Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

New Construction or Replace-on-Burnout

Energy Savings Algorithms

$$Energy\ Savings\ [\Delta kWh] = kWh_{baseline} - kWh_{ES}$$

Equation 131

Where:

$kWh_{baseline}$ = *Federal standard baseline energy usage (see Table 355)*

kWh_{ES} = *ENERGY STAR average energy usage (see Table 355)*

Demand Savings Algorithms

$$Peak\ Demand\ Savings\ [\Delta kW] = \frac{\Delta kWh}{8{,}760\ hrs} \times CF_{S/W}$$

Equation 132

Where:

$C_{S/W}$ = *Seasonal coincidence factor (see Table 356)*

Table 356. Refrigerators—Coincidence Factors[472]

Season	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
Summer	1.112	1.099	1.108	1.100	1.081
Winter	0.929	0.966	0.924	0.941	0.966

Early Retirement

Annual energy (kWh) and peak demand (kW) savings must be calculated separately for two time periods:

1. The estimated remaining life of the equipment that is being removed, designated the remaining useful life (RUL), and
2. The remaining time in the EUL period (EUL – RUL).

[472] See Volume 1, Section 4.

Annual energy and peak demand savings are calculated by weighting the early retirement and replace-on-burnout savings by the RUL of the unit and the remainder of the EUL period, as outlined in the Volume 3 appendices.

Where:

RUL = *Remaining useful life (see Table 357); if unknown, assume the age of the replaced unit is equal to the EUL resulting in a default RUL of 5.0 years*

EUL = *Estimated useful life = 16 years*[473]

Table 357. Refrigerators—RUL of Replaced Unit [474]

Age of replaced refrigerator (years)	RUL (years)	Age of replaced refrigerator (years)	RUL (years)
1	15.2	12	7.0
2	14.2	13	6.6
3	13.2	14	6.3
4	12.2	15	6.0
5	11.2	16	5.0
6	10.3	17	4.0
7	9.6	18	3.0
8	8.9	19	2.0
9	8.3	20	1.0
10	7.8	21[475,476]	0.0
11	7.4		

[473] Department of Energy, Federal Register, 76 Final Rule 57516, Technical Support Document: 8.2.3.1 Estimated Survival Function. September 15, 2011. http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/43. Download TSD at: https://www.regulations.gov/document/EERE-2008-BT-STD-0012-0128.

[474] Current federal standard effective date is 9/15/2014. Since the federal standard effective date occurred in late 2014, existing units manufactured as of 2015 are not eligible to use the early retirement baseline and should use the ROB baseline instead.

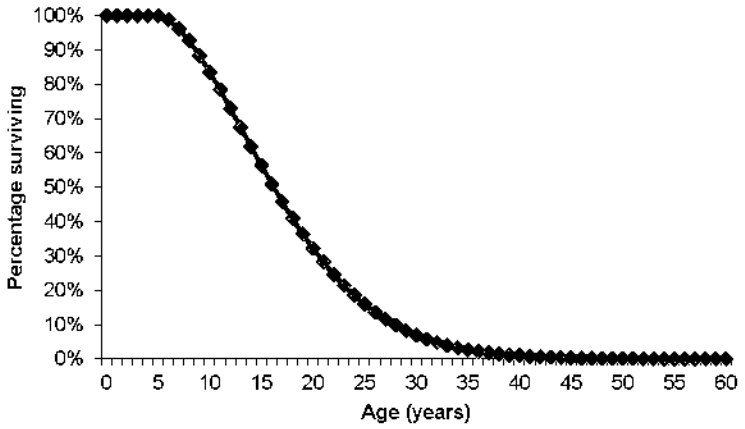
[475] RULs are capped at the 75th percentile of equipment age as determined based on DOE survival curves (see Figure 8). Systems older than this age should use the ROB baseline. See the January 2015 memo, "Considerations for early replacement of residential equipment," for further detail.

[476] Ward, B., Bodington, N., Farah, H., Reeves, S., and Lee, L. "Considerations for early replacement of residential equipment." Prepared by the Evaluation, Measurement, and Verification (EM&V) team for the Electric Utility Marketing Managers of Texas (EUMMOT). January 2015. This document has been made available to all Texas investor-owned utilities through the EM&V team's SharePoint.

Derivation of RULs

ENERGY STAR refrigerators have an estimated useful life of 16 years. This estimate is consistent with the age at which approximately 50 percent of the refrigerators installed in a given year will no longer be in service, as described by the survival function in Figure 8.

Figure 8. Refrigerators—Survival Function[477]



The method for estimating the RUL of a replaced system uses the age of the existing system to re-estimate the projected unit lifetime based on the survival function shown in Figure 8. The age of the refrigerator being replaced is found on the horizontal axis, and the corresponding percentage of surviving refrigerators is determined from the chart. The surviving percentage value is then divided in half, creating a new estimated useful lifetime applicable to the current unit age. Then, the age (year) that corresponds to this new percentage is read from the chart. RUL is estimated as the difference between that age and the current age of the system being replaced.

For example, assume a refrigerator being replaced is 15 years old. The corresponding percent surviving value is 56 percent. Half of 56 percent is 28 percent. The age corresponding to 28 percent on the chart is 21 years. Therefore, the RUL of the refrigerator being replaced is (21 – 15) = 6 years.

[477] Department of Energy, Federal Register, 76 Final Rule 57516, Technical Support Document: 8.2.3.1 Estimated Survival Function. September 15, 2011. http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/refrig_finalrule_tsd.pdf.

Energy Savings Algorithms

For the RUL time period:

$$kWh_{savings.ER} = kWh_{manf} - kWh_{ES}$$

Equation 133

For the remaining time in the EUL period~~.~~, calculate annual savings as you would for a replace-on-burnout project:

$$kWh_{savings.ROB} = kWh_{baseline} - kWh_{ES}$$

Equation 134

Where:

kWh_{manf} = ~~940~~968 kWh/Year[478]

Demand Savings Algorithms

To calculate demand savings for the early retirement of a refrigerator, a similar methodology is used as for replace-on-burnout installations, with separate savings calculated for the remaining useful life of the unit, and the remainder of the EUL as outlined in the section above.

For the RUL time period:

$$kW_{savings.ER} = \frac{kWh_{savings.ER}}{8{,}760\ hrs} \times CF_{S/W}$$

Equation 135

For the remaining time in the EUL period, calculate annual savings as you would for a replace-on-burnout project:

$$kW_{savings.ROB} = \frac{kWh_{savings.ROB}}{8{,}760\ hrs} \times CF_{S/W}$$

Equation 136

[478] ~~This is the weighted average of Adjusted annual unit energy consumption, derived from the MwEPA Refrigerator and Freezer Energy Rating Database (or from metering). Weights are calculated from the millions-of-households measurements obtained from the Residential Energy Consumption Survey, or RECS, (https://www.eia.gov/consumption/residential/data/2015/hc/php/hc3.6.php) corresponding to the year range classifications of refrigerators greater than 15 years old (specifically, 15-to-19-years-old and 20-or-more-years-old). Data in which refrigerators' model years were older than 1975 were excluded.~~ Existing unit consumption is derived from the MwEPA Refrigerator and Freezer Database. Consumption is weighted using appliance characteristics from the 2020 Residential Energy Consumption Survey (RECS) for units greater than 15 years old. Data for models manufactured prior to 1975 were excluded.
https://www.energy.gov/scep/wap/articles/refrigerator-and-freezer-energy-rating-online-search-tool,
https://www.eia.gov/consumption/residential/data/2020/hc/pdf/HC%203.8.pdf.

Annual deemed summer peak demand savings are calculated by weighting the early retirement and replace-on-burnout savings by the RUL of the unit and the remainder of the EUL period, as outlined in the Volume 3 appendices.

Deemed Energy Savings Tables

Table 358. Refrigerators—Energy Savings (kWh)

Through-the-door ice?	Door type	Product class	ROB savings (kWh/year)	ER savings (kWh/year)
No	Top freezer	3: Refrigerator freezers—automatic defrost with a top-mounted freezer without an automatic icemaker	37	215~~224~~
	Bottom freezer	5: Refrigerator-freezers—automatic defrost with a bottom-mounted freezer without an automatic icemaker	48	191~~200~~
Yes	Bottom freezer	5A: Refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker with TTD ice service	69	138~~147~~
	Side-by-side	7: Refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker with TTD ice service	61	121~~130~~
Unknown or average refrigerator[479]			44	196~~205~~

Commented [DN18]: Updated.

[479] An "Unknown or Average" refrigerator's savings are calculated as the difference between the weighted average of baseline energy usage ratings and the weighted average of ENERGY STAR energy usage ratings for the four selected refrigerator categories, with weights ascertained from averages of refrigerators in 10–14-year-old, 5–9-year-old, and 2–4-year-old age groups. The data used to calculate weights is hosted by Natural Resources Canada (NRCAN) at the following link which contains a table of the distribution of refrigerator types in households by year: http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/showTable.cfm?type=CM&sector=aaa&juris=ca&rn=3&page=1. Weights were similarly calculated utilizing data from RECS (data, which is summarized, i.e., not yearly, and located here: https://www.eia.gov/consumption/residential/data/2015/hc/php/hc3.6.php). While the reported distribution of refrigerator types between the two sets of data varies, we prefer the year-level granularity of the data from NRCAN considering that the differences between both sets of weighted average baseline energy usage and weighted average ENERGY STAR energy usage were nearly identical. Hence, we elect to utilize the more detailed weightings derived from the data hosted by NRCAN.

Deemed Summer Demand Savings Tables

Table 359. Refrigerators—Replace-on-Burnout – Summer Peak Demand Savings (kW)

Through-the-door ice?	Door type	Product class	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
No	Top freezer	3: Refrigerator freezers—automatic defrost with top-mounted freezer without an automatic icemaker	0.0047	0.0047	0.0047	0.0047	0.0046
	Bottom freezer	5: Refrigerator-freezers—automatic defrost with bottom-mounted freezer without an automatic icemaker	0.0061	0.0060	0.0061	0.0060	0.0059
Yes	Bottom freezer	5A: Refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker with TTD ice service	0.0087	0.0086	0.0087	0.0086	0.0085
	Side-by-side	7: Refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker with TTD ice service	0.0077	0.0076	0.0077	0.0076	0.0075
Unknown or average refrigerator			0.0056	0.0056	0.0056	0.0056	0.0055

Table 360. Refrigerators—Early Retirement—Summer Peak Demand Savings (kW)

Through-the-door ice?	Door type	Product class	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
No	Top freezer	3: Refrigerator freezers—automatic defrost with top-mounted freezer without an automatic icemaker	0.0278	0.0278	0.0278	0.0278	0.0278
	Bottom freezer	5: Refrigerator-freezers—automatic defrost with bottom-mounted freezer without an automatic icemaker	0.0245	0.0245	0.0245	0.0245	0.0245
Yes	Bottom freezer	5A: Refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker with TTD ice service	0.0156	0.0156	0.0156	0.0156	0.0156
	Side-by-side	7: Refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker with TTD ice service	0.0189	0.0178	0.0179	0.0178	0.0178
Unknown or average refrigerator			0.0256	0.0256	0.0256	0.0256	0.0245

Commented [DN19]: Updated.

Deemed Winter Demand Savings Tables

Table 361. Refrigerators—Replace-on-Burnout—Winter Peak Demand Savings (kW)

Through-the-door ice?	Door type	Product class	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
No	Top freezer	3: Refrigerator freezers—automatic defrost with top-mounted freezer without an automatic icemaker	0.0039	0.0041	0.0039	0.0040	0.0041
	Bottom freezer	5: Refrigerator-freezers—automatic defrost with bottom-mounted freezer without an automatic icemaker	0.0051	0.0053	0.0051	0.0052	0.0053
Yes	Bottom freezer	5A: Refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker with TTD ice service	0.0073	0.0076	0.0072	0.0074	0.0076
	Side-by-side	7: Refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker with TTD ice service	0.0064	0.0067	0.0064	0.0065	0.0067
Unknown or average refrigerator			0.0047	0.0049	0.0047	0.0048	0.0049

Table 362. Refrigerators—Early Retirement—Winter Peak Demand Savings (kW)

Through-the-door ice?	Door type	Product class	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
No	Top freezer	3: Refrigerator freezers—automatic defrost with top-mounted freezer without an automatic icemaker	0.0234	0.0245	0.0234	0.0234	0.0245
	Bottom freezer	5: Refrigerator-freezers—automatic defrost with bottom-mounted freezer without an automatic icemaker	0.0201	0.0212	0.0201	0.021	0.0212
Yes	Bottom freezer	5A: Refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker with TTD ice service	0.0134	0.0134	0.0134	0.0134	0.0134
	Side-by-side	7: Refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker with TTD ice service	0.0156	0.0156	0.015	0.0156	0.0156
Unknown or average refrigerator			0.0212	0.0223	0.0212	0.0212	0.0223

Commented [DN20]: Updated.

Claimed Peak Demand Savings

Refer to Volume 1, Section 4 for further details on peak demand savings and methodology.

Additional Calculators and Tools

Not applicable.

Measure Life and Lifetime Savings

The estimated useful life (EUL) is established at 16 years based on the current DOE Final Rule standards for residential refrigerators.[480]

Program Tracking Data and Evaluation Requirements

Primary inputs and contextual data that should be specified and tracked by the program database to inform the evaluation and apply the savings properly are:

- Climate zone or county
- Unit quantity
- Baseline type (new construction, replace-on-burnout, or early retirement)
- Manufacturer and model number
- Photograph demonstrating functionality of existing equipment and/or customer responses to survey questionnaire documenting the condition of the replaced unit and their motivation for measure replacement for early retirement eligibility determination (early retirement only)
- Document proper disposal of the existing refrigerator (early retirement only)
- Proof of purchase – with date of purchase and quantity
    - Alternative: photo of unit installed or another pre-approved method of installation verification

References and Efficiency Standards

Petitions and Rulings

Not applicable.

[480] Final Rule: Standards, Federal Register, 76 FR 57516 (Sept. 15, 2011) and associated Technical Support Document. http://www1.eere.energy.gov/buildings/appliance_sta https://www.regulations.gov/document/EERE-2008-BT-STD-0012-0128 ndards/product.aspx/productid/43. Download TSD at: http://www.regulations.gov/#!documentDetail;D=EERE-2008-BT-STD-0012-0128.

Relevant Standards and Reference Sources

Please refer to measure citations for relevant standards and reference sources.

