kWh for IQ (2025 on)]

CEE Advanced Tier ΔkWh_{water} = 2,709/1,000,000 * 5,010

= 13.6 kWh [19.3 kWh for IQ (2024), 14.2 kWh for IQ (2025 on)]

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ΔkWh/Hours * CF

Where:

ΔkWh = Energy Savings as calculated above. Note do not include the secondary savings in this calculation.

Hours = Assumed Run hours of Clothes Washer

= 295 hours[206]

CF = Summer Peak Coincidence Factor for measure.

= 0.038[207]

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

[205] This factor include 2571 kWh/MG for water supply based on Illinois energy intensity data from a 2012 ISAWWA study and 2439 kWh/MG for wastewater treatment based on national energy intensity use estimates. For more information please review Elevate Energy's 'IL TRM: Energy per Gallon Factor, May 2018 paper'.

[206] Based on a weighted average of 295 clothes washer cycles per year assuming an average load runs for one hour (2009 Residential Energy Consumption Survey (RECS) national sample survey of housing appliances section, Midwest Census Region, data for the state of Illinois)

[207] Calculated from Itron eShapes, 8760 hourly data by end use for Missouri, as provided by Ameren.

	ΔkW- Non IQ Participants								
	Electric DHW Electric Dryer	Gas DHW Electric Dryer	Electric DHW Gas Dryer	Gas DHW Gas Dryer	Electric DHW Unknown Dryer	Gas DHW Unknown Dryer	Unknown DHW Electric Dryer	Unknown DHW Gas Dryer	Unknown DHW Unknown Dryer
ENERGY STAR	0.0180	0.0134	0.0058	0.0013	0.0142	0.0097	0.0147	0.0026	0.0109
ENERGY STAR Most Efficient/CEE Tier 3	0.0328	0.0244	0.0099	0.0015	0.0257	0.0173	0.0268	0.0039	0.0197
CEE Advanced Tier	0.0355	0.0261	0.0109	0.0014	0.0272	0.0199	0.0303	0.0034	0.0219

	ΔkW- IQ Participants (2024)								
	Electric DHW Electric Dryer	Gas DHW Electric Dryer	Electric DHW Gas Dryer	Gas DHW Gas Dryer	Electric DHW Unknown Dryer	Gas DHW Unknown Dryer	Unknown DHW Electric Dryer	Unknown DHW Gas Dryer	Unknown DHW Unknown Dryer
ENERGY STAR	0.0399	0.0298	0.0129	0.0029	0.0315	0.0215	0.0326	0.0057	0.0243
ENERGY STAR Most Efficient/CEE Tier 3	0.0547	0.0406	0.0165	0.0025	0.0428	0.0288	0.0446	0.0064	0.0328
CEE Advanced Tier	0.0573	0.0421	0.0176	0.0023	0.0438	0.0321	0.0489	0.0054	0.0354

	ΔkW- IQ Participants (2025 on)								
	Electric DHW Electric Dryer	Gas DHW Electric Dryer	Electric DHW Gas Dryer	Gas DHW Gas Dryer	Electric DHW Unknown Dryer	Gas DHW Unknown Dryer	Unknown DHW Electric Dryer	Unknown DHW Gas Dryer	Unknown DHW Unknown Dryer
ENERGY STAR	0.0197	0.0148	0.0064	0.0014	0.0156	0.0106	0.0162	0.0028	0.0120
ENERGY STAR Most Efficient/CEE Tier 3	0.0346	0.0257	0.0105	0.0016	0.0271	0.0182	0.0282	0.0041	0.0207
CEE Advanced Tier	0.0373	0.0273	0.0114	0.0015	0.0285	0.0209	0.0318	0.0035	0.0230

FOSSIL FUEL SAVINGS

Break out savings calculated in Step 1 of electric energy savings (MEF savings) and extract Natural Gas DHW and Natural Gas dryer savings from total savings:

ΔTherm = [(Capacity * IQAdj/IMEFbase * Ncycles * ((%DHWbase * %Fossil_DHW * R_eff) + (%Dryerbase * %Gas _Dryer))) – (Capacity * 1/IMEFeff * Ncycles * ((%DHWeff * %Fossil_DHW * R_eff) + (%Dryereff * %Gas_Dryer)))] * Therm_convert

Where:

Therm_convert = Convertion factor from kWh to Therm

= 0.03412

R_eff = Recovery efficiency factor

= 1.26[208]

%Fossil_DHW = Percentage of DHW savings assumed to be Fossil Fuel

= 100 % for Fossil fuel

= 0 % for Electric

= If unknown[209], use the following table:

	Location				
Utility	Single Family	Single Family Low Income	Multi Family	Multi Family Low Income	Unknown
Ameren[210]	76%	75%	60%	57%	72%
ComEd[211]	92%		89%		91%
People's Gas[212]	77%	74%	51%	50%	63%
Northshore Gas[213]	80%				
Nicor Gas[214]	80%				
All DUs					**77%**

Note: If a measure is supported by a gas and electric utility, utilize the assumptions above for the gas utility

%Fossil_Dryer = Percentage of dryer savings assumed to be fossil fuel

Dryer fuel	%Gas_Dryer
Electric	0%
Fossil Fuel	100%
Unknown	31%[215]

Other factors as defined above.

Using the default/unknown assumptions provided above, the prescriptive savings for each configuration are

[208] 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 (see ENERGY STAR Waste Water Recovery Guidelines). Therefore a factor of 0.98/0.78 (1.26) is applied.

[209] Based on the average % electricity used for water heating in Unknown residential structure types across all utilities covered by the IL program. Residence types include: SF, SF LI, MF & MF LI. Utilities included: Ameren, ComEd, People's Gas, Northshore Gas & Nicor. Please see subsequent table and citations for specific sources.

[210] Provided by AEG from the 2020 Market Potential Study completed for AIC, as well as AIC Income Qualified Initiative: 2021 Participant Survey Results Memo (February 1, 2022) p. 17.

[211] Commonwealth Edison Residential Baseline Study (2020). p.4.4 & 4.19; Section 4-7 Water Heating. Prepared by Itron.

[212] Residential Appliance Saturation Survey of natural gas for space heating and water heating (2021). Note, Multifamily customers have a residential billing rate code and responded on the survey that they live in an apartment or condominium in a building that has either 2-4 or 5+ units.

[213] Ibid.

[214] Comparable service area & customers to NSG, therefore using their survey data.

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

presented below:

	ΔTherms – Non IQ Participants								
	Electric DHW Electric Dryer	Gas DHW Electric Dryer	Electric DHW Gas Dryer	Gas DHW Gas Dryer	Electric DHW Unknown Dryer	Gas DHW Unknown Dryer	Unknown DHW Electric Dryer	Unknown DHW Gas Dryer	Unknown DHW Unknown Dryer
ENERGY STAR	0.0	1.5	3.2	4.7	1.0	2.5	1.1	4.3	2.1
ENERGY STAR Most Efficient/CEE Tier 2	0.0	2.8	6.1	8.9	4.7	4.7	2.0	8.1	3.9
CEE Advanced Tier	0.0	3.2	6.5	9.7	4.6	4.6	1.7	8.9	4.0

	ΔTherms – IQ Participants (2024)								
	Electric DHW Electric Dryer	Gas DHW Electric Dryer	Electric DHW Gas Dryer	Gas DHW Gas Dryer	Electric DHW Unknown Dryer	Gas DHW Unknown Dryer	Unknown DHW Electric Dryer	Unknown DHW Gas Dryer	Unknown DHW Unknown Dryer
ENERGY STAR	0	3.3	7.1	10.4	2.2	5.5	2.4	9.5	4.7
ENERGY STAR Most Efficient/CEE Tier 2	0	4.7	10.2	14.8	7.8	7.8	3.3	13.5	6.5
CEE Advanced Tier	0	5.2	10.5	15.7	7.4	7.4	2.7	14.4	6.5

	ΔTherms – IQ Participants (2025 on)								
	Electric DHW Electric Dryer	Gas DHW Electric Dryer	Electric DHW Gas Dryer	Gas DHW Gas Dryer	Electric DHW Unknown Dryer	Gas DHW Unknown Dryer	Unknown DHW Electric Dryer	Unknown DHW Gas Dryer	Unknown DHW Unknown Dryer
ENERGY STAR	0	1.6	3.5	5.2	1.1	2.7	1.2	4.7	2.3
ENERGY STAR Most Efficient/CEE Tier 2	0	2.9	6.4	9.4	5.0	5.0	2.1	8.5	4.1
CEE Advanced Tier	0	3.4	6.8	10.2	4.8	4.8	1.8	9.3	4.2

WATER IMPACT DESCRIPTIONS AND CALCULATION

$$\Delta Water\ (gallons) = Capacity * ((IWFbase * IQAdj_{Water}) - IWFeff) * Ncycles$$

Where

ΔWater (gallons) = Water saved, in gallons

IWFbase = Integrated Water Factor of baseline clothes washer

= 5.59[216]

$IQAdj_{Water}$ = Baseline water consumption adjustment for IQ program participants to account for a

[216] Weighted average IWF 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 (products accessed on 04/21/2022).

portion of participants who would have utilized the secondary market.[217]

= 1.19 if IQ (for PY 2024 - note this value will be updated to 1.02 in 2025 to account for the Federal Standard shift that occurred in 2015), 1.0 if non-IQ

IWFeff = Water Factor of efficient clothes washer

= Actual. If unknown assume average values provided below.

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

Efficiency Level	IWF	ΔWater (gallons per year)		
		Non-IQ	IQ (2024)	IQ (2025 on)
Federal Standard	5.59	N/A	N/A	N/A
ENERGY STAR	4.07	1,595	2,722	1,706
ENERGY STAR Most Efficient/CEE Tier 2	3.2	2,500	3,633	2,617
CEE Advanced Tier	3	2,709	3,842	2,826

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-APL-ESCL-V12-240101

REVIEW DEADLINE: 1/1/2025

[217] It is assumed that a second-hand unit is on average 1/3 of a measure's EUL years old (9 years). The baseline consumption from the TRM in 2015 is assumed the second hand water consumption (note we do no assume a degradation over time for water consumption) was then weighted 1/3: 2/3 current new baseline to estimate a multiplier for IQ participants. See "IQ Appliance Calculations.xls" for information.

5.1.4 ENERGY STAR Dishwasher

DESCRIPTION

A standard or compact residential dishwasher meeting ENERGY STAR standards is installed in place of a model meeting the federal standard.

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

DEFINITION OF EFFICIENT EQUIPMENT

The efficient equipment is defined as a standard or compact dishwasher meeting the ENERGY STAR standards presented in the table below.

ENERGY STAR Requirements (Version 7.0, Effective July 19, 2023)

Dishwasher Type	Maximum kWh/year	Maximum gallons/cycle
Standard (≥ 8 place settings + six serving pieces)	240	3.2
Standard with Connected Functionality[218]	252	
Compact (< 8 place settings + six serving pieces)	155	2.0

DEFINITION OF BASELINE EQUIPMENT

The baseline reflects the minimum federal efficiency standards for dishwashers effective May 30, 2013, as presented in the table below.

Dishwasher Type	Maximum kWh/year	Maximum gallons/cycle
Standard	307	5.0
Compact	222	3.5

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The assumed lifetime of the measure is 11 years.[219]

DEEMED MEASURE COST

The incremental cost for standard and compact dishwashers is provided in the table below:[220]

[218] The ENERGY STAR specification "establishes optional connected criteria for dishwashers. ENERGY STAR certified dishwashers with connected functionality offer favorable attributes for demand response programs to consider, since their peak energy consumption is relatively high, driven by water heating. ENERGY STAR certified dishwashers with connected functionality will offer consumers new convenience and energy-saving features, such as alerts for cycle completion and/or recommended maintenance, as well as feedback on the energy use of the product". See 'ENERGY STAR Residential Dishwasher Final Version 6.0 Cover Memo.pdf'. Calculated as per Version 6.0 specification; "ENERGY STAR Residential Dishwasher Version 6.0 Final Program Requirements.pdf". As of July 2021, Version 7.0 specification is still under development. Note that the potential for demand response and additional peak savings from units with Connected Functionality have not been explored. This could be a potential addition in a future version.

[219] Measure lifetime from California DEER. See file California DEER 2014-EUL Table - 2014 Update.xlsx.

[220] Costs are based on data from U.S. DOE, Final Rule Life-Cycle Cost (LCC) Spreadsheet. See file Residential Dishwasher Analysis_Nov2017.xlsx for cost calculation details.

Dishwasher Type	Baseline Cost		ENERGY STAR Cost	Incremental Cost	
	Non-IQ	IQ[221]		Non-IQ	IQ
Standard	$255.63	$213.03	$331.30	$75.67	$118.28
Compact	$290.13	$241.78	$308.62	$18.49	$66.85

LOADSHAPE

Loadshape R02 - Residential Dish Washer

COINCIDENCE FACTOR

The coincidence factor is assumed to be 2.6%.[222]

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh^{223} = ((kWh_{Base} - kWh_{ESTAR}) * (\%kWh\_op + (\%kWh\_heat * \%Electric\_DHW)))$$

Where:

kWh_{BASE} = Baseline kWh consumption per year

Dishwasher Type	Maximum kWh/year	
	Non-IQ	IQ[224]
Standard	307	310
Compact	222	224

kWh_{ESTAR} = ENERGY STAR kWh annual consumption

Dishwasher Type	Maximum kWh/year
Standard	240
Standard with Connected Functionality	252
Compact	155

[221] 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.xls" for information.

[222] Calculated from Itron eShapes, 8760 hourly data by end use for Missouri, as provided by Ameren.

[223] The Federal Standard and ENERGY STAR annual consumption values include electric consumption for both the operation of the machine and for heating the water that is used by the machine.

[224] It is assumed that a second-hand unit is on average 1/3 of a measure's EUL years old (7 years). There has been no new Federal Standard in that period but new unit baseline consumption is increased by an estimate of 0.4% * 7 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.xls" for information.

%kWh_op = Percentage of dishwasher energy consumption used for unit operation

= 100 - 56%[225]

= 44%

%kWh_heat = Percentage of dishwasher energy consumption used for water heating

= 56%[226]

%Electric_DHW = Percentage of DHW savings assumed to be electric

= 100 % for Electric

= 0 % for Fossil Fuel

= If unknown[227], use the following table:

	Location				
Utility	**Single Family**	**Single Family Low Income**	**Multi Family**	**Multi Family Low Income**	**Unknown**
Ameren[228]	24%	25%	40%	43%	28%
ComEd[229]	8%		11%		9%
People's Gas[230]	23%	26%	49%	50%	37%
Northshore Gas[231]	20%				
Nicor Gas[232]	20%				
All DUs					23%

Note: If a measure is supported by a gas and electric utility, utilize the assumptions above for the gas utility

[225] ENERGY STAR Qualified Appliance Savings Calculator, last updated October 2016.
[226] Ibid.
[227] Based on the average % electricity used for water heating in Unknown residential structure types across all utilities covered by the IL program. Residence types include: SF, SF LI, MF & MF LI. Utilities included: Ameren, ComEd, People's Gas, Northshore Gas & Nicor. Please see subsequent table and citations for specific sources.
[228] Provided by AEG from the 2020 Market Potential Study completed for AIC, as well as AIC Income Qualified Initiative: 2021 Participant Survey Results Memo (February 1, 2022) p. 17.
[229] Commonwealth Edison Residential Baseline Study (2020). p.4.4 & 4.19; Section 4-7 Water Heating. Prepared by Itron.
[230] Residential Appliance Saturation Survey of natural gas for space heating and water heating (2021). Note, Multifamily customers have a residential billing rate code and responded on the survey that they live in an apartment or condominium in a building that has either 2-4 or 5+ units.
[231] Ibid.
[232] Comparable service area & customers to NSG, therefore using their survey data.

Dishwasher Type	ΔkWh - Non IQ			ΔkWh - IQ		
	With Electric DHW	With Gas DHW	With Unknown location and building type DHW	With Electric DHW	With Gas DHW	With Unknown location and building type DHW
ENERGY STAR Standard	67	29.5	38.1	69.8	30.7	39.8
ENERGY STAR Standard with Connected Functionality	55	24.2	31.3	57.8	25.4	33.0
ENERGY STAR Compact	67	29.5	38.1	69.1	30.4	39.2

<u>Secondary kWh Savings for Water Supply and Wastewater Treatment</u>

The following savings should be included in the total savings for this measure but should not be included in TRC tests to avoid double counting the economic benefit of water savings.

$$\Delta kWh_{water} = \Delta Water\ (gallons) / 1{,}000{,}000 * E_{water\ total}$$

Where

$E_{water\ total}$ = IL Total Water Energy Factor (kWh/Million Gallons)

=5,010[233]

Using defaults provided:

Standard ΔkWh_{water} = 252/1,000,000 * 5,010

= 1.3 kWh

Compact ΔkWh_{water} = 67/1,000,000 * 5,010

= 0.3 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS[234]

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

Where:

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

[233] This factor include 2571 kWh/MG for water supply based on Illinois energy intensity data from a 2012 ISAWWA study and 2439 kWh/MG for wastewater treatment based on national energy intensity use estimates. For more information please review Elevate Energy's 'IL TRM: Energy per Gallon Factor, May 2018 paper'.

[234] Note that the potential for demand response and additional peak savings from units with Connected Functionality have not been explored. This could be a potential addition in a future version.

Hours = Annual operating hours[235]

= 353 hours

CF = Summer Peak Coincidence Factor

= 2.6% [236]

Dishwasher Type	ΔkW - Non IQ			ΔkW - IQ		
	With Electric DHW	With Gas DHW	With Unknown location and building type DHW	With Electric DHW	With Gas DHW	With Unknown location and building type DHW
ENERGY STAR Standard	0.0049	0.0022	0.0028	0.0051	0.0023	0.0029
ENERGY STAR Standard with Connected Functionality	0.0041	0.0018	0.0023	0.0043	0.0019	0.0024
ENERGY STAR Compact	0.0049	0.0022	0.0028	0.0051	0.0022	0.0029

FOSSIL FUEL SAVINGS

$$\Delta \text{Therm} = (kWh_{Base} - kWh_{ESTAR}) * \%kWh\_heat * \%Fossil\_DHW * R\_eff * 0.03412$$

Where

%kWh_heat = % of dishwasher energy used for water heating

= 56%

%Fossil_DHW = Percentage of DHW savings assumed to be fossil fuel

= 100 % for Fossil Fuel

= 0 % for Electric

= If unknown[237], use the following table:

Utility	Location				
	Single Family	Single Family Low Income	Multi Family	Multi Family Low Income	Unknown
Ameren[238]	76%	75%	60%	57%	72%

---

235 Assuming 2.1 hours per cycle and 168 cycles per year therefore 353 operating hours per year. 168 cycles per year is based on a weighted average of dishwasher usage in Illinois derived from the 2009 RECs data.

236 End use data from Ameren representing the average DW load during peak hours/peak load.

237 Based on the average % electricity used for water heating in Unknown residential structure types across all utilities covered by the IL program. Residence types include: SF, SF LI, MF & MF LI. Utilities included: Ameren, ComEd, People's Gas, Northshore Gas & Nicor. Please see subsequent table and citations for specific sources.

238 Provided by AEG from the 2020 Market Potential Study completed for AIC, as well as AIC Income Qualified Initiative: 2021 Participant Survey Results Memo (February 1, 2022) p. 17.

	Location				
Utility	Single Family	Single Family Low Income	Multi Family	Multi Family Low Income	Unknown
ComEd[239]	92%		89%		91%
People's Gas[240]	77%	74%	51%	50%	63%
Northshore Gas[241]	80%				
Nicor Gas[242]	80%				
All DUs					**77%**

Note: If a measure is supported by a gas and electric utility, utilize the assumptions above for the gas utility

R_eff = Recovery efficiency factor

= 1.26[243]

0.03412 = factor to convert from kWh to Therm

Dishwasher Type	ΔTherms - Non IQ			ΔTherms - IQ		
	With Electric DHW	With Gas DHW	With Unknown location and building type DHW	With Electric DHW	With Gas DHW	With Unknown location and building type DHW
ENERGY STAR Standard	0	1.61	1.24	0	1.68	1.28
ENERGY STAR Standard with Connected Functionality	0	1.32	1.02	0	1.39	1.06
ENERGY STAR Compact	0	1.61	1.24	0	1.66	1.26

WATER IMPACT DESCRIPTIONS AND CALCULATION

$\Delta Water\ (gallons) = Water_{Base} - Water_{EFF}$

Where

$Water_{Base}$ = water consumption of conventional unit

[239] Commonwealth Edison Residential Baseline Study (2020). p.4.4 & 4.19; Section 4-7 Water Heating. Prepared by Itron.

[240] Residential Appliance Saturation Survey of natural gas for space heating and water heating (2021). Note, Multifamily customers have a residential billing rate code and responded on the survey that they live in an apartment or condominium in a building that has either 2-4 or 5+ units.

[241] Ibid.

[242] Comparable service area & customers to NSG, therefore using their survey data.

[243] 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 (see ENERGY STAR Waste Water Heat Recovery Guidelines). Therefore a factor of 0.98/0.78 (1.26) is applied.

Dishwasher Type	$Water_{Base}$ (gallons) [244]
Standard	840
Compact	588

$Water_{EFF}$ = annual water consumption of efficient unit:

Dishwasher Type	$Water_{EFF}$ (gallons) [245]
Standard	538
Compact	336

Dishwasher Type	ΔWater (gallons)
ENERGY STAR Standard	302
ENERGY STAR Compact	252

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-APL-ESDI-V10-240101

REVIEW DEADLINE: 1/1/2025

[244] Assuming maximum allowed from specifications and 168 cycles per year based on a weighted average of dishwasher usage in Illinois derived from the 2009 RECs data.

