Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Energy Savings Algorithms

Energy savings for this measure are calculated as follows:

$$Energy\ Savings\ per\ showerhead\ [\Delta kWh] = \frac{\rho \times C_P \times (GPM_{Base} - GPM_{Low}) \times N \times t \times 365 \times (T_{shower,avg} - T_{supply,avg})}{SPH \times RE \times 3{,}412}$$

Equation 82

Where:

ρ	=	*Water density [lbs/gal] = 8.33*
C_p	=	*Specific heat of water [Btu/lb°F] = 1*
GPM_{Base}	=	*Average baseline flow rate of aerator = 2.5 gallons per minute*
GPM_{Low}	=	*Post-installation flow rate of aerator; if unknown, assume 2.0 gallons per minute*
N	=	*Average number of persons per household = 2.83 persons*[369]
t	=	*Average time in minutes of hot water usage per person per day; default = 7.8 min/person/day*[370]
$T_{shower,avg}$	=	*Average shower temperature [°F]*[371] *= 101*
$T_{supply,avg}$	=	*Average annual supply water temperature [°F] (see Table 306)*
SPH	=	*Average number of showerheads per household = 1.74 showerheads*[372]

[369] Occupants per home for Texas from US Census Bureau, "Persons per household, 2016-2020". https://www.census.gov/quickfacts/fact/table/TX,US/PST045221.

[370] Cadmus and Opinion Dynamics Evaluation Team, "Memorandum: Showerhead and Faucet Aerator Meter Study." Prepared for Michigan Evaluation Working Group.

[371] Cadmus and Opinion Dynamics Evaluation Team, "Memorandum: Showerhead and Faucet Aerator Meter Study." Prepared for Michigan Evaluation Working Group

[372] Showerheads per home assumed to be equal to the number of full bathrooms per home as specified in the 2009 Residential Energy Consumption Survey (RECS), Table HC2.10.

RE	=	*Recovery Efficiency (or in the case of heat pump water heaters, COP); if unknown, use 0.98 as a default for electric resistance water heaters or 2.2 for heat pump water heaters*[373]
3,412	=	*Constant to convert from Btu to kWh*

Demand Savings Algorithms

Demand savings are calculated by substituting the average supply temperature for the average seasonal temperature, multiplying by a coincidence factor equivalent to the daily fraction hot water use during the weighted peak hour for each climate zone (see Volume 1, Section 4), and dividing by 365 days/year, with 365 canceling from the savings algorithm numerator and denominator.

$$Demand\ Savings\ per\ showerhead\ [\Delta kWh] = \frac{\rho \times C_P \times (GPM_{Base} - GPM_{Low}) \times N \times t \times (T_{shower,avg} - T_{supply,seasonal})}{SPH \times RE \times 3{,}412} \times CF_{S/W}$$

Equation 83

Where:

$T_{supply,seasonal}$	=	*Seasonal supply water temperature [°F] (see Table 306)*
$CF_{S/W}$	=	*Seasonal peak coincidence factor (see Table 307)*

Table 306. Low-Flow Showerheads—Water Mains Temperature (°F)[374]

Climate zone	$T_{SupplyAverage}$	$T_{SupplySeasonal}$	
		Summer	Winter
Zone 1: Amarillo	62.9	73.8	53.7
Zone 2: Dallas	71.8	84.0	60.6
Zone 3: Houston	74.7	84.5	65.5
Zone 4: Corpus Christi	77.2	86.1	68.5
Zone 5: El Paso	70.4	81.5	60.4

[373] Default values based on median recovery efficiency of residential water heaters by fuel type in the AHRI database, at http://cafs.ahrinet.org/gama_cafs/sdpsearch/search.jsp?table=CWH .

[374] Based on typical meteorological year (TMY) dataset for TMY3, available through the National Solar Radiation Database (NSRDB) Data Viewer. https://nsrdb.nrel.gov/data-viewer. Data for Texas climate zones can also be accessed directly here: https://texasefficiency.com/index.php/regulatory-filings/deemed-savings.

Table 307. Low-Flow Showerheads—Coincidence Factors

Climate zone	Summer	Winter
Zone 1: Amarillo	0.039	0.073
Zone 2: Dallas	0.035	0.075
Zone 3: Houston	0.038	0.080
Zone 4: Corpus Christi	0.038	0.068
Zone 5: El Paso	0.028	0.069

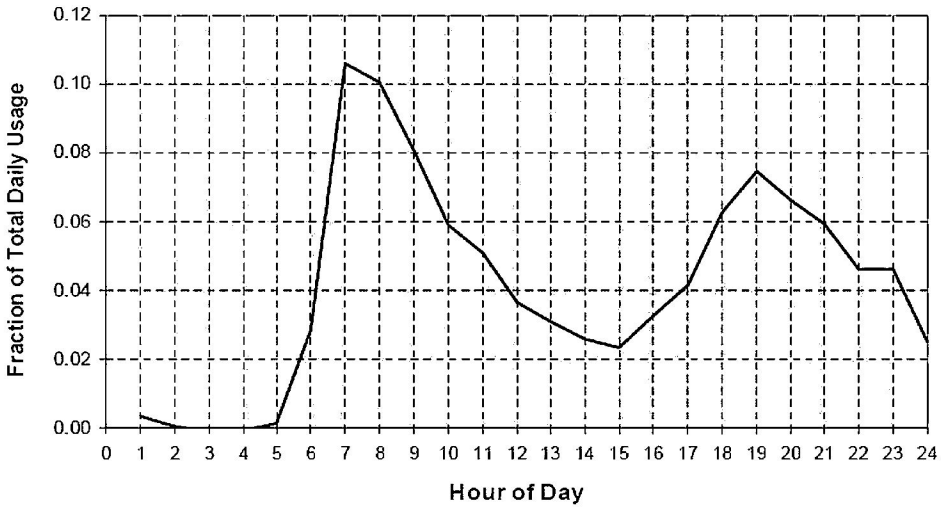


Figure 5. Low-Flow Showerheads—Shower, Bath, and Sink Hot Water Use Profile[375]

Source: Building America Performance Analysis Procedures for Existing Homes.

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.

[375] Building America performance analysis procedures for existing homes.

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, as specified in the California Database of Energy Efficiency Resources (DEER) READI tool for EUL ID WtrHt-WH-Shrhd.[376]

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
- Recovery efficiency (RE) or COP, if available
- Flow rate in gallons per minute (GPM) of showerhead installed
- Water heater type (e.g., heat pump, electric resistance)

References and Efficiency Standards

Petitions and Rulings

- Docket No. 41722. Petition of AEP Texas Central Company, AEP Texas North Company, CenterPoint Energy Houston Electric, LLC, El Paso Electric Company, Entergy Texas, Inc., Oncor Electric Delivery Company LLC, Sharyland Utilities, L.P., Southwestern Electric Power Company, Southwestern Public Service Company, and Texas-New Mexico Power Company to Approve Revisions to Residential Deemed Savings to Incorporate Winter Peak Demand Impacts and Update Certain Existing Deemed Savings Values. Public Utility Commission of Texas.

Relevant Standards and Reference Sources

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

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

Document Revision History

Table 308. Low-Flow Showerheads—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. Minor edits to language.
v2.1	1/30/2015	TRM v2.1 update. No revision.
v3.0	4/10/2015	TRM v3.0 update. No revision.
v3.1	11/05/2015	TRM v3.1 update. Provided clarification that savings are to be awarded per showerhead. Supplemented reference for water heater setpoint temperature.
v4.0	10/10/2016	TRM v4.0 update. Updated methodology to calculate energy and demand savings.
v5.0	10/2017	TRM v5.0 update. No revision.
v6.0	11/2018	TRM v6.0 update. No revision.
v7.0	11/2019	TRM v7.0 update. No revision.
v8.0	10/2020	TRM v8.0 update. Added new savings category and updated coincidence factors.
v9.0	10/2021	TRM v9.0 update. Updated EUL reference.
v10.0	10/2022	TRM v10.0 update. Updated number of occupants per home.
v11.0	10/2023	TRM v11.0 update. No revision.

2.4.8 Showerhead Temperature Sensitive Restrictor Valves Measure Overview

TRM Measure ID: R-WH-SV

Market Sector: Residential

Measure Category: Water heating

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 calculation

Savings Methodology: Engineering algorithms and estimates

Measure Description

This measure consists of installing a temperature sensitive restrictor valve (TSRV)[377] between the existing shower arm and showerhead. The valve restricts hot water flow through the showerhead once the water reaches a set temperature (generally 95˚F) to prevent water from going down the drain prior to the user entering the shower, thereby eliminating behavioral waste.

Eligibility Criteria

These deemed savings are for temperature sensitive restrictor valves installed in new construction or as a retrofit measure in residential applications. Buildings must have electrically-fueled hot water to be eligible for this measure.

Baseline Condition

The baseline condition is the residential shower arm and standard (2.5 GPM) showerhead without a temperature sensitive restrictor valve installed.

High-Efficiency Condition

The high-efficiency condition is a temperature sensitive restrictor valve installed on a residential shower arm and showerhead with either a standard (2.5 GPM) or low-flow (2.0, 1.75, or 1.5 GPM) showerhead. If this measure is installed in conjunction with a low-flow showerhead, refer to the Low-flow Showerheads measure and claim additional savings as outlined in that measure.