Document Revision History

Table 363. Refrigerators—Revision History

TRM version	Date	Description of change
v1.0	11/25/2013	TRM v1.0 origin
v2.0	4/18/2014	TRM v2.0 update. Low-income and hard-to-reach Market Transformation section merged with the main measure as "early retirement" option. Updated by Frontier Energy, March 2014, based on new federal standards.
v2.1	1/30/2015	TRM v2.1 update. New ENERGY STAR standards incorporated.
v3.0	4/10/2015	TRM v3.0 update. early retirement savings may be claimed through any appropriately designed program in accordance with the EM&V team's memo, "Considerations for early replacement of residential equipment." Remaining useful lifetimes updated. CF updated to align with new peak demand methodology.
v3.1	11/05/2015	TRM v3.1 update. Correction to legacy CF. Revision to align with ENERGY STAR calculator and specification.
v3.1	3/28/2016	TRM v3.1 March revision. Updated summer and winter coincidence factors.
v4.0	10/10/2016	TRM v4.0 update. Updated RUL value for units with the age of seven years and added RUL values for units with an age of one to five years. Added a default RUL value for when the age of the unit is unknown. Eliminated the eligibility requirement of the existing unit to have an age of minimum of five years.
v5.0	10/2017	TRM v5.0 update. No revision.
v6.0	11/2018	TRM v6.0 update. Updated database reference.
v7.0	10/2019	TRM v7.0 update. Established deemed savings approach.
v8.0	10/2020	TRM v8.0 update. Updated early retirement age eligibility.
v9.0	10/2021	TRM v9.0 update. Updated early retirement age eligibility.
v10.0	10/2022	TRM v10.0 update. Updated early retirement age eligibility.
v11.0	10/2023	TRM v11.0 update. Updated early retirement age eligibility.
v12.0	10/2024	TRM v12.0 update. Updated early retirement age eligibility and weighting using latest RECs data. Updated resulting early retirement savings tables. Clarified upcoming federal standard.

Commented [DN21]: Updated.

2.5.6 ENERGY STAR® Freezers Measure Overview

TRM Measure ID: R-AP-FZ

Market Sector: Residential

Measure Category: Appliances

Applicable Building Types: Single-family, multifamily, manufactured

Fuels Affected: Electricity

Decision/Action Type(s): Replace-on-burnout, early retirement, new construction

Program Delivery Type(s): Prescriptive

Deemed Savings Type: Deemed savings calculation

Savings Methodology: Engineering algorithms and estimates

Measure Description

This measure applies to all ENERGY STAR freezers that meet the criteria for the ENERGY STAR label specified below.

Eligibility Criteria

To qualify for early retirement, the ENERGY STAR unit must replace an existing, full-size unit with a maximum age of 27 years. To determine the remaining useful life of an existing unit, see Table 367. All retired freezers must be dismantled in an environmentally safe manner in accordance with applicable federal, state, and local regulations. The installer will provide documentation of proper disposal of freezers. In order to receive early retirement savings, the unit to be replaced must be functioning at the time of removal.

Newly-installed freezers must meet current ENERGY STAR efficiency levels.

Baseline Condition

For new construction or replace-on-burnout, the baseline is the Department of Energy (DOE) minimum efficiency standard[481] for freezers, effective September 15, 2014.

The DOE issued an updated direct final rule effective June 13, 2024. However, compliance with the new amended federal standard is not required until either January 31, 2029 or January 31, 2030 depending on product class.[482] The baseline will be updated at that time to reflect the current federal standard.

[481] DOE minimum efficiency standard for residential refrigerators and freezers. https://www.ecfr.gov/cgi-bin/text-idx?SID=48f64e166fe3561666f871e521996e13&mc=true&node=se10.3.430_132&rgn=div8.

[482] Notice of new DOE minimum efficiency standard for residential refrigerators and freezers. https://www.regulations.gov/document/EERE-2017-BT-STD-0003-0116.

For early retirement, the baseline for freezers is the annual unit energy consumption of a freezer's adjusted energy usage rating based on an average of values reported by the Midwest Energy Performance Analytics (MwEPA) Refrigerator and Freezer Energy Rating Database.[483] Since the federal standard effective date occurred in late 2014, existing units manufactured as of 2015 are not eligible for early retirement.

Alternatively, the baseline annual energy usage of the freezer being replaced may be estimated by metering for a period of at least two hours using the measurement protocol specified in the DOE report, "Incorporating Refrigerator Replacement into the Weatherization Assistance Program."[484]

To determine annual kWh of the freezer being replaced, use the following formula:

$$Annual\ kWh\ Usage = \frac{WH \times 8{,}760}{h \times 1{,}000}$$

Equation 137

Where:

WH	=	*Watt-hours metered during a time period*
h	=	*Measurement time period (hours)*
8,760	=	*Total hours per year*
1,000	=	*Constant to convert from W to kW*

High-Efficiency Condition

The table below displays the ENERGY STAR Final Version 5.1 Requirements for eligible consumer refrigeration products effective September 15, 2014.[485] Energy efficiency service providers are expected to comply with the latest ENERGY STAR requirements.

[483] Refrigerator and Freezer Energy Rating Database. Midwest Energy Performance Analytics, Inc. in combination with the State of Wisconsin and US Department of Energy's Weatherization Assistance Program. https://www.energy.gov/eere/wap/articles/refrigerator-and-freezer-energy-rating-database-search-tool.

[484] Alex Moore, DandR International, Ltd. "Incorporating Refrigerator Replacement into the Weatherization Assistance Program" Information Tool Kit." Department of Energy. November 19, 2001. https://aceee.org/files/proceedings/2002/data/papers/SS02_Panel2_Paper16.pdf.

[485] ENERGY STAR Consumer Refrigeration Products Final Version 5.1 Program Requirements. https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Version%205.1%20Consumer%20Refrigeration%20Products%20Final%20Specification_0.pdf.

Table 364. Freezers—ENERGY STAR Requirements

ENERGY STAR freezer		
Product type	Volume	Criteria as of September 15, 2014
Freezers	7.75 cubic feet or greater	Approximately ten percent more energy efficient than the minimum federal standard (see Table 355)
Compact freezers	Less than 7.75 cubic feet	Approximately ten percent more energy efficient than the minimum federal standard (see Table 355)

Table 365. Freezers—Formulas to Calculate the Energy Usage by Product Class[486]

Product number	Full product name[487]	Product class	Baseline energy usage federal standard (kWh/year)[488]	Average ENERGY STAR energy usage (kWh/year)[489]	Adjusted volume[490] (cubic feet)	Baseline energy usage (kWh/year)	ENERGY STAR energy usage (kWh/year)
8	Upright freezers with manual defrost	Upright (manual defrost)	5.57 × AV + 193.7	5.01 × AV + 174.3	16.12	283.5	255.1
9	Upright freezers with automatic defrost without an automatic icemaker	Upright (auto defrost)	8.62 × AV + 228.3	7.76 × AV + 205.5	29.96	486.6	438.0
10	Chest freezers and all other freezers except compact freezers	Chest	7.29 × AV + 107.8	6.56 × AV + 97	25.25	291.8	262.6
16	Compact upright freezers with manual defrost	Compact upright (manual defrost)	8.65 × AV + 225.7	7.79 × AV + 203.1	5.34	271.9	244.7
17	Compact upright freezers with automatic defrost	Compact upright (auto defrost)	10.17 × AV + 351.9	9.15 × AV + 316.7	7.95	432.7	389.4
18	Compact chest freezers	Compact chest	9.25 × AV + 136.8	8.33 × AV + 123.1	9.06	220.6	198.6

[486] Federal standard for refrigerators and freezers. https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=37&action=viewlive. Select product classes excluded.

[487] Note that when calculating deemed savings for upright freezers, we calculated a weighted average of adjusted energy usage of manual versus automatic defrost upright freezers, with weights based on the number of millions-of-households which contain these types of freezers, obtained from the Residential Energy Consumption Survey, or RECS, (https://www.eia.gov/consumption/residential/data/2015/hc/php/hc3.6.php), thus eliminating this input from consideration.

[488] https://www.ecfr.gov/cgi-bin/text-idx?SID=48f64e166fe3561666f871e521996e13&mc=true&node=se10.3.430_132&rgn=div8.

[489] Approximately 10 percent more efficient than baseline, as specified in the ENERGY STAR Appliance Savings Calculator (updated September 2015). The previously cited URL is no longer available, but a copy of the calculator can be provided upon request.

[490] AV is calculated as a simple average per selected freezer product type in the corresponding Product Class utilizing data provided by https://www.energystar.gov/productfinder/product/certified-residential-freezers/results.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

New Construction or Replace-on-Burnout

Energy Savings Algorithms

$$Energy\ Savings\ [\Delta kWh] = kWh_{baseline} - kWh_{ES}$$

Equation 138

Where:

$kWh_{baseline}$ = *Federal standard baseline energy usage (see Table 365)*

kWh_{ES} = *ENERGY STAR average energy usage (see Table 365)*

Demand Savings Algorithms

$$Peak\ Demand\ Savings\ [\Delta kW] = \frac{\Delta kWh}{8{,}760\ hrs} \times CF_{S/W}$$

Equation 139

Where:

$CF_{S/W}$ = *Seasonal coincidence factor (see Table 366)*

Table 366. Freezers—Coincidence Factors[491]

Season	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
Summer	1.112	1.099	1.108	1.100	1.081
Winter	0.929	0.966	0.924	0.941	0.966

Early Retirement

Annual energy (kWh) and peak demand (kW) savings must be calculated separately for two time periods:

1. The estimated remaining life of the equipment that is being removed, designated the remaining useful life (RUL), and
2. The remaining time in the EUL period (EUL – RUL)

[491] See Volume 1, Section 4.

Annual energy and peak demand savings are calculated by weighting the early retirement and replace-on-burnout savings by the RUL of the unit and the remainder of the EUL period, as outlined in the Volume 3 appendices.

Where:

RUL = *Remaining useful life (see Table 367); if unknown, assume the age of the replaced unit is equal to the EUL resulting in a default RUL of 5.0 years*

EUL = *Estimated useful life = 22 years*[492]

Table 367. Freezers—RUL of Replaced Unit [493]

Age of replaced freezer (years)	RUL (years)	Age of replaced freezer (years)	RUL (years)	Age of replaced freezer (years)	RUL (years)
1	20.7	10	12.1	19	6.6
2	19.7	11	11.3	20	6.2
3	18.7	12	10.6	21	5.9
4	17.7	13	9.9	22	5.0
5	16.7	14	9.2	23	4.0
6	15.7	15	8.6	24	3.0
7	14.8	16	8.1	25	2.0
8	13.8	17	7.5	26	1.0
9	13.0	18	7.1	27[494,495]	0.0

[492] Department of Energy, Federal Register, 76 Final Rule 57516, Technical Support Document: 8.2.3.1 Estimated Survival Function. September 15, 2011. Download TSD at: https://www.regulations.gov/document/EERE-2008-BT-STD-0012-0128.

[493] Current federal standard effective date is 9/15/2014. Since the federal standard effective date occurred in late 2014, existing units manufactured as of 2015 are not eligible to use the early retirement baseline and should use the ROB baseline instead.

[494] RULs are capped at the 75th percentile of equipment age as determined based on DOE survival curves (see Figure 8). Systems older than this age should use the ROB baseline. See the January 2015 memo, "Considerations for early replacement of residential equipment," for further detail.

[495] Ward, B., Bodington, N., Farah, H., Reeves, S., and Lee, L. "Considerations for early replacement of residential equipment." Prepared by the Evaluation, Measurement, and Verification (EM&V) team for the Electric Utility Marketing Managers of Texas (EUMMOT). January 2015. This document has been made available to all Texas investor-owned utilities through the EM&V team's SharePoint.

Derivation of RULs

ENERGY STAR freezers have an estimated useful life of 22 years. This estimate is consistent with the age at which approximately 50 percent of the freezers installed in a given year will no longer be in service, as described by the survival function in Figure 9.

Figure 9. Freezers—Survival Function[496]

The method for estimating the RUL of a replaced system uses the age of the existing system to re-estimate the projected unit lifetime based on the survival function shown in Figure 9. The age of the freezer being replaced is found on the horizontal axis, and the corresponding percentage of surviving freezers is determined from the chart. The surviving percentage value is then divided in half, creating a new estimated useful lifetime applicable to the current unit age. Then, the age (year) that corresponds to this new percentage is read from the chart. RUL is estimated as the difference between that age and the current age of the system being replaced.

For example, assume a freezer being replaced is 22 years old (the estimated useful life). The corresponding percent surviving value is approximately 50 percent. Half of 50 percent is 25 percent. The age corresponding to 25 percent on the chart is approximately 27 years. Therefore, the RUL of the freezer being replaced is 27 – 22 = 5 years.

[496] Department of Energy, Federal Register, 76 Final Rule 57516, Technical Support Document: 8.2.3.1 Estimated Survival Function. September 15, 2011. http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/refrig_finalrule_tsd.pdf.

Energy Savings Algorithms

For the RUL time period:

$$kWh_{savings,ER} = kWh_{manf} - kWh_{ES}$$

Equation 140

For the remaining time in the EUL period, calculate annual savings as you would for a replace-on-burnout project:

$$kWh_{savings,ROB} = kWh_{baseline} - kWh_{ES}$$

Equation 141

Where:

kWh_{manf} = 805~~841~~ kWh/Year[497]

Demand Savings Algorithms

To calculate demand savings for the early retirement of a freezer, a similar methodology is used as for replace-on-burnout installations, with separate savings calculated for the remaining useful life of the unit, and the remainder of the EUL as outlined in the section above.

For the RUL time period:

$$kW_{savings,ER} = \frac{kWh_{savings,ER}}{8{,}760\ hrs} \times CF_{S/W}$$

Equation 142

[497] ~~This is the weighted average of adjusted annual unit energy consumption, a metric obtained from the MwEPA Refrigerator and Freezer Energy Rating Database (if from metering, substitute recorded value in lieu of this weighted average). Weights are calculated from the millions-of-households measurements obtained from RECS, (https://www.eia.gov/consumption/residential/data/2015/hc/php/hc3.6.php) corresponding to the year range classifications of freezers greater than 15 years old (specifically, 15-to-19-years-old and 20-or-more-years-old). The oldest freezers for which we had data were from 1979.~~ Existing unit consumption is derived from the MwEPA Refrigerator and Freezer Database. Consumption is weighted using appliance characteristics from the 2020 Residential Energy Consumption Survey (RECS) for units greater than 15 years old. Data was only available for units manufactured on or after 1979. https://www.energy.gov/scep/wap/articles/refrigerator-and-freezer-energy-rating-online-search-tool. https://www.eia.gov/consumption/residential/data/2020/hc/pdf/HC%203.8.pdf.

For the remaining time in the EUL period, calculate annual savings as you would for a replace-on-burnout project:

$$kW_{savings,ROB} = \frac{kWh_{savings,ROB}}{8{,}760\ hrs} \times CF_{S/W}$$

Equation 143

Annual deemed summer peak demand savings are calculated by weighting the early retirement and replace-on-burnout savings by the RUL of the unit and the remainder of the EUL period, as outlined in the Volume 3 appendices.