[245] Ibid

5.1.7 ENERGY STAR and CEE Tier 2 Room Air Conditioner

DESCRIPTION

This measure relates to:

> Time of Sale the purchase and installation of a room air conditioning unit that meets ENERGY STAR version 5.0, which is effective October 30th 2023[246], or CEE Tier 2 minimum qualifying efficiency specifications, in place of a baseline unit. The baseline is based on the Federal Standard effective June 1st, 2014.

<table>
<tr><th colspan="2">Product Type and Class (Btu/hr)</th><th>Federal Standard with louvered sides (CEER) [247]</th><th>Federal Standard without louvered sides (CEER)</th><th>ENERGY STAR v5.0 with louvered sides (CEER) [248]</th><th>ENERGY STAR v5.0 without louvered sides (CEER)</th><th>CEE Tier 2 (CEER)[249]</th></tr>
<tr><td rowspan="7">Without Reverse Cycle</td><td>< 6,000</td><td rowspan="2">11.0</td><td rowspan="2">10.0</td><td>13.1</td><td rowspan="2">12.8</td><td rowspan="2">14.85</td></tr>
<tr><td>6,000 - 7,999</td><td>13.7</td></tr>
<tr><td>8,000 to 10,999</td><td>10.9</td><td>9.6</td><td>14.7</td><td>13.0</td><td>14.72</td></tr>
<tr><td>11,000 to 13,999</td><td>10.9</td><td>9.5</td><td>14.7</td><td>12.8</td><td>14.72</td></tr>
<tr><td>14,000 to 19,999</td><td>10.7</td><td>9.3</td><td>14.4</td><td>12.6</td><td>14.45</td></tr>
<tr><td>20,000 to 27,999</td><td>9.4</td><td>9.4</td><td>12.7</td><td>12.7</td><td>12.69</td></tr>
<tr><td>>=28,000</td><td>9.0</td><td>9.4</td><td>12.2</td><td>12.7</td><td>12.15</td></tr>
<tr><td rowspan="3">With Reverse Cycle</td><td><14,000</td><td>9.8</td><td>9.3</td><td>13.2</td><td>12.6</td><td>N/A</td></tr>
<tr><td>14,000 to 19,999</td><td>9.8</td><td>8.7</td><td>13.2</td><td>11.7</td><td>N/A</td></tr>
<tr><td>>=20,000</td><td>9.3</td><td>8.7</td><td>12.6</td><td>11.7</td><td>N/A</td></tr>
<tr><td colspan="2">Casement only</td><td colspan="2">9.5</td><td colspan="2">12.8</td><td></td></tr>
<tr><td colspan="2">Casement-Slider</td><td colspan="2">10.4</td><td colspan="2">14.0</td><td></td></tr>
</table>

Side louvers 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.

a) Early Replacement: the early removal of an existing residential inefficient Room AC unit from service, prior to its natural end of life, and replacement with a new ENERGY STAR qualifying unit. Savings are calculated between existing unit and efficient unit consumption during the remaining life of the existing unit, and between new baseline unit and efficient unit consumption for the remainder of the measure life.

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

[246] ENERGY STAR Version 5.0 Room Air Conditioners Program Requirements

[247] See DOE's Appliance and Equipment Standards for Room AC;

[248] ENERGY STAR Version 5.0 Room Air Conditioners Program Requirements

[249] The Consortium for Energy Efficiency Super Efficient Home Appliance Initiative, Room Air Conditioner Specification, CEE Advanced Tier (CEER), effective May 17, 2022. Please see file "CEE_RoomAC_Specification_17May2022.pdf". https://cee1.org/images/pdf/CEE_RoomAC_Specification_17May2022.pdf

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 version 5.0, which is effective October 30th 2023[250], efficiency standards presented above.

DEFINITION OF BASELINE EQUIPMENT

Time of Sale: the baseline assumption is a new room air conditioning unit that meets the Federal Standard (effective June 1st, 2014)[251] efficiency standards as presented above.

Early Replacement: the baseline is the existing Room AC 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 measure life is assumed to be 12 years.[252]

Remaining life of existing equipment is assumed to be 4 years.[253]

DEEMED MEASURE COST

Time of Sale: The incremental cost for this measure is assumed to be $40 for an ENERGY STAR unit and $261 for a CEE Tier 2 unit.[254]

Early Replacement: 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 unavailable assume $448 for ENERGY STAR unit and $669 for CEE Tier 2 unit.[255]

The avoided replacement cost (after 4 years) of a baseline replacement unit is $432.[256] This cost should be discounted to present value using the nominal societal discount rate.

LOADSHAPE

Loadshape R08 - Residential Cooling

COINCIDENCE FACTOR

The coincidence factor for this measure is assumed to be 0.3.[257]

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[250] ENERGY STAR Version 5.0 Room Air Conditioners Program Requirements

[251] See DOE's Appliance and Equipment Standards for Room AC.

[252] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007.

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

[254] ENERGY STAR cost based on field study conducted by Efficiency Vermont and Tier 2 based on Efficiency Vermont's characterization of the NEEP Mid-Atlantic TRM's (version 9.0, October 2019) incremental cost analysis. See 'room-ac-cost-analysis-10.2023.xlsx.'

[255] ENERGY STAR based on IL PHA Efficient Living Program Data for 810 replaced units showing $416 per unit plus $32 average recycling/removal cost. Differential in cost for the CEE Tiers is $221, therefore CEE Tier 2 is $448 + 221 = $669.

[256] Estimate based upon Time of Sale incremental costs and applying inflation rate of 1.91%.

[257] Consistent with coincidence factors found in: RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

Time of Sale: ΔkWh = $(FLH_{RoomAC} * Btu/H * (1/CEERbase - 1/CEERee))/1000$

Early Replacment:

ΔkWh for remaining life of existing unit (1^{st} 4 years) = $(FLH_{RoomAC} * Btu/H * (1/(EERexist/1.01) - 1/CEERee))/1000$

ΔkWh for remaining measure life (next 8 years) = $(FLH_{RoomAC} * Btu/H * (1/CEERbase - 1/CEERee))/1000$

Where:

FLH_{RoomAC} = Full Load Hours of room air conditioning unit

= dependent on location:[258]

Climate Zone (City based upon)	FLH_{RoomAC}
1 (Rockford)	235
2 (Chicago)	261
3 (Springfield)	340
4 (Belleville)	447
5 (Marion)	396
Weighted Average[259]	
ComEd	256
Ameren	364
Statewide	286

Btu/H = Size of rebated unit

= Actual. If unknown assume 8500 Btu/hr[260]

EERexist =Efficiency of existing unit

[258] Full load hours for room AC is significantly lower than for central AC. The average ratio of FLH for Room AC (provided in RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008) to FLH for Central Cooling for the same location is 31%. This ratio is applied to those IL cities that have FLH for Central Cooling provided in the ENERGY STAR calculator. For other cities this is extrapolated using the FLH assumptions VEIC have developed for Central AC. There is a county mapping table in Volume 1, Section 3.7 providing the appropriate city to use for each county of Illinois.

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

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

= Actual. If unknown assume 7.7 [261]

1.01 = Factor to convert EER to CEER (CEER includes standby and off power consumption)[262]

CEERbase = Combined Energy Efficiency Ratio of baseline unit

= As provided in tables above

CEERee = Combined Energy Efficiency Ratio of CEE Tier 1 or ENERGY STAR unit

= Actual. If unknown, assume minimum qualifying standard as provided in tables above

Time of Sale:

For example, for an 8,500 Btu/H capacity unit, with louvered sides, in an unknown location:

$\Delta kWH_{ENERGY\ STAR}$ = (286 * 8500 * (1/10.9 – 1/14.7)) / 1000

= 57.7 kWh

Early Replacement:

For example, a 7.7EER, 9000Btu/h unit is removed from a home in Springfield and replaced with an ENERGY STAR unit with louvered sides:

ΔkWh for remaining life of existing unit (1st 4 years) = (340 * 9000 * (1/(7.7/1.01) - 1/14.7))/1000

= 193.2 kWh

ΔkWh for remaining measure life (next 8 years) = (340 * 9000 * (1/10.9 - 1/14.7))/1000

= 72.6 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

Time of Sale: ΔkW = Btu/H * ((1/(CEERbase *1.01) - 1/(CEERee * 1.01)))/1000) * CF

Early Replacement: ΔkW = Btu/H * ((1/EERexist - 1/(CEERee * 1.01)))/1000) * CF

Where:

CF = Summer Peak Coincidence Factor for measure

= 0.3[263]

= Factor to convert CEER to EER (CEER includes standby and off power consumption)[264]

Other variable as defined above

[261] Based on Nexus Market Research Inc, RLW Analytics, December 2005; "Impact, Process, and Market Study of the Connecticut Appliance Retirement Program: Overall Report."

[262] Since the existing unit will be rated in EER, this factor is used to appropriately compare with the new CEER rating. Version 3.0 of the ENERGY STAR specification provided equivalent EER and CEER ratings and for the most popular size band the EER rating is approximately 1% higher than the CEER. See 'ENERGY STAR Version 3.0 Room Air Conditioners Program Requirements'.

[263] Consistent with coincidence factors found in: RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008

[264] Since the new CEER rating includes standby and off power consumption, for peak calculations it is more appropriate to apply the EER rating, but it appears as though new units will only be rated with a CEER rating. Version 3.0 of the ENERGY STAR specification provided equivalent EER and CEER ratings and for the most popular size band the EER rating is approximately 1% higher than the CEER. See 'ENERGY STAR Version 3.0 Room Air Conditioners Program Requirements'.

Time of Sale:

For example, for an 8,500 Btu/H capacity unit, with louvered sides, for an unknown location:

$\Delta kW_{ENERGY\ STAR}$ = ((8500 * (1/(10.9 * 1.01) – 1/(14.7*1.01))) / 1000) * 0.3

= 0.060 kW

Early Replacement:

For example, a 7.7 EER, 9000Btu/h unit is removed from a home in Springfield and replaced with an ENERGY STAR unit with louvered sides:

ΔkW for remaining life of existing unit (1st 4 years) = ((9000 * (1/7.7 - 1/(14.7 * 1.01)))/1000) * 0.3

= 0.169 kW

ΔkW for remaining measure life (next 8 years) = ((9000 * (1/(10.9 * 1.01) - 1/(14.7 * 1.01)))/1000) * 0.3

= 0.063 kW

FOSSIL FUEL SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-APL-ESRA-V11-240101

REVIEW DEADLINE: 1/1/2026

5.1.12 Ozone Laundry

Description

A new ozone laundry system is added-on to new or existing residential clothes washing machine(s) or washing machines located in multifamily building common areas. The system generates ozone (O_3), a naturally occurring molecule, which helps clean fabrics by chemically reacting with soils in cold water. Adding an ozone laundry system(s) eliminate the use of chemicals, detergents, and hot water by residential washing machine(s).

Energy savings will be achieved at the domestic hot water heater as it will no longer supply hot water to the washing machine. Cold water usage by the clothes washer will increase, but overall water usage will stay constant.

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

Definition of Efficient Equipment

A new, single-unit ozone laundry system(s) rated for residential clothes washing machines is added-on to new or existing residential clothes washing machines. The ozone laundry system must be connected to both the hot and cold water inlets of the clothes washing machine so that hot water from the domestic hot water heater is no longer provided to the clothes washer.

The ozone laundry system(s) must transfer ozone into the water through:

- Venturi injection
- Bubble diffusion
- Additional applications may be considered upon program review and approval on a case by case basis

Definition of Baseline Equipment

The base case equipment is a conventional residential washing machine with no ozone generator installed. The washing machine is provided hot water from a domestic hot water heater.

Deemed Lifetime of Efficient Equipment

The measure equipment effective useful life (EUL) is estimated at 8 years based on the typical lifetime of products currently available in the market.[265]

Deemed Measure Cost

The deemed measure cost is $300 for a new single-unit ozone laundry system.[266]

Loadshape

Loadshape R01 – Residential Clothes Washer

Coincidence Factor

The coincidence factor for this measure is 3.8%.[267]

[265] Average based on conversations with manufacturers and distributors of the four residential ozone laundry systems tested in the 2018 GTI Residential Ozone Laundry Field Demonstration (O3 Pure, Pure Wash, Eco Washer, Scent Crusher).
[266] 2018 GTI Residential Ozone Laundry Field Demonstration (May 2018).
[267] Calculated from Itron eShapes, 8760 hourly data by end use for Missouri, as provided by Ameren.

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS

$\Delta kWh = kWhHotWash * (\%HotWash_{base} - \%HotWash_{Ozone})$

Where:

kWhHotWash = (%ElectricDHW * Capacity * IWF * %HotWater * (T_{OUT} - T_{IN}) * 8.33 * 1.0 * Ncycles) / (RE_electric * 3.412)

%ElectricDHW = Proportion of water heating supplied by electric heating

= 100 % for Electric

= 0 % for Fossil Fuel

= If unknown[268], use the following table:

	Location				
Utility	Single Family	Single Family Low Income	Multi Family	Multi Family Low Income	Unknown
Ameren[269]	24%	25%	40%	43%	28%
ComEd[270]	8%		11%		9%
People's Gas[271]	23%	26%	49%	50%	37%
Northshore Gas[272]	20%				
Nicor Gas[273]	20%				
All DUs					**23%**

Note: If a measure is supported by a gas and electric utility, utilize the assumptions above for the gas utility

Capacity = Clothes washer capacity (cubic feet).

[268] Based on the average % electricity used for water heating in Unknown residential structure types across all utilities covered by the IL program. Residence types include: SF, SF LI, MF & MF LI. Utilities included: Ameren, ComEd, People's Gas, Northshore Gas & Nicor. Please see subsequent table and citations for specific sources.

[269] Provided by AEG from the 2020 Market Potential Study completed for AIC, as well as AIC Income Qualified Initiative: 2021 Participant Survey Results Memo (February 1, 2022) p. 17.

[270] Commonwealth Edison Residential Baseline Study (2020). p.4.4 & 4.19; Section 4-7 Water Heating. Prepared by Itron.

[271] Residential Appliance Saturation Survey of natural gas for space heating and water heating (2021). Note, Multifamily customers have a residential billing rate code and responded on the survey that they live in an apartment or condominium in a building that has either 2-4 or 5+ units.

[272] Ibid.

[273] Comparable service area & customers to NSG, therefore using their survey data.

= Actual. If unknown, assume 5.0 cubic feet.[274]

IWF = Integrated water factor (gallons/cycle/ft^3).

= Actual. If unknown, use the following values

Efficiency Level	IWF (gallons/cycle/ft3)	
	Top loading > 2.5 Cu ft	Front Loading > 2.5 Cu ft
Federal Standard (up to January 1, 2018)	8.4	4.7
Federal Standard (after January 1, 2018) – Use if unit level is unknown.	6.5	4.7
ENERGY STAR (as of February 2018)	4.3	3.2
CEE Tier 2	3.2	3.2

%HotWater = Percentage of water usage that is supplied by the domestic hot water heater when the hot or warm wash cycles are selected.[275]

Single-Family Home	Multifamily
0.1759	0.2960

T_{OUT} = Tank temperature

= 125°F

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

= 50.7°F [276]

8.33 = Specific weight of water (lbs/gallon)

1.0 = Heat capacity of water (Btu/lb °F)

Ncycles = Number of Cycles per year

[274] Average data from GTI Residential Ozone Laundry Field Demonstration (May 2018). As an add on to existing equipment it is assumed this is a larger capacity than the assumption for new Clothes Washers as old machines tended to have larger capacities. See 'Residential Ozone Summary Calcs_2019.xlsx' and 'Multifamily Ozone Summary Calcs_2019.xlsx' for more information. 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.

[275] Averaged data from GTI Residential Ozone Laundry Field Demonstration (May 2018). Hot and warm wash cycles were combined because data from the EIA Residential Energy Consumption Survey (RECS) 2015 East North Central Region show that, of the total hot and warm washes that occur, over 96% are warm washes. See 'Residential Ozone Summary Calcs_2019.xlsx' and 'Multifamily Ozone Summary Calcs_2019.xlsx' for more information.

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

Single-Family Home	Multifamily
295[277]	1,243[278]

RE_electric = Recovery efficiency of electric water heater

= 0.98[279] for Electric Resistance

= 3.51[280] for Electric HPWH

3412 = Btus to kWh conversion (Btu/kWh)

$\%HotWash_{base}$ = Average percentage of loads that use hot or warm water with baseline equipment. [281]

Single-Family Home	Multifamily
0.7743	0.7438

$\%HotWash_{Ozone}$ = Percentage of loads that use hot or warm water with efficient equipment.

= 0.0

For example, a residential ozone laundry system is installed in a single-family home with an electric domestic hot water heater. The capacity and IWF of the baseline equipment is unknown.

ΔkWh = (1 * 5.0 * 6.5 * 0.1759 * (125 – 50.7) * 8.33 * 1.0 * 295) / (0.98 * 3412) * (0.7743 – 0)

= 242 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ΔkWh/Hours * CF

Where:

ΔkWh = Energy Savings as calculated above

Hours = Assumed Run hours of Clothes Washer

= 264 hours[282]

[277] Weighted average of clothes washer cycles per year (based on 2009 Residential Energy Consumption Survey (RECS) national sample survey of housing appliances section, state of Illinois.
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.
[278] DOE Technical Support Document Chapter 6, 2010 https://www.regulations.gov/contentStreamer?documentId=EERE-2006-STD-0127-0118&attachmentNumber=8&disposition=attachment&contentType=pdf
[279] Review of AHRI database shows that electric water heaters have a recovery efficiency of 98%.
[280] Review of AHRI database shows that Electric Heat Pump Water Heaters support this recovery efficiency. For the raw data, and calculations, please see AHRI_ RES Water Heaters 2022.xlsx.
[281] GTI Residential Ozone Laundry Field Demonstration (May 2018). See 'Residential Ozone Summary Calcs_2019.xlsx' and 'Multifamily Ozone Summary Calcs_2019.xlsx' for more information.
[282] Based on a weighted average of 264 clothes washer cycles per year assuming an average load runs for one hour.

CF = Summer Peak Coincidence Factor for measure.

= 0.038[283]

For example, a residential ozone laundry system is installed in a single-family home with an electric domestic hot water heater. The capacity and IWF of the baseline equipment is unknown.

ΔkW = 231/295 * 0.038

= 0.0298kW

FOSSIL FUEL SAVINGS

$$\Delta Therm = ThermHotWash * (\%HotWash_{base} - \%HotWash_{Ozone})$$

Where:

ThermHotWash = (%FossilDHW * Capacity * IWF * %HotWater * (T_{OUT} - T_{IN}) * 8.33 * 1.0 * Ncycles) / (RE_gas * 100,000)

%FossilDHW = Percentage of DHW savings assumed to be fossil fuel

= 100 % for Fossil Fuel

= 0 % for Electric

= If unknown[284], use the following table:

	Location				
Utility	Single Family	Single Family Low Income	Multi Family	Multi Family Low Income	Unknown
Ameren[285]	76%	75%	60%	57%	72%
ComEd[286]	92%		89%		91%
People's Gas[287]	77%	74%	51%	50%	63%
Northshore Gas[288]	80%				
Nicor Gas[289]	80%				
All DUs					**77%**

[283] Calculated from Itron eShapes, 8760 hourly data by end use for Missouri, as provided by Ameren.

[284] Based on the average % electricity used for water heating in Unknown residential structure types across all utilities covered by the IL program. Residence types include: SF, SF LI, MF & MF LI. Utilities included: Ameren, ComEd, People's Gas, Northshore Gas & Nicor. Please see subsequent table and citations for specific sources.

[285] Provided by AEG from the 2020 Market Potential Study completed for AIC, as well as AIC Income Qualified Initiative: 2021 Participant Survey Results Memo (February 1, 2022) p. 17.

[286] Commonwealth Edison Residential Baseline Study (2020). p.4.4 & 4.19; Section 4-7 Water Heating. Prepared by Itron.

[287] Residential Appliance Saturation Survey of natural gas for space heating and water heating (2021). Note, Multifamily customers have a residential billing rate code and responded on the survey that they live in an apartment or condominium in a building that has either 2-4 or 5+ units.

[288] Ibid.

[289] Comparable service area & customers to NSG, therefore using their survey data.

Note: If a measure is supported by a gas and electric utility, utilize the assumptions above for the gas utility

RE_gas = Recovery efficiency of gas water heater

Single-Family Homes	Multifamily
79%[290]	67%[291]

100,000 = Btus to Therms conversion (Btu/Therm).

For example, a residential ozone laundry system is installed in a single-family home with a gas domestic hot water heater. The capacity and IWF of the baseline equipment is unknown.

ΔTherms = (1 * 5.0 * 6.5 * 0.1759 * (125 – 50.7) * 8.33 * 1.0 * 295)/(0.79 * 100,000)*(0.7743 – 0)

= 10.2 Therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

LAUNDRY DETERGENT SAVINGS

Annual savings from not purchasing laundry detergent that are realized by efficient equipment end-user(s) ($/year).

Detergent savings per year = Detergent_cost * Ncycles

Where:

Detergent_cost = Average laundry detergent cost per load ($/load).

= 0.16[292]

For example, a residential ozone laundry system is installed in a single-family home.