[377] A temperature sensitive restrictor valve is any device that uses water temperature to regulate water flow in showers.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Estimated Hot Water Usage Reduction

To determine gallons of behavioral waste (defined as hot water that goes down the drain before the user enters the shower) per year, the following formula was used:

$$Annual\ Showerhead\ Behavioral\ Waste = SHFR \times BW \times n_S \times 365 \times \frac{n_O}{n_{SH}}$$

Equation 84

Where:

SHFR	=	*Showerhead flow rate, gallons per minute [gpm] (see Table 309)*
BW	=	*Behavioral waste, minutes per shower (see Table 309)*
n_S	=	*Number of showers per person per day (see Table 309)*
365	=	*Constant to convert days to years (see Table 309)*
n_O	=	*Number of occupants per home (see Table 309)*
n_{SH}	=	*Number of showerheads per home (see Table 309)*

Applying the formula to the values from Table 309 returns the following values for baseline behavioral waste in gallons per showerhead per year:

$$Showerhead\ (2.5\ GPM): 2.5 \times\ 0.783 \times 0.6 \times 365 \times \frac{2.86}{1.72} = 713\ gal$$

$$Showerhead\ (2.0\ GPM): 2.0 \times 0.783 \times 0.6 \times 365 \times \frac{2.86}{1.72} = 570\ gal$$

$$Showerhead\ (1.75\ GPM): 1.75 \times 0.783 \times 0.6 \times 365 \times \frac{2.86}{1.72} = 499\ gal$$

$$Showerhead\ (1.5\ GPM): 1.5 \times 0.783 \times 0.6 \times 365 \times \frac{2.86}{1.72} = 428\ gal$$

Gallons of hot water saved per year can be found by multiplying the baseline behavioral waste gallons per year by the percent of hot water from Table 309.

$$Gallons\ of\ hot\ water\ saved\ per\ year = Annual\ Behavioral\ Waste \times HW\%$$

Equation 85

Where:

HW% = *Hot water percentage (see Table 309)*

$$Gallons\ of\ hot\ water\ saved\ per\ year\ (2.5\ GPM): 713 \times\ 0.825 = 588\ gal$$

$$Gallons\ of\ hot\ water\ saved\ per\ year\ (2.0\ GPM): 570 \times\ 0.825 = 470\ gal$$

$$Gallons\ of\ hot\ water\ saved\ per\ year\ (1.75\ GPM): 499 \times\ 0.825 = 412\ gal$$

$$Gallons\ of\ hot\ water\ saved\ per\ year\ (1.5\ GPM): 428 \times\ 0.825 = 353\ gal$$

Table 309. Showerhead TSRVs—Hot Water Usage Reduction

Description	2.5 GPM	2.0 GPM	1.75 GPM	1.5 GPM
Average behavioral waste (minutes per shower)[378]				0.783
Showers/person/day[379]				0.6
Occupants per home[380]				2.83
Showerheads/home[381]				1.72
Behavioral waste/showerhead/year (gal)	713	570	499	428
Percent hot water[382]				80-85%, or 82.5% average
Hot water saved/year (gal)	588	470	412	353

Energy Savings Algorithms

Energy savings for this measure are calculated as follows:

$$Energy\ Savings\ per\ TSRV\ [\Delta kWh] = \frac{\rho \times C_P \times V \times (T_{setpoint} - T_{supply,avg})}{RE \times 3{,}412}$$

Equation 86

[378] "Disaggregating Residential Shower Warm-Up Waste", Sherman, Troy. August 2014. Derived by dividing average behavioral waste time (47 seconds) by 60 seconds.

[379] Cadmus and Opinion Dynamics Evaluation Team, "Memorandum: Showerhead and Faucet Aerator Meter Study". Prepared for Michigan Evaluation Working Group. June 2013.

[380] Occupants per home for Texas from US Census Bureau, "Persons per household, 2016-2020". https://www.census.gov/quickfacts/fact/table/TX,US/PST045221.

[381] Showerheads per home assumed to be equal to the number of full bathrooms per home. Bathroom counts extracted from the 2015 Residential Energy Consumption Survey (RECS) Table HC2.8 Structural and geographic characteristics of homes in the West South-Central region. https://www.eia.gov/consumption/residential/data/2015/#structural.

[382] "Calculating Savings For: Auto-Diverting Tub Spout System with ShowerStart TSV", Sherman, Troy. Evolve Technologies. December 15, 2015.

Where:

ρ	=	*Water density [lbs/gal] = 8.33*
C_p	=	*Specific heat of water [Btu/lb°F] = 1*
V	=	*Gallons of hot water saved per year per showerhead (see Table 309)*
$T_{setpoint}$	=	*Water heater setpoint temperature [°F][383] = 120*
$T_{supply,avg}$	=	*Average annual supply water temperature [°F] (see Table 310)*
RE	=	*Recovery Efficiency (or in the case of heat pump water heaters, COP); if unknown, use 0.98 as a default for electric resistance water heaters or 2.2 for heat pump water heaters*
3,412	=	*Constant to convert from Btu to kWh*

Demand Savings Algorithms

Demand savings are calculated by substituting the average supply temperature for the average seasonal temperature, multiplying by a coincidence factor equivalent to the daily fraction hot water use during the weighted peak hour for each climate zone (see Volume 1, Section 4), and dividing by 365 days/year.

$$Peak\ Demand\ Savings\ per\ TSRV\ [\Delta kW] = \frac{\rho \times C_P \times V \times (T_{setpoint} - T_{supply,seasonal})}{RE \times 3{,}412 \times 365} \times CF_{S/W}$$

Equation 87

Where:

$T_{supply,seasonal}$	=	*Seasonal supply water temperature [°F] (see Table 310)*
$CF_{S/W}$	=	*Seasonal peak coincidence factor (see Table 311)*

[383] 120°F represents the assumed water heater setpoint. New York Department of Public Service recommends using water heater setpoint as a default value, see "New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs" October 2010, page 99.
Data collection discussed in Appendix D of the EM&V team's Annual Statewide Portfolio Report for Program Year 2014-Volume 1, Project Number 40891 (August 2015), also supports a default value of 120°F.

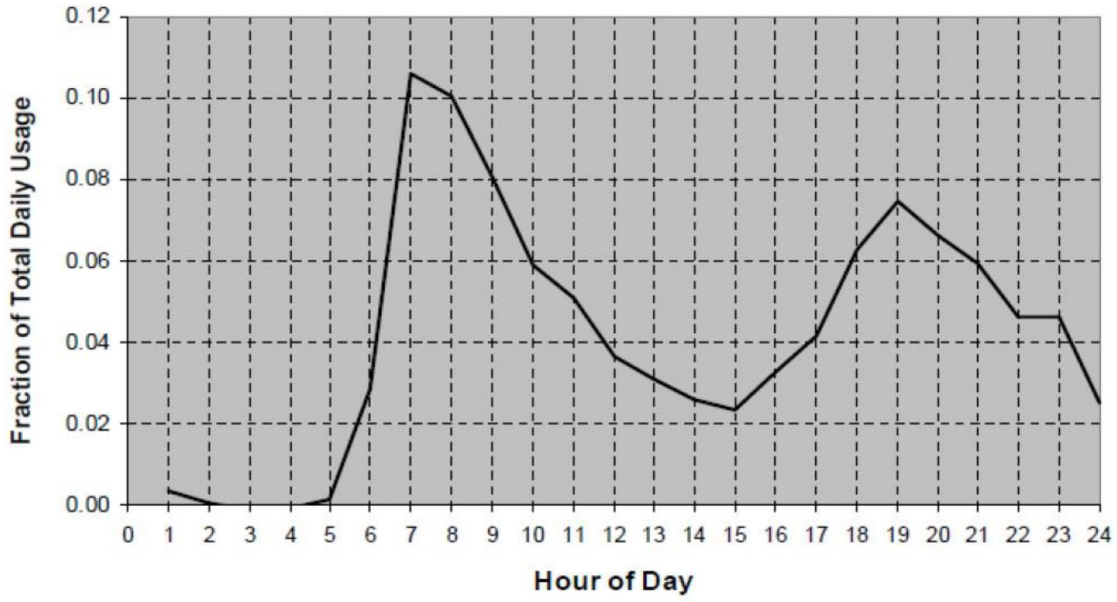
Table 310. Showerhead TSRVs—Water Mains Temperature (°F)[384]

Climate zone	$T_{SupplyAverage}$	$T_{SupplySeasonal}$	
		Summer	Winter
Zone 1: Amarillo	62.9	73.8	53.7
Zone 2: Dallas	71.8	84.0	60.6
Zone 3: Houston	74.7	84.5	65.5
Zone 4: Corpus Christi	77.2	86.1	68.5
Zone 5: El Paso	70.4	81.5	60.4

Table 311. Showerhead TSRVs—Coincidence Factors

Climate zone	Summer	Winter
Zone 1: Amarillo	0.039	0.073
Zone 2: Dallas	0.035	0.075
Zone 3: Houston	0.038	0.080
Zone 4: Corpus Christi	0.038	0.068
Zone 5: El Paso	0.028	0.069

Figure 6. Showerhead TSRVs—Shower, Bath, and Sink Hot Water Use Profile[385]



Source: Building America Performance Analysis Procedures for Existing Homes.

[384] Based on typical meteorological year (TMY) dataset for TMY3 available through the National Solar Radiation Database (NSRDB) Data Viewer. https://nsrdb.nrel.gov/data-viewer. Data for Texas climate zones can also be accessed directly here: https://texasefficiency.com/index.php/regulatory-filings/deemed-savings.

[385] Building America performance analysis procedures for existing homes.