Deemed Energy Savings Tables

Table 368. Freezers—Savings (kWh)

Freezer type	Size	ROB savings (kWh)	ER savings (kWh)
Chest	Standard (≥ 7.75 ft³)	29	146~~154~~
	Compact (< 7.75 ft³)	22	155~~163~~
Upright	Standard (≥ 7.75 ft³)	48	122~~130~~
	Compact (< 7.75 ft³)	32	143~~151~~

Commented [DN22]: Updated.

Deemed Summer Demand Savings Tables

Table 369. Freezers—Replace-on-Burnout—Summer Peak Demand Savings (kW)

Freezer type	Product class	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
Chest	Standard (≥ 7.75 ft^3)	0.004	0.004	0.004	0.004	0.004
	Compact (< 7.75 ft^3)	0.003	0.003	0.003	0.003	0.003
Upright	Standard (≥ 7.75 ft^3)	0.006	0.006	0.006	0.006	0.006
	Compact (< 7.75 ft^3)	0.004	0.004	0.004	0.004	0.004

Table 370. Freezers—Early Retirement—Summer Peak Demand Savings (kW)

Freezer type	Product class	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
Chest	Standard (≥ 7.75 ft^3)	0.01920	0.0188	0.0188	0.0188	0.0188
	Compact (< 7.75 ft^3)	0.0201	0.01920	0.0201	0.01920	0.01920
Upright	Standard (≥ 7.75 ft^3)	0.0167	0.0156	0.0156	0.0156	0.0156
	Compact (< 7.75 ft^3)	0.0189	0.0189	0.0189	0.0189	0.0189

Commented [DN23]: Updated.

Deemed Winter Demand Savings Tables

Table 371. Freezers—Replace-on-Burnout—Winter Peak Demand Savings (kW)

Freezer type	Product class	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
Chest	Standard (≥ 7.75 ft^3)	0.003	0.003	0.003	0.003	0.003
	Compact (< 7.75 ft^3)	0.002	0.002	0.002	0.002	0.002
Upright	Standard (≥ 7.75 ft^3)	0.005	0.005	0.005	0.005	0.005
	Compact (< 7.75 ft^3)	0.003	0.003	0.003	0.003	0.003

Table 372. Freezers—Early Retirement—Winter Peak Demand Savings (kW)

Freezer type	Product class	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
Chest	Standard (≥ 7.75 ft^3)	0.0156	0.0167	0.0156	0.0167	0.0167
	Compact (< 7.75 ft^3)	0.0167	0.0178	0.0167	0.0178	0.0178
Upright	Standard (≥ 7.75 ft^3)	0.0134	0.0134	0.0134	0.0134	0.0134
	Compact (< 7.75 ft^3)	0.0156	0.0167	0.0156	0.0156	0.0167

Commented [DN24]: Updated.

Claimed Peak Demand Savings

Refer to Volume 1, Section 4 for further details on peak demand savings and methodology.

Additional Calculators and Tools

Not applicable.

Measure Life and Lifetime Savings

The estimated useful life (EUL) is established at 22 years based on the current DOE Final Rule standards for residential freezers.[498]

Program Tracking Data and Evaluation Requirements

Primary inputs and contextual data that should be specified and tracked by the program database to inform the evaluation and apply the savings properly are:

- Climate zone or county
- Unit quantity
- Baseline type (new construction, replace-on-burnout, or early retirement)
- Manufacturer and model number
- Freezer type (upright or chest)
- Freezer size (standard, i.e., ≥ 7.75 ft^3, or compact, i.e., < 7.75 ft^3)
- Photograph demonstrating functionality of existing equipment and/or customer responses to survey questionnaire documenting the condition of the replaced unit and their motivation for measure replacement for early retirement eligibility determination (early retirement only)
- The installer will provide documentation of proper disposal of freezers in accordance with applicable federal, state, and local regulations (early retirement only)
- Proof of purchase – with date of purchase and quantity
    - Alternative: photo of unit installed or another pre-approved method of installation verification

[498] Final Rule: Standards, Federal Register, 76 FR 57516 (Sept. 15, 2011) and associated Technical Support Document. https://www.ecfr.gov/cgi-bin/text-idx?SID=48f64e166fe3561666f871e521996e13&mc=true&node=se10.3.430_132&rgn=div8. Download TSD at: https://www.regulations.gov/document/EERE-2008-BT-STD-0012-0128.

References and Efficiency Standards

Petitions and Rulings

Not applicable.

Relevant Standards and Reference Sources

Please refer to measure citations for relevant standards and reference sources

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Document Revision History

Table 373. Freezers—Revision History

TRM version	Date	Description of change
v7.0	10/2019	TRM v7.0 origin.
v8.0	10/2020	TRM v8.0 update. Updated early retirement age eligibility.
v9.0	10/2021	TRM v9.0 update. Updated early retirement age eligibility.
v10.0	10/2022	TRM v10.0 update. Updated early retirement age eligibility.
v11.0	10/2023	TRM v11.0 update. Updated early retirement age eligibility.
v12.0	10/2024	TRM v12.0 update. Updated early retirement age eligibility and weighting using latest RECs data. Updated resulting early retirement savings tables. Clarified upcoming federal standard.

Commented [DN25]: Updated.

2.5.7 Refrigerator/Freezer Recycling Measure Overview

TRM Measure ID: R-AP-RR

Market Sector: Residential

Measure Category: Appliance Recycling

Applicable Building Types: Single-family, multifamily, manufactured

Fuels Affected: Electricity

Decision/Action Type(s): Early retirement

Program Delivery Type(s): Prescriptive

Deemed Savings Type: Deemed savings calculation

Savings Methodology: Engineering algorithms and estimates

Measure Description

This measure involves early retirement and recycling of an existing, full-size (7.75 ft^3 or greater) refrigerator or combined refrigerator/freezer in a residential application. Savings represent the entire estimated energy consumption of the existing unit and are applicable over the estimated remaining life of the existing unit.

Eligibility Criteria

This measure applies to operable primary and secondary retired refrigerators/freezers. Recycling savings for this measure are limited to the removal of a working refrigerator/freezer from the electrical grid and differ from the savings specified in the ENERGY STAR Refrigerator replacement measure. The latter, which pertain to the direct replacement of a refrigerator and reflect the difference in energy consumption between new ENERGY STAR qualifying and standard efficiency models, may be claimed for the recycling of primary refrigerators/freezers that have been replaced if savings for that replacement were not already claimed in another energy efficiency program. To qualify, the customer must release the existing unit to the utility or utility representative to ensure proper disposal in accordance with applicable federal, state, and local regulations.

Baseline Condition

Without program intervention, the recycled refrigerator or refrigerator/freezer would have remained operable on the electrical grid. As a result, the baseline condition for early retirement programs is continued operation of the existing refrigerator.

High-Efficiency Condition

There is no efficiency standard for a recycling measure because the energy efficient action is the removal of an operable appliance, not—as with most demand-side management programs—the installation of a higher efficiency model.

Energy and Demand Savings Methodology

The basis for estimating energy savings is the annual energy consumption of the refrigerator or refrigerator/freezer being retired.

Savings Algorithms and Input Variables

Energy Savings Algorithms

Energy savings are calculated as follows:

$$Energy\ Savings\ [\Delta kWh] = kWh_{existig} \times ISAF \times PUF$$

Equation 144

Where:

$kWh_{existing}$ = *Average annual energy consumption[499] (see Table 374)*

ISAF = *In situ adjustment factor[500] = 0.942*

PUF = *Part use factor[501] = 0.915*

Table 374. Refrigerator/Freezer Recycling—Average Annual Energy Consumption

Total capacity (ft³)	Year manufactured	$kWh_{existing}$ by freezer configuration				
		Top	Bottom	Side	Upright	Chest
< 16.5	≤ 2000	861	962	1,139	937	532
	2001-2010	556	724	747	713	435
	≥ 2011	374	483	592	449	292

[499] ENERGY STAR Flip Your Fridge Calculator. https://www.energystar.gov/index.cfm?fuseaction=refrig.calculator.

[500] The Cadmus Group, Inc. "Residential Retrofit High Impact Measure Evaluation Report". Prepared for California Public Utilities Commission Energy Division. February 8, 2010. Factor to account for variation between site conditions and controlled DOE testing conditions (90 °F test chamber, empty refrigerator and freezer cabinets, and no door openings). Appliances in warmer climate zones use more energy than those in cooler climate zones; utilized SCE data (highest percentage of warm climate projects) to best approximate Texas climate, p. 139-140.

[501] Ibid. Factor to account for the number of refrigerators that were running, running part time, or not running at the time of recycling, p. 142-143 (weighted by representative utility survey participation, p. 117).

Total capacity (ft^3)	Year manufactured	$kWh_{existing}$ by freezer configuration				
		Top	Bottom	Side	Upright	Chest
16.5-18.9	≤ 2000	962	1,051	1,266	1,058	621
	2001-2010	613	747	818	805	508
	≥ 2011	412	517	640	507	341
19.0-21.4	≤ 2000	1,031	1,110	1,329	1,138	680
	2001-2010	651	762	854	866	557
	≥ 2011	438	539	664	545	373
21.5-24.4	≤ 2000	1,090	1,172	1,368	1,194	721
	2001-2010	683	777	876	909	591
	≥ 2011	459	562	679	572	396
≥ 24.5	≤ 2000	1,223	1,347	1,528	1,355	840
	2001-2010	758	822	966	1,031	688
	≥ 2011	508	627	740	648	461

Demand Savings Algorithms

Summer peak demand savings are calculated as follows:

$$Peak\ Demand\ Svings\ [\Delta \text{kW}] = \frac{\Delta kWh}{AOH} \times CF_{S/W}$$

Equation 145

Where:

AOH = *Annual operating hours = 8,760 hours*

$CF_{S/W}$ = *Seasonal coincidence factor (see Table 375)*

Table 375. Refrigerator/Freezer Recycling—Coincidence Factors[502]

Season	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
Summer	1.112	1.099	1.108	1.100	1.081
Winter	0.929	0.966	0.924	0.941	0.966

[502] See Volume 1, Appendix B.

Deemed Energy Savings Tables

There are no lookup tables available for this measure. See engineering algorithms in the previous section for calculating energy and demand savings.

Deemed Summer Demand Savings Tables

There are no lookup tables available for this measure. See engineering algorithms in the previous section for calculating energy and demand savings.

Deemed Winter Demand Savings Tables

There are no lookup tables available for this measure. See engineering algorithms in the previous section for calculating energy and demand savings.

Claimed Peak Demand Savings

Refer to Volume 1, Section 4 for further details on peak demand savings and methodology.

Additional Calculators and Tools

Not applicable.

Measure Life and Lifetime Savings

Based on the KEMA Residential Refrigerator Recycling Ninth Year Retention Study,[503] the Estimated Useful Life of Refrigerator Recycling is 8 years, representing the assumed remaining useful life of the retired unit.

Program Tracking Data and Evaluation Requirements

Primary inputs and contextual data that should be specified and tracked by the program database to inform the evaluation and apply the savings properly are:

- Climate zone or county
- Number of refrigerators/freezers removed
- Year removed unit manufactured
- Total capacity (in cubic feet)
- Freezer configuration (top, bottom, side-by-side, upright, or chest)

[503] KEMA, Inc. "Residential Refrigerator Recycling Ninth Year Retention Study." Prepared for Southern California Edison Company. July 22, 2004.

References and Efficiency Standards

Petitions and Rulings

- Docket No. 42212. Petition of El Paso Electric Company to Approve Revisions to the Deemed Savings for the Appliance Recycling Market Transformation program. Public Utility Commission of Texas.

Relevant Standards and Reference Sources

Please refer to measure citations for relevant standards and reference sources.

Document Revision History

Table 376. Refrigerator/Freezer Recycling—Revision History

TRM version	Date	Description of change
v2.1	1/30/2015	TRM v2.1 origin.
v3.0	4/10/2015	TRM v3.0 update. CF updated to align with new peak demand methodology.
v3.1	11/05/2015	TRM v3.1 update. No revision.
v3.1	3/28/2016	TRM v3.1 March revision. Updated summer and winter CFs.
v4.0	10/10/2016	TRM v4.0 update. No revision.
v5.0	10/2017	TRM v5.0 update. No revision.
v6.0	11/2018	TRM v6.0 update. No revision.
v7.0	10/2019	TRM v7.0 update. No revision.
v8.0	10/2020	TRM v8.0 update. Updated baseline energy consumption.
v9.0	10/2021	TRM v9.0 update. Correct deemed ranges for refrigerator volume.
v10.0	10/2022	TRM v10.0 update. No revision.
v11.0	10/2023	TRM v11.0 update. No revision.
v12.0	10/2024	TRM v12.0 update. No revision.

2.5.8 ENERGY STAR® Air Purifiers Measure Overview

TRM Measure ID: R-AP-AP

Market Sector: Residential

Measure Category: Appliances

Applicable Building Types: Single-family, multifamily, manufactured

Fuels Affected: Electricity

Decision/Action Type(s): Replace-on-burnout, new construction

Program Delivery Type(s): Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: Engineering algorithms and estimates

Measure Description

This document presents the accepted deemed savings awarded for the installation of an ENERGY STAR air purifier. Savings are awarded at a flat per-unit rate, both for energy and demand savings. This measure will apply to existing homes and new construction.

Eligibility Criteria

This measure applies to floor, tabletop, and wall-mounted air purifiers/room air cleaners.

Baseline Condition

The baseline condition is the current federal standard Tier 1 requirements, effective August 9, 2023, with compliance enforced as of December 31, 2023. The standard will increase to Tier 2 requirements on December 31, 2025.[504]

Table 377. Air Purifiers—Federal Standard

Smoke CADR	Tier 1 CADR/W	Tier 2 CADR/W
10–99	1.7	1.9
100–149	1.9	2.4
150+	2.0	2.9

[504] DOE minimum efficiency standard for residential air cleaners. https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=77. https://www.energy.gov/sites/default/files/2023-03/air-cleaners-ecs-dfr.pdf.

High-Efficiency Condition

The table below displays the ENERGY STAR Final Version 2.0 Requirements for eligible room air cleaners effective October 17, 2020, and revised May 2022.[505] Energy efficiency service providers are expected to comply with the latest ENERGY STAR requirements.

Table 378. Air Purifiers—ENERGY STAR Requirements

Smoke CADR	Minimum CADR/W
10–99	1.9
100–149	2.4
150+	2.9

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Energy Savings Algorithms

Energy savings for this measure were derived using the ENERGY STAR Appliance Savings Calculator and the revised ENERGY STAR specification in Table 348.[506] Default baseline standby power and clean air delivery rate (CADR) efficiency (CADR/W) values were taken from the ENERGY STAR calculator. ENERGY STAR standby power, CADR, and CADR/W are averages from the ENERGY STAR qualified product listing. Baseline CADR is assumed to be equivalent to ENERGY STAR CADR.