Detergent savings per year = 0.16 * 295

= $47.20

MEASURE CODE: RS-APL-OZNE-V06-240101

REVIEW DEADLINE: 1/1/2026

290 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 79%.

291 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.

292 Based on cost analysis of products available on www.Jet.com and www.Amazon.com.

5.1.13 Income Qualified: ENERGY STAR and CEE Tier 2 Room Air Conditioner

DESCRIPTION

This measure relates to the purchase and installation of a room air conditioning unit that meets ENERGY STAR version 5.0 which is effective October 30th 2023 (equivalent to CEE Tier 1) or CEE Tier 2 minimum qualifying efficiency specifications, in place of an existing inefficient unit or a newly acquired inefficient unit through the secondary market. This measure is to be used by programs supporting the installation of efficient Room AC in income qualified households. The COVID pandemic of 2020 has meant that opportunities for income qualified populations to keep themselves and their families cool and comfortable during the summer heat have been restricted as access to cooling centers and air conditioned public areas have become limited. This can result in hospitalization or even death from heat exhaustion.

It is assumed that the Room AC's characterized in this measure are being used less as a luxury and more as a necessity and that access to a single AC unit per household will result in run hours more consistent with central AC usage.

This measure was developed to be applicable to the following program types: TOS, 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 version 5.0 (effective October 30th 2023)[293] efficiency standards presented above.

Product Type and Class (Btu/hr)		ENERGY STAR v5.0 with louvered sides (CEER)	ENERGY STAR v5.0 without louvered sides (CEER)	CEE Tier 2 (CEER)[294]
Without Reverse Cycle	< 6,000	13.1	12.8	14.85
	6,000 - 7,999	13.7		
	8,000 to 10,999	14.7	13.0	14.72
	11,000 to 13,999	14.7	12.8	14.72
	14,000 to 19,999	14.4	12.6	14.45
	20,000 to 27,999	12.7	12.7	12.69
	>=28,000	12.2	12.7	12.15
With Reverse Cycle	<14,000	13.2	12.6	N/A
	14,000 to 19,999	13.2	11.7	N/A
	>=20,000	12.6	11.7	N/A
Casement only		12.8		
Casement-Slider		14.0		

DEFINITION OF BASELINE EQUIPMENT

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.

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293 ENERGY STAR Version 5.0 Room Air Conditioners Program Requirements

294 The Consortium for Energy Efficiency Super Efficient Home Appliance Initiative, Room Air Conditioner Specification, CEE Advanced Tier (CEER), effective May 17, 2022. Please see file "CEE_RoomAC_Specification_17May2022.pdf". https://cee1.org/images/pdf/CEE_RoomAC_Specification_17May2022.pdf

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure life is assumed to be 12 years.[295]

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.

DEEMED MEASURE COST

The actual full cost of the ENERGY STAR unit should be used. If unavailable assume \$300.[296] If a CEE Tier 2 unit is installed assume \$508.[297]

The cost of the inefficient secondary market unit is assumed to be \$50.

Therefore, where the new unit replaces an existing unit the measure cost is \$300 for ENERGY STAR or \$508 for CEE Tier 2, and where there is no existing unit the measure cost is assumed to be \$250 for ENERGY STAR or \$458 for CEE Tier 2.

The avoided replacement cost (after 6 years) of the replacement secondary market unit is \$50. This cost should be discounted to present value using the nominal societal discount rate.

LOADSHAPE

Loadshape R08 - Residential Cooling

COINCIDENCE FACTOR

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

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)
= 68%[298]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)
= 46.6%[299]

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[295] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007.

[296] To promote improved cost effectiveness, it is assumed that the lower cost ENERGY STAR Room AC units would be used. Units between \$200-\$400 are available dependent on capacity.

[297] Consistent with Non IQ version of the measure.

[298] Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.

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

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = (FLH_{RoomAC} * Btu/H * (1/(EERbase/1.01) - 1/CEERee))/1000$$

Where:

FLH_{RoomAC} = Full Load Hours of room air conditioning unit

= dependent on location[300] [301]:

Climate Zone (City based upon)	FLHcool (single family)	FLHcool (multifamily)	FLH_cooling (weatherized multifamily)[302]
1 (Rockford)	547	499	320
2 (Chicago)	709	629	403
3 (Springfield)	779	707	453
4 (Belleville)	1082	982	630
5 (Marion/ Murphysboro)	956	868	557
Weighted Average[303]			
ComEd	676	603	386
Ameren	875	791	507
Statewide	731	655	420

Btu/H = Size of installed unit

= Actual. If unknown assume 8500 Btu/hr[304]

EERbase =Efficiency of existing / baseline unit

[300] Full load hours for Chicago, Moline and Rockford are provided in "Final Evaluation Report: Central Air Conditioning Efficiency Services (CACES), 2010, Navigant Consulting", p.33. An average FLH/Cooling Degree Day (from NCDC) ratio was calculated for these locations and applied to the CDD of the other locations in order to estimate FLH. There is a county mapping table in Volume 1, Section 3.7 providing the appropriate city to use for each county of Illinois. Note, full load hours for IQ homes are estimated to be higher than non-IQ homes and are assumed consistent with the Central AC FLH assumption. In a non-IQ home, it is expected that there be multiple Room AC units, many in bedrooms, and therefore the usage for each one would likely be lower. However in an IQ home it is assumed that the Room AC is being used as the main cooling system for the home are run more like a CAC.

[301] Applied percent change of CDD65, NCEI Annual Normals from 30 yr data set (1981-2010) to more recent 15 yr data (2006-2020) to all FLHcool values.

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

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

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

= Actual. If unknown assume 7.7 [305]

1.01 = Factor to convert EER to CEER (CEER includes standby and off power consumption)[306]

CEERee = Combined Energy Efficiency Ratio of ENERGY STAR unit

= Actual. If unknown assume minimum qualifying standard as provided in tables above

For example, for an 8,500 Btu/H capacity unit, with louvered sides, in an unknown multifamily location:

$\Delta kWH_{ENERGY\ STAR}$ = (655 * 8500 * (1/(7.7/1.01) – 1/14.7)) / 1000

= 352 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = Btu/H * ((1/EERexist - 1/(CEERee * 1.01)))/1000) * CF

Where:

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

= 68%[307]

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

= 46.6%[308]

= Factor to convert CEER to EER (CEER includes standby and off power consumption)[309]

Other variable as defined above

For example, for an 8,500 Btu/H capacity unit, with louvered sides, for an unknown multifamily location:

ΔkW_{SSP} = (8500 * (1/7.7– 1/(14.7*1.01))) / 1000 * 0.68

= 0.3613 kW

ΔkW_{PJM} = (8500 * (1/7.7– 1/(14.7*1.01))) / 1000 * 0.466

= 0.2476 kW

[305] Based on Nexus Market Research Inc, RLW Analytics, December 2005; "Impact, Process, and Market Study of the Connecticut Appliance Retirement Program: Overall Report."

[306] Since the existing unit will be rated in EER, this factor is used to appropriately compare with the new CEER rating. Version 3.0 of the ENERGY STAR specification provided equivalent EER and CEER ratings and for the most popular size band the EER rating is approximately 1% higher than the CEER. See 'ENERGY STAR Version 3.0 Room Air Conditioners Program Requirements'.

[307] Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.

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

[309] Since the new CEER rating includes standby and off power consumption, for peak calculations it is more appropriate to apply the EER rating, but it appears as though new units will only be rated with a CEER rating. Version 3.0 of the ENERGY STAR specification provided equivalent EER and CEER ratings and for the most popular size band the EER rating is approximately 1% higher than the CEER. See 'ENERGY STAR Version 3.0 Room Air Conditioners Program Requirements'.

FOSSIL FUEL SAVINGS
N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION
N/A

DEEMED O&M COST ADJUSTMENT CALCULATION
N/A

MEASURE CODE: RS-APL-IQRA-V05-240101

REVIEW DEADLINE: 1/1/2026

5.3.13 Residential Furnace Tune-Up

DESCRIPTION

This measure is for a natural gas Residential furnace that provides space heating. The tune-up will improve furnace performance by inspecting, cleaning and adjusting the furnace and appurtenances for correct and efficient operation. Additional savings maybe realized through a complete system tune-up.

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

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

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure an approved technician must complete the tune-up requirements listed below:[310]

- Measure combustion efficiency using an electronic flue gas analyzer
- Check and clean blower assembly and components per manufacturer's recommendations
- Where applicable Lubricate motor and inspect and replace fan belt if required
- Inspect for gas leaks
- Clean burner per manufacturer's recommendations and adjust as needed
- Check ignition system and safety systems and clean and adjust as needed
- Check and clean heat exchanger per manufacturer's recommendations
- Inspect exhaust/flue for proper attachment and operation
- Inspect control box, wiring and controls for proper connections and performance
- Check air filter and clean or replace per manufacturer's
- Inspect duct work connected to furnace for leaks or blockages
- Measure temperature rise and adjust flow as needed
- Check for correct line and load volts/amps
- Check thermostat operation is per manufacturer's recommendations(if adjustments made, refer to 'Residential Programmable Thermostat' measure for savings estimate)
- Perform Carbon Monoxide test and adjust heating system until results are within standard industry acceptable limits

DEFINITION OF BASELINE EQUIPMENT

The baseline is furnace assumed not to have had a tune-up in the past 3 years.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure life for the clean and check tune up is 3 years.[311]

DEEMED MEASURE COST

The incremental cost for this measure should be the actual cost of tune up.

DEEMED O&M COST ADJUSTMENTS

There are no expected O&M savings associated with this measure.

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[310] American Standard Maintenance for Indoor Units (see 'HVAC Maintenance American Standard')

[311] Assumed consistent with other tune-up measures.

LOADSHAPE

Loadshape R09 - Residential Electric Space Heat

COINCIDENCE FACTOR

N/A

Algorithms

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS

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

Where:

ΔTherms = as calculated below

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

= 3.14%[312]

29.3 = kWh per therm

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

FOSSIL FUEL SAVINGS

$$\Delta Therms = \frac{(CAPInputPre * EFLH * (1/\ Effbefore - 1/\ (Effbefore + Ei)))}{100{,}000}$$

Where:

$CAPInput_{Pre}$ = Gas Furnace input capacity pre tune-up (Btuh)

= Measured input capacity from HVAC SAVE

EFLH = Equivalent Full Load Hours for heating

Climate Zone (City based upon)	EFLH[313]
1 (Rockford)	1022
2 (Chicago)	976
3 (Springfield)	836
4 (Belleville)	645
5 (Marion)	656

[312] 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.

[313] Full load hours for Chicago, are based on findings in ‘Energy Efficiency / Demand Response Nicor Gas Plan Year 1 (6/1/2011-5/31/2012) Research Report: Furnace Metering Study (August 1, 2013), prepared by Navigant Consulting, Inc. Values for other cities are then calculated by comparing relative HDD at base 60F.

Climate Zone (City based upon)	EFLH[313]
Weighted Average[314]	
ComEd	978
Ameren	800
Statewide	928

Effbefore = Efficiency of the furnace before the tune-up

= Actual

Note: Contractors should select a mid-level firing rate that appropriately represents the average building operating condition over the course of the heating season and take readings at a consistent firing rate for pre and post tune-up.

EI = Efficiency Improvement of the furnace tune-up measure

= Actual

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HVC-FTUN-V08-240101

REVIEW DEADLINE: 1/1/2025

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

5.3.20 Residential Energy Recovery Ventilator (ERV)

Description

Unconditioned outdoor air is typically warmer or cooler than desired by the occupants and is often also more humid than desired. A Residential ERV system provides necessary outdoor air ventilation while preheating or precooling the outdoor air, and, in some Residential ERV systems, pre-dehumidifying the outdoor air as well. This saves energy required for heating, cooling, and dehumidifying the residence.

An ERV generally comprises two fans (Exhaust and Outdoor Intake) that pass the two streams of air through a heat exchanger, which may be a fixed plate heat exchanger or a rotary heat recovery wheel. Sensible heat from the warmer air stream is transferred to the cooler air stream, thereby reducing the amount of heating energy or cooling energy needed to condition the outdoor air to desired indoor air temperature and humidity levels. The heat exchanger surfaces, in some ERV models, may be coated with a hydroscopic material that absorbs/releases or transfers latent moisture from one air stream to the other. This increases the overall energy transfer efficiency during humid summer months by partially dehumidifying moist outdoor air using the relatively drier indoor exhaust air. In the winter, this same effect serves to humidify the outdoor air, making the space more comfortable, but not saving significant energy.

The current measure serves all residential single family and Group R2, R3 and R4 dwellings of 3 stories or less, both existing and new, where ERV is not required to comply with energy code.

This measure was developed to be applicable to electric cooling systems and electric or natural gas heating systems in the following program types: RF, NC, TOS. If applied to other program types, the measure savings should be verified.

Definition of Efficient Equipment

The Residential ERV, proposed for installation, must be listed in the Home Ventilation Institute's HVI-Certified Ratings Listing by its Brand and Model Number, and the HVI-Certified Ratings Listing must include the Model's Maximum CFM, ASRE (Adjusted Sensible Recovery Efficiency) and ATRE (Adjusted Total Recovery Efficiency) ratings values.

Definition of Baseline Equipment

The baseline equipment is a residential HVAC system with no energy recovery ventilator installed.

Deemed Lifetime of Efficient Equipment

The expected measure life of an ERV is estimated as 15 Years.[315]

Deemed Measure Cost

The actual cost of the ERV should be used. If unknown assume an incremental measure cost of $25.00 per Maximum CFM HVI-Certified Rating of proposed Brand and Model Number.[316]

Loadshape

R10 Residential Electric Heating and Cooling.

[315] State of Minnesota Technical Reference Manual, version 3, pp. 350+. https://mn.gov/commerce/industries/energy/utilities/cip/technical-reference-manual/

[316] This installed cost amount is estimated by Leidos based on 2Q2021 list prices from SupplyHouse.com for a variety of ERVs of nominally 95-117 CFM capacity plus an estimated $2,000 per ERV for electrical and mechanical installation services, divided by the Maximum listed CFM specified in the Home Ventilating Institute's Certified Products Directory for the specific ERVs offered by SupplyHouse.com. Unit installed prices ranged from $24.27 to $28.93 per CFM based on the above.

COINCIDENCE FACTOR

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

$CF_{SSP\ SF}$ = Summer System Peak Coincidence Factor for ERV (during utility peak hour)

= 95%[317]

$CF_{PJM\ SF}$ = PJM Summer Peak Coincidence Factor for ERV (average during PJM peak period)

= 95%[318]

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS

ERV Electric Heating Savings

If residence uses Electric heating,

ΔkWh_heating = 1.08 * HVI_Max_CFM * HDD60 * 24 * HVI_Rated_ASRE / ηHeat / 3412 * Daily_Hrs_Ventilation / 24 * %ElectricHeat

Where:

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

HVI_Max_CFM = HVI-Certified Maximum CFM of the Brand/Model of ERV proposed to be used[319]

If ERV Brand and Model are unknown, use the appropriate values in following Table of ERV Default Values[320]:

ERV Default Values:

	ERV Default Heating and Cooling CFM	ERV Default ASRE	ERV Default ATRE	ERV Default Watts
Single-family	114	70%	56%	94
Multi-family	64	65%	53%	49

[317] Based on 24 hr /day, 7 day/w operation.

[318] Ibid.

[319] Please see file 'HVIProd_ER.xlsx' for all related values. This is a lookup based on Customer inputs of ERV Brand and Model Number, which must match one of the HVI-Certified listings.

[320] Table of ERV Default Values is based on all available ERV Certified Data from file 'HVIProd_ER.xlsx' published by Home Ventilating Institute (https://www.hvi.org/hvi-certified-products-directory/section-iii-hrv-erv-directory-listing/). This table lists certified values of 387 models of ERVs. The default values above assume that Single-family residences will install ERVs with Heating CFM > 75 and Multi-family residences will install ERVs with Heating CFM <= 75 cfm. The respective default values represent arithmetic averages of the respective HVI ERV values separated into these two ERV CFM ranges.

Unknown Residence[321]	99	68%	55%	80
Custom	*Actual*	*Actual*	*Actual*	*Actual*

HDD60 = Heating Degree Days, base 60F, for the Climate Zone of Customer's site, from the following Table [322, 323]

Table 1: Climate Variables - Deemed Values based on nearest city below to Customer's Site.[324]

Climate Zone	Climate Heating Factor (CHF)	Heating based on Sensible: HDD60	Cooling based on Sensible: CDD65	Heating Design Day DBT	Cooling Design Day DBT	Cooling Design Day OA Enthalpy	Heating Design Day OA Enthalpy	Cooling Design Day RA Enthalpy	Heating Design Day RA Enthalpy	ΔEnthalpy [325] (Btu-hr/lb)	Daily fan use[326]
1 - Rockford	58%	5,552	991	0.3	88.0	41.0	0.07	28.36	25.34	6,375	17.8
2 - Chicago	55%	4,919	1,018	4.4	88.5	40.8	1.06	28.36	25.34	7,243	18.9
3 - Springfield	48%	4,259	1,339	7.3	90.7	42.8	1.75	28.36	25.34	11,311	18.9
4 - Belleville	49%	4,139	1,426	12.7	92.7	43.3	3.05	28.36	25.34	11,885	18.4
5 - Marion	46%	4,139	1,426	12.1	92.7	44.5	2.90	28.36	25.34	11,885	18.4

24 = Number of Hours in a Day [327]

HVI_Rated_ASRE = HVI-Certified Adjusted Sensible Recovery Efficiency of the Brand/Model of ERV proposed to be used[328]

= If ERV Brand and Model are unknown, use default values in previous table of ERV Default Values.

ηHeat = Efficiency of heating system

= Actual (where new or where it is possible to measure or reasonably estimate, assuming heat pump 85% distribution efficiency if only equipment efficiency is available). If using rated efficiencies, derate efficiency value by 1% per year (maximum of 30 years) to

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[321] Table HC2.9 Structural and Geographic Characteristics of Homes in Midwest Region, Divisions, and States, 2009. 69% Multi-Family and 31% Single Family.

[322] HDD values found in IL TRM v.9, volume 3, 5.1.8 are populated by Climate Zone nearest to the Customer's Site Address.

[323] National Climatic Data Center, Cooling Degree Days are based on a base temp of 65°F. There is a county mapping table Volume 1, Section 3.7 providing the appropriate city to use for each county of Illinois.

[324] 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 determines that using the minimum standard is appropriate.

[325] Base: 28.4 BTU/lb Return Air

[326] Based on defrost oversizing factor.

[327] Used to convert Annual HDD (F-Days) to total deltaT-hours (F-Hr) per year. Also used to convert daily ERV run hours to % runtime.

[328] Please see file 'HVIProd_ER.xlsx' for all related values. This is a lookup based on Customer inputs of ERV Brand and Model Number, which must match one of the HVI-Certified listings.

account for degradation over time,[329] or if not available refer to default table below:[330]

System Type	Age of Equipment	HSPF2 Estimate	ηHeat (Effective COP Estimate)= (HSPF2/3.413)*0.85
Heat Pump (if age unknown assume 2006-2014)	Before 2006	5.8	1.44
	2006 - 2014	6.5	1.62
	2015 on	7.0	1.74
Resistance	N/A	N/A	1
Unknown (for use in program evaluation only)[331]	N/A	N/A	1.28

3412 = Converts Btu to kWh

Daily_Hrs_Ventilation = Average annual daily ERV run time during which heat/cooling is being recovered, based on the assumption that ERV is selected to provide adequate ventilation rate when operated continuously on the coldest day of the year, when the defrost cycle interrupts heat recovery for a period of time depending on outdoor air temperature. ERV is assumed to be oversized so that on this coldest day, the ERV will provide the total ventilation air quantity during the minutes that is is not in defrost. As an example, if a coldest day results in 20% defrost time, the ERV is assumed to be selected at 1/0.8 or 125% oversizing. On the coldest day, the fan would operate 100% of the time. When not in defrost, it is assumed the homeowner would reduced fan operation to 80% runtime to avoid overventilating the residence. This assumed behavior results in an average annual runtime per day ranging from 17.8 to 18.9 hours/day.

The following defrost schedule is typical of ERV manufacturers and was used to calcuate average daily run hours:

OA DBT	Defrost	On	Total	% Runtime
27 F	3.0 Min.	25.0 Min.	28.0 Min.	89.3%
-4 F	4.5 Min.	17.0 Min.	21.5 Min.	79.1%
-31 F	7.0 Min.	15.0 Min.	22.0 Min.	68.2%

%ElectricHeat = Percent of homes that have electric space heating

= 100 % for Electric Resistance or Heat Pump

= 0 % for Natural Gas

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

[330] 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.

[331] Calculation assumes 35% Heat Pump and 65% Resistance, which is based upon data from Energy Information Administration, 2009 Residential Energy Consumption Survey, see "HC6.9 Space Heating in Midwest Region.xls", using average for East North Central Region. Average efficiency of heat pump is based on assumption that 50% are units from before 2006 and 50% from 2006-2014. Program or evaluation data should be used to improve this assumption if available.