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

The estimated useful life (EUL) is 10 years, as specified in the California Database of Energy Efficiency Resources (DEER) READI tool for EUL ID WtrHt-WH-Shrhd.[386]

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
- DHW recovery efficiency (RE) or COP, if available
- Flow rate in gallons per minute (GPM) of showerhead installed
- Water heater type (heat pump, electric resistance)

References and Efficiency Standards

Petitions and Rulings

Not applicable.

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

Relevant Standards and Reference Sources

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

Document Revision History

Table 312. Showerhead TSRVs—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. No revision.
v8.0	10/2020	TRM v8.0 update. Updated coincidence factors.
v9.0	10/2021	TRM v9.0 update. Updated EUL reference and restricted measure to electric DHW.
v10.0	10/2022	TRM v10.0 update. Updated number of occupants per home.
v11.0	10/2023	TRM v11.0 update. No revision.

2.4.9 Tub Spout and Showerhead Temperature Sensitive Restrictor Valves Measure Overview

TRM Measure ID: R-WH-TV

Market Sector: Residential

Measure Category: Water heating

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 calculation

Savings Methodology: Engineering algorithms and estimates

Measure Description

This measure consists of replacing existing tub spouts and showerheads with an automatically diverting tub spout and showerhead system with a temperature sensitive restrictor valve (TSRV) [387] between the existing shower arm and showerhead. The tub spout will contain temperature sensitive restrictor technology that will cause the tub spout to automatically engage the anti-leak diverter once the water reaches a set temperature (generally 95˚F). The water will divert to a showerhead with a normally closed valve that will prevent the hot water from going down the drain prior to the user entering the shower, thereby eliminating behavioral waste and tub spout leakage waste.

Eligibility Criteria

These deemed savings are for tub spout and showerhead systems with temperature sensitive restrictor technology installed in new construction or as a retrofit measure in existing homes. Buildings must have electrically fueled hot water to be eligible for this measure.

Baseline Condition

The baseline condition is the residential tub spout with a standard diverter and a standard (2.5 gpm) showerhead.

[387] A temperature sensitive restrictor valve is any device that uses water temperature to regulate water flow in showers.

High-Efficiency Condition

The high-efficiency condition is an anti-leak, automatically diverting tub spout system with temperature sensitive restrictor technology installed on a residential shower arm and showerhead with a standard (2.5 GPM) or low-flow (2.0, 1.75, or 1.5 GPM) showerhead. If this measure is installed in conjunction with a low-flow showerhead, refer to the Low-flow Showerheads measure and claim additional savings as outlined in that measure.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Estimated Hot Water Usage Reduction

This system provides savings in two parts: elimination of behavioral waste (hot water that goes down the drain prior to the user entering the shower) and elimination of tub spout diverter leakage.

Part 1: To determine baseline gallons of behavioral waste per year, the following formula was used:

$$Annual\ Showerhead\ Behavioral\ Waste = \%WUE_{SH} \times SHFR \times BW \times n_S \times 365 \times \frac{n_O}{n_{SH}}$$

Equation 88

$$Annual\ Tub\ Spout\ Behavioral\ Waste = \%WUE_{TS} \times TSFR \times BW \times n_S \times 365 \times \frac{n_O}{n_{SH}}$$

Equation 89

Where:

$\%WUE_{SH}$	=	*Showerhead percentage of warm-up events (see Table 313)*
$\%WUE_{TS}$	=	*Tub spout percentage of warm-up events (see Table 313)*
$SHFR$	=	*Showerhead flow rate, gallons per minute [gpm] (see Table 313)*
$TSFR$	=	*Tub spout flow rate, gallons per minute [gpm] (see Table 313)*
BW	=	*Behavioral waste, minutes per shower (see Table 313)*
n_S	=	*Number of showers per person per day (see Table 313)*
365	=	*Constant to convert days to years (see Table 313)*
n_O	=	*Number of occupants per home (see Table 313)*
n_{SH}	=	*Number of showerheads per home (see Table 313)*

Applying the formula to the values from Table 313 returns the following values:

$$Showerhead\ (1.5\ GPM)\text{: } 0.6 \times \left(1.5 \times 0.783 \times 0.60 \times 365 \times \frac{2.86}{1.72}\right) = 257$$

$$Showerhead\ (1.75\ GPM)\text{: } 0.6 \times \left(1.75 \times 0.783 \times 0.60 \times 365 \times \frac{2.86}{1.72}\right) = 299$$

$$Showerhead\ (2.0\ GPM)\text{: } 0.6 \times \left(2.0 \times 0.783 \times 0.60 \times 365 \times \frac{2.86}{1.72}\right) = 342$$

$$Showerhead\ (2.5\ GPM)\text{: } 0.6 \times \left(2.5 \times 0.783 \times 0.60 \times 365 \times \frac{2.86}{1.72}\right) = 428$$

$$Tub\ Spout\ (5.0\ GPM)\text{: } 0.4 \times \left(5.0 \times 0.783 \times 0.60 \times 365 \times \frac{2.86}{1.72}\right) = 570$$

Part 2: To determine baseline gallons of diverter leakage per year, the following formula was used:

$$Annual\ Diverter\ Waste = DLR \times t_S \times n_S \times 365\ \frac{days}{year} \times \frac{n_O}{n_{SH}}$$

Equation 90

Where:

DLR	=	*Diverter leakage rate [gpm] (see Table 313)*
t_S	=	*Shower time (min/shower) (see Table 313)*

Applying the formula to the values from Table 313 returns the following values:

$$Diverter\ (0.8\ GPM)\text{: } 0.8 \times 7.8 \times 0.60 \times 365 \times \frac{2.86}{1.72} = 2{,}272$$

Part 3: To determine gallons of water saved per year can be found by multiplying the total waste by the percent of hot water from Table 313.

$$Gallons\ of\ hot\ water\ saved = (SHBW + TSBW) \times HW\%_{SH,TS} + DW \times HW\%_D$$

Equation 91

Where:

SHBW	=	*Showerhead behavioral waste [gal]*
TSBW	=	*Tub spout behavioral waste [gal]*
DW	=	*Diverter waste [gal]*
$HW\%_{SH,TS}$	=	*Showerheads and tub spout hot water percentage (see Table 313)*
$HW\%_D$	=	*Diverter hot water percentage (see Table 313)*

Applying the formula to the values from Table 313 returns the following values:

$$Total\ Annual\ Waste\ (1.5\ gpm): (257 + 570) \times 0.825 + 2{,}272 \times 0.737 = 2{,}357$$

$$Total\ Annual\ Waste\ (1.75\ gpm): (299 + 570) \times 0.825 + 2{,}272 \times 0.737 = 2{,}392$$

$$Total\ Annual\ Waste\ (2.0\ gpm): (342 + 570) \times 0.825 + 2{,}272 \times 0.737 = 2{,}427$$

$$Total\ Annual\ Waste\ (2.5\ gpm): (428 + 570) \times 0.825 + 2{,}272 \times 0.737 = 2{,}498$$

Table 313. Tub Spout/Showerhead TSRVs—Hot Water Usage Reduction

Description	Part 1—Behavioral waste		Part 2—Diverter leakage	Part 3—Total
	SH Warm-up	TS Warm-up		
Baseline showerhead flow rate (GPM)	1.5, 1.75, 2.0, or 2.5			–
Tub spout flow rate (GPM)[388]	–	5.0		–
Percent of warm-up events[389]	60%	40%		–
Average behavioral waste (minutes per shower)[390]		0.783		–
Average diverter leakage rate (GPM)[391]		–	0.80	–
Average shower time (minutes per shower)[392]		–	7.8	–
Showers/person/day[393]				0.60
Occupants/home[394]				2.83
Showerheads/home[395]				1.72
Gallons behavioral waste. per tub spout/showerhead per year (1.5 GPM)	257	570	2,272	3,099
Gallons behavioral waste per tub spout/showerhead per year (1.75 GPM)	299			3,142
Gallons behavioral waste per tub spout/showerhead per year (2.0 GPM)	342			3,185

[388] Assumption from (Sherman 2015) Calculating Savings For: Auto-Diverting Tub Spout System with ShowerStart TSV.
[389] Percent of warm-up events from (Sherman 2014) Disaggregating Residential Shower Warm-Up Waste (Appendix B, Question 8).
[390] Average behavioral waste from Lutz (2004) Feasibility Study and Roadmap to Improve Residential Hot Water Distribution Systems and Sherman (2014) Disaggregating Residential Shower Warm-Up Waste. Derived by dividing 47 seconds by 60 seconds.
[391] Average diverter leak rate from (Taitem 2011) Taitem Tech Tip – Leaking Shower Diverters.
[392] Cadmus and Opinion Dynamics Evaluation Team, "Memorandum: Showerhead and Faucet Aerator Meter Study". Prepared for Michigan Evaluation Working Group.
[393] Derivation of value for showers per person per day defined in the Low Flow Showerhead measure.
[394] Occupants per home for Texas from US Census Bureau, Texas, "Persons per household, 2016-2020." https://www.census.gov/quickfacts/fact/table/TX,US/PST045221.
[395] Showerheads per home assumed to be equal to the number of full bathrooms per home, taken from 2015 RECS, Table HC2.8. https://www.eia.gov/consumption/residential/data/2015/#structural.