This measure will be updated to comply with the latest available ENERGY STAR specification and appliance calculator. It will also periodically be updated to comply with the latest updates to the ENERGY STAR qualified product listing.

$$Energy\ Savings\ |\Delta kWh| = (kWh_{baseline,OP} + kWh_{baseline,SB}) - (kWh_{ES,OP} + kWh_{ES,SB})$$

Equation 146

$$kWh_{baseline,OP} = \left(\frac{CADR_{baseline}}{\eta_{baseline}}\right) / 1{,}000 \times hours \times days$$

Equation 147

$$kWh_{baseline,SB} = (8{,}760 - hours \times days) \times \frac{W_{baseline,SB}}{1{,}000}$$

Equation 148

[505] ENERGY STAR Room Air Cleaners Final Version 2.0 Program Requirements. https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Version%202.0%20Room%20Air%20Cleaners%20Specification%20%28Rev.%20May%202022%29_0.pdf.

[506] ENERGY STAR Appliance Savings Calculator (updated October 2016). The previously cited URL is no longer available, but a copy of the calculator can be provided upon request.

$$kWh_{ES,OP} = \left(\frac{CADR_{ES}}{\eta_{ES}}\right)/1{,}000 \times hours \times days$$

Equation 149

$$kWh_{ES,SB} = (8{,}760 - hours \times days) \times \frac{W_{ES,SB}}{1{,}000}$$

Equation 150

Where:

$kWh_{baseline,OP}$ =		*Baseline/conventional operating energy usage*
$kWh_{baseline,SB}$	=	*Baseline/conventional standby energy usage*
$kWh_{ES,OP}$	=	*ENERGY STAR average operating energy usage*
$kWh_{ES,SB}$	=	*ENERGY STAR average standby energy usage*
$CADR_{baseline}$	=	*Baseline unit clean air delivery rate (cu ft/min), assume equivalent to $CADR_{ES}$*
$CADR_{ES}$	=	*ENERGY STAR unit clean air delivery rate (cu ft/min) (see Table 380)*
$\eta_{baseline}$	=	*Baseline clean air delivery efficiency = 1.0 cfm/W*
η_{ES}	=	*ENERGY STAR air delivery efficiency (cfm/W) (see Table 380)*
hours	=	*Average hours of operation per day = 16*
days	=	*Average days of operation per year = 365*
$W_{baseline,SB}$	=	*Conventional model standby power = 1.0 W*
$W_{ES,SB}$	=	*ENERGY STAR model standby power = 0.6 W*
1,000	=	*Constant to convert from W to kW*
8,760	=	*Total hours per year*

Demand Savings Algorithms

$$Peak\ Demand\ Savings\ |\Delta kW| = \frac{\Delta kWh}{hours \times days} \times CF_{S/W}$$

Equation 151

Where:

$CF_{S/W}$	=	*Seasonal peak coincidence factor (see Table 379)*

Table 379. Air Purifiers—Coincidence Factors[507]

Season	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
Summer	0.636	0.617	0.631	0.620	0.564
Winter	0.882	0.907	0.829	0.876	0.926

Deemed Energy Savings Tables

Table 380. Air Purifiers—Energy Savings (kWh)

Smoke CADR range (cu ft/min)	ENERGY STAR QPL Average Smoke CADR	ENERGY STAR QPL Average Smoke CADR/W	kWh savings
10–99	75	3.0	115
100–149	129	4.3	222
150–199	171	4.6	284
200–249	225	4.4	363
250–299	275	5.7	522
300+	375	5.5	699

Deemed Summer Demand Savings Tables

Table 381. Air Purifiers—Summer Peak Demand Savings (kW)

Smoke CADR range (cu ft/min)	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
10–99	0.012	0.012	0.012	0.012	0.011
100–149	0.024	0.023	0.024	0.024	0.021
150–199	0.031	0.030	0.031	0.030	0.027
200–249	0.040	0.038	0.039	0.039	0.035
250–299	0.057	0.055	0.056	0.055	0.051
300+	0.076	0.074	0.076	0.074	0.068

[507] See Volume 1, Section 4.

Deemed Winter Demand Savings Tables

Table 382. Air Purifiers—Winter Peak Demand Savings (kW)

Smoke CADR range (cu ft/min)	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
10–99	0.017	0.018	0.016	0.017	0.018
100–149	0.034	0.034	0.032	0.033	0.035
150–199	0.043	0.044	0.040	0.043	0.045
200–249	0.055	0.056	0.052	0.054	0.058
250–299	0.079	0.081	0.074	0.078	0.083
300+	0.106	0.109	0.099	0.105	0.111

Claimed Peak Demand Savings

Refer to Volume 1, Section 4 for further details on peak demand savings and methodology.

Additional Calculators and Tools

Not applicable.

Measure Life and Lifetime Savings

The estimated useful life (EUL) is 9 years, as specified in the California Database of Energy Efficiency Resources (DEER) READI tool for EUL ID RES-AirCleaner.[508]

Program Tracking Data and Evaluation Requirements

Primary inputs and contextual data that should be specified and tracked by the program database to inform the evaluation and apply the savings properly are:

- Climate zone or county
- Unit quantity
- Manufacturer and model number
- ENERGY STAR certificate matching model number
- Smoke clean air delivery rate (CADR) in cu ft/min (cfm)
- Proof of purchase – including date of purchase and quantity
    - Alternative: photo of unit installed or another pre-approved method of installation verification.

[508] DEER READI (Remote Ex-Ante Database Interface). http://www.deeresources.com/index.php/readi.

References and Efficiency Standards

Petitions and Rulings

Not applicable.

Relevant Standards and Reference Sources

Please refer to measure citations for relevant standards and reference sources.

Document Revision History

Table 383. Air Purifiers—Revision History

TRM version	Date	Description of change
v7.0	10/2019	TRM v7.0 origin.
v8.0	10/2020	TRM v8.0 update. No revision.
v9.0	10/2021	TRM v9.0 update. Updated EUL reference.
v10.0	10/2022	TRM v10.0 update. Verified compliance with ENERGY STAR Final Version 2.0 Requirements. Updated dust CADR references to refer to smoke CADR. Updated deemed savings ranges and values.
v11.0	10/2023	TRM v11.0 update. Updated baseline to Tier 1 federal standard.
v12.0	10/2024	TRM v12.0 update. ~~Updated baseline to Tier 1 federal standard.~~ No revision.

2.5.9 ENERGY STAR® Dehumidifiers

TRM Measure ID: R-AP-DH

Market Sector: Residential

Measure Category: Appliance

Applicable Business Types: Single-family, manufactured

Fuels Affected: Electricity

Decision/Action Type: Retrofit, new construction

Program Delivery Type: Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: Engineering algorithms and estimates

Measure Description

This measure applies to the installation of an ENERGY STAR-compliant dehumidifier.

Eligibility Criteria

Eligible equipment includes both portable and whole-home dehumidifiers that are compliant with the current ENERGY STAR specification.[509]

Baseline Condition

The baseline condition for this measure is a new dehumidifier that meets the current federal standard, effective June 13, 2019.[510] These standards are provided in Table 384 for portable dehumidifiers and Table 385 for whole-home dehumidifiers.

High-Efficiency Condition

The high-efficiency condition is a dehumidifier that meets the ENERGY STAR Version 5.0 Program Requirements for Dehumidifiers, effective October 31, 2019.[511] Units meeting ENERGY STAR Most Efficient 2020 Criteria are eligible for additional savings. These standards are provided in Table 384 and Table 385.

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[509] ENERGY STAR Dehumidifier Qualified Product Listing. https://www.energystar.gov/productfinder/product/certified-dehumidifiers/results.

[510] Energy Conservation Program: Energy Conservation Standards for Dehumidifiers. https://www.federalregister.gov/documents/2022/06/22/2022-13322/energy-conservation-program-energy-conservation-standards-for-dehumidifiers

[511] ENERGY STAR Version 5.0 Program Requirements for Dehumidifiers. https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Dehumidifiers%20Version%205.0%20Program%20Requirements_0.pdf.

A new ENERGY STAR Final Version 6.0 specification will be effective October 1, 2025.[512] Texas TRM v13 will be updated for compliance with that updated specification.

Table 384. Dehumidifiers—Federal and ENERGY STAR standards for Portable Dehumidifiers

Product Capacity (pints/day)	Federal Standard Criteria (L/kWh)	ENERGY STAR (EF (L/kWh))	ENERGY STAR Most Efficient (L/kWh)
≤ 25	≥ 1.30	≥ 1.57	≥ 1.70
> 25 to ≤ 50	≥ 1.60	≥ 1.80	≥ 1.90
> 50	≥ 2.80	≥ 3.30	≥ 3.40

Table 385. Dehumidifiers—Federal and ENERGY STAR standards for Whole-Home Dehumidifiers

Case Volume (ft³)	Federal Standard (EF (L/kWh))	ENERGY STAR (EF (L/kWh))	ENERGY STAR Most Efficient (L/kWh)
≤ 8.0	≥ 1.77	≥ 2.09	≥ 2.22
> 8.0	≥ 2.41	≥ 3.30	≥ 3.40

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Energy Savings Algorithms

The annual energy savings are calculated using the following equation:

$$Annual\ Energy\ Savings\ [\Delta kWh] = \frac{Cap \times 0.473}{24} \times HOU \times \left(\frac{1}{L/kWh_{Base}} - \frac{1}{L/kWh_{ES}}\right)$$

Equation 152

Where:

Cap = *Average product capacity (pints/day), from ENERGY STAR (See Table 386)*

0.473 = *Constant to convert from pints to liters*

24 = *Constant to convert from from hours to days*

[512] ENERGY STAR Version 6.0 Program Requirements for Dehumidifiers. https://www.energystar.gov/sites/default/files/2024-08/ENERGY%20STAR%20Dehumidifiers%20V6.0%20Final%20Specification%20with%20Partner%20Commitments.pdf.

[513] ENERGY STAR Dehumidifiers Key Efficiency Criteria. https://www.energystar.gov/products/appliances/dehumidifiers/key_efficiency_criteria.

HOU = *Hours of use per year [hours]*[514] = 1,632

L/kWh_{base} = *Baseline liters of water per kWh consumed (see Table 384 and Table 385)*

L/kWh_{ES} = *ENERGY STAR liters of water per kWh consumed (see Table 386)*

Table 386. Dehumidifiers—Savings Calculation Input Assumptions[515]

Dehumidifier Type	Must Recover Condensate?	Capacity Range (pints/day)	ENERGY STAR Min Capacity (pints/day)	ENERGY STAR Min Efficiency (L/kWh)
Portable	No	≤ 25	22.0	1.63
	No	> 25 to ≤ 50	43.0	1.85
	Yes	≤ 25	20.8	1.78
	Yes	> 25 to ≤ 50	44.5	2.01
Whole-Home	No	Any	79.1	2.13
	Yes	Any	82.8	2.35

Demand Savings Algorithms

No winter peak demand electric savings are calculated for this measure.

The summer peak electric demand savings are calculated using the following equation.

$$Peak\ Demand\ Savings\ [\Delta kW] = \frac{kWh_{Savings}}{HOU} \times CF_S$$

Equation 153

Where:

CF_S = *Summer peak coincidence factor (See Table 356)*

Table 387. Dehumidifiers—Coincidence Factors[516]

Season	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Austin/Corpus Christi	Climate Zone 5: El Paso
Summer	0.355	0.345	0.353	0.346	0.315
Winter[517]	0.000	0.000	0.000	0.000	0.000

[514] ENERGY STAR calculator, assuming 24 hour operation over 68 days of the year. Updated October 1, 2016.

[515] Values were averaged from August 2024 ENERGY STAR Dehumidifier QPL. No items on QPL had capacities above 50 pints/day for portable dehumidifiers, or case volumes larger than 8 ft^3 for whole-home dehumidifiers, so these size ranges are excluded.

[516] See Volume 1, Section 4.

[517] The ENERGY STAR appliance calculator only assumes operation April through September.

Deemed Energy Savings Tables

Table 388. Dehumidifiers—Annual Energy Savings (kWh)

Dehumidifier Type	Must Withstand	Capacity (pints/day)	Annual Savings
Portable	No	≤ 25	110
-	No	> 25 to ≤ 50	117
-	Yes	≤ 25	139
-	Yes	> 25 to ≤ 50	182
Whole-Home	No	Any	243
-	Yes	Any	371

Deemed Summer Demand Savings Tables

Table 389. Dehumidifiers—Summer Peak Demand Savings (kW)

Dehumidifier Type	Must Withstand	Capacity (pints/day)	Climate Zone 1: Abilene	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
Portable	No	≤ 25	0.024	0.023	0.024	0.023	0.021
-	No	> 25 to ≤ 50	0.025	0.025	0.025	0.025	0.023
-	Yes	≤ 25	0.030	0.029	0.030	0.030	0.027
-	Yes	> 25 to ≤ 50	0.040	0.038	0.039	0.039	0.035
Whole-Home	No	Any	0.053	0.051	0.053	0.052	0.047
-	Yes	Any	0.081	0.078	0.080	0.079	0.072

Claimed Peak Demand Savings

Refer to Volume 1, Section 4 for further details on peak demand savings and methodology.

Additional Calculators and Tools

Not applicable.

Measure Life and Lifetime Savings

The estimated useful life (EUL) for Dehumidifiers is 12 years.[518]

[518] ENERGY STAR Dehumidifier Calculator based on 2012 EPA Research.

Program Tracking Data and Evaluation Requirements

Primary inputs and contextual data that should be specified and tracked by the program database to inform the evaluation and apply the savings properly:

- Climate zone or county
- Unit quantity
- Manufacturer and model number
- ENERGY STAR Most Efficient status (yes, no)
- Type of dehumidifier (portable, whole-home)
- Capacity/size of the new and old unit (pints/day)
- Proof of purchase – with date of purchase and quantity
    - Alternative: photo of unit installed or another pre-approved method of installation verification

References and Efficiency Standards

Petitions and Rulings

Not applicable.

Relevant Standards and Reference Sources

Please refer to measure citations for relevant standards and reference sources.

Document Revision History

Table 390. Dehumidifiers—Revision History

TRM version	Date	Description of change
v12.0	10/2024	TRM v12.0 origin.

2.5.10 ENERGY STAR® Ventilation Fans

TRM Measure ID: R-AP-VF

Market Sector: Residential

Measure Category: Appliance

Applicable Business Types: Single-family, manufactured

Fuels Affected: Electricity

Decision/Action Type: Retrofit, new construction

Program Delivery Type: Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: Engineering algorithms and estimates

Measure Description

This measure applies to the installation of ENERGY STAR-compliant bathroom and utility room ventilation fans.