= If unknown[332], use the following table:

Utility	Residence Type				
	Single Family	Single Family Low Income	Multi Family	Multi Family Low Income	Unknown
Ameren	18%	26%	38%	39%	29%
ComEd	14%	22%	43%	48%	21%
PGL	16%	22%	40%	50%	31%
NSG	8%	16%	35%	41%	20%
Nicor	8%	16%	35%	41%	20%
All DUs					**24%**

Note: If a measure is supported by a gas and electric utility, utilize the assumptions above for the gas utility

For example, assuming HVI Max CFM = 117 cfm; HDD60 = 5,552 (Rockford, IL); Electric Resistance Heat (COP=1.0); HVI Rated ASRE = 75%; Heating COP = 1.0; Daily_Hrs_Ventilation = 17.8; %ElectricHeat = 100%

ΔkWh_heating = ((1.08 * 117 * 5552 * 24) * 75% / 1.0 / 3412) * 17.8 / 24 * 100%

= 2742 kWh of heating energy saved

ERV Electric Cooling Savings

If residence uses Electric cooling, the cooling savings is calculated by the following equation:

ΔkWh_cooling = 4.5 * HVI_Max_CFM * ΔEnthalpy * HVI_Rated_ATRE / 1000 / ηCool * Daily_Hrs_Ventilation / 24 * %Cool

Where:

4.5 = Density of inlet air at 70F x 60 min/hr in lb-min/ft3 -hr

HVI_Max_CFM = HVI-Certified Maximum CFM of the Brand/Model of ERV proposed to be used[333]

= If ERV Brand and Model are unknown, use default values in previous "Table of ERV Default Values".

ΔEnthalpy = Difference between Outdoor Air and Return Air Enthalpies (Btu/lb air) for each weather

[332] Based on the average % Natural Gas used for space heating in Unknown residential structure types across all utilities covered by the IL program. Residence types include: SF, SF LI, MF & MF LI. Utilities included: Ameren, ComEd, People's Gas, Northshore Gas & Nicor. Data provided from 2016 Ameren Illinois Demand Side Management (DSM) Market Potential Study by Applied Energy Group, ComEd's 2019 Baseline Survey on residential space heating share, and Peoples & Northshore Gas potential study of end use saturations.

[333] Please see HVI Table at the end of this document. This is a lookup based on Customer inputs of ERV Brand and Model Number, which must match one of the HVI-Certified listings".

bin of the Climate Zone of Customer's site[334] times the number of hours of occurrence per year of each weather bin

= Values contained in Table 1, above, for 5 representative climate zones

= $\sum$ [($H\_OA\_Cool_{bin}$ - $H\_RA\_Cool_{bin}$) * Annual $Hours_{bin}$] summed over all temperature bins where $H\_OA\_Cool_{bin} > H\_RA\_Cool_{bin}$.

Where:

H_OA_Cool = Weather Bin Outdoor Air Enthalpy

H_RA_Cool = Cooling Mode Return Air Enthalpy = 28.36 Btu/lb, a deemed value.

1000 = Conversion of btu to kbtu.

ηCool = Seasonal Cooling = Efficiency (SEER2) of Air Conditioning equipment (kBtu/kWh)

= Actual (where new or where it is possible to measure or reasonably estimate). If using rated efficiencies, derate efficiency value by 1% per year (maximum of 30 years) to account for degradation over time,[335] or if unknown assume the following:[336]

Age of Equipment	SEER2 Estimate
Window Air Conditioner	8.6
Central AC before 2006	9.5
Central AC 2006 - 2014	12.4
Central AC After 1/1/2015	12.4
Heat Pump After 1/1/2015	13.3
Unknown (for use in program evaluation only)	10.0

HVI_Rated_ATRE = HVI-Certified Adjusted Total Heat Recovery Efficiency of the Brand/Model of ERV proposed to be used[337].

Daily_Hrs_Ventilation = As previously defined

24 = Hours in a day

[334] This is based the Climate Zone based on the Customer's Site Address, informed by the Minnesota Technical Reference Manual v.3, page 350, commercial ERV measure assumptions modified for Illinois climate conditions using ASHRAE Design Data Tables. The table recreates enthalpy assumptions originating in the Minnesota TRM v3 for commercial ERV measure, page 350, tables 1 and 2, modified for Illinois climate conditions

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

[336] 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.

[337] Please see file 'HVIProd_ER.xlsx' for all related values. This is a lookup based on Customer inputs of ERV Brand and Model Number, which must match one of the HVI-Certified listings.

%Cool = Percent of homes that have cooling

Is Residence Cooled?	%Cool
Yes	100%
No	0%
Unknown (for use in program evaluation only)[338]	66%

For example, assuming HVI Max CFM = 117 cfm; ΔEnthalpy = 6,375 BTU-hr/lb (Rockford, IL); Air Conditioner, vintage older than 2006 (ηCool = 9.3); HVI Rated ATRE = 48%; Daily_Hrs_Ventilation = 17.8; %Cool = 100%

ΔkWh_cooling = 4.5 * 117 * 6375 / 1000 / 9.3 * 48% * 17.8 / 24 * 100%

= 128 kWh

ERV Fan Energy Savings

For all heating or heating/cooling ERV applications, the ERV fan savings represents the change in energy usage of the ERV fan annual energy use versus the base case standard (non-ERV) exhaust fan energy use.

The base case non-ERV exhaust fan energy use is deemed to be equal to the average ERV daily exhaust volume of air exhausted, times the deemed fan efficiency of a continuously-operated bathroom exhaust fan, as defined in Section 5.3.9 of IL-TRM_Effective_010122_v10.0_Vol_3_Res_08062021_DRAFT.docx: 1.7 CFM/Watt. The daily average total exhaust volume of the existing bathroom exhaust fan(s) is deemed to be equal to the proposed ERV daily average total exhaust volume, after taking into account the defrost cycle periods wherein ERV fan energy is consumed but no ventilation occurs.

Therefore:

Exist_Exh_Fan_Use = HVI_Rated_CFM * Daily_Hrs_Ventilation / 24 / 1.7 CFM/Watt / 1000 * Daily_Fan_Use * 365.25

Where:

HVI_Rated_CFM = HVI-Certified Heating CFM at Maximum Air Flow of the Brand/Model of ERV proposed to be used[339]

= If ERV Brand and Model are unknown, use default values in previous "Table of ERV Default Values".

Daily_Hrs_Ventilation = As previously defined.

1.7 CFM/Watt = Deemed base case bathroom exhaust fan efficiency

24 = Hours in a Day

Daily_Hrs_Fan_Use = Deemed 24 hr/day because of continuous ERV fan use whether ERV is in defrost cycle

[338] Percentage of homes in Illinois that have central cooling from "Table HC7.9 Air Conditioning in Homes in Midwest Region, Divisions, and States, 2009" from Energy Information Administration, 2009 Residential Energy Consumption Survey

[339] Please see file 'HVIProd_ER.xlsx' for all related values. This is a lookup based on Customer inputs of ERV Brand and Model Number, which must match one of the HVI-Certified listings.

or in ventilation cycle

365.25 = Days in a Year

1000 = Conversion of watts to kW

8766 = Annual Hours of Bathroom Fan Use

ERV_Fan_Use = HVI_Rated_W / 1000 * Daily_Hrs_Fan_Use * 365

Where:

HVI_Rated_W = HVI-Certified Wattage at Maximum Air Flow of the Brand/Model of ERV proposed to be used[340]

= If ERV Brand and Model are unknown, use default Watts/CFM in previous "Table of ERV Default Values" x ERV CFM (also from "Table of ERV Default Values").

1000 = Conversion of watts to kW

Daily_Hrs_Fan_Use = Deemed to be 24 hr/day because of continuous ERV fan use whether ERV is in defrost cycle or in ventilation cycle.

Savings (positive or negative) therefore are calculated by the following equation:

Exist_Exh_Fan_Use - ERV_Fan_Use

Where both terms in the equation are as previously defined.

For Example, assuming HVI_Rated_CFM = 117 CFM; HVI Rated Watts = 106 W; Daily_Hrs_Ventilation = 17.8; Daily_Hrs_Fan_Use = 24; Base Case Bathroom Exhaust Fan Efficiency = 1.7 CFM/Watt.

Exist_Exh_Fan_Use = 117 * 17.8 / 24 / 1.7 / 1000 * 24 * 365.25 = 447 kWh/Year

ERV_Fan_Use = 106 / 1000* 24 * 365.25 = 929 kWh

ERV Fan Energy Savings = 447 kWh - 929 kWh = - (482) kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$\Delta kW = \Delta kWh_{Annual}$ / HOU * CF * Daily_Hrs_Ventilation / 24

Where:

[340] Please see file 'HVIProd_ER.xlsx' for all related values. This is a lookup based on Customer inputs of ERV Brand and Model Number, which must match one of the HVI-Certified listings".

ΔkWh_{Annual} = ΔkWh_heating + ΔkWh_cooling

HOU = Annual Hours of Use of ERV, including defrost hours where fan recirculates indoor air through outdoor air heat exchanger.

= Actual. Use 8,766 hours/year if actual is not available.[341]

$CF_{SSP\ SF}$ = Summer System Peak Coincidence Factor for ERV (during utility peak hour)

= 95%[342]

$CF_{PJM\ SF}$ = PJM Summer Peak Coincidence Factor for ERV (average during PJM peak period)

= 95%[343]

Daily_Hrs_Ventilation = As defined previously.

24 = Hours in a day

For example, assuming Annual kWh Saved = 1989 kWh/year; HOU = 8,760 Hr/Yr; CF = 0.95; Daily_hr_use = 17.8

ΔkW = 1989 / 8766 * 0.95 * 17.8 / 24

= 0.16 kW

FOSSIL FUEL SAVINGS

$\Delta Therms_{Annual}$ = 1.08 * HVI_Max_CFM * HDD60 * 24 * HVI_Rated_ASRE / ηHeat / 100,000 * Daily_Hrs_Ventilation / 24 * %GasHeat

Where:

1.08 = Conversion of CFM air * delta T to BTU/hr

HVI_Max_CFM = HVI-Certified Maximum CFM of the Brand/Model of ERV proposed to be used[344]

HDD60 = Heating Degree Days base 60F, for the Climate Zone of Customer's site

= Value obtained from Table 1, above.

24 = Converts Days to Hours[345]

HVI_Rated_ASRE = HVI-Certified Adjusted Sensible Recovery Efficiency of the Brand/Model of ERV

[341] Deemed continual operation of ERV throughout year.
[342] Based on 24 hr /day, 7 day/w operation.
[343] Ibid.
[344] Please see file 'HVIProd_ER.xlsx' for all related values. This is a lookup based on Customer inputs of ERV Brand and Model Number, which must match one of the HVI-Certified listings.
[345] Used to convert Annual HDD (F-Days) to total deltaT-hours (F-Hr) per year.

proposed to be used[346]

= If ERV Brand and Model are unknown, use default values in previous table of ERV Default Values.

ηHeat = Efficiency of heating system

= Equipment efficiency * distribution efficiency

= Actual (where new or where it is possible to measure or reasonably estimate, assuming 85% distribution efficiency if only equipment efficiency is available).[347] If using rated efficiencies, derate efficiency value by 1% per year (maximum of 30 years) to account for degradation over time,[348] or if Equipment Efficiency is not available, use Section 5.3 to select the appropriate equipment efficiency for the project.

100,000 = Converts Btu/hr to Therms

%GasHeat = Percent of homes that have gas space heating

= 100 % for Natural Gas

= 0 % for Electric Resistance or Heat Pump

= If unknown[349], use the following table:

Utility	Residence Type				
	Single Family	Single Family Low Income	Multi Family	Multi Family Low Income	Unknown
Ameren	82%	74%	62%	61%	71%
ComEd	86%	78%	57%	52%	79%
PGL	84%	78%	60%	50%	69%
NSG	92%	84%	65%	59%	80%
Nicor	92%	84%	65%	59%	80%
All DUs					**76%**

Note: If a measure is supported by a gas and electric utility, utilize the assumptions above for the gas utility

[346] Please see file 'HVIProd_ER.xlsx' for all related values. This is a lookup based on Customer inputs of ERV Brand and Model Number, which must match one of the HVI-Certified listings.

[347] 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: (see 'BPI Distribution Efficiency Table') or by performing duct blaster testing.

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

[349] Based on the average % Natural Gas used for space heating in Unknown residential structure types across all utilities covered by the IL program. Residence types include: SF, SF LI, MF & MF LI. Utilities included: Ameren, ComEd, People's Gas, Northshore Gas & Nicor. Data provided from 2016 Ameren Illinois Demand Side Management (DSM) Market Potential Study by Applied Energy Group, ComEd's 2019 Baseline Survey on residential space heating share, and Peoples & Northshore Gas potential study of end use saturations.

Other factors as defined above.

For example, assuming: HVI_Max_CFM =117; HDD60 = 5552; HVI_Rated_ASRE = 75%; ηHeat = 0.80 (Non-condensing Gas Heat); Daily_Hrs_Ventilation = 17.8, then

$\Delta Therms_{Annual}$ = 1.08 * 117 * 5552 * 24 * 75% / 0.80 / 100,000 * 17.8 / 24

= 117 Therms

WATER AND OTHER NON-ENERGY IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HVC-ERVS-V03-240101

REVIEW DEADLINE: 1/1/2025

5.4.1 Domestic Hot Water Pipe Insulation

DESCRIPTION

This measure describes adding insulation to un-insulated domestic hot water pipes. The measure assumes the pipe wrap is installed either to the first length of both the hot and cold pipe (this is the most cost-effective section to insulate in non-circulating systems, since the water pipes act as an extension of the hot water tank) or to a hot water recirculating loop. Insulating this length therefore helps reduce standby losses. Default savings are provided per 3ft length and are appropriate up to 6ft of the hot water pipe and 3ft of the cold. Where a hot water recirculating pump is in use, this measure is viable for the entire hot water loop.

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

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

DEFINITION OF EFFICIENT EQUIPMENT

The efficient case is installing pipe wrap insulation to a length of hot water pipe.

DEFINITION OF BASELINE EQUIPMENT

The baseline is an un-insulated hot water pipe.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure life is assumed to be 15 years.[350]

DEEMED MEASURE COST

The actual installation cost should be used if known. If unknown, the measure cost including material and installation is assumed to be $3 per linear foot.[351] For foam pipe insulation assume a measure cost of $0.26/ft for ½" insulation and $0.31/ft for ¾" insulation.[352]

LOADSHAPE

Loadshape C53 - Flat

COINCIDENCE FACTOR

This measure assumes a flat loadshape since savings relate to reducing standby losses and as such the coincidence factor is 1.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = \%Electric\_DHW * ((1 / R_{exist} - 1 / R_{new}) * C_{inside} * L_{effective} * \Delta T * 8{,}766 * ISR) / \eta DHW / 3412$$

Where:

%Electric_DHW = Percentage of DHW savings assumed to be electric

[350] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007.

[351] Consistent with DEER 2008 Database Technology and Measure Cost Data (www.deeresources.com).

[352] Review of website cost data for Homedepot.com, Lowes.com, and Menards.com for locations in Peoria, IL.

= 100 % for Electric

= 0 % for Fossil Fuel

= If unknown[353], use the following table:

Utility	Location				
	Single Family	Single Family Low Income	Multi Family	Multi Family Low Income	Unknown
Ameren[354]	24%	25%	40%	43%	28%
ComEd[355]	8%		11%		9%
People's Gas[356]	23%	26%	49%	50%	37%
Northshore Gas[357]	20%				
Nicor Gas[358]	20%				
All DUs					23%

Note: If a measure is supported by a gas and electric utility, utilize the assumptions above for the gas utility

R_{exist} = Pipe heat loss coefficient of uninsulated pipe (existing) [(hr-°F-ft)/Btu]

= Varies based on pipe size and material. See table below for values.

R_{new} = Pipe heat loss coefficient of insulated pipe (new) [(hr-°F-ft)/Btu]

= Actual (R_{exist} + R value of insulation[359])

C_{inside} = Inside circumference of the pipe [ft]

= Actual (0.5” pipe = 0.1427 ft, 0.75” pipe = 0.2055 ft); See table below for values.

$L_{effective}$ = Effective length of pipe from water heating source covered by pipe insulation (ft) [360]

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[353] Based on the average % electricity used for water heating in Unknown residential structure types across all utilities covered by the IL program. Residence types include: SF, SF LI, MF & MF LI. Utilities included: Ameren, ComEd, People's Gas, Northshore Gas & Nicor. Please see subsequent table and citations for specific sources.

[354] Provided by AEG from the 2020 Market Potential Study completed for AIC, as well as AIC Income Qualified Initiative: 2021 Participant Survey Results Memo (February 1, 2022) p. 17.

[355] Commonwealth Edison Residential Baseline Study (2020). p.4.4 & 4.19; Section 4-7 Water Heating. Prepared by Itron.

[356] Residential Appliance Saturation Survey of natural gas for space heating and water heating (2021). Note, Multifamily customers have a residential billing rate code and responded on the survey that they live in an apartment or condominium in a building that has either 2-4 or 5+ units.

[357] Ibid.

[358] Comparable service area & customers to NSG, therefore using their survey data.

[359] Where possible it should be ensured that the R-value of the insulation is at the appropriate mean rating temperature (100F).

[360] In cases with zero wind, heat loss (and therefore) savings is larger from horizontal pipe configurations than vertical pipe configurations due, perhaps to the way in which convective losses are handled. Given that most DHW pipe insulation installations begin with a vertical orientation from the water heater, an adjustment to the engineering calculation is needed. An analysis of

= $L_{Horizontal} + \alpha L_{Vertical}$

= Actual; See table below for α values. If unknown, assume 3ft of vertical and remaining horizontal.

ΔT = Average temperature difference between supplied water and outside air temperature (°F)

= 60°F [361]

8,766 = Hours per year

ISR = In Service Rate

= 0.50 for Kits distribution[362], 0.78 for Virtual Assessment followed by Self-Installation[363], and 1.0 for Direct Install, TOS, or Verified Install program types

ηDHW = Recovery efficiency of electric hot water heater

= 0.98 [364]

3412 = Conversion from Btu to kWh

Parameter assumptions for various pipe sizes and materials:

the 3E PLUS tool by NAIMA (https://insulationinstitute.org/tools-resources/free-3e-plus/) yielded adjustment factors for horizontal to vertical loss and savings values. See DHW_PipeInsulationCalcs_062121.xlsx for details of the analysis and comparisons.

361 Assumes 125°F water leaving the hot water tank and average temperature of basement of 65°F.

362 Results from Home Energy Worksheets completed by student/families in 2020, 2021, and 2022 were nearly the same as values from: 2020 survey research by Guidehouse, conducted with Peoples Gas income qualified recipients of self-install efficiency kits distributed by mail in late 2019 (with 117 survey respondents) and research from 2021 Ameren Illinois Income Qualified participant survey, available on IL SAG website:
https://ilsag.s3.amazonaws.com/AIC-Income-Qualified-Initiative-Participant-Survey-Results-Memo-FINAL-2022-02-01.pdf.
Home Energy Worksheets also establish the fraction of participants who indicate they "will install later" for specific measures. Follow-up research completed by Guidehouse for Nicor Gas in 2022 found that, on average, 51.3% of respondents who initially reported that they hadn't installed specific kit measures, but "planned to" subsequently had installed the measures. Combining these findings allows for an ISR that accounts for initial and one round of subsequent installations. To maintain a conservative estimate of ISR, the remaining 48.7% are presumed uninstalled. See: EESchoolKitSubsequentInstall_HEW.xlsx for data and calculations.

363 An equal weighted average of Direct Install and Kit ISRs. Interest and applicability of measures confirmed through virtual assessment followed by self-installation without verification of install.

364 Electric water heaters have recovery efficiency of 98%.

Type and Size	C_{inside}[365] (I.D.*π/12) (ft)	Product of Overall Heat Transfer Coefficient and Pipe Area (UA) per foot[366] from bare pipe (BTU/hr·ft·°F)	Pipe Area per linear foot (ft^3)[367]	R_{exist} ((hr·ft·°F)/BTU)	Horizontal to Vertical Adjustment Factor (α)
½" Copper Pipe	0.1427	0.345	0.153	0.444	0.67
¾" Copper Pipe	0.2055	0.417	0.217	0.521	0.72
½" PEX	0.1270	0.438	0.145	0.332	0.73
¾" PEX	0.1783	0.545	0.204	0.374	0.77

For example, insulating 6 feet of 0.75" copper pipe (4ft vertical + 2ft horizontal) with R-5 wrap through a Direct Install program:

$$\Delta kWh = (((1 / R_{exist} - 1 / R_{new}) * C_{inside} * L_{effective} * \Delta T * 8{,}766 * 1.0) / \eta DHW) / 3412$$

$$= (((1/0.521 - 1/3.521) * 0.2055 * (2 + 4 * 0.72) * 60 * 8766 * 1.0) / 0.98)/3412$$

$$= 258 \text{ kWh}$$

The following table provides annual energy savings per foot of pipe insulation for various configurations:

Measure Configuration	ΔkWh Savings per Foot of Insulation (kWh/ft) Kit Distribution (ISR = 50%)	ΔkWh Savings per Foot of Insulation (kWh/ft) All Other Programs (ISR = 100%)
Horizontal Pipe Orientation		
½" Copper Pipe insulated with R-3, ½" thick insulation	22	44.0
¾" Copper Pipe insulated with R-3, ½" thick insulation	26.5	52.9
½" PEX insulated with R-3, ½" thick insulation	27.1	54.2
¾" PEX insulated with R-3, ½" thick insulation	33.4	66.7
Vertical Pipe Orientation		
½" Copper Pipe insulated with R-3, ½" thick insulation	14.8	29.5
¾" Copper Pipe insulated with R-3, ½" thick insulation	19.1	38.1
½" PEX insulated with R-3, ½" thick insulation	19.8	39.5
¾" PEX insulated with R-3, ½" thick insulation	25.7	51.3
Unknown		
R-3, ½" thick insulation for ½" pipes – pipe type and configuration unknown (average of vertical and horizontal configurations for ½"pipe)	20.9	41.8
R-3, ½" thick insulation for ¾" pipes – pipe type and configuration unknown (average of vertical and horizontal configurations for ¾"pipe)	26.1	52.2

365 See: https://energy-models.com/pipe-sizing-charts-tables (last accessed 5/7/21) for copper pipe sizes and https://www.garagesanctum.com/size-chart/pex-tubing-size-chart/ (last accessed 5/7/21) for PEX pipe sizes.
366 Laboratory measured values from Hoeschele and Weitzel (2012), Figure 1.
367 Calculated using the average pipe thickness (I.D. + O.D.)*0.5.