Description	Part 1—Behavioral waste		Part 2—Diverter leakage	Part 3—Total
	SH Warm-up	TS Warm-up		
Gallons behavioral waste per tub spout/showerhead per year (2.5 GPM)	428			3,270
Percentage hot water[396]	80-85%, or 82.5% average		73.7%	–
Gallons hot water saved per year (1.5 GPM)			–	2,357
Gallons hot water saved per year (1.75 GPM)			–	2,392
Gallons hot water saved per year (2.0 GPM)			–	2,427
Gallons hot water saved per year (2.5 GPM)			–	2,498

Energy Savings Algorithms

Energy savings for this measure are calculated as follows:

$$Energy\ Savings\ per\ TSRV\ [\Delta kWh] = \frac{\rho \times C_P \times V \times (T_{setpoint} - T_{supply,avg})}{RE \times 3{,}412}$$

Equation 92

Where:

ρ	=	*Water density [lbs/gal] = 8.33*
C_p	=	*Specific heat of water [Btu/lb°F] = 1*
V	=	*Gallons of hot water saved per year per showerhead (see Table 313)*
$T_{setpoint}$	=	*Water heater setpoint temperature [397] [°F] = 120*
$T_{supply,avg}$	=	*Average annual supply water temperature [°F] (see Table 314)*
RE	=	*Recovery Efficiency (or in the case of heat pump water heaters, COP); if unknown, use 0.98 as a default for electric resistance water heaters or 2.2 for heat pump water heaters*
3,412	=	*Constant to convert from Btu to kWh*

[396] Average percentage hot water for warm up events from (Lutz 2004) Feasibility Study and Roadmap to Improve Residential Hot Water Distribution Systems and (Sherman 2015) Calculating Savings For: Auto-Diverting Tub Spout System with ShowerStart TSV.

[397] 120°F represents the assumed water heater setpoint. New York Department of Public Service recommends using water heater setpoint as a default value, see "New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs" October 2010, page 99.
Data collection discussed in Appendix D of the EM&V team's Annual Statewide Portfolio Report for Program Year 2014-Volume 1, Project Number 40891 (August 2015), also supports a default value of 120°F.

Demand Savings Algorithms

Demand savings are calculated by substituting the average supply temperature for the average seasonal temperature, multiplying by a coincidence factor equivalent to the daily fraction hot water use during the weighted peak hour for each climate zone (see Volume 1, Section 4), and dividing by 365 days/year.

$$Peak\ Demand\ Savings\ per\ TSRV\ [\Delta kW] = \frac{\rho \times C_P \times V \times (T_{setpoint} - T_{supply,seasonal})}{RE \times 3{,}412 \times 365} \times CF_{S/W}$$

Equation 93

Where:

$T_{supply,seasonal}$ = *Seasonal supply water temperature [°F] (see Table 314)*

$CF_{S/W}$ = *Peak coincidence factor (see Table 315)*

Table 314. Tub Spout/Showerhead TSRVs—Water Mains Temperature (°F)[398]

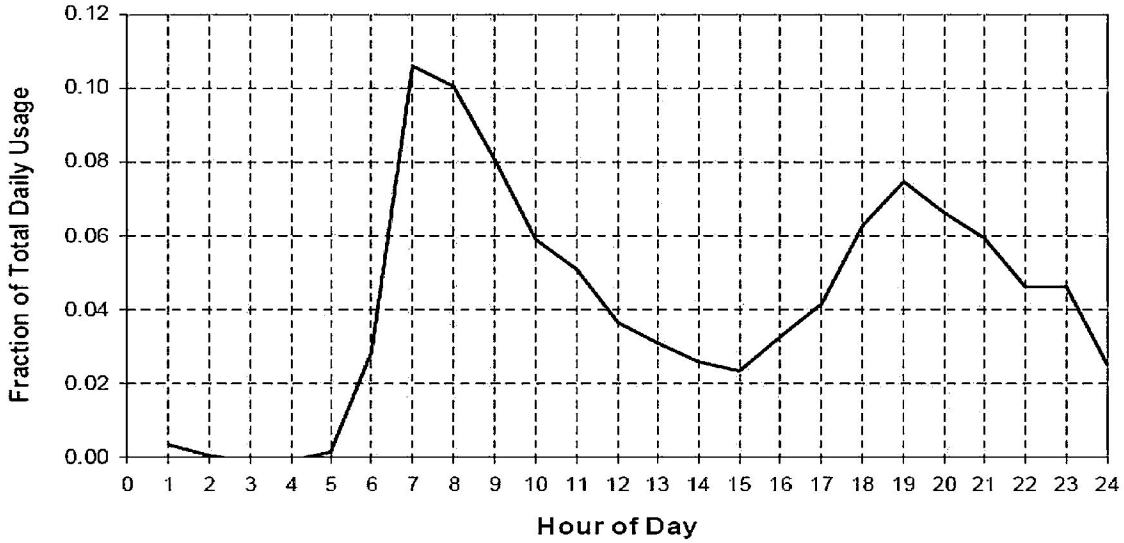
Climate zone	$T_{SupplyAverage}$	$T_{SupplySeasonal}$	
		Summer	Winter
Zone 1: Amarillo	62.9	73.8	53.7
Zone 2: Dallas	71.8	84.0	60.6
Zone 3: Houston	74.7	84.5	65.5
Zone 4: Corpus Christi	77.2	86.1	68.5
Zone 5: El Paso	70.4	81.5	60.4

Table 315. Tub Spout/Showerhead TSRVs—Coincidence Factors

Climate zone	Summer	Winter
Zone 1: Amarillo	0.039	0.073
Zone 2: Dallas	0.035	0.075
Zone 3: Houston	0.038	0.080
Zone 4: Corpus Christi	0.038	0.068
Zone 5: El Paso	0.028	0.069

[398] Based on typical meteorological year (TMY) dataset for TMY3, available through the National Solar Radiation Database (NSRDB) Data Viewer. https://nsrdb.nrel.gov/data-viewer. Data for Texas climate zones can also be accessed directly here: https://texasefficiency.com/index.php/regulatory-filings/deemed-savings.

Figure 7. Tub Spout/Showerhead TSRVs—Shower, Bath, and Sink Hot Water Use Profile[399]



Source: Building America Performance Analysis Procedures for Existing Homes.

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.

[399] Building America performance analysis procedures for existing homes.

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 WtrHt-WH-Shrhd.[400]

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
- Flow rate in gallons per minute (GPM) of showerhead installed
- Water heater type (heat pump, electric resistance)
- DHW recovery efficiency (RE) or COP, 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 316. Tub Spout/Showerhead TSRVs—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. No revision.
v8.0	10/2020	TRM v8.0 update. Updated coincidence factors.
v9.0	10/2021	TRM v9.0 update. Updated EUL reference and restricted measure to electric DHW.
v10.0	10/2022	TRM v10.0 update. Updated number of occupants per home.
v11.0	10/2023	TRM v11.0 update. No revision.

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

2.4.10 Water Heater Temperature Setback Measure Overview

TRM Measure ID: R-WH-TS

Market Sector: Residential

Measure Category: Water heating

Applicable Building Types: Single-family, multifamily, manufactured

Fuels Affected: Electricity

Decision/Action Type(s): Retrofit

Program Delivery Type(s): Prescriptive

Deemed Savings Type: Deemed savings calculation

Savings Methodology: Engineering algorithms and estimates

Measure Description

This measure outlines the demand and energy savings yielded from reprogramming residential water heater thermostats with default settings of greater than 120°F to 120°F.

Eligibility Criteria

Electric storage water heaters with default temperature setpoints in excess of 120°F are eligible to claim savings from this measure.

Baseline Condition

The baseline condition is an electric storage water heater with a thermostat setting that is higher than 120°F.

High-Efficiency Condition

The efficient condition is an electric storage water heater with a thermostat setting reduced to 120°F.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Water heater temperature setback savings are calculated on a per-unit basis. Deemed savings variables include the tank surface area, the heat transfer coefficient for the tank, and hot water setpoint prior to adjustment.

Energy Savings Algorithm

$$Energy\ Savings\ [\Delta kWh] = \frac{A \times U \times (T_{pre} - T_{post}) \times 8{,}760}{RE \times 3{,}412}$$

Equation 94

Where:

A = *Tank surface area insulated in square feet (πDL) with L (length) and D (tank diameter) in feet; if the tank area is not known, use Table 317*

Table 317. DHW Temperature Setback—Estimated Tank Area[401]

Volume (gal)	A (sq. ft.)
30	17.45
40	21.81
50	22.63
60	26.94
80	30.36
120	38.73

U = *Overall heat transfer coefficient for the tank*[402] *(Btu/Hr·°F·ft²)*

T_{pre} = *Hot water setpoint prior to adjustment [°F]*

T_{post} = *Water heater setpoint [°F]*[403] *= 120*

8,760 = *Total hours per year*

RE = *Recovery efficiency of electric hot water heater = 0.98*[404]

3,412 = *Constant to convert from Btu to kWh*

[401] Texas TRM Vol 2, 2.4.4 Water Heater Tank Insulation, Table 317.
[402] If unknown, assume R-5 (U = 1/5).
[403] 120°F represents the assumed water heater setpoint. The New York Department of Public Service recommends using the water heater setpoint as a default value, see "New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs." Page 99. October 2010. The data collection discussed in Appendix D of the EM&V team's Annual Statewide Portfolio Report for Program Year 2014-Volume 1, Project Number 40891 (August 2015) also supports a default value of 120°F.
[404] Default values based on median recovery efficiency of residential water heaters by fuel type in the AHRI database, at http://www.ahrinet.org.

Demand Savings Algorithm

$$Summer\ Peak\ Demand\ Savings\ [\Delta kW] = \frac{kWh_{savings}}{8{,}760} \times CF_S$$

Equation 95

Where:

CF_S = *Summer peak coincidence factor = 1.0*

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

The estimated useful life (EUL) is 2 years[405].