Eligibility Criteria

Eligible equipment includes ventilation fans that are compliant with the current ENERGY STAR specification.[519] The new ventilation fans must also have a capacity that is between 10 CFM and 500 CFM.

Baseline Condition

ENERGY STAR does not specify a baseline efficacy for existing residential ventilation fans. Therefore, a conservative improvement of 15 percent for the efficient case is used to determine the baseline. The resulting baseline efficacy values are provided in Table 391.

Table 391. Ventilation Fans—Baseline Bathroom and Utility Room Ventilating Fan Efficacy

Fan Flow (CFM)	Baseline Efficacy (CFM/Watt)
10-89	2.4
90-200	3.0
201-500	3.4

[519] ENERGY STAR Ventilation Fan Qualified Product Listing, https://www.energystar.gov/products/ventilation_fans.

High-Efficiency Condition

The high-efficiency condition is a ventilation fan that meets the ENERGY STAR Version 4.1 Program Requirements for Residential Ventilating Fans, effective October 1, 2015.[520] These standards are provided in Table 384 and Table 393.

Table 392. Ventilation Fans—ENERGY STAR Minimum Efficacy Levels

Air Flow (CFM)	ENERGY STAR	ENERGY STAR Most Efficient
	Minimum Efficacy Level (CFM/W)	
10-89	≥ 2.8	≥ 10.0
90-200	≥ 3.5	
201-500	≥ 4.0	

Table 393. Ventilation Fans— ENERGY STAR Maximum Sound Levels

Air Flow (CFM)	ENERGY STAR	ENERGY STAR Most Efficient
	Maximum Sound Level (Sones)	
10-200	< 2.0	< 4.0
201-500	< 3.0	

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Energy Savings Algorithms

The annual energy savings are calculated using the following equation:

$$Annual\ Energy\ Savings\ [\Delta kWh] = Cap \times \left(\frac{1}{\eta_{base}} - \frac{1}{\eta_{ES}}\right) \times \frac{1}{1{,}000} \times AOH$$

Equation 154

Where:

Cap = *Nominal ENERGY STAR capacity of the exhaust fan (use maximum value for multi-speed fans) [CFM]*

η_{base} = *Baseline fan efficacy (CFM/Watt), (see Table 391)*

η_{ES} = *ENERGY STAR fan efficacy (CFM/Watt) (see Table 394)*

[520] ENERGY STAR Version 4.1 Program Requirements for Residential Ventilating Fans. https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Ventilating%20Fans%20Specification%20Version%204.2.pdf.

AOH = *Annual operating hours*[521] *= 438*

1,000 = *Constant to convert from W to kW*

Table 394. Ventilation Fans – ENERGY STAR Average Airflow and Efficacy[522]

Air Flow (CFM)	Heat Recovery	ENERGY STAR Average Airflow (CFM)	ENERGY STAR Average Efficacy (CFM/Watt)
10-89	No	72	5.6
90-300		117	6.3
201-500		295	4.4
10-89	Yes	68	12.0
90-300		128	11.7
201-500		260	6.7

Demand Savings Algorithms

No winter peak electric demand savings are calculated for this measure.

The summer peak electric demand savings are calculated using the following equation.

$$Peak\ Demand\ Savings\ [\Delta kW] = CFM \times \left(\frac{1}{\eta_{base}} - \frac{1}{\eta_{ES}}\right) \times \frac{1}{1{,}000} \times CF$$

Equation 155

Where:

CF = *Seasonal peak coincidence factor (see Table 395)*

Table 395. Ventilation Fans—Coincidence Factors[523]

Season	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
Summer	0.060	0.053	0.063	0.059	0.032
Winter	0.275	0.232	0.199	0.263	0.358

[521] "Residential Lighting End-Use Consumption Study: Estimateion Framework and Initial Estimates", U.S. Department of Energy, December 2012, Page 50. Bathroom lights estimated to run 1.2 hours day, or 438 hours per year (1.2 x 365 = 438), assuming ventilation fan operation when the bathroom light was on. https://www1.eere.energy.gov/buildings/publications/pdfs/ssl/2012_residential-lighting-study.pdf.

[522] Values were averaged from August 2024 ENERGY STAR Ventilation Fans QPL.

[523] See Volume 1, Section 4, Using values from the Residential Lighting measure.

Deemed Energy Savings Tables

Table 396. Ventilation fans - Annual Energy Savings (kWh)

Air Flow (CFM)	Short Efficient	Energy Savings (kWh)
10-89	No	8
90-300		9
201-500		9
10-89	Yes	10
90-300		14
201-500		16

Deemed Summer Demand Savings Tables

Table 397. Ventilation Fans – Summer Peak Demand Savings (kW)

Air Flow (CFM)	Short Efficient	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
10-89	No	0.0010	0.0009	0.0011	0.0010	0.0005
90-300	No	0.0012	0.0011	0.0013	0.0012	0.0007
201-500	No	0.0012	0.0010	0.0012	0.0012	0.0006
10-89	Yes	0.0014	0.0012	0.0014	0.0013	0.0007
90-300	Yes	0.0019	0.0017	0.0020	0.0019	0.0010
201-500	Yes	0.0023	0.0020	0.0024	0.0022	0.0012

Claimed Peak Demand Savings

Refer to Volume 1, Section 4 for further details on peak demand savings and methodology.

Additional Calculators and Tools

Not applicable.

Measure Life and Lifetime Savings

The estimated useful life (EUL) for a ventilation fan is 19 years.[524]

[524] "Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures". Prepared by GDS Associates for the New England State Program Working Group (SPWG). June 2007. Table 1, Page 1-3. Conservative estimate based 25-year EUL for for whole-house fans and 19-year EUL for thermostatically-controlled attic fans. https://energizect.com/sites/default/files/documents/Measure%20Life%20Report%202007.pdf.

Program Tracking Data and Evaluation Requirements

Primary inputs and contextual data that should be specified and tracked by the program database to inform the evaluation and apply the savings properly:

- Climate zone or county
- Unit quantity
- Manufacturer and model number
- ENERGY STAR Most Efficient status (yes, no)
- Nominal capacity of the ventilation fan
- Proof of purchase – with date of purchase and quantity
    - Alternative: photo of unit installed or another pre-approved method of installation verification

References and Efficiency Standards

Petitions and Rulings

Not applicable.

Relevant Standards and Reference Sources

Please refer to measure citations for relevant standards and reference sources.

Document Revision History

Table 398. Ventilation Fans—Revision History

TRM version	Date	Description of change
v12.0	10/2024	TRM v12.0 origin.

2.5.11 ENERGY STAR® Water Coolers

TRM Measure ID: R-AP-WC

Market Sector: Residential

Measure Category: Appliances

Applicable Business Types: Single-family, manufactured

Fuels Affected: Electricity

Decision/Action Type: Retrofit, new construction

Program Delivery Type: Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: Engineering algorithms and estimates

Measure Description

This measure applies to the installation of ENERGY STAR-compliant water coolers. Water coolers are a home appliance that offer consumers the ability to enjoy hot and/or cold water on demand.

Eligibility Criteria

Eligible equipment includes water coolers that are compliant with the current ENERGY STAR specification.[525]

This measure applies to bottled water and point-of-use units, conditioned storage water coolers and on-demand water coolers, and products that provide sparkling, alkaline, or flavored water in addition to chilled water. Units that provide pressurized water and are not freestanding, are air-source or use a water source other than bottled or tap water, and units that are primarily ice makers with a water dispensing function are ineligible under this measure.

Water coolers must be installed in a residential application.

Baseline Condition

The baseline condition is a non-ENERGY STAR-certified water cooler.

[525] ENERGY STAR Water Coolers Qualified Product Listing (QPL). https://www.energystar.gov/products/water_coolers.

High-Efficiency Condition

The high-efficiency condition is a water heater that meets the ENERGY STAR Version 3.0 Program Requirements for Water Coolers, effective March 23, 2022.[526]

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Energy Savings Algorithms

$$Energy\ Savings\ [\Delta kWh] = (kWh_{base} - kWh_{ES}) \times AOD$$

Equation 156

Where:

kWh_{base} = *Daily energy use for baseline water cooler [kWh/day] (see)*

kWh_{ES} = *Daily energy use for ENERGY STAR water cooler [kWh/day] (see)*

AOD = *Annual operating days*[527] *= 365*

Table 399. Water Coolers—Baseline & Efficient Water Cooler Daily Energy Use (kWh/day)

Type of Water Cooler	kWh_{base}[528]	kWh_{ES}[529]
Hot and Cold Water (Storage)	0.891	0.695
Hot and Cold Water (On Demand)	0.183	0.143
Cold Water Only	0.184	0.144

Demand Savings Algorithms

$$Peak\ Demand\ Savings\ [\Delta kW] = \frac{\Delta kWh}{8{,}760} \times CF_{S/W}$$

Equation 157

[526] ENERGY STAR Version 3.0 Program Requirements for Water Coolers. https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20Verison%203.0%20Water%20Coolers%20Final%20Specification_0.pdf.

[527] Assumed 365 days per year and 24 hours per day as utilized in daily energy consumption from ENERGY STAR Program Requirements Product Specification 3.0 for Water Coolers Test Method.

[528] Assuming a baseline energy consumption of 22% greater than the ENERGY STAR specification. https://www.energystar.gov/products/water_coolers.

[529] Average ratings from certified products on ENERGY STAR Water Coolers Qualified Product Listing. https://www.energystar.gov/products/water_coolers.

Where:

CF_{SW} = *Seasonal coincidence factor (See Table 401)*

8,760 = *Total hours per year*

Table 400. Water Coolers—Coincidence Factors[530]

Season	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Austin/Corpus	Climate Zone 5: El Paso
Summer	1.112	1.099	1.108	1.100	1.081
Winter	0.929	0.966	0.924	0.941	0.966

Deemed Energy Savings Tables

Table 401. Water Coolers—Energy Savings (kWh)

Type of Water Cooler	kWh
Hot and Cold Water (Storage)	72
Hot and Cold Water (On Demand)	15
Cold Water Only	

Deemed Summer Demand Savings Tables

Table 402. Water Coolers—Summer Peak Demand Savings (kW)

Type of Water Cooler	kW
Hot and Cold Water (Storage)	0.009
Hot and Cold Water (On Demand)	0.002
Cold Water Only	

Deemed Winter Demand Savings Tables

Table 403. Water Coolers—Winter Peak Demand Savings (kW)

Type of Water Cooler	kW
Hot and Cold Water (Storage)	0.008
Hot and Cold Water (On Demand)	0.002
Cold Water Only	

Claimed Peak Demand Savings

Refer to Volume 1, Section 4 for further details on peak demand savings and methodology.

[530] See Volume 1, Section 4. Using values from the Residential Refrigerators measure.

Additional Calculators and Tools

Not applicable.

Measure Life and Lifetime Savings

The estimated useful life (EUL) for an ENERGY STAR water cooler is 5 years based on the maximum observed manufacturer warranty period for products on the ENERGY STAR QPL.[531]

Program Tracking Data and Evaluation Requirements

Primary inputs and contextual data that should be specified and tracked by the program database to inform the evaluation and apply the savings properly:

- Climate zone or county
- Unit quantity
- Manufacturer and model number
- Type of water cooler (storage, on demand)
- Water temperature (hot and cold, cold water only)
- Proof of purchase – with date of purchase and quantity
    - Alternative: photo of unit installed or another pre-approved method of installation verification

References and Efficiency Standards

Petitions and Rulings

Not applicable.

Relevant Standards and Reference Sources

Please refer to measure citations for relevant standards and reference sources.

Document Revision History

Table 404. Water Coolers—Revision History

TRM Version	Date	Description of Change
v12.0	10/2024	TRM v12.0 origin.

[531] Oasis Coolers had the most products rated on the ENERGY STAR QPL when accessed on 9/11/2024. https://www.oasiscoolers.com/service-support/warranty-information.html.

2.5.12 ENERGY STAR® Pool Pumps Measure Overview

TRM Measure ID: R-AP-PP

Market Sector: Residential

Measure Category: Appliances

Applicable Building Types: Single-family, multifamily, manufactured

Fuels Affected: Electricity

Decision/Action Type(s): Retrofit

Program Delivery Type(s): Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: Engineering algorithms and estimates

Measure Description

This measure involves the replacement of a single-speed pool pump with an ENERGY STAR-certified variable-speed or multi-speed pool pump.

Eligibility Criteria

This measure applies to all residential applications of in-ground pools or above-ground pools. Pools that serve multiple tenants in a common area are not eligible for this measure. Ineligible pump products include waterfall, integral cartridge filter, integral sand filter, storable electric spa, and rigid electric spa.[532]

Multi-speed pool pumps are an alternative to variable speed pumps. The multi-speed pump uses an induction motor that functions as two motors in one, with full-speed and half-speed options. Multi-speed pumps may enable significant energy savings. However, if the half-speed motor is unable to complete the required water circulation task, the larger motor will operate exclusively. Having only two speed-choices limits the ability of the pump motor to fine-tune the flow rates required for maximum energy savings.[533] Therefore, multi-speed pumps must have a high-speed override capability to revert to low speed after a period not to exceed 24 hours.

[532] These product types are excluded by the ENERGY STAR specification. https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Version%203.1%20Pool%20Pumps%20Final%20Specification_0.pdf.

[533] Hunt, A. and Easley, S., 2012, "Measure Guideline: Replacing Single-Speed Pool Pumps with Variable Speed Pumps for Energy Savings." Building America Retrofit Alliance (BARA), US DOE. May 2012. http://www.nrel.gov/docs/fy12osti/54242.pdf.

Baseline Condition

The baseline is assumed to be a new pool pump that is compliant with the current federal standard, effective July 19, 2021.[534] Weighted energy factor (WEF) requirements are based on rated hydraulic horsepower (hhp).

Table 405. Pool Pumps—Baseline Condition—~~Federal Standard Effective July 19, 2021~~

Pump subtype	Size class	WEF
Self-priming (inground) pool pumps	Extra small (hhp ≤ 0.13)	WEF = 5.55
	Small (hhp > 0.13 to < 0.711)	WEF = -1.30 x ln(hhp) + 2.90
	Standard (hhp ≥ 0.711)	WEF = -2.30 x ln(hhp) + 6.59
Non-self priming (above ground) pool pumps	Extra small (hhp ≤ 0.13)	WEF = 4.60
	Standard size (hhp > 0.13)	WEF = -0.85 x ln(hhp) + 2.87

High-Efficiency Condition

The high-efficiency condition is a 1 to 5 hp variable speed pump (VSP) or multi-speed pool pump that is compliant with the ENERGY STAR Final Version 3.1 Requirements for pool pumps effective July 19, 2021.[535] Energy efficiency service providers are expected to comply with the latest ENERGY STAR requirements.