	ΔkWh Savings per Foot of Insulation (kWh/ft)	
Measure Configuration	Kit Distribution (ISR = 50%)	All Other Programs (ISR = 100%)
Unknown pipe type (straight average) and configuration (average of all vertical and horizontal configurations) insulated with R-3, ½" thick insulation	23.5	46.9

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ΔkWh / 8766

Where:

ΔkWh = kWh savings from pipe wrap installation

8766 = Number of hours in a year (since savings are assumed to be constant over year).

For example, insulating 6 feet of 0.75" copper pipe (4ft vertical + 2ft horizontal) with R-5 wrap through a Direct Install program:

ΔkW = 258/8766
= 0.0294kW

The following table provides peak demand savings per foot of pipe insulation for various configurations:

	ΔkW Savings per Foot of Insulation (kW/ft)	
Measure Configuration	Kit Distribution (ISR = 50%)	All Other Programs (ISR = 100%)
Horizontal Pipe Orientation		
½" Copper Pipe insulated with R-3, ½" thick insulation	0.0025	0.0050
¾" Copper Pipe insulated with R-3, ½" thick insulation	0.0030	0.0060
½" PEX insulated with R-3, ½" thick insulation	0.0031	0.0062
¾" PEX insulated with R-3, ½" thick insulation	0.0038	0.0076
Vertical Pipe Orientation		
½" Copper Pipe insulated with R-3, ½" thick insulation	0.0017	0.0034
¾" Copper Pipe insulated with R-3, ½" thick insulation	0.0022	0.0043
½" PEX insulated with R-3, ½" thick insulation	0.0023	0.0045
¾" PEX insulated with R-3, ½" thick insulation	0.0030	0.0059
Unknown		
R-3, ½" thick insulation for ½" pipes – pipe type and configuration unknown (average of vertical and horizontal configurations for ½"pipe)	0.0024	0.0048

Measure Configuration	ΔkW Savings per Foot of Insulation (kW/ft) Kit Distribution (ISR = 50%)	All Other Programs (ISR = 100%)
R-3, ½" thick insulation for ¾" pipes – pipe type and configuration unknown (average of vertical and horizontal configurations for ¾"pipe)	0.0030	0.0060
Unknown pipe type (straight average) and configuration (average of vertical and horizontal configurations for all pipes) insulated with R-3, ½" thick insulation	0.0027	0.0053

NATURAL GAS SAVINGS

For Natural Gas DHW systems:

$$\Delta Therm = \%Fossil\_DHW * (((1 / R_{exist} - 1 / R_{new}) * C_{inside} * L_{effective} * \Delta T * 8,766 * ISR) / \eta DHW) / 100,000$$

Where:

%Fossil_DHW = Percentage of DHW savings assumed to be fossil fuel

= 100 % for Fossil Fuel

= 0 % for Electric

= If unknown[368], use the following table:

Utility	Location: Single Family	Single Family Low Income	Multi Family	Multi Family Low Income	Unknown
Ameren[369]	76%	75%	60%	57%	72%
ComEd[370]	92%		89%		91%
People's Gas[371]	77%	74%	51%	50%	63%
Northshore Gas[372]	80%				
Nicor Gas[373]	80%				

[368] Based on the average % electricity used for water heating in Unknown residential structure types across all utilities covered by the IL program. Residence types include: SF, SF LI, MF & MF LI. Utilities included: Ameren, ComEd, People's Gas, Northshore Gas & Nicor. Please see subsequent table and citations for specific sources.
[369] Provided by AEG from the 2020 Market Potential Study completed for AIC, as well as AIC Income Qualified Initiative: 2021 Participant Survey Results Memo (February 1, 2022) p. 17.
[370] Commonwealth Edison Residential Baseline Study (2020). p.4.4 & 4.19; Section 4-7 Water Heating. Prepared by Itron.
[371] Residential Appliance Saturation Survey of natural gas for space heating and water heating (2021). Note, Multifamily customers have a residential billing rate code and responded on the survey that they live in an apartment or condominium in a building that has either 2-4 or 5+ units.
[372] Ibid.
[373] Comparable service area & customers to NSG, therefore using their survey data.

	Location				
Utility	Single Family	Single Family Low Income	Multi Family	Multi Family Low Income	Unknown
All DUs					**77%**

Note: If a measure is supported by a gas and electric utility, utilize the assumptions above for the gas utility

ηDHW = Recovery efficiency of fossil hot water heater

= 0.78 [374]

Other variables as defined above

For example, insulating 6 feet of 0.75" copper pipe (4ft vertical + 2ft horizontal) with R-5 wrap through a Direct Install program:

ΔTherm $= (((1 / R_{exist} - 1 / R_{new}) * C_{inside} * L_{effective} * \Delta T * 8{,}766 * ISR) / \eta DHW) / 100{,}000$

$= (((1/0.521 - 1/3.521) * 0.2055 * (2 + 4 * 0.72) * 60 * 8766 * 1.0) / 0.78 / 100{,}000$

= 11.06 therms

The following table provides Natural Gas savings per foot of pipe insulation for various configurations:

	ΔTherm Savings per Foot of Insulation (Therms/ft)	
Measure Configuration	Kit Distribution (ISR = 50%)	All Other Programs (ISR = 100%)
Horizontal Pipe Orientation		
½" Copper Pipe insulated with R-3, ½" thick insulation	0.95	1.89
¾" Copper Pipe insulated with R-3, ½" thick insulation	1.14	2.27
½" PEX insulated with R-3, ½" thick insulation	1.16	2.32
¾" PEX insulated with R-3, ½" thick insulation	1.43	2.86
Vertical Pipe Orientation		
½" Copper Pipe insulated with R-3, ½" thick insulation	0.63	1.26
¾" Copper Pipe insulated with R-3, ½" thick insulation	0.82	1.63
½" PEX insulated with R-3, ½" thick insulation	0.85	1.70
¾" PEX insulated with R-3, ½" thick insulation	1.1	2.20
Unknown		
R-3, ½" thick insulation for ½" pipes – pipe type and configuration unknown (average of vertical and horizontal configurations for ½"pipe)	0.9	1.79

[374] 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%

	ΔTherm Savings per Foot of Insulation (Therms/ft)	
Measure Configuration	Kit Distribution (ISR = 50%)	All Other Programs (ISR = 100%)
R-3, ½" thick insulation for ¾" pipes – pipe type and configuration unknown (average of vertical and horizontal configurations for ¾"pipe)	1.12	2.24
Unknown pipe type (straight average) and configuration (average of vertical and horizontal configurations for all pipes) insulated with R-3, ½" thick insulation	1.01	2.01

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HWE-PINS-V08-240101

REVIEW DEADLINE: 1/1/2025

5.4.4 Low Flow Faucet Aerators

DESCRIPTION

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

This measure 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, 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 2.2 GPM or greater, or a standard kitchen faucet aerator rated at 2.2 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.[375]

DEEMED MEASURE COST

For time of sale or new construction the incremental cost for this measure is $3,[376] or program actual.

For faucet aerators provided through Direct Install or within Efficiency Kits, the actual program delivery costs (including labor if applicable) should be utilized. If unknown, assume $8 for Direct Install[377] and $3 for Efficiency Kits.

LOADSHAPE

Loadshape R03 - Residential Electric DHW

COINCIDENCE FACTOR

The coincidence factor for this measure is assumed to be 2.2%.[378]

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[375] As recommended in Navigant 'ComEd Effective Useful Life Research Report', May 2018.

[376] 2011, Market research average of $3.

[377] Includes assess and install labor time of $5 (20min @ $15/hr)

[378] Calculated as follows: Assume 18% aerator use takes place during peak hours (based on: Oreo et al, "The end uses of hot water in single family homes from flow trace analysis", 2001.) There are 65 days in the summer peak period, so the percentage of total annual aerator use in peak period is 0.18*65/365 = 3.21%. The number of hours of recovery during peak periods is therefore assumed to be 3.21% *180 = 5.8 hours of recovery during peak period where 180 equals the average annual electric DHW recovery hours for faucet use including SF and MF homes. There are 260 hours in the peak period so the probability you will see savings during the peak period is 5.8/260 = 0.022

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

Note these savings are *per* faucet retrofitted[379] (unless faucet type is unknown, then it is per household).

ΔkWh = %ElectricDHW * ((GPM_base * L_base - GPM_low * L_low) * Household * 365.25 *DF / FPH) * EPG_electric * ISR

Where:

%ElectricDHW = Percentage of DHW savings assumed to be electric

= 100 % for Electric

= 0 % for Fossil Fuel

= If unknown[380], use the following table:

	Location				
Utility	**Single Family**	**Single Family Low Income**	**Multi Family**	**Multi Family Low Income**	**Unknown**
Ameren[381]	24%	25%	40%	43%	28%
ComEd[382]	8%		11%		9%
People's Gas[383]	23%	26%	49%	50%	37%
Northshore Gas[384]	20%				
Nicor Gas[385]	20%				
All DUs					23%

Note: If a measure is supported by a gas and electric utility, utilize the assumptions above for the gas utility

GPM_base = Average flow rate, in gallons per minute, of the baseline faucet "as-used."

[379] This algorithm calculates the amount of energy saved per aerator by determining the fraction of water consumption savings for the upgraded fixture.
[380] Based on the average % electricity used for water heating in Unknown residential structure types across all utilities covered by the IL program. Residence types include: SF, SF LI, MF & MF LI. Utilities included: Ameren, ComEd, People's Gas, Northshore Gas & Nicor. Please see subsequent table and citations for specific sources.
[381] Provided by AEG from the 2020 Market Potential Study completed for AIC, as well as AIC Income Qualified Initiative: 2021 Participant Survey Results Memo (February 1, 2022) p. 17.
[382] Commonwealth Edison Residential Baseline Study (2020). p.4.4 & 4.19; Section 4-7 Water Heating. Prepared by Itron.
[383] Residential Appliance Saturation Survey of natural gas for space heating and water heating (2021). Note, Multifamily customers have a residential billing rate code and responded on the survey that they live in an apartment or condominium in a building that has either 2-4 or 5+ units.
[384] Ibid.
[385] Comparable service area & customers to NSG, therefore using their survey data.

= If unknown assume values in table below, or custom based on metering studies,[386] or if measured during DI:

= Measured full throttle flow * 0.83 throttling factor[387]

Note, if GPM_base is based upon the deemed assumptions below, since these include participants that had existing low flow fixtures, the freerider rate for this measure should be 0.

Faucet Type	GPM[388]
Kitchen	1.63
Bathroom	1.53
If faucet location unknown	1.58

GPM_low = Average flow rate, in gallons per minute, of the low-flow faucet aerator "as-used"

= 0.94,[389] or custom based on metering studies,[390] or if measured during DI:

= Rated full throttle flow * 0.95 throttling factor[391]

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	4.5[392]
Bathroom	1.6[393]
If faucet location unknown (total for household):	9.0[394]

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

[387] 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. Page 1-265. www.seattle.gov/light/Conserve/Reports/paper_10.pdf

[388] Based on flow meter bag testing conducted from June 2013 to January 2014 by Franklin Energy. Over 300 residential sites in the Chicago area were tested.

[389] Average retrofit flow rate for kitchen and bathroom faucet aerators from sources 2, 4, 5, and 7(see source table at end of characterization). This accounts for all throttling and differences from rated flow rates. Assumes all kitchen aerators at 2.2 gpm or less and all bathroom aerators at 1.5 gpm or less. The most comprehensive available studies did not disaggregate kitchen use from bathroom use, but instead looked at total flow and length of use for all faucets. This makes it difficult to reliably separate kitchen water use from bathroom water use. It is possible that programs installing low flow aerators lower than the 2.2 gpm for kitchens and 1.5 gpm for bathrooms will see a lower overall average retrofit flow rate.

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

[391] 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. Page 1-265.

[392] 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.

[393] Ibid.

[394] One kitchen faucet plus 2.83 bathroom faucets. Based on findings from a 2009 ComEd residential survey of 140 sites, provided by Cadmus.

Single-Family except mobile homes	
If location unknown (total for household): Multifamily and mobile homes	6.9[395]
If faucet location and building type unknown (total for household)	8.3[396]

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	4.5[397]
Bathroom	1.6[398]
If faucet location unknown (total for household): Single-Family except mobile homes	9.0[399]
If faucet location unknown (total for household): Multifamily	6.9[400]
If faucet location and building type unknown (total for household)	8.3[401]

Household = Average number of people per household

Household Unit Type	Household
Single-Family - Deemed	2.56[402]
Multi-Family - Deemed	2.1[403]
Household type unknown	2.42[404]
Custom	Actual Occupancy or Number of Bedrooms[405]

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

[395] One kitchen faucet plus 1.5 bathroom faucets. Based on findings from a 2009 ComEd residential survey of 140 sites, provided by Cadmus.
[396] Unknown is based on statewide weighted average of 69% single family and 31% multifamily, based on IL data from 2009 RECS Table HC2.9 Structural and Geographic Characteristics of Homes in Midwest Region, Divisions and States, 2009.
[397] Cadmus and Opinion Dynamics Showerhead and Faucet Aerator Meter Study Memorandum dated June 2013, directed to Michigan Evaluation Working Group.
[398] Ibid.
[399] One kitchen faucet plus 2.83 bathroom faucets. Based on findings from a 2009 ComEd residential survey of 140 sites, provided by Cadmus.
[400] One kitchen faucet plus 1.5 bathroom faucets. Based on findings from a 2009 ComEd residential survey of 140 sites, provided by Cadmus.
[401] Unknown is based on statewide weighted average of 69% single family and 31% multifamily, based on IL data from 2009 RECS Table HC2.9 Structural and Geographic Characteristics of Homes in Midwest Region, Divisions and States, 2009.
[402] ComEd Energy Efficiency/ Demand Response Plan: Plan Year 2 (6/1/2009-5/31/2010) Evaluation Report: All Electric Single Family Home Energy Performance Tune-Up Program citing 2006-2008 American Community Survey data from the US Census Bureau for Illinois cited on p. 17 of the PY2 Evaluation report. 2.75 * 93% evaluation adjustment
[403] Navigant, ComEd PY3 Multifamily Home Energy Savings Program Evaluation Report Final, May 16, 2012.
[404] Unknown is based on statewide weighted average of 69% single family and 31% multifamily, based on IL data from 2009 RECS Table HC2.9 Structural and Geographic Characteristics of Homes in Midwest Region, Divisions and States, 2009.
[405] 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.

365.25 = Days in a year, on average.

DF = Drain Factor

Faucet Type	Drain Factor[406]
Kitchen	75%
Bath	90%
Unknown	79.5%

FPH = Faucets Per Household

Faucet Type	FPH
Kitchen Faucets Per Home (KFPH)	1
Bathroom Faucets Per Home (BFPH): Single-Family except mobile homes	2.83[407]
Bathroom Faucets Per Home (BFPH): Multifamily and mobile homes	1.5[408]
If faucet location unknown (total for household): Single-Family except mobile homes	3.83
If faucet location unknown (total for household): Multifamily and mobile homes	2.5
If faucet location and building type unknown (total for household)	3.42[409]

EPG_electric = Energy per gallon of water used by faucet supplied by electric water heater

= (8.33 * 1.0 * (WaterTemp - SupplyTemp)) / (RE_electric * 3412)

= (8.33 * 1.0 * (86 – 50.7)) / (0.98 * 3412)

= 0.0879 kWh/gal (Bath), 0.1054 kWh/gal (Kitchen), 0.1004 kWh/gal (Unknown)

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 Bath, 93F for Kitchen 91F for Unknown[410]

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

[407] Based on findings from a 2009 ComEd residential survey of 140 sites, provided by Cadmus.

[408] Ibid.

[409] Unknown is based on statewide weighted average of 69% single family and 31% multifamily, based on IL data from 2009 RECS Table HC2.9 Structural and Geographic Characteristics of Homes in Midwest Region, Divisions and States, 2009.

[410] Cadmus and Opinion Dynamics Showerhead and Faucet Aerator Meter Study Memorandum dated June 2013, directed to

SupplyTemp = Assumed temperature of water entering house

= 50.7°F [411]

RE_electric = Recovery efficiency of electric water heater

= 98% [412]

3412 = Converts Btu to kWh (btu/kWh)

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

Selection	ISR
Direct Install	0.93[413,414]
Virtual Assessment followed by Unverified Self-Install	0.77[415,416]
Requested Efficiency Kit	0.60[417]
Distributed Efficiency Kit (Income Eligible)	0.46[418]
Community Distributed Kit	0.45[419]
Distributed School Efficiency Kit	0.505[420]

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)=91F.

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

[412] Electric water heaters have recovery efficiency of 98%.

[413] ComEd Energy Efficiency/ Demand Response Plan: Plan Year 2 (6/1/2009-5/31/2010) Evaluation Report: All Electric Single Family Home Energy Performance Tune-Up Program Table 3-8.

[414] Navigant, ComEd-Nicor Gas EPY4/GPY1 Multifamily Home Energy Savings Program Evaluation Report DRAFT 2013-01-28

[415] An equal weighted average of Direct Install and Efficiency Kit ISRs. Guidehouse, *In-Service Rates for CY2020 Single Family Virtual Assessment Measures*, August 20, 2020. Interest and applicability of measures confirmed through virtual assessment. Please note, these ISRs do not apply to retail purchases by end user.

[416] An equal weighted average of Direct Install and Efficiency Kit ISRs. Interest and applicability of measures confirmed through virtual assessment. Please note, these ISRs do not apply to retail purchases by end user.

[417] A weighted ISR was found by weighting Nicor and Ameren efficiency kit program uptake and their previously found ISRs. This analysis can be found in Faucet Aerators and Showerheads Weighted Average ISR IL TRM.xlsx.

[418] Average of Guidehouse survey research for Peoples Gas, June 16, 2020 and Research from 2021 Ameren Illinois Income Qualified participant survey, available on IL SAG website: https://ilsag.s3.amazonaws.com/AIC-Income-Qualified-Initiative-Participant-Survey-Results-Memo-FINAL-2022-02-01.pdf

[419] Research from 2018 Ameren Illinois Income Qualified participant survey.

[420] Results from Home Energy Worksheets completed by student/families in 2020, 2021, and 2022 were nearly the same as values from: Opinion Dynamics and Cadmus. 2018 AIC Residential Program Annual Impact Evaluation Report. April 30, 2019. Results from implementer-administered participant survey. Home Energy Worksheets also establish the fraction of participants who indicate they "will install later" for specific measures. Follow-up research completed by Guidehouse for Nicor Gas in 2022 found that, on average, 51.3% of respondents who initially reported that they hadn't installed specific kit measures, but "planned to" subsequently had installed the measures. Combining these findings allows for an ISR that accounts for initial and one round of subsequent intallations. To maintain a conservative estimate of ISR, the remaining 48.7% are presumed uninstalled. See: EESchoolKitSubsequentInstall_HEW.xlsx for data and calculations.

For example, a direct installed kitchen low flow faucet aerator in an individual electric DHW home:

ΔkWh = 1.0 * (((1.63 * 4.5 – 0.94 * 4.5) * 2.56 * 365.25 *0.75) / 1) * 0.1054 * 0.93

= 213.4 kWh

For example, a direct installed bath low flow faucet aerator in a shared electric DHW home:

ΔkWh = 1.0 * (((1.53 * 1.6 – 0.94 * 1.6) * 2.1 * 365.25 * 0.90) /1.5) * 0.0879 * 0.93

= 35.5 kWh

For example, a direct installed low flow faucet aerator in unknown faucet in an individual electric DHW home:

ΔkWh = 1.0 * (((1.58 * 9.0 – 0.94 * 9.0) * 2.56 * 365.25 * 0.795) /3.83) * 0.1004 * 0.93

= 104.4 kWh

Secondary kWh Savings for Water Supply and Wastewater Treatment

The following savings should be included in the total savings for this measure but should not be included in TRC tests to avoid double counting the economic benefit of water savings.

ΔkWh_{water} = ΔWater (gallons) / 1,000,000 * $E_{water\ total}$

Where

$E_{water\ total}$ = IL Total Water Energy Factor (kWh/Million Gallons)

=5010[421]

For example, a direct installed kitchen low flow aerator in an single family home

ΔWater (gallons) = (((1.63 * 4.5 – 0.94 * 4.5) * 2.56 * 365.25 *0.75) / 1) * 0.93

= 2025 gallons

ΔkWh_{water} = 2025/1000000 * 5010

=10.1 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ΔkWh / Hours * CF

Where:

ΔkWh = calculated value above. Note do not include the secondary savings in this calculation.

Hours = Annual electric DHW recovery hours for faucet use per faucet

= ((GPM_base * L_base) * Household/FPH * 365.25 * DF) * 0.567[422] / GPH

Building	Faucet	Calculation	Hours per

[421] This factor includes 2571 kWh/MG for water supply based on Illinois energy intensity data from a 2012 ISAWWA study and 2439 kWh/MG for wastewater treatment based on national energy intensity use estimates. For more information please review Elevate Energy's 'IL TRM: Energy per Gallon Factor, May 2018 paper'.