[405] 2022 Illinois Statewide Technical Reference Manual Version 10.0, Volume 3 – 5.4.6 Water Heater Temperature Setback. September 24, 2021.

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
- R-value or overall heat transfer coefficient of tank (1 / R-value)
- Tank surface area insulated in square feet (πDL) with L (length) and D (tank diameter) in feet; if unable to determine tank area, tank volume must be recorded
- Hot water setpoint prior to adjustment
- Photo of reprogrammed temperature setpoint or another pre-approved method of verification
- Water heater manufacture date

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 318. DHW Temperature Setback—Revision History

TRM version	Date	Description of change
v10.0	10/2022	TRM v10.0 origin.
v11.0	10/2023	TRM v11.0 update. No revision.

2.5 RESIDENTIAL: APPLIANCES

2.5.1 ENERGY STAR® Ceiling Fans Measure Overview

TRM Measure ID: R-AP-CF

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 calculation

Savings Methodology: Engineering algorithms and estimates

Measure Description

This document presents the accepted deemed savings awarded for the installation of an ENERGY STAR ceiling fan and light kit. 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

Savings values in this measure are based on indoor usage patterns and are not applicable to outdoor applications.

Baseline Condition

The baseline is a conventional non-ENERGY STAR labeled ceiling fan and light kit.

High-Efficiency Condition

The table below displays the ENERGY STAR Version 4.0 Requirements for eligible ceiling fans effective June 15, 2018.[406] Energy efficiency service providers are expected to comply with the latest ENERGY STAR requirements.

[406] ENERGY STAR Ceiling Fan and Light Kits, Final Version 4.0 Program Requirements. https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Ceiling%20Fans%20and%20Ceiling%20Fan%20Light%20Kits%20Version%204.0_Program%20Requirements_0_0.pdf.

Table 319. Ceiling Fans—Fan Definitions

Fan type	Description
Ceiling fan	A non-portable device designed for home use that is suspended from the ceiling for circulating air via the rotation of fan blades; for which the lowest point on fan blades is greater than 10 inches from the ceiling.
Hugger ceiling fan	A ceiling fan for which the lowest point on the fan blades is less than or equal to 10 inches from the ceiling. Hugger ceiling fans can be safely installed on low ceilings, and some are sold with ceiling fan light kits.

Table 320. Ceiling Fans—Efficiency Requirements

Type	Diameter (inches)	Minimum efficiency (cfm/W)	Minimum high speed airflow (cfm)
Ceiling fan	D ≤ 36	≥ 0.72 x D + 41.93	≥ 1,767
	36 < D < 78	≥ 2.63 x D – 26.83	≥ 250 x π x $(D/24)^2$
	D ≥ 78		≥ 8,296
Hugger ceiling fan	D ≤ 36	≥ 0.31 x D + 36.84	≥ 1,414
	36 < D < 78	≥ 1.75 x D – 15	≥ 200 x π x $(D/24)^2$
	D ≥ 78		≥ 6,637

Table 321. Ceiling Fans—Light Kit Efficacy Requirements

Type	Minimum efficacy (lumens/W)	Minimum light output (lumens)
Shipped with ENERGY STAR certified light bulbs	65.0	–
Separable light source	65.0	800
Integrated light source	70.0	

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Energy Savings Algorithms

Energy savings were calculated using the ENERGY STAR Ceiling Fan Savings Calculator found on the ENERGY STAR website.[407] Default values were taken directly from the ENERGY STAR Ceiling Fan Savings Calculator, unless otherwise specified.

[407] ENERGY STAR Ceiling Fan Savings Calculator (updated September 2013). https://www.energystar.gov/sites/default/files/asset/document/light_fixture_ceiling_fan_calculator.xlsx.

$$Energy\ Savings\ [\Delta kWh] = (kWh_{baseline} - kWh_{ES})_{fan} + (kWh_{baseline} - kWh_{ES})_{lgt} \times IEF_E$$

Equation 96

$$kWh_{baseline,Fan} = \frac{W_{Fan,baseline} \times AOH_{Fan}}{1{,}000}$$

Equation 97

$$kWh_{ES,Fan} = \frac{W_{Fan,ES} \times AOH_{Fan}}{1{,}000}$$

Equation 98

$$W_{Fan} = (W_{LS} \times OP_{LS}) + (W_{MS} \times OP_{MS}) + (W_{HS} \times OP_{HS})$$

Equation 99

$$kWh_{baseline,Lgt} = \frac{W_{Lgt,baseline} \times AOH_{Lgt}}{1{,}000}$$

Equation 100

$$kWh_{ES,Lgt} = \frac{W_{Lgt,ES} \times AOH_{Lgt}}{1{,}000}$$

Equation 101

Where:

$kWh_{baseline}$	=	*Non-ENERGY STAR baseline energy usage*
kWh_{ES}	=	*ENERGY STAR average energy usage*
IEF_E	=	*Energy interactive effects factor from Table 322 assuming heating/cooling unknown*[408]
$W_{Lgt,baseline}$	=	*Conventional lighting total wattage = 58 W (160 W default value from ENERGY STAR calculator reduced to comply with EISA 2007 45 lumens/watt backstop)*[409]
$W_{Lgt,ES}$	=	*Actual wattage of installed ENERGY STAR lighting; assume one high-efficiency 32 W lamp*
$W_{Fan,baseline}$	=	*Conventional fan motor wattage*
$W_{Fan,ES}$	=	*ENERGY STAR fan motor wattage*
$W_{LS/MS/HS}$	=	*Fan motor wattage at low, medium, and high speed; see Table 323*

[408] The assumed energy interactive effects factors are taken from the residential lighting measure.
[409] Assumes a mix of general service incandescent lamps. EISA 2007 45 lumens/watt backstop is approximately 36 percent of standard incandescent wattages for the 40, 60, 75, and 100 equivalent wattage categories. 160 W x 0.36 = 58 W.

$OP_{LS/MS/HS}$ = *Fan operating percentage at low, medium, and high speed; see Table 324*

AOH_{Lgt} = *Annual lighting operating hours = 803 hours/year (assuming 2.2 hours/day and 365 days/year operation)*[410]

AOH_{Fan} = *Annual fan operating hours = 1,095 hours/year (assuming 3.0 hours/day and 365 days/year operation)*[411]

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

Table 322. Ceiling Fans—Interactive Effects Factor for Cooling Energy Savings and Heating Energy Penalties[412]

IEF_E					
Heating/cooling type	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
Heating/cooling unknown[413]	0.88	0.98	1.04	1.07	0.95

Table 323. Ceiling Fans— Motor Wattages

Fan type	Fan speed	Fan motor wattage (W)
Conventional	Low	15
	Medium	34
	High	67
ENERGY STAR	Low	6
	Medium	23
	High	56

[410] The assumed annual operating hours are taken from the residential lighting measure.

[411] The assumed annual operating hours are taken from the previously cited ENERGY STAR Light Fixture and Ceiling Fan Calculator.

[412] Extracted from BEopt energy models used to estimate savings for envelope measures. Referencing the EISA baseline table, the typical lumen output was determined by taking the midpoint for the 60-watt equivalent lamp (900 lm), which was assumed to be the most typical installation. The resulting lumens were divided by the default wattage for incandescents (43 W), CFLs (13 W), and LEDs (10 W) resulting in an assumed efficacy for incandescents (21 lm/W), CFLs (70 lm/W), and LEDs (90 lm/W). IEF values were calculated using the following formula: $1 + HVAC_{savings}/Lighting_{savings}$.

[413] Calculated using IEFs from Cadmus report, weighted using TMY CDD and HDD for Texas, and adjusted to exclude 16 percent outdoor lighting except for upstream defaults. Cadmus report: Cadmus. Entergy Energy-Efficiency Portfolio Evaluation Report 2013 Program Year. Prepared for Entergy Arkansas, Inc. March 14, 2014. Docket No. 07-082-TF.

Table 324. Ceiling Fans—Operating Percentages

Fan speed	Operating percentage (OP)
Low	40%
Medium	40%
High	20%

Demand Savings Algorithms

Peak demand savings were calculated using separate coincidence factors for the lighting and the fan motor portion of the ceiling fan savings. For lighting the coincidence factor varies based on climate zone. For the fan motor a coincidence factor of 0.446 was applied (derived from the EnergyGauge software ceiling fan profiles).

$$Peak\ Demand\ Savings\ [\Delta kW] = kW_{Fan} + kW_{Lgt}$$

Equation 102

$$kW_{Fan} = \frac{W_{Fan,baseline} - W_{Fan,ES}}{1{,}000} \times CF_{Fan}$$

Equation 103

$$kW_{Lgt} = \frac{W_{Lgt,baseline} - W_{Lgt,ES}}{1{,}000} \times CF_{Lgt,S/W} \times IEF_{D,S/W}$$

Equation 104

Where:

kW_{Fan}	=	*Fan demand savings*
CF_{Fan}	=	*Fan motor peak coincidence factor = 0.446*
kW_{Lgt}	=	*Lighting demand savings*
$CF_{Lgt,S/W}$	=	*Lighting seasonal peak coincidence factor (Table 325)*
$IEF_{D,S/W}$	=	*Demand interactive effects factor from Table 326 assuming heating/cooling unknown*[414]

[414] The assumed demand interactive effects factors are taken from the residential lighting measure.