Additional optional efficiency standards are available, aligning with recommendations from the Consortium for Energy Efficiency (CEE) residential swimming pool pump specification, effective October 21, 2020.[536] For all in-ground pumps, CEE Tier 1 matches the current federal standard, and CEE Tier 2 matches the current ENERGY STAR specification for in-ground standard size pumps. Additional savings are only specified for CEE tiers where there is an incremental efficiency improvement above the ENERGY STAR specification.

Compliance only needs to be verified against the CEE specification when claiming CEE savings that exceed the corresponding ENERGY STAR savings values. ENERGY STAR savings should be claimed for all pumps where CEE compliance is not verified and where there are no CEE savings specified.

[534] Federal standard for dedicated-purpose pool pumps. https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=67.

[535] ENERGY STAR Pool Pumps Final Version 3.1 Program Requirements. https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Version%203.1%20Pool%20Pumps%20Final%20Specification_0.pdf.

[536] CEE Residential Swimming Pool Pump Specification. https://library.cee1.org/system/files/library/14404/CEE_ResSwimmingPoolPump_Specification_21Oct2020.pdf.

Table 406. ~~ENERGY STAR~~ Pool Pumps ~~Energy Efficiency Level~~High Efficiency Condition

Pump Subtype	Size class	ENERGY STAR	CEE Tier 1	CEE Tier 2
Self-priming (inground) pool pumps	Extra small (hhp ≤ 0.13)	WEF ≥ 13.40	–	–
	Small (hhp > 0.13 to < 0.711)	WEF ≥ -2.45 x ln(hhp) + 8.40	WEF ≥ -1.30 x ln(hhp) + 4.95	WEF ≥ -2.83 x ln(hhp) + 8.84
	Standard (hhp ≥ 0.711)		WEF ≥ -2.30 x ln(hhp) + 6.59	WEF ≥ -2.45 x ln(hhp) + 8.40
Non-self-priming (above ground) pool pumps	Extra small (hhp ≤ 0.13)	WEF ≥ 4.92	–	–
	Standard size (hhp > 0.13)	WEF ≥ -1.00 x ln(hhp) + 3.85	WEF ≥ -1.60 x ln(hhp) + 9.10	–

Energy and Demand Savings Methodology

Savings for this measure are based on methods and input assumptions from the ENERGY STAR Pool Pump Savings Calculator.

Savings Algorithms and Input Variables

Energy Savings Algorithms

Energy savings for this measure were derived using the ENERGY STAR Pool Pump Savings Calculator with Texas selected as the applicable location, so Texas-specific assumptions were used.[537]

$$Energy\ Savings\ |\Delta kWh| = kWh_{base} - kWh_{ES}$$

Equation 158

Where:

kWh_{base} = *Baseline pool pump energy (kWh)*

kWh_{ES} = *ENERGY STAR variable speed pool pump energy (kWh)*

Algorithms to calculate the above parameters are defined as:

$$kWh_{base} = \frac{PFR_{base} \times 60 \times hours \times days}{WEF_{base} \times 1{,}000}$$

Equation 159

$$kWh_{ES} = \frac{V \times TO \times days}{WEF_{ES} \times 1{,}000}$$

Equation 160

Where:

PFR_{base} = *Baseline pump flow rate [gal/min] (Table 407)*

$_{w}EF_{base}$ = *Baseline pump energy factor [gal/W x hr] (Table 407)*

WEF_{ES} = *ENERGY STAR pump energy factor [gal/W x hr] (Table 408)*

hours = *Pump daily operating hours (Table 407)*

days = *Operating days per year = 365 days (default)*

[537] The ENERGY STAR Pool Pump Savings Calculator, updated February 2013, can be found on the ENERGY STAR website at: https://www.energystar.gov/productfinder/product/certified-pool-pumps/results.

V	=	*Pool volume [gal] (Table 407)*
TO	=	*Turnovers per day, number of times the volume of the pool is run through the pump per day (Table 408)*
60	=	*Constant to convert between minutes and hours*
1,000	=	*Constant to convert from W to kW*

Table 407. Pool Pumps—Baseline Assumptions[538]

New pump HP	Reference HP	Reference HHP[539]	Hours[540]	PFR_{base} (gal/min)
≤ 1.25	1.0	0.533	4.9	75.5000
1.25 < hp ≤ 1.75	1.5	0.800	4.7	78.1429
1.75 < hp ≤ 2.25	2.0	1.066	4.1	88.6667
2.25 < hp ≤ 2.75	2.5	1.333	4.0	93.0910
2.75 < hp ≤ 5	3.0	1.599	4.0	101.6667

Table 408. Pool Pumps—ENERGY STAR Assumptions[541]

New pump HP	V (gal)	Turnovers/day
≤ 1.25	22,000	1.0
1.25 < hp ≤ 1.75		
1.75 < hp ≤ 2.25		
2.25 < hp ≤ 2.75		
2.75 < hp ≤ 5		

Demand Savings Algorithms

$$Peak\ Demand\ Savings\ [\Delta kW] = \frac{kWh_{base} - kWh_{ES}}{hours} \times \frac{CF_{S/W}}{days}$$

Equation 161

[538] Conventional pump PFR and EF values are taken from pump curves found in the ENERGY STAR Pool Pump Savings Calculator. Note: input assumptions will be updated once calculator has been updated for compliance with the current specification.

[539] Hhp not available in ENERGY STAR calculator. Assumed hhp calculated as follows: Ref. horsepower x AF. AF = 0.533 based on ratio of hhp to hp from ENERGY STAR qualified product listing. Accessed 8/11/2023.

[540] The daily average operating hours for conventional single-speed pumps, based on 2014 residential pool pump program survey results from CenterPoint Energy.

[541] ENERGY STAR values are taken from default inputs and pump curves found in the ENERGY STAR Pool Pump Savings Calculator. Note: input assumptions will be updated once calculator has been updated for compliance with the current specification.

Where:

$CF_{S/W}$ = *Seasonal peak coincidence factor (Table 409)*

Table 409. Pool Pumps—Coincidence Factors[542]

Climate zone	Summer CF	Winter CF
Zone 1: Amarillo	0.258	-0.002
Zone 2: Dallas	0.329	0.025
Zone 3: Houston	0.276	0.108
Zone 4: Corpus Christi	0.266	0.036
Zone 5: El Paso	0.497	-0.143

Deemed Energy Savings Tables

Table 410. Pool Pumps—Energy Savings (kWh)[543]

New pump hp	Inground	Above ground
ENERGY STAR		
≤ 1.25	1,371	587
1.25 < hp ≤ 1.75	235	657
1.75 < hp ≤ 2.25	262	707
2.25 < hp ≤ 2.75	332	852
2.75 < hp ≤ 5	509	1,229
CEE Tier 1		
≤ 1.25	–	1,585
1.25 < hp ≤ 1.75	–	1,779
1.75 < hp ≤ 2.25	–	1,935
2.25 < hp ≤ 2.75	–	2,176
2.75 < hp ≤ 5	–	2,642
CEE Tier 2		
≤ 1.25	1,423	–
1.25 < hp ≤ 5	–	–

[542] Coincidence factors are calculated according to the method in Section 4 of the Texas TRM Vol 1 using data from the US Department of Energy's Building America B10 Benchmark load profiles for pool pumps. The profile used to determine coincidence factors is calculated as the difference of single speed and variable speed profiles. Summer profiles include April through September and winter profiles include October through March.

[543] The results in this table may vary slightly from results produced by the ENERGY STAR calculator because of rounding of default savings coefficients throughout the measure and pool volume.

Deemed Summer Demand Savings Tables[544]

Table 411. Pool Pumps—Summer Peak Demand Savings (kW) for Inground Pools

New pump HP	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
ENERGY STAR					
≤ 1.25	0.198	0.252	0.212	0.204	0.381
1.25 < hp ≤ 1.75	0.035	0.045	0.038	0.036	0.068
1.75 < hp ≤ 2.25	0.045	0.057	0.048	0.046	0.087
2.25 < hp ≤ 2.75	0.059	0.075	0.063	0.060	0.113
2.75 < hp ≤ 5	0.090	0.115	0.096	0.093	0.173
CEE Tier 1					
All sizes	–	–	–	–	–
CEE Tier 2					
≤ 1.25	0.206	0.262	0.220	0.212	0.396
1.25 < hp ≤ 5	–	–	–	–	–

Table 412. Pool Pumps—Summer Peak Demand Savings (kW) for Above Ground Pools

New pump HP	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
ENERGY STAR					
≤ 1.25	0.085	0.108	0.091	0.087	0.163
1.25 < hp ≤ 1.75	0.099	0.126	0.106	0.102	0.190
1.75 < hp ≤ 2.25	0.122	0.155	0.130	0.126	0.235
2.25 < hp ≤ 2.75	0.151	0.192	0.161	0.155	0.290
2.75 < hp ≤ 5	0.218	0.277	0.233	0.224	0.418
CEE Tier 1					
≤ 1.25	0.229	0.291	0.245	0.236	0.441
1.25 < hp ≤ 1.75	0.268	0.341	0.287	0.276	0.516
1.75 < hp ≤ 2.25	0.334	0.425	0.357	0.344	0.643
2.25 < hp ≤ 2.75	0.385	0.490	0.412	0.396	0.741
2.75 < hp ≤ 5	0.468	0.595	0.500	0.481	0.900

[544] Ibid.

New pump HP	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
CEE Tier 2					
All sizes	–	–	–	–	–

Deemed Winter Demand Savings Tables

Table 413. Pool Pumps—Winter Peak Demand Savings (kW) for Inground Pools

New pump HP	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
ENERGY STAR					
≤ 1.25	-0.001	0.019	0.083	0.027	-0.110
1.25 < hp ≤ 1.75	0.000	0.003	0.015	0.005	-0.020
1.75 < hp ≤ 2.25	0.000	0.004	0.019	0.006	-0.025
2.25 < hp ≤ 2.75	0.000	0.006	0.025	0.008	-0.032
2.75 < hp ≤ 5	-0.001	0.009	0.038	0.012	-0.050
CEE Tier 1					
All sizes	–	–	–	–	–
CEE Tier 2					
≤ 1.25	-0.001	0.020	0.086	0.029	-0.114
1.25 < hp ≤ 5	–	–	–	–	–

Table 414. Pool Pumps—Peak Demand Savings (kW) for Above Ground Pools

New pump HP	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
ENERGY STAR					
≤ 1.25	-0.001	0.008	0.036	0.012	-0.047
1.25 < hp ≤ 1.75	-0.001	0.010	0.042	0.014	-0.055
1.75 < hp ≤ 2.25	-0.001	0.012	0.051	0.017	-0.067
2.25 < hp ≤ 2.75	-0.001	0.014	0.063	0.021	-0.083
2.75 < hp ≤ 5	-0.001	0.021	0.091	0.030	-0.120

New pump HP	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
CEE Tier 1					
≤ 1.25	-0.001	0.022	0.096	0.032	-0.127
1.25 < hp ≤ 1.75	-0.002	0.026	0.112	0.037	-0.148
1.75 < hp ≤ 2.25	-0.002	0.032	0.140	0.046	-0.185
2.25 < hp ≤ 2.75	-0.002	0.037	0.162	0.053	-0.213
2.75 < hp ≤ 5	-0.003	0.045	0.196	0.065	-0.259
CEE Tier 2					
All sizes	–	–	–	–	–

Claimed Peak Demand Savings

Refer to Volume 1, Section 4 for further details on peak demand savings and methodology.

Additional Calculators and Tools

ENERGY STAR Pool Pump Savings Calculator, updated May 2020, can be found on the ENERGY STAR website at https://www.energystar.gov/productfinder/product/certified-pool-pumps/results.

Measure Life and Lifetime Savings

The estimated useful life (EUL) is 10 years, as specified in the California Database of Energy Efficiency Resources (DEER) READI tool for EUL ID OutD-PoolPump.[545]

Program Tracking Data and Evaluation Requirements

Primary inputs and contextual data that should be specified and tracked by the program database to inform the evaluation and apply the savings properly include the below.

For all projects collect:

- Climate zone or county
- Unit quantity
- Manufacturer and model number of new pool pump
- ENERGY STAR certificate matching model number
- Weighted energy factor of new pool pump
- Rated hydraulic horsepower of new pool pump

[545] DEER READI (Remote Ex-Ante Database Interface). http://www.deeresources.com/index.php/readi.

- Rated horsepower of new pool pump
- Proof of purchase – with date of purchase and quantity
    - Alternative: photo of unit installed or other pre-approved method of installation verification

For a significant sample of projects where attainable (e.g., those projects that are selected for inspection, not midstream or retail programs):

- Items listed for all projects above
- Decision/action type: early retirement, replace-on-burnout, or new construction
- Rated horsepower of existing pool pump
- Existing and new pool pump operating hours

References and Efficiency Standards

Petitions and Rulings

Not applicable.

Relevant Standards and Reference Sources

Please refer to measure citations for relevant standards and reference sources.

Document Revision History

Table 415. Pool Pumps—Revision History

TRM version	Date	Description of change
v5.0	10/2017	TRM v5.0 origin.
v6.0	11/2018	TRM v6.0 update. No revision.
v7.0	10/2019	TRM v7.0 update. Updated eligibility to include above ground pool pumps now eligible for ENERGY STAR certification. Acknowledged the forthcoming ENERGY STAR v2.0.
v8.0	10/2020	TRM v8.0 update. Incorporated ENERGY STAR v2.0 updated deemed savings.
v9.0	10/2021	TRM v9.0 update. Updated EUL reference and documentation requirements.
v10.0	10/2022	TRM v10.0 update. Verified compliance with ENERGY STAR Final Version 3.1 Requirements. Updated savings coefficient definitions.
v11.0	10/2023	TRM v11.0 update. Updated baseline to current federal standard. Added new savings tiers. Updated documentation requirements.
v12.0	10/2024	TRM v12.0 update. No revision.

2.5.13 Advanced Power Strips Measure Overview

TRM Measure ID: R-AP-PS

Market Sector: Residential

Measure Category: Appliances

Applicable Building Types: Single-family, multifamily, manufactured

Fuels Affected: Electricity

Decision/Action Type(s): Retrofit, new construction

Program Delivery Type(s): Prescriptive

Deemed Savings Type: Deemed savings values

Savings Methodology: Engineering algorithms and estimates

Measure Description

This measure involves the installation of a multi-plug advanced power strip (APS) with the ability to automatically disconnect specific loads depending on the power draw of a specified, or "master," load.

For a Tier 1 APS, a load sensor in the strip disconnects power from the control outlets when the master power draw is below a certain threshold. This feature allows for a reduction of power draw from peripheral consumer electronics, which usually maintain some load even when in the off or standby position. Therefore, when the master device (e.g., television) is turned off, the power supply is cut to other related equipment (e.g., set-top boxes, speakers, video game consoles).