[422] 56.7% is the proportion of hot 120F water mixed with 50.7F supply water to give 90F mixed faucet water.

Type	location		faucet
Single Family	Kitchen	((1.63 * 4.5) * 2.56/1 * 365.25 * 0.75) * 0.567 / 26.1	112
	Bathroom	((1. 53 * 1.6) * 2.56/2.83 * 365.25 * 0.9) * 0.567 / 26.1	16
	Unknown	((1. 58* 9.0) * 2.56/3.83 * 365.25 * 0.795) * 0.567 / 26.1	60
Multifamily	Kitchen	((1. 63 * 4.5) * 2.1/1 * 365.25 * 0.75) * 0.567 / 26.1	92
	Bathroom	((1. 53* 1.6) * 2.1/1.5 * 365.25 * 0.9) * 0.567 / 26.1	24
	Unknown	((1. 58 * 6.9) * 2.1/2.5 * 365.25 * 0.795) * 0.567 / 26.1	58

GPH = Gallons per hour recovery of electric water heater calculated for 69.3F temp rise (120-50.7), 98% recovery efficiency, and typical 4.5kW electric resistance storage tank.

= 26.1

CF = Coincidence Factor for electric load reduction

= 0.022[423]

For example, a direct installed kitchen low flow faucet aerator in a single family electric DHW home:

ΔkW =178/112 * 0.022

= 0.035 kW

FOSSIL FUEL SAVINGS

ΔTherms = %FossilDHW * ((GPM_base * L_base - GPM_low * L_low) * Household * 365.25 *DF / FPH) * EPG_gas * ISR

Where:

%FossilDHW = Percentage of DHW savings assumed to be fossil fuel

= 100 % for Fossil Fuel

= 0 % for Electric

= If unknown[424], use the following table:

[423] Calculated as follows: Assume 18% aerator use takes place during peak hours (based on: Oreo et al, "The end uses of hot water in single family homes from flow trace analysis", 2001.) There are 65 days in the summer peak period, so the percentage of total annual aerator use in peak period is 0.18*65/365 = 3.21%. The number of hours of recovery during peak periods is therefore assumed to be 3.21% *180 = 5.8 hours of recovery during peak period where 180 equals the average annual electric DHW recovery hours for faucet use including SF and MF homes. There are 260 hours in the peak period so the probability you will see savings during the peak period is 5.8/260 = 0.022

[424] Based on the average % electricity used for water heating in Unknown residential structure types across all utilities covered by the IL program. Residence types include: SF, SF LI, MF & MF LI. Utilities included: Ameren, ComEd, People's Gas, Northshore Gas & Nicor. Please see subsequent table and citations for specific sources.

	Location				
Utility	Single Family	Single Family Low Income	Multi Family	Multi Family Low Income	Unknown
Ameren[425]	76%	75%	60%	57%	72%
ComEd[426]	92%		89%		91%
People's Gas[427]	77%	74%	51%	50%	63%
Northshore Gas[428]	80%				
Nicor Gas[429]	80%				
All DUs					**77%**

Note: If a measure is supported by a gas and electric utility, utilize the assumptions above for the gas utility

EPG_gas = Energy per gallon of Hot water supplied by gas

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

= 0.0038 Therm/gal for SF homes (Bath), 0.0045 Therm/gal for SF homes (Kitchen), 0.0043 Therm/gal for SF homes (Unknown)

= 0.0044 Therm/gal for MF homes (Bath), 0.0053 Therm/gal for MF homes (Kitchen), 0.0050 Therm/gal for MF homes (Unknown)

RE_gas = Recovery efficiency of gas water heater

= 78% For individual water heater[430]

= 67% For shared water heater[431]

If unknown, use individual water heater value for single family, use shared water heater value for multifamily. Use multifamily if building meets utility's definition for multifamily.

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

[425] Provided by AEG from the 2020 Market Potential Study completed for AIC, as well as AIC Income Qualified Initiative: 2021 Participant Survey Results Memo (February 1, 2022) p. 17.
[426] Commonwealth Edison Residential Baseline Study (2020). p.4.4 & 4.19; Section 4-7 Water Heating. Prepared by Itron.
[427] Residential Appliance Saturation Survey of natural gas for space heating and water heating (2021). Note, Multifamily customers have a residential billing rate code and responded on the survey that they live in an apartment or condominium in a building that has either 2-4 or 5+ units.
[428] Ibid.
[429] Comparable service area & customers to NSG, therefore using their survey data.
[430] 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%.
[431] 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.

Other variables as defined above.

For example, a direct-installed kitchen low flow faucet aerator in a fuel DHW single-family home:

ΔTherms = 1.0 * (((1.63 * 4.5 – 0.94 * 4.5) * 2.56 * 365.25 *0.75) / 1) * 0.0045 * 0.93

= 9.11 Therms

For example, a direct installed bath low flow faucet aerator in a fuel DHW multi-family home:

ΔTherms = 1.0 * (((1.53 * 1.6 – 0.94 * 1.6) * 2.1 * 365.25 * 0.90) /1.5) * 0.0044 * 0.93

= 1.78 Therms

For example, a direct installed low flow faucet aerator in unknown faucet in a fuel DHW single-family home:

ΔTherms = 1.0 * (((1.58 * 9.0 – 0.94 * 9.0) * 2.56 * 365.25 * 0.795) /3.83) * 0.0043 * 0.93

= 4.47 Therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

ΔWater (gallons) = ((GPM_base * L_base - GPM_low * L_low) * Household * 365.25 *DF / FPH) * ISR

Variables as defined above

For example, a direct-installed kitchen low flow aerator in a single family home

ΔWater (gallons) = (((1.63 * 4.5 – 0.94 * 4.5) * 2.56 * 365.25 *0.75) / 1) * 0.93

= 2025 gallons

For example, a direct installed bath low flow faucet aerator in a multi-family home:

ΔWater (gallons) = (((1.53 * 1.6 – 0.94 * 1.6) * 2.1 * 365.25 * 0.90) /1.5) * 0.93

= 404 gallons

For example, a direct installed low flow faucet aerator in unknown faucet in a single family home:

ΔWater (gallons) = (((1.58 * 9.0 – 0.94 * 9.0) * 2.56 * 365.25 * 0.795) /3.83) * 0.93

= 1040 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.
2	2000, Mayer, Peter, William DeOreo, and David Lewis. Seattle Home Water Conservation Study. December 2000.
3	1999, Mayer, Peter, William DeOreo. Residential End Uses of Water. Published by AWWA Research Foundation and American Water Works Association. 1999.
4	2003, Mayer, Peter, William DeOreo. Residential Indoor Water Conservation Study. Aquacraft, Inc. Water Engineering and Management. Prepared for East Bay Municipal Utility District and the US EPA. July 2003.
5	2011, DeOreo, William. Analysis of Water Use in New Single Family Homes. By Aquacraft. For Salt Lake City Corporation and US EPA. July 20, 2011.
6	2011, Aquacraft. Albuquerque Single Family Water Use Efficiency and Retrofit Study. For Albuquerque Bernalillo County Water Utility Authority. December 1, 2011.
7	2008, Schultdt, Marc, and Debra Tachibana. Energy related Water Fixture Measurements: Securing the Baseline for Northwest Single Family Homes. 2008 ACEEE Summer Study on Energy Efficiency in Buildings.

MEASURE CODE: RS-HWE-LFFA-V14-240101

REVIEW DEADLINE: 1/1/2025

5.4.5 Low Flow Showerheads

DESCRIPTION

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

This measure 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, RF, NC, DI, 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 rated at least 0.5 gallons per minute (GPM) less than the existing showerhead. Savings are calculated on a per showerhead fixture basis.

DEFINITION OF BASELINE EQUIPMENT

For Direct install programs, the baseline condition is assumed to be a standard showerhead rated at 2.0 GPM or greater.

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

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 shower 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.[432]

DEEMED MEASURE COST

For time of sale or new construction the incremental cost for this measure is $7 or program actual.[433]

For low flow showerheads provided through Direct Install or within Efficiency Kits, the actual program delivery costs (including labor if applicable) should be utilized. If unknown assume $12 for Direct Install[434] and $7 for Efficiency Kits.

LOADSHAPE

Loadshape R03 - Residential Electric DHW

COINCIDENCE FACTOR

The coincidence factor for this measure is assumed to be 2.78%.[435]

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[432] 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.

[433] Market research average of $7.

[434] Includes assess and install labor time of $5 (20min @ $15/hr)

[435] Calculated as follows: Assume 11% showers take place during peak hours (based on: Oreo et al, "The end uses of hot water in single family homes from flow trace analysis", 2001.). There are 65 days in the summer peak period, so the percentage of total annual aerator use in peak period is 0.11*65/365 = 1.96%. The number of hours of recovery during peak periods is

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

Note these savings are per showerhead fixture

ΔkWh = %ElectricDHW * ((GPM_base * L_base - GPM_low * L_low) * Household * SPCD * 365.25 / SPH) * EPG_electric * ISR

Where:

%ElectricDHW = Percentage of DHW savings assumed to be electric

= 100 % for Electric

= 0 % for Fossil Fuel

= If unknown[436], use the following table:

	Location				
Utility	Single Family	Single Family Low Income	Multi Family	Multi Family Low Income	Unknown
Ameren[437]	24%	25%	40%	43%	28%
ComEd[438]	8%		11%		9%
People's Gas[439]	23%	26%	49%	50%	37%
Northshore Gas[440]	20%				
Nicor Gas[441]	20%				
All DUs					23%

Note: If a measure is supported by a gas and electric utility, utilize the assumptions above for the gas utility

GPM_base = Average flow rate, in gallons per minute, of the baseline faucet "as-used."

Note, if GPM_base is based upon the deemed assumptions below, since these include

therefore assumed to be 1.96% * 369 = 7.23 hours of recovery during peak period, where 369 equals the average annual electric DHW recovery hours for showerhead use including SF and MF homes with Direct Install and Retrofit/TOS measures. There are 260 hours in the peak period so the probability you will see savings during the peak period is 7.23/260 = 0.0278

436 Based on the average % electricity used for water heating in Unknown residential structure types across all utilities covered by the IL program. Residence types include: SF, SF LI, MF & MF LI. Utilities included: Ameren, ComEd, People's Gas, Northshore Gas & Nicor. Please see subsequent table and citations for specific sources.

437 Provided by AEG from the 2020 Market Potential Study completed for AIC, as well as AIC Income Qualified Initiative: 2021 Participant Survey Results Memo (February 1, 2022) p. 17.

438 Commonwealth Edison Residential Baseline Study (2020). p.4.4 & 4.19; Section 4-7 Water Heating. Prepared by Itron.

439 Residential Appliance Saturation Survey of natural gas for space heating and water heating (2021). Note, Multifamily customers have a residential billing rate code and responded on the survey that they live in an apartment or condominium in a building that has either 2-4 or 5+ units.

440 Ibid.

441 Comparable service area & customers to NSG, therefore using their survey data.

participants that had existing low flow fixtures, the freerider rate for this measure should be 0.

Program	GPM_base
Direct-install	2.24[442]
Retrofit, Efficiency Kits, NC or TOS	2.35[443]

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

Rated Flow
2.0 GPM
1.75 GPM
1.5 GPM
Custom or Actual[444]

L_base = Shower length in minutes with baseline showerhead

= 7.8 min[445]

L_low = Shower length in minutes with low-flow showerhead

= 7.8 min[446]

Household = Average number of people per household

Household Unit Type[447]	Household
Single-Family - Deemed	2.56[448]
Multi-Family - Deemed	2.1[449]
Household type unknown	2.42[450]

[442] Based on measurements conducted from June 2013 to January 2014 by Franklin Energy. Over 300 residential sites in the Chicago area were tested.

[443] 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.

[444] 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.

[445] 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.

[446] Ibid.

[447] If household type is unknown, as may be the case for time of sale measures, then single family deemed value shall be used.

[448] ComEd Energy Efficiency/ Demand Response Plan: Plan Year 2 (6/1/2009-5/31/2010) Evaluation Report: All Electric Single Family Home Energy Performance Tune-Up Program citing 2006-2008 American Community Survey data from the US Census Bureau for Illinois cited on p. 17 of the PY2 Evaluation report. 2.75 * 93% evaluation adjustment

[449] ComEd PY3 Multifamily Evaluation Report REVISED DRAFT v5 2011-12-08.docx

[450] Unknown is based on statewide weighted average of 69% single family and 31% multifamily, based on IL data from 2009 RECS Table HC2.9 Structural and Geographic Characteristics of Homes in Midwest Region, Divisions and States, 2009.

Custom	Actual Occupancy or Number of Bedrooms[451]

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

SPCD = Showers Per Capita Per Day

= 0.6[452]

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 except mobile homes	1.79[453]
Multifamily and mobile homes	1.3[454]
Household type unknown	1.64[455]
Custom	Actual

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

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 – 50.7)) / (0.98 * 3412)

= 0.125 kWh/gal

8.33 = Specific weight of water (lbs/gallon)

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

ShowerTemp = Assumed temperature of water

= 101°F[456]

SupplyTemp = Assumed temperature of water entering house

[451] 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.
[452] Cadmus and Opinion Dynamics Showerhead and Faucet Aerator Meter Study Memorandum dated June 2013, directed to Michigan Evaluation Working Group.
[453] Based on findings from a 2009 ComEd residential survey of 140 sites, provided by Cadmus.
[454] Ibid.
[455] Unknown is based on statewide weighted average of 69% single family and 31% multifamily, based on IL data from 2009 RECS Table HC2.9 Structural and Geographic Characteristics of Homes in Midwest Region, Divisions and States, 2009.
[456] Cadmus and Opinion Dynamics Showerhead and Faucet Aerator Meter Study Memorandum dated June 2013, directed to Michigan Evaluation Working Group.

= 50.7°F [457]

RE_electric = Recovery efficiency of electric water heater

= 98%[458]

3412 = Converts Btu to kWh (btu/kWh)

ISR = In service rate of showerhead dependant on install method as listed in table below

Selection	ISR
Direct Install	0.96[459,460]
Virtual Assessment followed by Unverified Self-Install	0.803[461]
Requested Efficiency Kits	0.65[462]
Distributed Efficiency Kits (Income Eligible)	0.48[463]
Distributed School Efficiency Kit showerhead	0.574[464]

For example, a direct-installed 1.5 GPM low flow showerhead in a single family home with electric DHW where the number of showers is not known:

ΔkWh = 1.0 * ((2.24 * 7.8 – 1.5 * 7.8) * 2.56 * 0.6 * 365.25 / 1.79) * 0.125 * 0.96

= 217 kWh

Secondary kWh Savings for Water Supply and Wastewater Treatment

The following savings should be included in the total savings for this measure, but should not be included in TRC tests to avoid double counting the economic benefit of water savings.

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

458 Electric water heaters have recovery efficiency of 98%.

459 Weighted average of 98% found in ComEd Energy Efficiency/ Demand Response Plan: Plan Year 2 (6/1/2009-5/31/2010) Evaluation Report: All Electric Single Family Home Energy Performance Tune-Up Program Table 3-8 (quantity surveyed = 163), and 87% from ComEd Single Family Retrofits CY2018 Field Work Memo 2019-07-19, Table 1 (quantity surveyed = 15). Alternative ISRs may be developed for program delivery methods based on evaluation results.

460 Navigant, ComEd-Nicor Gas EPY4/GPY1 Multifamily Home Energy Savings Program Evaluation Report FINAL 2013-06-05

461 An equal weighted average of Direct Install and Efficiency Kit ISRs. Interest and applicability of measures confirmed through virtual assessment. Average of homes using 1 Showerhead & 2 Showerhead.

462 A weighted ISR was found by weighting Nicor and Ameren efficiency kit program uptake and their previously found ISRs. This analysis can be found in Faucet Aerators and Showerheads Weighted Average ISR IL TRM.xlsx.

463 Average of Guidehouse survey research for Peoples Gas, June 16, 2020 and Research from 2021 Ameren Illinois Income Qualified participant survey, available on IL SAG website: https://ilsag.s3.amazonaws.com/AIC-Income-Qualified-Initiative-Participant-Survey-Results-Memo-FINAL-2022-02-01.pdf

464 Results from Home Energy Worksheets completed by student/families in 2020, 2021, and 2022 were nearly the same as values from: Opinion Dynamics and Cadmus. 2018 AIC Residential Program Annual Impact Evaluation Report. April 30, 2019. Results from implementer-administered participant survey. Home Energy Worksheets also establish the fraction of participants who indicate they "will install later" for specific measures. Follow-up research completed by Guidehouse for Nicor Gas in 2022 found that, on average, 51.3% of respondents who initially reported that they hadn't installed specific kit measures, but "planned to" subsequently had installed the measures. Combining these findings allows for an ISR that accounts for initial and one round of subsequent intallations. To maintain a conservative estimate of ISR, the remaining 48.7% are presumed uninstalled. See: EESchoolKitSubsequentInstall_HEW.xlsx for data and calculations.

$\Delta kWh_{water} = \Delta Water\ (gallons) / 1,000,000 * E_{water\ total}$

Where

$E_{water\ total}$ = IL Total Water Energy Factor (kWh/Million Gallons)

= 5010[465]

For example, a direct installed 1.5 GPM low flow showerhead in a single family where the number of showers is not known:

ΔWater (gallons) = ((2.24 * 7.8 – 1.5 * 7.8) * 2.56 * 0.6 * 365.25 / 1.79) * 0.96

= 1737 gallons

ΔkWh_{water} = 1737/1,000,000 * 5010

= 8.7 kWh

Summer Coincident Peak Demand Savings

ΔkW = ΔkWh/Hours * CF

Where:

ΔkWh = calculated value above. Note do not include the secondary savings in this calculation.

Hours = Annual electric DHW recovery hours for showerhead use

= ((GPM_base * L_base) * Household * SPCD * 365.25) * 0.726[466] / GPH

= 273 for SF Direct Install; 224 for MF Direct Install

= 286 for SF Retrofit, Efficiency Kits, NC and TOS; 236 for MF Retrofit, Efficiency Kits, NC and TOS

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

GPH = Gallons per hour recovery of electric water heater calculated for 69.3F temp rise (120-50.7), 98% recovery efficiency, and typical 4.5kW electric resistance storage tank.

= 26.1

CF = Coincidence Factor for electric load reduction

= 0.0278[467]

---

[465] This factor includes 2571 kWh/MG for water supply based on Illinois energy intensity data from a 2012 ISAWWA study and 2439 kWh/MG for wastewater treatment based on national energy intensity use estimates. For more information please review Elevate Energy's 'IL TRM: Energy per Gallon Factor, May 2018 paper'.

[466] 72.6% is the proportion of hot 120F water mixed with 50.7F supply water to give 101F shower water.

[467] Calculated as follows: Assume 11% showers take place during peak hours (based on: Oreo et al, "The end uses of hot water in single family homes from flow trace analysis", 2001.). There are 65 days in the summer peak period, so the percentage of total annual aerator use in peak period is 0.11*65/365 = 1.96%. The number of hours of recovery during peak periods is therefore assumed to be 1.96% * 369 = 7.23 hours of recovery during peak period where 369 equals the average annual electric DHW recovery hours for showerhead use including SF and MF homes with Direct Install and Retrofit/TOS measures. There are 260 hours in the peak period so the probability you will see savings during the peak period is 7.23/260 = 0.0278

> **For example**, a direct installed 1.5 GPM low flow showerhead in a single family home with electric DHW where the number of showers is not known:
>
> $\Delta kW = 217/273 * 0.0278$
>
> $= 0.022$ kW

FOSSIL FUEL SAVINGS

$$\Delta Therms = \%FossilDHW * ((GPM\_base * L\_base - GPM\_low * L\_low) * Household * SPCD * 365.25 / SPH) * EPG\_gas * ISR$$

Where:

%FossilDHW = Percentage of DHW savings assumed to be fossil fuel

= 100 % for Fossil Fuel

= 0 % for Electric

= If unknown[468], use the following table:

	Location				
Utility	**Single Family**	**Single Family Low Income**	**Multi Family**	**Multi Family Low Income**	**Unknown**
Ameren[469]	76%	75%	60%	57%	72%
ComEd[470]	92%		89%		91%
People's Gas[471]	77%	74%	51%	50%	63%
Northshore Gas[472]	80%				
Nicor Gas[473]	80%				
All DUs					**77%**

Note: If a measure is supported by a gas and electric utility, utilize the assumptions above for the gas utility

EPG_gas = Energy per gallon of Hot water supplied by gas

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

= 0.0054 Therm/gal for SF homes

468 Based on the average % electricity used for water heating in Unknown residential structure types across all utilities covered by the IL program. Residence types include: SF, SF LI, MF & MF LI. Utilities included: Ameren, ComEd, People's Gas, Northshore Gas & Nicor. Please see subsequent table and citations for specific sources.

469 Provided by AEG from the 2020 Market Potential Study completed for AIC, as well as AIC Income Qualified Initiative: 2021 Participant Survey Results Memo (February 1, 2022) p. 17.

470 Commonwealth Edison Residential Baseline Study (2020). p.4.4 & 4.19; Section 4-7 Water Heating. Prepared by Itron.

471 Residential Appliance Saturation Survey of natural gas for space heating and water heating (2021). Note, Multifamily customers have a residential billing rate code and responded on the survey that they live in an apartment or condominium in a building that has either 2-4 or 5+ units.