Table 325. Ceiling Fans—Lighting Coincidence Factors[415]

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

Table 326. Ceiling Fans—Interactive Effects Factor for Cooling Demand Savings and Heating Demand Penalties[416]

$IEF_{D,S}$					
Heating/cooling type	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
Heating/cooling unknown[417]	1.39	1.28	1.58	1.20	1.38
$IEF_{D,W}$					
Heating/cooling type	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
Heating/cooling unknown[418]	0.76	0.72	0.73	0.75	0.80

Deemed Energy Savings Tables

Table 327. Ceiling Fans—Energy Savings (kWh)

Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
29.5	31.6	32.9	33.5	31.0

Deemed Summer Demand Savings Tables

Table 328. Ceiling Fans—Summer Peak Demand Savings (kW)

Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
0.007	0.006	0.007	0.006	0.006

[415] See Volume 1, Section 4.
[416] See Table 322.
[417] Calculated using IEFs from Cadmus report, weighted using TMY CDD and HDD for Texas, and adjusted to exclude 16 percent outdoor lighting except for upstream defaults. Cadmus report: Cadmus. Entergy Energy-Efficiency Portfolio Evaluation Report 2013 Program Year. Prepared for Entergy Arkansas, Inc. March 14, 2014. Docket No. 07-082-TF.
[418] Calculated using IEFs from Cadmus report, weighted using TMY CDD and HDD for Texas, and adjusted to exclude 16 percent outdoor lighting except for upstream defaults. Cadmus report: Cadmus. Entergy Energy-Efficiency Portfolio Evaluation Report 2013 Program Year. Prepared for Entergy Arkansas, Inc. March 14, 2014. Docket No. 07-082-TF.

Deemed Winter Demand Savings Tables

Table 329. Ceiling Fans—Winter Peak Demand Savings (kW)

Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
0.010	0.009	0.008	0.010	0.012

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 10 years according to the ENERGY STAR Ceiling Fan Savings Calculator.

This EUL is consistent with Docket No. 38025 approved in 2010.[419]

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
- Quantity of installed ENERGY STAR ceiling fan and light kits
- Manufacturer and model number
- 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

- Docket No. 38025. Petition of Electric Utility Marketing Managers of Texas to Amend Deemed Savings for ENERGY STAR Appliance Measures. Public Utility Commission of Texas.

[419] Docket No. 38025. Petition of Electric Utility Marketing Managers of Texas to Amend Deemed Savings for ENERGY STAR Appliance Measures. 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 330. Ceiling Fans—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. Minor edits to language and updates to the ENERGY STAR specification table.
v2.1	1/30/2015	TRM v2.1 update. No revision.
v3.0	4/10/2014	TRM v3.0 update. Explanation of methodology and alignment with ENERGY STAR calculator. Introduction of interactive effects factors and in-service rates. New peak savings calculated according to revised peak definition.
v3.1	11/05/2015	TRM v3.1 update. Revision of interactive effects factors to reflect indoor-specific values for additional heating and cooling equipment types.
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 interactive effect values using building energy simulation.
v5.0	10/2017	TRM v5.0 update. Updated footnote reference to ENERGY STAR calculator.
v6.0	11/2018	TRM v6.0 update. Updated interactive effect values.
v7.0	11/2019	TRM v7.0 update. Established deemed savings approach.
v8.0	10/2020	TRM v8.0 update. No revision.
v9.0	10/2021	TRM v9.0 update. No revision.
v10.0	10/2022	TRM v10.0 update. Reduced baseline lighting wattage and resulting deemed energy savings for compliance with reinstated EISA 2007 45 lumens/watt baseline.
v11.0	10/2023	TRM v11.0 update. No revision.

2.5.2 ENERGY STAR® Clothes Washers Measure Overview

TRM Measure ID: R-AP-CW

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

This document presents the accepted deemed savings awarded for the installation of an ENERGY STAR clothes washer. 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.

These deemed savings are calculated using the federal standards effective January 1, 2018.

Eligibility Criteria

Not applicable.

Baseline Condition

Effective January 1, 2018, the baseline is the Department of Energy (DOE) minimum efficiency standard[420] for top-loading clothes washers. While the DOE provides criteria for both top- and front-loading washers, only the standards for top-loading washers are listed below, as a top-loading unit is assumed to be the baseline equipment. This approach is based on customers having the option to install a top-loading clothes washer. Therefore, savings are calculated using the lower top-loading baseline condition.

[420] DOE minimum efficiency standard for residential clothes washers. https://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/39.

Table 331. Clothes Washers—Federal Standard

Product type	Current criteria as of January 1, 2018
Top-loading, standard (1.6 ft^3 or greater capacity)	IMEF ≥ 1.57 IWF≤ 6.5
Top-loading, compact (less than 1.6 ft^3 capacity)	IMEF ≥ 1.15 IWF≤ 12.0

High-Efficiency Condition

The table below displays the ENERGY STAR Final Version 8.1 Requirements for eligible clothes washers effective February 5, 2018.[421] Energy efficiency service providers are expected to comply with the latest ENERGY STAR requirements.

Table 332. Clothes Washers—ENERGY STAR Requirements

Product type	Current criteria as of February 5, 2018
ENERGY STAR residential front-loading (> 2.5 ft^3)	IMEF ≥ 2.76 IWF ≤ 3.2
ENERGY STAR residential top-loading (> 2.5 ft^3)	IMEF ≥ 2.06 IWF ≤ 4.3
ENERGY STAR residential small or compact (< 2.5 ft^3)	IMEF ≥ 2.07 IWF ≤ 4.2

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 found on the ENERGY STAR website.[422] This document will be updated regularly to apply the values provided in the latest available ENERGY STAR Appliance Savings Calculator. The most recent TRM version should be referenced to determine the savings for this measure.

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

Equation 105

[421] ENERGY STAR Clothes Washer Final Version 8.1 Program Requirements. https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Final%20Version%208.0%20Clothes%20Washer%20Partner%20Commitments%20and%20Eligibility%20Criteria.pdf.

[422] 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.

Baseline Unit

$$kWh_{baseline} = kWh_{conv,machine} + kWh_{conv,WH} + kWh_{conv,dryer} + kWh_{conv,LPM}$$

Equation 106

$$kWh_{conv,machine} = MCF \times RUEC_{conv} \times \frac{LPY}{RLPY}$$

Equation 107

$$kWh_{conv,WH} = WHCF \times RUEC_{conv} \times \frac{LPY}{RLPY}$$

Equation 108

$$kWh_{conv,LPM} = kW_{conv,LPM} \times (8{,}760 - LPY)$$

Equation 109

$$kWh_{conv,dryer} = \left[\left(\frac{Cap_{conv}}{IMEF_{FS}} \times LPY\right) - \left(RUEC_{conv} \times \frac{LPY}{RLPY}\right) - kWh_{conv,LPM}\right] \times \frac{DU}{DUF}$$

Equation 110

Where:

$kWh_{baseline}$	=	*Federal standard baseline energy usage*
$kWh_{conv,machine}$	=	*Conventional machine energy*
$kWh_{conv,WH}$	=	*Conventional water heater energy*
$kWh_{conv,dryer}$	=	*Conventional dryer energy*
$kWh_{conv,LPM}$	=	*Conventional combined low-power mode energy*
$RUEC_{conv}$	=	*Conventional rated unit electricity consumption = 381 kWh/year (top-loading, standard)* [423]*, 163 kWh/year top-loading, compact)*
LPY	=	*Loads per year = 295*
$RLPY$	=	*Reference loads per year = 392*
$kW_{conv,LPM}$	=	*Combined low-power mode wattage of conventional unit = 0.00115 kW (top-loading, standard), 0.00144 kW (top-loading, compact)*
Cap_{conv}	=	*Average machine capacity = 4.5 ft³ (top-loading, standard), 2.1 ft³ (top-loading, compact)*
$IMEF_{FS}$	=	*Federal standard integrated modified energy factor (Table 331)*

[423] This value is taken from the ENERGY STAR appliance calculator and corresponds with the federal standard after March 7, 2015.

MCF	=	*Machine consumption factor = 20 percent*
WHCF	=	*Water heater consumption factor = 80 percent*
DU	=	*Dryer usage in households with both a washer and a dryer = 95 percent*
DUF	=	*Dryer use factor (percentage of washer loads dried in machine) = 91 percent*

ENERGY STAR Unit

$$kWh_{ES} = kWh_{ES,machine} + kWh_{ES,WH} + kWh_{ES,dryer} + kWh_{ES,LPM}$$

Equation 111

$$kWh_{ES,machine} = MCF \times RUEC_{ES} \times \frac{LPY}{RLPY}$$

Equation 112

$$kWh_{ES,WH} = WHCF \times RUEC_{ES} \times \frac{LPY}{RLPY}$$

Equation 113

$$kWh_{ES,LPM} = kW_{ES,LPM} \times (8{,}760 - LPY)$$

Equation 114

$$kWh_{ES,dryer} = \left[\left(\frac{Cap_{ES}}{IMEF_{ES}} \times LPY\right) - \left(RUEC_{ES} \times \frac{LPY}{RLPY}\right) - kWh_{ES,LPM}\right] \times \frac{DU}{DUF}$$

Equation 115

Where:

kWh_{ES}	=	*ENERGY STAR average energy usage*
$kWh_{ES,machine}$	=	*ENERGY STAR machine energy*
$kWh_{ES,WH}$	=	*ENERGY STAR water heater energy*
$kWh_{ES,dryer}$	=	*ENERGY STAR dryer energy*
$kWh_{ES,LPM}$	=	*ENERGY STAR combined low-power mode energy*
$RUEC_{ES}$	=	*ENERGY STAR rated unit electricity consumption (see Table 333)*
$kW_{ES,LPM}$	=	*Combined low-power mode wattage of ENERGY STAR unit (see Table 333)*
$IMEF_{ES}$	=	*ENERGY STAR integrated modified energy factor (see Table 332)*
Cap_{ES}	=	*Average machine capacity (see Table 333)*