A Tier 2 APS uses an external sensor paired with a configurable countdown timer to manage both active and standby power loads for controlled devices in a complete system. A Tier 2 APS may operate either with or without a master control socket. Those without a master control socket sense power of all devices connected to the controlled sockets, while those with a master control socket sense power for the device connected to the master control socket. The external sensor of a Tier 2 APS may use an infrared-only sensor, or it may use a "multi-sensor," which detects both infrared (IR) remote control signals and motion to determine device inactivity and deliver additional savings as compared to a Tier 1 APS. Both versions of external sensors use IR filtering to prevent inappropriate switching events that may have otherwise resulted from natural interference, such as sunlight or CFL light bulbs.

Eligibility Criteria

This measure applies to all residential applications. For Tier 2 applications, the APS must control at least two audiovisual devices.

Baseline Condition

The baseline condition is assumed to be uncontrolled peripheral loads, each plugged into a traditional surge protector or wall outlet.

High-Efficiency Condition

The high-efficiency condition is peripheral loads controlled by a Tier 1 or Tier 2 APS.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Savings were developed based on reported plug load electricity consumption and hourly use data. A set of home entertainment and home office peripheral equipment and related performance data are presented in the following table. "Daily Standby Hours" and "Daily Off Hours" represent the average number of hours the device is left in standby or off mode. For each device, a weighted watt per hour value is calculated based on projected watts consumed in either mode.

There are ~~three~~two savings paths available for Tier 1. Savings can be estimated by:

1. Per system type (home entertainment or home office)
2. Per APS for an average complete system if the type is unknown
3. ~~Per individual peripheral device~~

Tier 2 savings are determined using the average component uses for a complete system and an energy reduction percentage.

Table 416. APS—Peripheral Watt Consumption Breakdown[546]

System type	Peripheral device	Daily standby hours	Daily off hours	Standby power (W)	Off power (W)	Weighted W/hr	Annual APS hours
Home entertainment	Audio equipment: AV receiver	0.0	18.0	19.2	3.1	3.1	6,570
	Audio equipment: Speakers	0.0	18.0	3.0	0.0	0.0	6,570
	Audio equipment: Subwoofer	0.0	18.0	7.8	0.6	0.6	6,570
	Media player: Blu-ray	2.5	20.8	7.0	0.1	0.8	8,505
	Media player: DVD	2.5	20.8	5.0	2.0	2.3	8,505
	Media player: DVD-R	2.5	20.8	7.0	3.0	3.4	8,505
	Media player: DVD/VCR	2.5	20.4	8.0	4.0	4.4	8,359
	Media player: VCR	2.2	21.4	6.0	3.0	3.3	8,614
	Set-top box: Cable	0.0	16.5	25.0	16.0	16.0	6,023
	Set-top box: Cable with DVR	0.0	16.5	45.0	43.0	43.0	6,023
	Set-top box: Satellite	0.0	15.1	10.0	15.0	15.0	5,512
	Set-top box: Satellite with DVR	0.0	15.1	27.0	28.0	28.0	5,512
	Set-top box: Stand-alone DVR	0.0	18.3	27.0	27.0	27.0	6,680
	Television: CRT	0.0	18.7	5.3	1.6	1.6	6,826
	Television: LCD	0.0	18.7	2.2	0.5	0.5	6,826
	Television: Plasma	0.0	18.7	0.9	0.6	0.6	6,826
	Television: Projection	0.0	18.7	4.4	7.0	7.0	6,826
	Video game console: Nintendo Wii	1.5	21.4	10.5	1.9	2.5	8,359
	Video game console: Wii U	1.5	21.4	34.0	0.4	2.6	8,359
	Video game console: PlayStation 2	1.5	21.4	17.0	0.2	1.3	8,359

[546] Derived from New York State Energy Research and Development Authority (NYSERDA), "Advanced Power Strip Research Report." August 2011.

System type	Peripheral device	Daily standby hours	Daily off hours	Standby power (W)	Off power (W)	Weighted W/hr	Annual APS hours
Home entertainment	Video game console: PlayStation 3	1.5	21.4	152.9	1.1	11.0	8,359
	Video game console: PlayStation 4	1.5	21.4	137.0	6.4	14.9	8,359
	Video game console: XBOX	1.5	21.4	68.0	2.0	6.3	8,359
	Video game console: XBOX 360	1.5	21.4	117.5	3.1	10.6	8,359
	Video game console: XBOX One	1.5	21.4	112.0	11.9	18.4	8,359
Home office	Computer: Desktop	4.1	16.7	11.6	3.3	4.9	7,592
	Computer: Laptop	4.1	16.7	7.6	4.4	5.0	7,592
	Computer monitor: CRT	2.4	16.5	7.6	1.5	2.3	6,899
	Computer monitor: LCD	2.4	16.5	1.9	1.1	1.2	6,899
	Computer speakers	0.0	18.7	3.7	2.3	2.3	6,826
	Copier	0.0	23.5	2.8	1.5	1.5	8,578
	Fax machine: Inkjet	0.5	23.3	6.0	5.3	5.3	8,687
	Fax machine: Laser	0.5	23.3	5.3	2.2	2.3	8,687
	Printer: Inkjet	4.4	19.5	2.5	1.3	1.5	8,724
	Printer: Laser	4.4	19.5	9.0	3.3	4.3	8,724
	Scanner	0.0	23.5	3.6	2.1	2.1	8,578

Energy Savings Algorithms

Tier 1 APS

Energy savings for a Tier 1 APS in use for home entertainment or home office are calculated using the following algorithm, where kWh saved is calculated and summed for all peripheral devices.

$$Energy\ Savings\ |\Delta kWh| = \sum \frac{W_i \times H_i}{1{,}000} \times ISR$$

Equation 162

Where:

W	=	*Weighted watts per hour consumed in standby/off mode for each peripheral device (see* Table 416*)*
H	=	*Annual hours per year controlled by APS (see Table 416)*
1,000	=	*Constant to convert from W to kW*
ISR	=	*In-service rate or the percentage of units rebated that are installed, see Table 417*

Tier 2 APS

Energy savings for a Tier 2 APS are calculated using the average household home entertainment and home office usages, multiplied by an assumed energy reduction percentage.

$$\Delta kWh_{Home\ Entertainment} = kWh_{TV} \times ERP \times ISR$$

Equation 163

$$\Delta kWh_{Home\ Office} = kWh_{Comp} \times ERP \times ISR$$

Equation 164

$$\Delta kWh_{Unspecified} = \frac{kWh_{TV} + kWh_{Comp}}{2} \times ERP \times ISR$$

Equation 165

Where:

kWh_{TV}	=	*Average annual energy consumption of Tier 2 qualifying TV systems: default = 602.8 kWh*[547]

[547] New York State Energy Research and Development Authority (NYSERDA), "Advanced Power Strip Research Report". August 2011. Page 30.

kWh_{Comp} = *Average annual energy consumption of Tier 2 qualifying computer systems; default = 197.9 kWh*[548]

ERP = *Energy reduction percentage (default = 47.5%*[549]*)*

Table 417. APS—In-Service Rates by Program Type

Program Type	ISR
All[550]	0.83

Demand Savings Algorithms

Tier 1 and Tier 2 APS

Demand savings for a Tier 1 APS in use for a home entertainment system or home office are calculated using the following algorithm, where kWh saved is calculated and summed for all peripheral devices. Demand savings for a Tier 2 APS are calculated using the average household home office and home entertainment center usages, multiplied by an assumed energy reduction percentage.

$$Peak\ Demand\ Savings\ [\Delta kW] = \sum \frac{\Delta kWh}{hours} \times CF_{S/W}$$

Equation 166

Where:

hours = *Annual hours per year controlled by APS (see Table 416 for Tier 1 APS; assume 4,380 for Tier 2 APS*[551]*)*

$CF_{S/W}$ = *Seasonal peak coincidence factor (see Table 418)*[552]

Table 418. APS—Coincidence Factors[553]

Season	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
Summer	0.33	0.43	0.36	0.30	0.66
Winter	0.89	0.88	0.86	0.85	0.87

[548] New York State Energy Research and Development Authority (NYSERDA), "Advanced Power Strip Research Report". August 2011. Page 30.

[549] Average of ERP from Northeast Energy Efficiency Partnerships (NEEP), "Case Study: Tier 2 Advanced Power Strips and Efficiency Programs". April 2015.

[550] MidAmerican Energy Company & Tetra Tech "Residential Assessment Impact and Process Evaluation FINAL". December 22, 2020, APPENDIX B: IN-SERVICE RATES ANALYSIS, p. 47.

[551] Estimated based on assumption that approximately half of savings are during active hours (assumed to be 5.3 hours/day, or 1,936 hours/year) and half during standby hours (8,760-1,936 = 6,824 hours/year). The resulting weighted average is 4,380 hours/year.

[552] Derived using Electric Power Research Institute (EPRI) End Use Load Shapes for Residential TV and PC. http://loadshape.epri.com/enduse.

[553] See Volume 1, Section 4.

Deemed Energy Savings Tables

Refer to Table 419 and Table 420. The savings presented in these tables must be adjusted by applying the program-specific ISR values specified in Table 417.

Deemed Summer Demand Savings Tables

Refer to Table 419 and Table 420. The savings presented in these tables must be adjusted by applying the program-specific ISR values specified in Table 417Table 18.

Deemed Winter Demand Savings Tables

Refer to Table 419 and Table 420. The savings presented in these tables must be adjusted by applying the program-specific ISR values specified in Table 417.

Table 419. APS—Tier 1 Unadjusted Savings Before Applying ISR[554]

System type	kWh savings	Summer kW savings					Winter kW savings				
		Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
Home entertainment[555]	269.9	0.0132	0.0174	0.0143	0.0119	0.0265	0.0358	0.0354	0.0345	0.0342	0.0348
Home office[556]	87.1	0.0037	0.0049	0.0041	0.0034	0.0075	0.0101	0.0100	0.0098	0.0097	0.0098
Upstream/midstream[557]	178.5	0.0084	0.0112	0.0092	0.0077	0.0170	0.0230	0.0227	0.0221	0.0219	0.0223

Table 420. APS—Tier 2 Unadjusted Savings Before Applying ISR[558]

System type	kWh savings	Summer kW savings					Winter kW savings				
		Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
Home entertainment	286.3	0.021	0.028	0.023	0.019	0.043	0.058	0.058	0.056	0.056	0.057
Home office	94.0	0.007	0.009	0.008	0.006	0.014	0.019	0.019	0.018	0.018	0.019
Upstream/midstream	190.2	0.014	0.019	0.015	0.013	0.029	0.039	0.038	0.037	0.037	0.038

[554] Apply in-service rate to adjust savings for specific program delivery type.
[555] Assuming audio equipment: AV receiver, media player: average, set-top box: average, and video game console: average.
[556] Assuming computer: desktop, computer monitor: LCD, computer speakers, and printer: average.
[557] Average of *home entertainment* and *home office system* averages.
[558] Apply in-service rate to adjust savings for specific program delivery type.

Claimed Peak Demand Savings

Refer to Volume 1, Section 4 for further details on peak demand savings and methodology.

Additional Calculators and Tools

Not applicable.

Measure Life and Lifetime Savings

The estimated useful life (EUL) is 10 years for a Tier 1 APS, according to the 2011 NYSERDA Advanced Power Strip Research Report.[559] While Tier 2 APS is not covered by the NYSERDA report, assume the same 10-year EUL for Tier 2 APS.

Program Tracking Data and Evaluation Requirements

Primary inputs and contextual data that should be specified and tracked by the program database to inform the evaluation and apply the savings properly are:

- Climate zone or county
- Unit quantity
- Manufacturer and model number
- APS type (Tier 1 or Tier 2)
- System type (home entertainment, home office, unspecified)
- Proof of purchase – including date of purchase and quantity
    - Alternative: photo of unit installed or another pre-approved method of installation verification.

References and Efficiency Standards

Petitions and Rulings

Not applicable.

Relevant Standards and Reference Sources

Please refer to measure citations for relevant standards and reference sources.

[559] New York State Energy Research and Development Authority (NYSERDA), "Advanced Power Strip Research Report". August 2011. Page 30.

Document Revision History

Table 421. APS—Revision History

TRM version	Date	Description of change
v7.0	10/2019	TRM v7.0 origin.
v8.0	10/2020	TRM v8.0 update. No revision.
v9.0	10/2021	TRM v9.0 update. Updated savings with current coincidence factors.
v10.0	10/2022	TRM v10.0 update. Corrected typos in deemed savings tables from TRM v9.0 update.
v11.0	10/2023	TRM v11.0 update. Added in-service rates.
v12.0	10/2024	TRM v12.0 update. No revision.

2.5.14 ENERGY STAR® Electric Vehicle Supply Equipment

TRM Measure ID: R-AP-EV

Market Sector: Residential

Measure Category: Appliance

Applicable Business Types: Single-family, manufactured

Fuels Affected: Electricity

Decision/Action Type: Retrofit, new construction

Program Delivery Type: Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: Engineering algorithms and estimates

Measure Description

This measure applies to the installation of ENERGY STAR qualified Level 2 electric vehicle supply equipment (EVSE) at a residential site. EVSE is the infrastructure that enables plug-in electric vehicles (PEV) to charge onboard batteries. Level 2 EVSE requires 240-volt electrical service. This measure provides deemed savings for the energy efficiency improvement of an ENERGY STAR EVSE compared to~~ever~~ a standard Level 1 ~~or non-ENERGY STAR~~ EVSE.

Eligibility Criteria

Eligible equipment includes an ENERGY STAR qualified Level 2 EVSE installed at a residence. The EVSE may be installed for use on either an all-battery electric vehicle (BEV) or a plug-in hybrid electric vehicle (PHEV). Multifamily buildings should use the commercial EVSE measure.

Baseline Condition

The baseline condition is assumed to be a blend of 49%[560]~~a~~ Level 1 EVSEs (ENERGY STAR or non-ENERGY STAR) and 51% Level 2 EVSEs. Energy savings are available for the 49% market share of Level 1 EVSEs. ~~non-ENERGY STAR qualified Level 2 EVSE~~.

[560] Calculated as the number of normal power outlets divided by the total number of sampled EV owners for the home category. "Exploring consumer sentiment on electric-vehicle charging", McKinsey & Company. January 9, 2024. Exhibit 2. https://www.mckinsey.com/features/mckinsey-center-for-future-mobility/our-insights/exploring-consumer-sentiment-on-electric-vehicle-charging.