472 Ibid.

473 Comparable service area & customers to NSG, therefore using their survey data.

= 0.0063 Therm/gal for MF homes

RE_gas = Recovery efficiency of gas water heater

= 78% For individual water heater[474]

= 67% For shared water heater[475]

If unknown, use individual water heater value for single family, use shared water heater value for multifamily. Use multifamily if building meets utility's definition for multifamily.

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

Other variables as defined above.

For example, a direct installed 1.5 GPM low flow showerhead in a gas fired DHW single family home where the number of showers is not known:

ΔTherms = 1.0 * ((2.24 * 7.8 – 1.5 * 7.8) * 2.56 * 0.6 * 365.25 / 1.79) * 0.0054 * 0.96

= 9.4 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

ΔWater (gallons) = ((GPM_base * L_base - GPM_low * L_low) * Household * SPCD * 365.25 / SPH) * ISR

Variables as defined above

For example, a direct installed 1.5 GPM low flow showerhead in a single family home where the number of showers is not known:

ΔWater (gallons) = ((2.24 * 7.8 – 1.5 * 7.8) * 2.56 * 0.6 * 365.25 / 1.79) * 0.96

= 1737 gallons

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

SOURCES

[474] 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%.

[475] 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.

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

MEASURE CODE: RS-HWE-LFSH-V13-240101

REVIEW DEADLINE: 1/1/2025

5.4.8 Thermostatic Restrictor Shower Valve

DESCRIPTION

The measure is the installation of a thermostatic restrictor shower valve in a single or multi-family 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, 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.[476]

DEEMED MEASURE COST

The incremental cost of the measure should be the actual program cost (including labor if applicable), or $30[477] plus $20 labor[478] if not available.

LOADSHAPE

Loadshape R03 - Residential Electric DHW

COINCIDENCE FACTOR

The coincidence factor for this measure is assumed to be 0.22%.[479]

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS

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

Where:

[476] Assumptions based on NY TRM, Pacific Gas and Electric Company Work Paper PGECODHW113, and measure life of low-flow showerhead.

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

[478] Estimate for contractor installation time.

[479] Calculated as follows: Assume 11% showers take place during peak hours (based on: Oreo et al, “The end uses of hot water in single family homes from flow trace analysis”, 2001.). There are 65 days in the summer peak period, so the percentage of total annual use in peak period is 0.11*65/365 = 1.96%. The number of hours of recovery during peak periods is therefore assumed to be 1.96% * 29.5 = 0.577 hours of recovery during peak period, where 29.5 equals the average annual electric DHW recovery hours for showerhead use prevented by the device including SF and MF homes with Direct Install and Retrofit/TOS measures. There are 260 hours in the peak period so the probability you will see savings during the peak period is 0.577/260 = 0.0022

%ElectricDHW = Percentage of DHW savings assumed to be electric

= 100 % for Electric

= 0 % for Fossil Fuel

= If unknown[480], use the following table:

	Location				
Utility	**Single Family**	**Single Family Low Income**	**Multi Family**	**Multi Family Low Income**	**Unknown**
Ameren[481]	24%	25%	40%	43%	28%
ComEd[482]	8%		11%		9%
People's Gas[483]	23%	26%	49%	50%	37%
Northshore Gas[484]	20%				
Nicor Gas[485]	20%				
All DUs					23%

Note: If a measure is supported by a gas and electric utility, utilize the assumptions above for the gas utility

GPM_base_S = Flow rate of the basecase showerhead, or actual if available

Program	GPM
Direct-install, device only	2.24[486]
New Construction or direct install of device and low flow showerhead	Rated or actual flow of program-installed showerhead
Retrofit or TOS	2.35[487]

L_showerdevice = Hot water waste time avoided due to thermostatic restrictor valve

[480] Based on the average % electricity used for water heating in Unknown residential structure types across all utilities covered by the IL program. Residence types include: SF, SF LI, MF & MF LI. Utilities included: Ameren, ComEd, People's Gas, Northshore Gas & Nicor. Please see subsequent table and citations for specific sources.

[481] Provided by AEG from the 2020 Market Potential Study completed for AIC, as well as AIC Income Qualified Initiative: 2021 Participant Survey Results Memo (February 1, 2022) p. 17.

[482] Commonwealth Edison Residential Baseline Study (2020). p.4.4 & 4.19; Section 4-7 Water Heating. Prepared by Itron.

[483] Residential Appliance Saturation Survey of natural gas for space heating and water heating (2021). Note, Multifamily customers have a residential billing rate code and responded on the survey that they live in an apartment or condominium in a building that has either 2-4 or 5+ units.

[484] Ibid.

[485] Comparable service area & customers to NSG, therefore using their survey data.

[486] Based on measurements conducted from June 2013 to January 2014 by Franklin Energy. Over 300 residential sites in the Chicago area were tested.

[487] 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.

= 0.89 minutes[488]

Household = Average number of people per household

Household Unit Type[489]	Household
Single-Family - Deemed	2.56[490]
Multi-Family - Deemed	2.1[491]
Household type unknown	2.42[492]
Custom	Actual Occupancy or Number of Bedrooms[493]

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

SPCD = Showers Per Capita Per Day

= 0.6[494]

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	1.79[495]
Multifamily	1.3[496]
Household type unknown	1.64[497]
Custom	Actual

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

EPG_electric = Energy per gallon of hot water supplied by electric

= (8.33 * 1.0 * (ShowerTemp - SupplyTemp)) / (RE_electric * 3412)

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488 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.

489 If household type is unknown, as may be the case for time of sale measures, then single family deemed value shall be used.

490 ComEd Energy Efficiency/ Demand Response Plan: Plan Year 2 (6/1/2009-5/31/2010) Evaluation Report: All Electric Single Family Home Energy Performance Tune-Up Program citing 2006-2008 American Community Survey data from the US Census Bureau for Illinois cited on p. 17 of the PY2 Evaluation report. 2.75 * 93% evaluation adjustment

491 ComEd PY3 Multifamily Evaluation Report REVISED DRAFT v5 2011-12-08.docx

492 Unknown is based on statewide weighted average of 69% single family and 31% multifamily, based on IL data from 2009 RECS Table HC2.9 Structural and Geographic Characteristics of Homes in Midwest Region, Divisions and States, 2009.

493 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.

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

495 Based on findings from a 2009 ComEd residential survey of 140 sites, provided by Cadmus.

496 Ibid.

497 Unknown is based on statewide weighted average of 69% single family and 31% multifamily, based on IL data from 2009 RECS Table HC2.9 Structural and Geographic Characteristics of Homes in Midwest Region, Divisions and States, 2009.

= (8.33 * 1.0 * (101 – 50.7)) / (0.98 * 3412)

= 0.125 kWh/gal

8.33 = Specific weight of water (lbs/gallon)

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

ShowerTemp = Assumed temperature of water

= 101F [498]

SupplyTemp = Assumed temperature of water entering house

= 50.7°F [499]

RE_electric = Recovery efficiency of electric water heater

= 98% [500]

3412 = Converts Btu to kWh (btu/kWh)

ISR = In service rate of showerhead

= Dependent on program delivery method as listed in table below

Selection	ISR
Direct Install - Single Family	0.98[501]
Direct Install – Multi Family	0.95[502]
Efficiency Kits	To be determined through evaluation

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

For example, a direct installed valve in a single-family home with electric DHW:

ΔkWh = 1.0 * (2.24 * 0.89 * 2.56 * 0.6 * 365.25 / 1.79) * 0.125 * 0.98

= 76.5 kWh

Secondary kWh Savings for Water Supply and Wastewater Treatment

The following savings should be included in the total savings for this measure, but should not be included in TRC

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

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

[500] Electric water heaters have recovery efficiency of 98%.

[501] Deemed values are from ComEd Energy Efficiency/ Demand Response Plan: Plan Year 2 (6/1/2009-5/31/2010) Evaluation Report: All Electric Single Family Home Energy Performance Tune-Up Program Table 3-8. Alternative ISRs may be developed for program delivery methods based on evaluation results.

[502] Navigant, ComEd-Nicor Gas EPY4/GPY1 Multifamily Home Energy Savings Program Evaluation Report FINAL 2013-06-05

tests to avoid double counting the economic benefit of water savings.

ΔkWh_{water} = ΔWater (gallons) / 1,000,000 * $E_{water\ total}$

Where

$E_{water\ total}$ = IL Total Water Energy Factor (kWh/Million Gallons)

=5,010[503]

For example, a direct installed thermostatic restrictor device in a single family home where the number of showers is not known: ΔWater (gallons) = ((2.24* 0.89) * 2.56 * 0.6 * 365.25 / 1.79) * 0.98 = 612 gallons ΔkWh_{water} = 612/1,000,000 * 5010 = 3.1 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ΔkWh/Hours * CF

Where:

ΔkWh = calculated value above. Note do not include the secondary savings in this calculation.

Hours = Annual electric DHW recovery hours for wasted showerhead use prevented by device

= ((GPM_base_S * L_showerdevice) * Household * SPCD * 365.25) * 0.726[504] / GPH

GPH = Gallons per hour recovery of electric water heater calculated for 69.3F temp rise (120-50.7), 98% recovery efficiency, and typical 4.5kW electric resistance storage tank.

= 26.1

= 31.1 for SF Direct Install; 25.5 for MF Direct Install

= 32.6 for SF Retrofit and TOS; 26.7 for MF Retrofit and TOS

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

CF = Coincidence Factor for electric load reduction

= 0.0022[505]

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503 This factor include 2571 kWh/MG for water supply based on Illinois energy intensity data from a 2012 ISAWWA study and 2439 kWh/MG for wastewater treatment based on national energy intensity use estimates. For more information please review Elevate Energy's 'IL TRM: Energy per Gallon Factor, May 2018 paper'.

504 72.6% is the proportion of hot 120F water mixed with 50.7F supply water to give 101F shower water.

505 Calculated as follows: Assume 11% showers take place during peak hours (based on: Oreo et al, "The end uses of hot water

> **For example**, a direct installed thermostatic restrictor device in a home with electric DHW where the number of showers is not known.
>
> ΔkW = 76.5/31.1 * 0.0022
>
> = 0.0054 kW

FOSSIL FUEL SAVINGS

ΔTherms = %FossilDHW * ((GPM_base_S * L_showerdevice)* Household * SPCD * 365.25 / SPH) * EPG_gas * ISR

Where:

%FossilDHW = Percentage of DHW savings assumed to be fossil fuel

= 100 % for Fossil Fuel

= 0 % for Electric

= If unknown[506], use the following table:

	Location				
Utility	**Single Family**	**Single Family Low Income**	**Multi Family**	**Multi Family Low Income**	**Unknown**
Ameren[507]	76%	75%	60%	57%	72%
ComEd[508]	92%		89%		91%
People's Gas[509]	77%	74%	51%	50%	63%
Northshore Gas[510]	80%				
Nicor Gas[511]	80%				
All DUs					**77%**

Note: If a measure is supported by a gas and electric utility, utilize the assumptions above for the gas utility

in single family homes from flow trace analysis", 2001.). There are 65 days in the summer peak period, so the percentage of total annual use in peak period is 0.11*65/365 = 1.96%. The number of hours of recovery during peak periods is therefore assumed to be 1.96% * 29.5 = 0.577 hours of recovery during peak period, where 29.5 equals the average annual electric DHW recovery hours for showerhead use prevented by the device including SF and MF homes with Direct Install and Retrofit/TOS measures. There are 260 hours in the peak period so the probability you will see savings during the peak period is 0.577/260 = 0.0022

[506] Based on the average % electricity used for water heating in Unknown residential structure types across all utilities covered by the IL program. Residence types include: SF, SF LI, MF & MF LI. Utilities included: Ameren, ComEd, People's Gas, Northshore Gas & Nicor. Please see subsequent table and citations for specific sources.

[507] Provided by AEG from the 2020 Market Potential Study completed for AIC, as well as AIC Income Qualified Initiative: 2021 Participant Survey Results Memo (February 1, 2022) p. 17.

[508] Commonwealth Edison Residential Baseline Study (2020). p.4.4 & 4.19; Section 4-7 Water Heating. Prepared by Itron.

[509] Residential Appliance Saturation Survey of natural gas for space heating and water heating (2021). Note, Multifamily customers have a residential billing rate code and responded on the survey that they live in an apartment or condominium in a building that has either 2-4 or 5+ units.

[510] Ibid.

[511] Comparable service area & customers to NSG, therefore using their survey data.

EPG_gas = Energy per gallon of Hot water supplied by gas

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

= 0.0054 Therm/gal for SF homes

= 0.0063 Therm/gal for MF homes

RE_gas = Recovery efficiency of gas water heater

= 78% For SF homes[512]

= 67% For MF homes[513]

Use Multifamily if: Building has shared DHW.

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

Other variables as defined above.

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 * ((2.24 * 0.89) * 2.56 * 0.6 * 365.25 / 1.79) * 0.0054 * 0.98

= 3.3 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

ΔWater (gallons) = ((GPM_base_S * L_showerdevice) * Household * SPCD * 365.25 / SPH) * ISR

Variables as defined above

For example, a direct installed thermostatic restrictor device in a single family home where the number of showers is not known:

ΔWater (gallons) = ((2.24 * 0.89) * 2.56 * 0.6 * 365.25 / 1.79) * 0.98

= 612 gallons

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

SOURCES

512 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%.

513 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.

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

MEASURE CODE: RS-HWE-TRVA-V08-240101

REVIEW DEADLINE: 1/1/2023

5.4.9 Shower Timer

DESCRIPTION

Shower Timers are designed to make it easy for people to consistently take short showers, resulting in water and energy savings.

The shower timer provides a reminder to participants on length of their shower visually or auditorily.

This measure was developed to be applicable to the following program type: KITS, DI.

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

DEFINITION OF EFFICIENT EQUIPMENT

The shower timer should provide a reminder to participants to keep showers to a length of 5 minutes or less.

DEFINITION OF BASELINE EQUIPMENT

The baseline is no shower timer.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The deemed lifetime is 2 years.[514]

DEEMED MEASURE COST

For shower timers provided in Efficiency Kits, the actual program delivery costs should be utilized.

LOADSHAPE

Loadshape R03 - Residential Electric DHW

COINCIDENCE FACTOR

The coincidence factor for this measure is assumed to be 2.78%.[515]

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS

ΔkWh = %Electric DHW * GPM * (L_base – L_timer) * Household * Days/yr * SPCD * UsageFactor * EPG_Electric

Where:

%Electric DHW = Percentage of DHW savings assumed to be electric

= 100 % for Electric

[514] Estimate of persistence of behavior change instigated by the shower timer.

[515] Calculated as follows: Assume 11% showers take place during peak hours (based on: Oreo et al, "The end uses of hot water in single family homes from flow trace analysis", 2001.). There are 65 days in the summer peak period, so the percentage of total annual aerator use in peak period is 0.11*65/365 = 1.96%. The number of hours of recovery during peak periods is therefore assumed to be 1.96% * 369 = 7.23 hours of recovery during peak period, where 369 equals the average annual electric DHW recovery hours for showerhead use including SF and MF homes with Direct Install and Retrofit/TOS measures. There are 260 hours in the peak period so the probability you will see savings during the peak period is 7.23/260 = 0.0278

= 0 % for Fossil Fuel

= If unknown[516], use the following table:

Utility	Location: Single Family	Single Family Low Income	Multi Family	Multi Family Low Income	Unknown
Ameren[517]	24%	25%	40%	43%	28%
ComEd[518]	8%		11%		9%
People's Gas[519]	23%	26%	49%	50%	37%
Northshore Gas[520]	20%				
Nicor Gas[521]	20%				
All DUs					23%

Note: If a measure is supported by a gas and electric utility, utilize the assumptions above for the gas utility

GPM = Flow rate of showerhead as used

= Custom, to be determined through evaluation. If data is not available use 1.93[522]

L_base = Number of minutes in shower without a shower timer

=7.8 minutes[523]

L_timer = Number of minutes in shower after shower timer

= Custom, to be determined through evaluation. If data is not available use 5.79.[524]

Household = Number in household using timer

[516] Based on the average % electricity used for water heating in Unknown residential structure types across all utilities covered by the IL program. Residence types include: SF, SF LI, MF & MF LI. Utilities included: Ameren, ComEd, People's Gas, Northshore Gas & Nicor. Please see subsequent table and citations for specific sources.
[517] Provided by AEG from the 2020 Market Potential Study completed for AIC, as well as AIC Income Qualified Initiative: 2021 Participant Survey Results Memo (February 1, 2022) p. 17.
[518] Commonwealth Edison Residential Baseline Study (2020). p.4.4 & 4.19; Section 4-7 Water Heating. Prepared by Itron.
[519] Residential Appliance Saturation Survey of natural gas for space heating and water heating (2021). Note, Multifamily customers have a residential billing rate code and responded on the survey that they live in an apartment or condominium in a building that has either 2-4 or 5+ units.
[520] Ibid.
[521] Comparable service area & customers to NSG, therefore using their survey data.
[522] Navigant Elementary Education GPY4 Evaluation Report, dated May 12, 2016. Average of all utilities.
[523] 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.
[524] Navigant Elementary Education GPY4 Evaluation Report, dated May 12, 2016. Average of all utilities.

Household Unit Type[525]	Household
Single-Family - Deemed	2.56[526]
Multi-Family - Deemed	2.1[527]
Household type unknown	2.42[528]
Custom	Actual Occupancy or Number of Bedrooms[529]

Days/yr = 365.25

SPCD = Showers Per Capita Per Day

= 0.6[530]

UsageFactor = How often each participant is using shower timer

=Custom, to be determined through evaluation. If data is not available use 0.34[531]

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 – 50.7)) / (0.98 * 3412)

=0.125 kWh/gal

Where:

ShowerTemp = Assumed temperature of water

= 101°F[532]

SupplyTemp = Assumed temperature of water entering house

= 50.7°F [533]

[525] If household type is unknown, as may be the case for time of sale measures, then single family deemed value shall be used.

[526] ComEd Energy Efficiency/ Demand Response Plan: Plan Year 2 (6/1/2009-5/31/2010) Evaluation Report: All Electric Single Family Home Energy Performance Tune-Up Program citing 2006-2008 American Community Survey data from the US Census Bureau for Illinois cited on p. 17 of the PY2 Evaluation report. 2.75 * 93% evaluation adjustment

[527] ComEd PY3 Multifamily Evaluation Report REVISED DRAFT v5 2011-12-08.docx

[528] Unknown is based on statewide weighted average of 69% single family and 31% multifamily, based on IL data from 2009 RECS Table HC2.9 Structural and Geographic Characteristics of Homes in Midwest Region, Divisions and States, 2009.

[529] 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.

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

[531] Navigant Elementary Education GPY4 Evaluation Report, dated May 12, 2016. Average of all utilities.

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

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

Based on default assumptions provided above, the savings for a single family home would be:

ΔkWh = %Electric DHW * GPM * (L_base – L_timer) * Household * Days/yr * SPCD * UsageFactor * EPG_Electric

= 0.16 * 1.93 * (7.8 – 5.79) * 2.56 * 365.25 * 0.6 * 0.34 * 0.125

=14.8kWh

Secondary kWh Savings for Water Supply and Wastewater Treatment

The following savings should be included in the total savings for this measure, but should not be included in TRC tests to avoid double counting the economic benefit of water savings.

ΔkWh_{water} = ΔWater (gallons) / 1,000,000 * $E_{water\ total}$

Where

$E_{water\ total}$ = IL Total Water Energy Factor (kWh/Million Gallons)

=5,010[534]

Based on default assumptions provided above, the savings for a single family home would be:

ΔWater (gallons) = GPM * (L_base – L_timer) * Household * Days/yr * SPCD * UsageFactor

= 1.93 * (7.8 – 5.79) * 2.56 * 365.25 * 0.6 * 0.34

= 740.0 gallons

ΔkWh_{water} = 740/1,000,000 * 5010

= 3.7 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ΔkWh/Hours * CF

Where:

ΔkWh = calculated value above. Note do not include the secondary savings in this calculation.

Hours = Annual electric DHW recovery hours for showerhead use

= (GPM_base * L_base * Household * SPCD * UsageFactor * 365.25) * 0.726 [535] / GPH

[534] This factor include 2571 kWh/MG for water supply based on Illinois energy intensity data from a 2012 ISAWWA study and 2439 kWh/MG for wastewater treatment based on national energy intensity use estimates. For more information please review Elevate Energy's 'IL TRM: Energy per Gallon Factor, May 2018 paper'.

[535] 72.6% is the proportion of hot 120F water mixed with 50.7F supply water to give 101F shower water.

GPH = Gallons per hour recovery of electric water heater calculated for 69.3F temp rise (120-50.7), 98% recovery efficiency, and typical 4.5kW electric resistance storage tank.