Table 333. Clothes Washers—ENERGY STAR Characteristics[424]

Product type	ENERGY STAR rated unit electricity consumption (kWh)	Average capacity (ft^3)	Combined low-power mode wattage (kW)
Residential front-loading (> 2.5 ft^3)	127	4.0	0.00160
Residential top-loading (> 2.5 ft^3)	230	4.5	0.00115
Residential small or compact (< 2.5 ft^3)	108	2.1	0.00144

Demand Savings Algorithms

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

Equation 116

$$AOH = LPY \times d$$

Equation 117

Where:

AOH	=	*Annual operating hours*
$CF_{S/W}$	=	*Seasonal peak coincidence factor (Table 334)*
LPY	=	*Loads per year = 295*
d	=	*Average wash cycle duration = 1 hour [425,426]*

Table 334. Clothes Washers—Coincidence Factors[427]

Season	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
Summer	0.040	0.040	0.040	0.041	0.041
Winter	0.043	0.043	0.043	0.044	0.039

[424] This value is taken from the ENERGY STAR appliance calculator and corresponds with the ENERGY STAR specification after March 7, 2015.
[425] Weighted average of Consumer Reports Cycle Times for Top and Front-Loading Clothes Washers.
[426] Consumer Reports. "Top-loading washers remain more popular with Americans". April 13, 2010. Weighted average of 75 percent Top-Loading Clothes Washers and 25 percent Front-Loading Clothes Washers.
[427] See Volume 1, Section 4.

Deemed Energy Savings Tables

Table 335. Clothes Washers—Energy Savings (kWh)

Type	Water heater fuel type	Dryer fuel type	kWh/unit
Front-loading > 2.5 ft^3	Electric	Electric	428
		Gas	187
	Gas	Electric	275
		Gas	34
Top-loading > 2.5 ft^3	Electric	Electric	205
		Gas	114
	Gas	Electric	114
		Gas	23
All ≤ 2.5 ft^3	Electric	Electric	248
		Gas	41
	Gas	Electric	215
		Gas	8

Deemed Summer Demand Savings Tables

Table 336. Clothes Washers—Summer Peak Demand Savings (kW)

Washer type	Fuel Type		Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
	Water heater	Dryer					
Front-loading > 2.5 ft^3	Electric	Electric	0.058	0.058	0.058	0.060	0.060
		Gas	0.025	0.025	0.025	0.026	0.026
	Gas	Electric	0.037	0.037	0.037	0.038	0.038
		Gas	0.005	0.005	0.005	0.005	0.005
Top-loading > 2.5 ft^3	Electric	Electric	0.028	0.028	0.028	0.028	0.028
		Gas	0.015	0.015	0.015	0.016	0.016
	Gas	Electric	0.015	0.015	0.015	0.016	0.016
		Gas	0.003	0.003	0.003	0.003	0.003
All ≤ 2.5 ft^3	Electric	Electric	0.034	0.034	0.034	0.034	0.034
		Gas	0.006	0.006	0.006	0.006	0.006
	Gas	Electric	0.029	0.029	0.029	0.030	0.030
		Gas	0.001	0.001	0.001	0.001	0.001

Deemed Winter Demand Savings Tables

Table 337. Clothes Washers—Winter Peak Demand Savings (kW)

Washer type	Fuel type		Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
	Water heater	Dryer					
Front-loading > 2.5 ft^3	Electric	Electric	0.062	0.062	0.062	0.064	0.057
		Gas	0.027	0.027	0.027	0.028	0.025
	Gas	Electric	0.040	0.040	0.040	0.041	0.036
		Gas	0.005	0.005	0.005	0.005	0.005
Top-loading > 2.5 ft^3	Electric	Electric	0.030	0.030	0.030	0.031	0.027
		Gas	0.017	0.017	0.017	0.017	0.015
	Gas	Electric	0.017	0.017	0.017	0.017	0.015
		Gas	0.003	0.003	0.003	0.003	0.003
All ≤ 2.5 ft^3	Electric	Electric	0.036	0.036	0.036	0.037	0.033
		Gas	0.006	0.006	0.006	0.006	0.005
	Gas	Electric	0.031	0.031	0.031	0.032	0.028
		Gas	0.001	0.001	0.001	0.001	0.001

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 ENERGY STAR clothes washer is established at 11 years based on the Technical Support Document for the current DOE Final Rule standards for residential clothes washers.[428]

[428] The median lifetime was calculated using the survival function outlined in the DOE Technical Support Document. Final Rule: Standards, Federal Register, 77 FR 32308 (May 31, 2012) and associated Technical Support Document. https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=68&action=viewlive. Download TSD at: https://www.regulations.gov/document/EERE-2008-BT-STD-0019-0047.

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
- Type of unit (top-loading, front-loading, or compact)
- DHW fuel type (gas or electric)
- Dryer fuel type (gas or electric)
- 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 338. Clothes Washers—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. 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. Updated EUL to align with median lifetime. New peak savings calculated according to revised peak definition.
v3.1	11/05/2015	TRM v3.1 update. New ENERGY STAR algorithms and default assumptions incorporated.
v3.1	3/28/2016	TRM v3.1 March revision. Updated winter coincidence factors and winter and summer demand savings tables.
v4.0	10/10/2016	TRM v4.0 update. No revision.

TRM version	Date	Description of change
v5.0	10/2017	TRM v5.0 update. Updated baseline IMEF to reflect changes in Federal Standard. Updated Front Load Washer IMEF to reflect changes in ENERGY STAR Specification. Added baseline for compact units to reflect Federal Standard for compact washers.
v6.0	11/2018	TRM v6.0 update. No revision.
v7.0	11/2019	TRM v7.0 update. Updated links and dates.
v8.0	10/2020	TRM v8.0 update. No revision.
v9.0	10/2021	TRM v9.0 update. General reference checks and text edits. Updated deemed savings tables to match savings algorithms and ENERGY STAR calculator.
v10.0	10/2022	TRM v10.0 update. No revision.
v11.0	10/2023	TRM v11.0 update. No revision.

2.5.3 ENERGY STAR® Clothes Dryers Measure Overview

TRM Measure ID: R-AP-CD

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

This document presents the accepted deemed savings awarded for the installation of an ENERGY STAR electric clothes dryer. 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

Gas dryers are ineligible to claim savings under this measure. Savings may be claimed for the replacement of gas dryers if the decision to switch fuels predates the decision to install efficient equipment.

Baseline Condition

Effective January 1, 2015, the baseline is the Department of Energy (DOE) minimum federal efficiency standard[429], adjusted to reflect recent combined energy factor (CEF) definition updates for vented and ventless clothes dryers. These adjusted baselines consider calculated differences between CEF values under original clothes dryer testing procedures of 10 CFR 430, Subpart B, Appendix D1, and those amended procedures outlined in Appendix D2; a change indicated in detail in the September 5, 2013, ENERGY STAR stakeholder webinar. These values are consistent with the current ENERGY STAR Appliance Savings Calculator.

[429] DOE minimum efficiency standard for residential clothes dryers. https://www.regulations.gov/document?D=EERE-2007-BT-STD-0010-0050.

Table 339. Clothes Dryers—Federal Standard

Product type	Average capacity (ft^3)	Amended minimum CEF: calculations	Minimum CEF levels (lbs/kWh)
Vented electric, standard	≥ 4.4	3.73 – (3.73 x 0.166)	3.11
Vented electric, compact (120 V)	< 4.4	3.61 – (3.61 x 0.166)	3.01
Vented electric, compact (240 V)	< 4.4	3.27 – (3.27 x 0.166)	2.73
Ventless electric, compact (240 V)	< 4.4	2.55 – (2.55 x 0.166)	2.13

High-Efficiency Condition

The table below displays the ENERGY STAR Final Version 1.1 Requirements for eligible clothes dryers effective January 1, 2015.[430] Energy efficiency service providers are expected to comply with the latest ENERGY STAR requirements.

Table 340. Clothes Dryers—ENERGY STAR Requirements

Product type	Average Capacity (ft^3)	Minimum CEF levels (lbs/kWh)
ENERGY STAR ventless or vented electric, standard	≥ 4.4	3.93
ENERGY STAR ventless or vented electric, compact (120 V)	< 4.4	3.80
ENERGY STAR vented electric, compact (240 V)	< 4.4	3.45
ENERGY STAR ventless electric, compact (240 V)	< 4.4	2.68

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 found on the ENERGY STAR website.[431] This document will be updated regularly to apply the values provided in the latest available ENERGY STAR appliance calculator. The most recent TRM version should be referenced to determine the savings for this measure.

[430] ENERGY STAR Clothes Dryers Final Version 1.1 Program Requirements. https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20Final%20Version%201.1%20Clothes%20Dryers%20Specification%20-%20Program%20Commitment%20Criteria%20and%20Eligibility%20Criteria.pdf.

[431] 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.