High-Efficiency Condition

The high-efficiency EVSE is a Level 2 EVSE compliant with ENERGY STAR Final Version 1.1 specification for eligible EVSE, effective March 31, 2021.[561] Energy efficiency service providers are expected to comply with the latest ENERGY STAR requirements.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Savings for EVSE come from efficiency gains of the ENERGY STAR equipment during operating modes when the vehicle is plugged in ~~but not~~and ~~charging~~ charging. Following a study conducted by Frontier Energy, energy savings are established by estimating annual miles driven, average EV fuel economy, and approximate percent (%) of energy savings ~~because of~~attributed to charging with ENERGY STAR Level 2 EVSE as opposed to Level 1 EVSE ~~and when not plugged in. Deemed savings are calculated according to the following algorithms.~~

Energy Savings Algorithms

Table 422~~Table 1~~ presents the most common registered EVs in Texas and their corresponding fuel economy to establish an average annual energy per individual affected by this measure.

Table 422~~1~~. EV Registration by Model - Fuel Economy for EVs in Texas[562]

Make	Model	% of Registrations	EPA Fuel Economy (MPGe) [563]	Weighted Avg. Fuel Economy
Tesla	Model 3	24.6%	25	6.2
Tesla	Model Y	22.5%	27	6.1
Tesla	Model S	6.5%	28	1.8
Tesla	Model X	4.1%	32	1.3
Chevrolet	Bolt EV/EUV	3.3%	29	0.8
Ford	Mustang Mach-E	2.4%	34	1.0
Nissan	Leaf	2.0%	31	0.6
Volkswagen	ID.4	1.3%	31	0.4
Ford	F150 Lightning	1.1%	50	0.5
Multiple	Multiple	32.2%	32[565]	10.3
	Total	**100.0%**	–	**29.0**

[561] ENERGY STAR EVSE Final Version 1.1 Program Requirements. https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20V1.1%20DC%20EVSE%20Final%20Specification_0.pdf.
[562] EVs in Texas, DFW Clean Cities. https://www.dfwcleancities.org/evsintexas.
[563] All models with less than 1 percent of market share were combined.
[564] U.S. Department of Energy. https://www.fueleconomy.gov/.
[565] Average of EPA fuel economy for models with a higher market share.

$$Annual\ Energy\ Consumption\ [kWh_e] = miles \times WAFE$$

Equation 167

$$Annual\ Energy\ Savings\ [\Delta kWh] = kWh_e \times L2\% \times BAF$$

Equation 168

Where:

miles	=	Average distance driven per year in the U.S.[566] [miles] = 13,476
WAFE	=	Weighted Average Fuel Economy [kWh/mi] = 0.290 (see Table 422)
L2%	=	Percent savings achieved by Level 2 EVSE compared to Level 1 EVSE[567] = 10%
BAF	=	Baseline Adjustment Factor [%] = 49% (representation of market charging with Level 1 EVSE)

Demand Savings Algorithms

Demand (kW) savings are not estimated for this measure.

~~$$Peak\ Demand\ Savings\ [\Delta kW] = \frac{\Delta kWh \times HCF \times DCF}{days_e \times hours_{p,e}}$$~~

~~**Equation 161**~~

~~Where:~~

~~ΔkWh_{ss}~~	~~=~~	~~Steady state energy savings (Table 402)~~
~~HCF~~	~~=~~	~~Hourly coincidence factor (Table 401)~~
~~DCF~~	~~=~~	~~Daily coincidence factor[568] = 0.88~~
~~$days_e$~~	~~=~~	~~Number of charging days = 321~~
~~$hours_{p,e}$~~	~~=~~	~~Hours per day vehicle is plugged in and charging = 2.4 hr[569]~~

[566] Average Annual Miles per Driver by Age Group, U.S. Department of Transportation Federal Highway Administration. https://www.fhwa.dot.gov/ohim/onh00/bar8.htm.

[567] "Texas Residential R&D Electrical Vehicle Study", Frontier Energy for AEP Texas. March 2024.

~~[568] Idaho National Lab (INL) EV Project, June 2015, "Characterize the Demand and Energy Characteristics of Residential Electric Vehicle Supply Equipment," page 6. Eighty-eight percent of PEV owners charge every day.~~

~~[569] INL, page 5. A vehicle plugged in for 11.7 hours and charging for 2.4 hours leaves 9.3 hours when it is plugged in and not charging.~~

Table 401. EVSE—Coincidence Factors[570]

Climate zone	Summer	Winter
Zone 1: Amarillo	0.044	0.058
Zone 2: Dallas	0.040	0.053
Zone 3: Houston	0.043	0.041
Zone 4: Corpus Christi	0.042	0.059
Zone 5: El Paso	0.033	0.085

Deemed Energy Savings Tables

Table 423 presents the deemed energy savings per EVSE. Networked chargers refer to EVSE that are connected remotely to a larger network and are part of an infrastructure system of connected chargers.

Table 423. EVSE—Energy Savings (kWh)

Deemed kWh savings value
19140
71

Deemed Summer and Winter Demand Savings Tables

Not applicable Table 403 presents the deemed summer and winter peak kW savings per EVSE.

Table 403. EVSE—Summer/Winter Peak Demand Savings (kW)[571]

Climate Zone	Summer	Winter
Zone 1: Amarillo	0.0009	0.0012
Zone 2: Dallas	0.0008	0.0011
Zone 3: Houston	0.0009	0.0008
Zone 4: Corpus Christi	0.0009	0.0012
Zone 5: El Paso	0.0007	0.0017

Claimed Peak Demand Savings

Refer to Volume 1, Section 4 for further details on peak demand savings and methodology. Not applicable.

[570] Probability weighted peak load factors are calculated according to the method in Section 4 of the Texas TRM Vol 1 using data from 3 studies: CCET Wind Integration in ERCOT, Avista Utilities Semi-Annual Report on Electric Vehicle Supply, and Xcel CO EVCS Pilot.

[571] Demand savings are only presented for steady state charging because those savings are higher than demand for plugged-in standby mode.

Additional Calculators and Tools

Not applicable.

Measure Life and Lifetime Savings

The estimated useful life (EUL) for an EVSE is assumed to be 10 years.[572]

Program Tracking Data and Evaluation Requirements

Primary inputs and contextual data that should be specified and tracked by the program database to inform the evaluation and apply the savings properly:

- Climate zone or county
- Manufacturer and model number
- ~~EVSE type (networked, non-networked)~~
- ESVE quantity
- ENERGY STAR certificate matching EVSE model number
- Vehicle year, make, and model (if available)
- Estimated number of miles driven per day (if available)

References and Efficiency Standards

Petitions and Rulings

Not applicable.

Relevant Standards and Reference Sources

Please refer to measure citations for relevant standards and reference sources.

Document Revision History

Table 424. EVSE—Revision History

TRM version	Date	Description of change
v7.0	10/2019	TRM v7.0 origin.
v8.0	10/2020	TRM v8.0 update. Updated deemed savings tables
v9.0	10/2021	TRM v9.0 update. Updated documentation requirements.

[572] US Department of Energy Vehicle Technologies Office, November 2015, "Costs Associated with Non-Residential Electric Vehicle Supply Equipment" p. 21. https://afdc.energy.gov/files/u/publication/evse_cost_report_2015.pdf.

TRM version	Date	Description of change
v10.0	10/2022	TRM v10.0 update. Verified compliance with ENERGY STAR Final Version 1.1 Requirements. Updated savings calculation assumptions, deemed savings, and documentation requirements.
v11.0	10/2023	TRM v11.0 update. Updated algorithm with days coefficient. Updated documentation requirements.
v12.0	10/2024	TRM v12.0 update. Updated savings methodology to use a weighted Level 1 and Level 2 baseline.

2.5.15 Induction Cooking

TRM Measure ID: R-AP-IC

Market Sector: Residential

Measure Category: Appliances

Applicable Building Types: Single-family, multifamily, manufactured

Fuels Affected: Electricity

Decision/Action Type(s): Retrofit, new construction

Program Delivery Type(s): Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: Engineering algorithms and estimates

Measure Description

Residential cooking appliances include ovens, cooktops, and full ranges. A full range consists of an oven with a built-in cooktop. An induction range is an electric oven with a built-in induction cooktop.

Induction technology works on the principle of magnetic induction, where excited eddy currents in ferromagnetic cookware within the presence of an oscillating magnetic field dissipate heat through the Joule effect. This heat is directly generated by the cookware and is transmitted to the food within it, lessening thermal condition heat loss between the heating element and the cookware. Induction cooktops include a switching-power electronics circuit that delivers high-frequency current to a planar coil of wire embedded in the cooking surface. The cookware is magnetically coupled to the coil by the oscillating magnetic field. Current flows in the cooking vessel due to the low resistance of the metal. Resistance is a function of permeability and resistivity of the cookware as well as the frequency of excitation. Typical induction cooktops operate at switching frequency between 25 kHz and 50 kHz, which restricts coupling to ferromagnetic cookware such as cast iron, and some alloys of stainless steel.[573]

According to manufacturers, induction cooktops heat food faster, are easier to clean, are less likely to burn those using them, and have a higher cooking efficiency than electric resistance cooktops.

Eligibility Criteria

This measure requires the installation of an electric range with an induction cooktop or a standalone induction cooktop in a residential application. This measure assumes the use of small cookware typical of residential applications.

[573] Sweeney, M., J. Dols, B. Fortenbery, and F. Sharp (EPRI), "Induction Cooking Technology Design and Assessment." Proceedings of the 2014 ACEEE Summer Study on Energy Efficiency in Buildings, p. 9-370. https://www.aceee.org/files/proceedings/2014/data/papers/9-702.pdf.

Baseline Condition

The baseline condition is defined as an electric range with electric resistance cooktop or a standalone electric resistance cooktop. This measure assumes a default of four burners.

Table 425. Induction Cooking—Baseline Electric Resistance Cooktop Energy Consumption[574]

Number of burners	Electric cooktop baseline kWh
0	84
1	89
2	95
3	101
4	106
5	112
6	118
7+	124

High-Efficiency Condition

The high efficiency condition is defined as an electric range with an induction cooktop or a standalone induction cooktop.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Energy Savings Algorithms

Energy savings are calculated as the difference between the baseline and high-efficiency condition unit energy consumption (UEC). These exclude HVAC interactive effects or savings due to reduced kitchen hood consumption. Range oven cooking efficiency varies by cooktop type. Ranges with electric resistance and induction cooktops both have electric resistance oven components. Therefore, baseline and high-efficiency condition oven cooking efficiencies are equivalent and are excluded from the savings calculation.

$$Energy\ Savings\ [\Delta kWh] = UEC_{base} - UEC_{IC}$$

Equation 169

[574] "Plug Loads and Lighting Modeling," Codes and Standards Enhancement Initiative (CASE). 2016 California Building Energy Efficiency Standards. June 2016. Table 35. https://www.caetrm.com/media/reference-documents/2016_T24CASE_Report_-_Plug_Load_and_Ltg_Modeling_-_June_2016.pdf.

$$UEC_{IC} = UEC_{base} \times \frac{CE_{base}}{CE_{IC}}$$

Equation 170

Where:

UEC_{base} = *Baseline annual unit energy consumption [kWh]; see Table 425*

UEC_{IC} = *Induction cooking annual unit energy consumption [kWh]*

CE_{base} = *Baseline cooking efficiency = 75 percent*[575]

CE_{IC} = *Induction cooking efficiency = 85 percent*[576]

Summer Demand Savings Algorithms

$$Peak\ Demand\ Savings\ [\Delta kW] = \frac{kWh_{savings}}{8{,}760} \times CF_{S/W}$$

Equation 171

8,760 = *Total hours per year*

$CF_{S/W}$ = *Seasonal peak coincidence factor (Table 426)*

Table 426. Induction Cooking—Coincidence Factors[577]

Season	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
Summer	0.003	0.003	0.003	0.003	0.002
Winter	0.009	0.008	0.007	0.008	0.010

Deemed Energy Savings Tables

For all applications, this measure assumes a default value of four burners.[578]

[575] "2021-2022 Residential Induction Cooking Tops," ENERGY STAR. https://www.energystar.gov/about/2021_residential_induction_cooking_tops#:~:text=The%20per%20unit%20efficiency%20of,times%20more%20efficient%20than%20gas.

[576] Ibid.

[577] Calculated according to TX TRM Volume 1, Section 4 using data from the US DOE Building America B10 Benchmark load profiles for cooking equipment. Summer profiles include April through September, and winter profiles include October through March. https://www.energy.gov/eere/buildings/building-america-analysis-spreadsheets.

[578] Savings for 0–7+ burners only vary from 10–15 kWh.

Table 427. Induction Cooking—Energy Savings (kWh)

Number of burners	kWh savings
4	12

Deemed Summer Demand Savings Tables

For all applications, this measure assumes a default value of four burners.

Table 428. Induction Cooking—Summer Peak Demand Savings (kW)

Number of burners	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
4	0.000004	0.000004	0.000004	0.000004	0.000003

Deemed Winter Demand Savings Tables

For all applications, this measure assumes a default value of four burners.

Table 429. Induction Cooking—Winter Peak Demand Savings (kW)

Number of burners	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
4	0.000013	0.000011	0.000010	0.000011	0.000014

Claimed Peak Demand Savings

Refer to Volume 1, Section 4 for further details on peak demand savings and methodology.

Additional Calculators and Tools

Not applicable.

Measure Life and Lifetime Savings

The estimated useful life (EUL) of an induction cooktop is 16 years based on the average lifetime specified for electric cooktops in the 2016 DOE life-cycle cost tool for residential cooking products.[579]

[579] US Department of Energy (DOE), Energy Efficiency and Renewable Energy Office (EERE). 2016 SNOPR Analytical Tools: Life-Cycle Cost and Payback Period Analysis Spreadsheet. "Cooking_Pds_LCC_SNOPR_DOE_2016_publication.xlsm." Dockett EERE-2014-BT-STD-0005.

Program Tracking Data and Evaluation Requirements

Primary inputs and contextual data that should be specified and tracked by the program database to inform the evaluation and apply the savings properly are:

- Climate zone or county
- Decision/action type (new construction, retrofit)
- Baseline unit type (electric range with electric resistance cooktop, standalone electric resistance cooktop)
- New unit type (electric range with induction cooktop, standalone induction cooktop)
- Manufacturer and model number
- Unit quantity
- Burner quantity
- Proof of purchase – with date of purchase and quantity
    - Alternative: photo of unit installed or another pre-approved method of installation verification

References and Efficiency Standards

Petitions and Rulings

Not applicable.

Relevant Standards and Reference Sources

Please refer to measure citations for relevant standards and reference sources.

Document Revision History

Table 430. Induction Cooking—Revision History

TRM version	Date	Description of change
v10.0	10/2022	TRM v10.0 origin.
v11.0	10/2023	TRM v11.0 update. Updated documentation requirements.
v12.0	10/2024	TRM v12.0 update. No revision.