= 26.1

CF = Coincidence Factor for electric load reduction

= 0.0278[536]

Based on default assumptions provided above, the savings for a single family home would be:

Hours = (1.93 * 7.8 * 2.56 * 0.6 * 0.34 * 365.25) * 0.726/26.1

= 79.9 Hours

ΔkW = ΔkWh/Hours * CF

= 14.8 / 79.9 * 0.0278

= 0.0051 kW

FOSSIL FUEL SAVINGS

ΔTherms = %FossilDHW * GPM * (L_base – L_timer) * Household * Days/yr * SPCD * UsageFactor * EPG_Gas

%FossilDHW = Percentage of DHW savings assumed to be fossil fuel

= 100 % for Fossil Fuel

= 0 % for Electric

= If unknown[537], use the following table:

Utility	Location				
	Single Family	Single Family Low Income	Multi Family	Multi Family Low Income	Unknown
Ameren[538]	76%	75%	60%	57%	72%
ComEd[539]	92%		89%		91%

[536] Calculated as follows: Assume 11% showers take place during peak hours (based on: Oreo et al, "The end uses of hot water in single family homes from flow trace analysis", 2001.). There are 65 days in the summer peak period, so the percentage of total annual aerator use in peak period is 0.11*65/365 = 1.96%. The number of hours of recovery during peak periods is therefore assumed to be 1.96% * 369 = 7.23 hours of recovery during peak period where 369 equals the average annual electric DHW recovery hours for showerhead use including SF and MF homes with Direct Install and Retrofit/TOS measures. There are 260 hours in the peak period so the probability you will see savings during the peak period is 7.23/260 = 0.0278

[537] Based on the average % electricity used for water heating in Unknown residential structure types across all utilities covered by the IL program. Residence types include: SF, SF LI, MF & MF LI. Utilities included: Ameren, ComEd, People's Gas, Northshore Gas & Nicor. Please see subsequent table and citations for specific sources.

[538] Provided by AEG from the 2020 Market Potential Study completed for AIC, as well as AIC Income Qualified Initiative: 2021 Participant Survey Results Memo (February 1, 2022) p. 17.

[539] Commonwealth Edison Residential Baseline Study (2020). p.4.4 & 4.19; Section 4-7 Water Heating. Prepared by Itron.

Utility	Location				
	Single Family	Single Family Low Income	Multi Family	Multi Family Low Income	Unknown
People's Gas[540]	77%	74%	51%	50%	63%
Northshore Gas[541]	80%				
Nicor Gas[542]	80%				
All DUs					**77%**

Note: If a measure is supported by a gas and electric utility, utilize the assumptions above for the gas utility

EPG_gas = Energy per gallon of Hot water supplied by gas

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

= 0.00537 Therm/gal for SF homes

= 0.00625 Therm/gal for MF homes

RE_gas = Recovery efficiency of gas water heater

= 78% For SF homes [543]

= 67% For MF homes[544]

Use Multifamily if: Building has shared DHW.

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

Other variables as defined above.

Based on default assumptions provided above, the savings for a single family home would be:

Δ Therms = %FossilDHW * GPM * (L_base – L_timer) * Household * Days/yr * SPCD * UsageFactor * EPG_Gas

= 0.84 * 1.93 * (7.8 – 5.79) * 2.56 * 365.25 * 0.6 * 0.34 * 0.00537

540 Residential Appliance Saturation Survey of natural gas for space heating and water heating (2021). Note, Multifamily customers have a residential billing rate code and responded on the survey that they live in an apartment or condominium in a building that has either 2-4 or 5+ units.
541 Ibid.
542 Comparable service area & customers to NSG, therefore using their survey data.
543 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%.
544 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 Therms

WATER DESCRIPTIONS AND CALCULATION

ΔWater (gallons) = GPM * (L_base – L_timer) * Household * Days/yr * SPCD * UsageFactor

Variables as defined above

Based on default assumptions provided above, the savings for a single family home would be:

ΔWater (gallons) = GPM * (L_base – L_timer) * Household * Days/yr * SPCD * UsageFactor

= 1.93 * (7.8 – 5.79) * 2.56 * 365.25 * 0.6 * 0.34

= 740.0 gallons

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-DHW-SHTM-V06-240101

REVIEW DEADLINE: 1/1/2026

5.6.8 High Performance Windows

DESCRIPTION

High Performance Windows (HPWs) greatly improve building thermal envelope performance compared to code standard double-glazed windows. HPWs must achieve a U-value ≤ 0.22 for the Northern climate zone,[545] or ≤ 0.25 for the North-Central climate zone. High performance windows significantly decrease heat loss through a building's envelope in a number of ways: by adding one or more additional panes of glass in the insulating glass unit (IGU), applying additional coatings to the glass panes, adding new gas fill, and/or using thermally improved spacers.

HPWs' reduced heat transfer significantly effects home energy savings as windows are often the weakest part of any building envelope. In addition to reducing heat transfer, HPWs also reduce air infiltration, thereby contributing to decreased HVAC loads. HPWs provide benefits for both heating and cooling seasons, and for both natural gas- and electrically-heated and cooled homes. They also have non-energy benefits such as increased thermal comfort and decreased outside noise.

This measure was developed for the following program types: New Construction (NC), Retrofit (RF), Time of Sale (TOS), and Early Replacement (EREP). If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

HPWs are windows that meet the ENERGY STAR® version 7.0 performance specifications shown below:

Table 1: Key Product Criteria for High Performance Windows[546]

<table>
<tr><th>IL Degree-Day Zone</th><th>ENERGY STAR Climate Zone</th><th>U-Value</th><th>SHGC</th><th>Prescriptive or Performance-Based</th></tr>
<tr><td rowspan="5">1 – Rockford
2 – Chicago
3 – Springfield</td><td rowspan="5">Northern</td><td>≤ 0.22</td><td>≥ 0.17</td><td>Prescriptive</td></tr>
<tr><td>= 0.23</td><td rowspan="2">≥ 0.35</td><td rowspan="4">Equivalent Energy Performance</td></tr>
<tr><td>= 0.24</td></tr>
<tr><td>= 0.25</td><td rowspan="2">≥ 0.40</td></tr>
<tr><td>= 0.26</td></tr>
<tr><td>4 – Belleville</td><td rowspan="2">North-Central</td><td rowspan="2">≤ 0.25</td><td rowspan="2">≤ 0.40</td><td>Prescriptive</td></tr>
<tr><td>5 – Marion</td><td>Prescriptive</td></tr>
</table>

HPWs can achieve these performance specifications in a number of ways. Some examples of HPWs include:

- Thin Triple Windows (TTW) – the insulating glass unit (IGU) contains three panes of glass. A thin pane of center glass allows the IGU to fit within a standard window frame, eliminating the need to redesign the window. The inclusion of a thin pane of center glass allows for an additional surface for low-E coating, reducing the window's emissivity of thermal radiation and the rate of heat transfer by improving the U-value of the IGU and overall assembly. TTWs have two equal width panes of glass on the exterior and interior of the IGU and a thin center piece of glass that allows the IGU to fit within an existing double-pane window frame.
- Triple Pane Windows – conventional triple pane windows that contain three panes of standard thickness glass. These windows provide an additional surface for a low-e coating and provide improved thermal performance by decreasing a window's emissivity and improving the window's resistance to heat loss. These windows are typically heavier than double-panes or TTWs and require a redesign of the window to allow the heavier, wider IGU to fit within the window frame.
- Double-pane windows that have low-e coatings on the two surfaces that face the cavity between the two

[545] In some cases, HPWs can have U-values of up to 0.26 in the Northern climate zone if the window meets alternative, performance-based SHGC thresholds. See **Error! Reference source not found.** for the specifications.

[546]ENERGY STAR® Version 7.0 Residential Windows, Doors, and Skylights Final Specification.

panes of glass as well as on the interior-facing interior pane of glass, warm edge spacers, and improved frame thermal properties (e.g., adding foam or other insulation to the frame cavities).[547]

Definition of Baseline Equipment

New Construction and Time of Sale: The tables below show International Energy Conservation Code (IECC) 2018 and IECC 2021 window codes for new construction. For first permits dated November 1, 2022 or later in the city of Chicago, residential new construction must be built in accordance with IECC 2021. The remainder of Illinois must be built in accordance with IECC 2018 until the IECC 2021 effective date.

Table 2: IECC – Fenestration Requirements[548,549]

IL Degree-Day Zone	IECC Climate Zone	U-Value	SHGC
1 – Rockford	5	≤ 0.30	*Not Rated*[550]
2 – Chicago			≤ 0.40[551]
3 – Springfield			*Not Rated*[552]
4 – Belleville	4	≤ 0.32	≤ 0.40
5 – Marion			

Early Replacement in Existing Homes:

Table 3: Existing Homes – Existing Window Values: Double Pane[553]

IL Degree-Day Zone	U-Value	SHGC
1 – Rockford	0.55	0.63
2 – Chicago		
3 – Springfield		
4 – Belleville		
5 – Marion		

[547] Stephen Selkowitz Consultants. Study of High-Performance Windows Incremental Manufacturing Cost. Prepared for NEEA, Report #E23-336. January 3, 2023.

[548] 2018 International Energy Conservation Code, Fifth Version: November 2021. TABLE R402.1.2. https://codes.iccsafe.org/content/IECC2018P5/chapter-4-re-residential-energy-efficiency

[549] 2021 International Energy Conservation Code, Second Version: September 2021. TABLE R402.1.2. https://codes.iccsafe.org/content/IECC2021P2/chapter-4-re-residential-energy-efficiency

[550] Value used in modeling: SHGC=0.30. Engineering judgement made during EnergyPlus modeling by Lili Yu and Robert Hart, Lawrence Berkeley National Laboratory, May 11, 2023.

[551] The Chicago SHGC shown in this table is based on IECC 2021 since--effective November 1, 2022--all first permits for new residential construction in Chicago must be built in accordance with IECC 2021. SHGCs for the other cities shown in this table are based on IECC 2018. Refer to local codes to determine the version of IECC that pertains to a specific municipality or region.

[552] Value used in modeling: SHGC=0.30. Engineering judgement made during EnergyPlus modeling by Lili Yu and Robert Hart, Lawrence Berkeley National Laboratory, May 11, 2023.

[553] Engineering judgement made during EnergyPlus modeling by Lili Yu and Robert Hart, Lawrence Berkeley National Laboratory, "High Performance Windows - Illinois Modeled Savings Summary," April 2021. Informed by 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.

Table 4: Existing Homes – Existing Window Values: Single Pane[554]

IL Degree-Day Zone	U-Value	SHGC
1 – Rockford	1.0	0.76
2 – Chicago		
3 – Springfield		
4 – Belleville		
5 – Marion		

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure life is assumed to be 40 years.[555]

The remaining life of existing equipment is assumed to be 13 years.[556]

DEEMED MEASURE COST

The incremental cost for this measure depends on the program delivery type/baseline and climate zone.

New Construction (NC) and Time of Sale (TOS): includes only equipment cost above baseline:

IL Degree-Day Zone	ENERGY STAR Climate Zone	NC or TOS[557]
1 – Rockford 2 – Chicago 3 - Springfield	Northern	$3.85/ft^2$
4 – Belleville 5 – Marion	North-Central	$2.18/ft^2$

Early Replacement (EREP): Actual equipment and labor costs for installation, less the present value of the assumed deferred replacement cost, should be used. If this is unknown, assume the defaults below. The assumed deferred cost (after 13 years) of replacing existing windows with a new code required double-pane baseline unit is assumed to be $48.50 per square foot[558].

IL Degree-Day Zone	ENERGY STAR Climate Zone	EREP
1 – Rockford 2 – Chicago	Northern	$52.35/ft^2$

[554] Ibid

[555] The Northwest Power Plan (NPCC). Please see sheet "Source Summary" within file: Com-Windows-2021P_V17.xlsx. Link: https://nwcouncil.app.box.com/s/u0dgjxkoxoj2tttym81uka3wrjcy6bo6/file/655810989510

[556] Assumed to be one third of effective useful life. For future TRM versions, recommend RUL be informed from program research.

[557] Based on US EPA. ENERGY STAR® Windows, Doors, and Skylights Draft 1 Version 7 Stakeholder Webinar. July 27, 2021. https://www.energystar.gov/sites/default/files/asset/document/V7_Stakeholder%20Meeting_7-27-2021_final.pdf. Costs on slide 20 were averaged across both SHGC values as both can meet ENERGY STAR v.7 performance specifications. These costs assume a 3'x5' (15ft^2) window.

[558] $37.82 inflated using 1.91% rate.

IL Degree-Day Zone	ENERGY STAR Climate Zone	EREP
3 - Springfield		
4 – Belleville 5 – Marion	North-Central	$50.68/ft^2

Retrofit (RF): Actual costs of equipment and labor should be used.

LOADSHAPE

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

COINCIDENCE FACTOR

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

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

= 68%[559]

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

= 72%[560]

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

= 67%[561]

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

= 46.6%[562]

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

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559 Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.

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

561 Multifamily coincidence factors both from; *All-Electric Homes PY6 Metering Results: Multifamily HVAC Systems*, Cadmus, October 2015

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

= 46.6%[563]

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

= 28.5%

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = \Delta kWh_{cooling} + \Delta kWh_{heating} + \Delta kWh_{fan}$$

$$\Delta kWh = CS_{cz} * Area_{window}$$

Where:

CS_{cz} = Annual heating, cooling + fan savings per area of window by climate zone, see Tables 5-7 below.

$Area_{window}$ = Total area of installed high performance windows. Use site specific value.

Table 5: Air Conditioner with Gas Furnace – electric savings per window area (kWh/ft^2)[564]

IL Degree-Day Zone	NC or TOS	EREP: Double Pane	EREP: Single Pane
1 – Rockford	0.58	1.22	2.33
2 – Chicago	0.61	1.20	2.24
3 – Springfield	0.51	1.39	2.70
4 – Belleville	0.53	1.39	2.74
5 – Marion	0.62	1.25	2.64

Table 6: Air Conditioner with Electric Resistance Heat – electric savings per window area (kWh/ft^2)[565]

IL Degree-Day Zone	NC or TOS	EREP: Double Pane	EREP: Single Pane
1 – Rockford	2.42	4.24	14.77
2 – Chicago	2.79	4.04	13.43
3 – Springfield	2.64	3.70	11.39
4 – Belleville	2.97	4.10	12.35
5 – Marion	2.16	3.95	9.88

[563] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.
[564] EnergyPlus modeling performed by Lili Yu and Robert Hart, "2023-07-26 LBNL Modeling_NC-TOS_TMYx.xlsx", " 2023-08-04 LBNL Modeling_EREP_TMYx_Double Pane", "2023-08-30 LBNL Modeling_EREP_TMYx_Single Pane," Lawrence Berkeley National Laboratory. May 11, 2023. Yu and Hart's energy modeling incorporated the most commonly commercially available windows that meet or exceed the energy performance criteria relevant to each climate zone (CZ). Specifically, the analysts derived energy savings using these specifications for HPWs: 1) Northern CZ, NC/TOS: U=0.30/SHGC=0.30; 2) Northern CZ, RF/EREP: U=0.22/SHGC=0.25; 3) North-Central CZ, NC/TOS: U=0.22/SGHC=0.25; 4) North-Central CZ RF/EREP: average of savings from U=0.25/SHGC=0.20 and U=0.25/SHGC=0.28.
[565] Ibid

Table 7: Heat Pump – electric savings per window area (kWh/ft²)[566]

IL Degree-Day Zone	NC or TOS	EREP: Double Pane	EREP: Single Pane
1 – Rockford	1.73	7.62	19.68
2 – Chicago	1.69	6.95	17.14
3 – Springfield	1.92	6.24	15.01
4 – Belleville	1.76	6.36	14.98
5 – Marion	1.43	5.90	12.62

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = \left(\frac{\Delta kWh_{cooling}}{FLH_{cooling}}\right) * CF$$

Where:

$\Delta kWh_{cooling}$ = Annual cooling-only electricity savings, based on climate zone and equipment type. See Tables 9-11

$FLH_{cooling}$ = Full load hours of air conditioning

= dependent on location:[567]

Climate Zone (City based upon)	Single Family	Multifamily
1 (Rockford)	547	499
2 (Chicago)	709	629
3 (Springfield)	779	707
4 (Belleville)	1082	982
5 (Marion)	956	868
Weighted Average[568]		
ComEd	676	603
Ameren	875	791
Statewide	731	655

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

= 68%[569]

$CF_{SSP\ SF}$ = Summer System Peak Coincidence Factor for Heat Pumps in single-family homes

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566 Ibid

567 Full load hours for Chicago, Moline and Rockford are provided in "Final Evaluation Report: Central Air Conditioning Efficiency Services (CACES), 2010, Navigant Consulting", p.33. An average FLH/Cooling Degree Day (from NCDC) ratio was calculated for these locations and applied to the CDD of the other locations in order to estimate FLH. There is a county mapping table in Volume 1, Section 3.7 providing the appropriate city to use for each county of Illinois. During update cycle for version v.12, applied percent change of CDD65, NCEI Annual Normals from 30 yr data set (1981-2010) to more recent 15 yr data (2006-2020) to all FLHcool values.

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

569 Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.

(during system peak hour)

= 72%[570]

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

= 67%[571]

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

= 46.6%[572]

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

= 46.6%[573]

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

= 28.5%

Table 9: Air Conditioner with Gas Furnace – cooling only electric savings per window area (kWh/ft^2)[574]

IL Degree-Day Zone	NC or TOS	EREP: Double Pane	EREP: Single Pane
1 – Rockford	0.35	0.60	1.24
2 – Chicago	0.36	0.53	1.13
3 – Springfield	0.39	0.61	1.37
4 – Belleville	0.40	0.60	1.38
5 – Marion	0.46	0.48	1.27

Table 10: Air Conditioner with Electric Resistance Heat – cooling only electric savings per window area (kWh/ft^2)[575]

570 Based on analysis of metering results from 24 heat pumps in Ameren Illinois service territory in PY5 coincident with AIC's 2010 system peak; 'Impact and Process Evaluation of Ameren Illinois Company's Residential HVAC Program (PY5)'.
571 Multifamily coincidence factors both from; *All-Electric Homes PY6 Metering Results: Multifamily HVAC Systems*, Cadmus, October 2015
572 Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.
573 Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.
574 EnergyPlus modeling performed by Lili Yu and Robert Hart, "2023-07-26 LBNL Modeling_NC-TOS_TMYx.xlsx", " 2023-08-04 LBNL Modeling_EREP_TMYx_Double Pane", "2023-08-30 LBNL Modeling_EREP_TMYx_Single Pane," Lawrence Berkeley National Laboratory. May 11, 2023. Yu and Hart's energy modeling incorporated the most commonly commercially available windows that meet or exceed the energy performance criteria relevant to each climate zone (CZ). Specifically, the analysts derived energy savings using these specifications for HPWs: 1) Northern CZ, NC/TOS: U=0.30/SHGC=0.30; 2) Northern CZ, RF/EREP: U=0.22/SHGC=0.25; 3) North-Central CZ, NC/TOS: U=0.22/SGHC=0.25; 4) North-Central CZ RF/EREP: average of savings from U=0.25/SHGC=0.20 and U=0.25/SHGC=0.28.
575 Ibid

IL Degree-Day Zone	NC or TOS	EREP: Double Pane	EREP: Single Pane
1 – Rockford	0.31	0.48	2.17
2 – Chicago	0.33	0.47	1.97
3 – Springfield	0.35	0.43	1.65
4 – Belleville	0.39	0.36	1.67
5 – Marion	0.44	0.36	1.31

Table 11: Heat Pump – cooling only electric savings per window area (kWh/ft^2)[576]

IL Degree-Day Zone	NC or TOS	EREP: Double Pane	EREP: Single Pane
1 – Rockford	0.31	0.56	2.27
2 – Chicago	0.32	0.58	2.04
3 – Springfield	0.34	0.50	1.78
4 – Belleville	0.39	0.41	1.67
5 – Marion	0.43	0.39	1.41

FOSSIL FUEL SAVINGS

$$\Delta Therms = HS_{cz} * Area_{window}$$

Where:

HS_{cz} = Annual heating savings per area of window by climate zone, see Table 12.

$Area_{window}$ = Total area of installed high performance windows. Use site specific value.

Table 12: Gas heating savings per window area by climate zone and baseline window condition (therm/ft^2)[577]

IL Degree-Day Zone	NC or TOS	EREP: Double Pane	EREP: Single Pane
1 – Rockford	0.12	0.22	1.27
2 – Chicago	0.12	0.21	1.12
3 – Springfield	0.16	0.17	0.91
4 – Belleville	0.17	0.16	0.89
5 – Marion	0.14	0.16	0.73

576 Ibid

577 EnergyPlus modeling performed by Lili Yu and Robert Hart, "2023-07-26 LBNL Modeling_NC-TOS_TMYx.xlsx", " 2023-08-04 LBNL Modeling_EREP_TMYx_Double Pane", "2023-08-30 LBNL Modeling_EREP_TMYx_Single Pane," Lawrence Berkeley National Laboratory. May 11, 2023. Yu and Hart's energy modeling incorporated the most commonly commercially available windows that meet or exceed the energy performance criteria relevant to each climate zone (CZ). Specifically, the analysts derived energy savings using these specifications for HPWs: 1) Northern CZ, NC/TOS: U=0.30/SHGC=0.30; 2) Northern CZ, RF/EREP: U=0.22/SHGC=0.25; 3) North-Central CZ, NC/TOS: U=0.22/SGHC=0.25; 4) North-Central CZ RF/EREP: average of savings from U=0.25/SHGC=0.20 and U=0.25/SHGC=0.28.

For example, a single family residence in Rockford with a gas furnace and air conditioner replaces 10 existing double pane windows with HPW. Each window is 12 square feet, so the total window area is 120 square feet.

1st 13 years savings calculation:

$$\Delta Therms = 0.22 * 120 = 26.4\ therms$$

$$\Delta kWh = 1.22 * 120 = 146.4\ kWh$$

$$\Delta kW_{PJM} = \left(\frac{146.4}{512}\right) * 0.466 = 0.13\ kW$$

Remaining 27 years savings calculation:

$$\Delta Therms = 0.12 * 120 = 14.4\ therms$$

$$\Delta kWh = 0.58 * 120 = 69.6\ kWh$$

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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