Table 341. Clothes Dryers—Default Average Load

Product type	Average load (lbs)
Vented electric, standard	8.45
Vented electric, compact (120 V)	3.00
Vented electric, compact (240 V)	3.00
Ventless electric, compact (240 V)	3.00

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

Equation 118

Baseline Unit

$$kWh_{baseline} = \frac{AvgLoad \times LPY}{CEF_{baseline}}$$

Equation 119

Where:

$kWh_{baseline}$ = *Federal standard baseline energy usage*

AvgLoad = *Average load in lbs (Table 341)*

LPY = *Loads per year = 283*

$CEF_{baseline}$ = *Baseline combined energy factor (see Table 339)*

ENERGY STAR Unit

$$kWh_{ES} = \frac{AvgLoad \times LPY}{CEF_{ES}}$$

Equation 120

Where:

kWh_{ES} = *ENERGY STAR average energy usage*

CEF_{ES} = *ENERGY STAR minimum combined energy factor (see Table 340)*

Demand Savings Algorithms

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

Equation 121

Where:

AOH = *Annual operating hours = (8,760 – 8,463) = 297 hours*[432]

$CF_{S/W}$ = *Seasonal peak coincidence factor (Table 342)*

Table 342. Clothes Dryers—Coincidence Factors[433]

Season	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
Summer	0.041	0.041	0.041	0.041	0.042
Winter	0.045	0.045	0.041	0.048	0.047

Deemed Energy Savings Tables

Table 343. Clothes Dryers—Energy Savings (kWh)

Product type	Average capacity (ft^3)	Energy savings (kWh)
Ventless or vented electric, standard	≥ 4.4	160
Ventless or vented electric, compact (120 V)	< 4.4	59
Vented electric, compact (240 V)	< 4.4	65
Ventless electric, compact (240 V)	< 4.4	82

Deemed Summer Demand Savings Tables

Table 344. Clothes Dryers—Summer Peak Demand Savings (kW)

Product type	Average capacity (ft^3)	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
Ventless or vented electric, standard	≥ 4.4	0.022	0.022	0.022	0.022	0.023
Ventless or vented electric, compact (120 V)	< 4.4	0.008	0.008	0.008	0.008	0.008
Vented electric, compact (240 V)	< 4.4	0.009	0.009	0.009	0.009	0.009
Ventless electric, compact (240 V)	< 4.4	0.011	0.011	0.011	0.011	0.012

[432] Concerning annual operating hours: Minute-by-minute field data shows "96.6% ± 0.5% idle time, or about 8463 hours." Hannas, Benjamin and Gilman, Lucinda. Dryer Field Study, 39. https://neea.org/img/uploads/neea-clothes-dryer-field-study.pdf.

[433] See Volume 1, Section 4.

Deemed Winter Demand Savings Tables

Table 345. Clothes Dryers—Winter Peak Demand Savings (kW)

Product type	Average capacity (ft^3)	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
Ventless or vented electric, standard	≥ 4.4	0.024	0.024	0.022	0.026	0.025
Ventless or vented electric, compact (120 V)	< 4.4	0.009	0.009	0.008	0.009	0.009
Vented electric, compact (240 V)	< 4.4	0.010	0.010	0.009	0.011	0.010
Ventless electric, compact (240 V)	< 4.4	0.012	0.013	0.011	0.013	0.013

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 ENERGY STAR clothes dryer is established at 16 years based on the current DOE Final Rule standards for clothes dryers.[434]

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
- Type of unit (vented or ventless)
- Capacity (≥ 4.4 ft^3/standard or < 4.4 ft^3/compact)
- Proof of purchase – including date of purchase and quantity
    - Alternative: photo of unit installed or another pre-approved method of installation verification

[434] Technical Support Document (April 2011). See "Appendix 8C.Lifetime Distributions": https://www.regulations.gov/document?D=EERE-2007-BT-STD-0010-0053

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 346. Clothes Dryers—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. No revision.
v10.0	10/2022	TRM v10.0 update. No revision.
v11.0	10/2023	TRM v11.0 update. No revision.

2.5.4 ENERGY STAR® Dishwashers Measure Overview

TRM Measure ID: R-AP-DW

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

This document presents the accepted deemed savings awarded for the installation of an ENERGY STAR dishwasher. 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 both standard and compact dishwasher types.

Baseline Condition

Effective May 30, 2013, the baseline is the Department of Energy (DOE) minimum efficiency standard[435] for dishwashers.

Table 347. Dishwashers—Federal Standard

Product type	Annual energy use (kWh/year)	Water consumption (gallons/cycle)
Standard (≥ 8 place settings)	≤ 307	≤ 5.0
Compact (< 8 place settings)	≤ 222	≤ 3.5

[435] DOE minimum efficiency standard for residential dishwashers. https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=38&action=viewlive.

High-Efficiency Condition

The following table displays the ENERGY STAR Final Version 6.0 Requirements for eligible dishwashers effective January 29, 2016.[436] Energy efficiency service providers are expected to comply with the latest ENERGY STAR requirements.

Table 348. Dishwashers—ENERGY STAR Requirements

Product type	Annual energy use (kWh/year)	Water consumption (gallons/cycle)
Standard (≥ 8 place settings + 6 serving pieces)	≤ 270	≤ 3.5
Compact (< 8 place settings + 6 serving pieces)	≤ 203	≤ 3.1

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 found on the ENERGY STAR website and the revised ENERGY STAR specification in Table 348.[437] Default values were taken directly from the ENERGY STAR Appliance Savings Calculator. This document will be updated regularly to apply the values provided in the latest available ENERGY STAR specification and appliance calculator. The most recent TRM version should be referenced to determine measure savings for this measure.

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

Equation 122

$$kWh_{baseline} = kWh_{conv,machine} + kWh_{conv,WH}$$

Equation 123

$$kWh_{conv,machine} = RUEC_{conv} \times MCF$$

Equation 124

$$kWh_{conv,WH} = RUEC_{conv} \times WHCF$$

Equation 125

$$kWh_{ES} = kWh_{ES,machine} + kWh_{ES,WH}$$

Equation 126

[436] ENERGY STAR Dishwashers Final Version 6.0 Program Requirements. https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Residential%20Dishwasher%20Version%206.0%20Final%20Program%20Requirements.pdf.

[437] 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.

$$kWh_{ES,machine} = RUEC_{ES} \times MCF$$

Equation 127

$$kWh_{ES,WH} = RUEC_{ES} \times WHCF$$

Equation 128

Where:

$kWh_{baseline}$	=	*Federal standard baseline energy usage*
kWh_{ES}	=	*ENERGY STAR average energy usage*
$kWh_{conv,machine}$	=	*Conventional machine energy*
$kWh_{conv,WH}$	=	*Conventional water heater energy*
$kWh_{ES,machine}$	=	*ENERGY STAR machine energy*
$kWh_{ES,WH}$	=	*ENERGY STAR water heater energy*
$RUEC_{conv}$	=	*Conventional rated use electricity consumption = 307 kWh/year for standard and 222 kWh/year for compact (Table 347)*
$RUEC_{ES}$	=	*ENERGY STAR rated use electricity consumption = 270 kWh/year for standard and 203 kWh/year for compact (Table 348)*
MCF	=	*Machine consumption factor = 44 percent*
WHCF	=	*Water heater consumption factor = 56 percent*

Demand Savings Algorithms

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

Equation 129

$$AOH = CPY \times d$$

Equation 130

Where:

AOH	=	*Annual operating hours*
$CF_{S/W}$	=	*Seasonal peak coincidence factor = (Table 349)*
CPY	=	*Cycles per year = 215*
d	=	*Average wash cycle duration = 2.1 hours*[438]

[438] Average of consumer reports cycle times for dishwashers.

Table 349. Dishwashers—Coincidence Factors[439]

Season	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
Summer	0.042	0.041	0.042	0.041	0.042
Winter	0.106	0.104	0.090	0.112	0.129

Deemed Energy Savings Tables

Table 350. Dishwashers—Energy Savings (kWh)

Product type	Electric DHW	Gas DHW
Standard	37	16
Compact	19	8

Deemed Summer Demand Savings Tables

Table 351. Dishwashers—Summer Peak Demand Savings (kW)

Dishwasher type	DHW fuel	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
Standard	Electric	0.003	0.003	0.003	0.003	0.003
	Gas	0.002	0.001	0.002	0.001	0.002
Compact	Electric	0.002	0.002	0.002	0.002	0.002
	Gas	0.001	0.001	0.001	0.001	0.001

Deemed Winter Demand Savings Tables

Table 352. Dishwashers—Winter Peak Demand Savings (kW)

Dishwasher type	DHW fuel	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
Standard	Electric	0.009	0.009	0.007	0.009	0.011
	Gas	0.004	0.004	0.003	0.004	0.005
Compact	Electric	0.004	0.004	0.004	0.005	0.005
	Gas	0.002	0.002	0.002	0.002	0.002

[439] See Volume 1, Section 4.

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 15 years based on the Technical Support Document for the current DOE Final Rule standards for residential dishwashers.[440]

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
- Type of dishwasher (standard or compact)
- Fuel type of water heater (gas or electric)
- 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.

[440] The median lifetime was calculated using the survival function outlined in the DOE Technical Support Document. Final Rule: Standards, Federal Register, 77 FR 31918 (May 30, 2012) and associated Technical Support Document. https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=38&action=viewlive.

Document Revision History

Table 353. Dishwashers—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. Updated by Frontier Energy, March 2014, based on new federal standards.
v2.1	1/30/2015	TRM v2.1 update. No revision.
v3.0	4/10/2015	TRM v3.0 update. New ENERGY STAR specification incorporated into the measure. New peak savings calculated according to revised peak definition.
v3.1	11/05/2015	TRM v3.1 update. Final ENERGY STAR specification incorporated into the measure. Consolidated table formats.
v3.1	3/28/2016	TRM 3.1 March revision. Updated summer and winter coincidence factors and demand savings tables.
v4.0	10/10/2016	TRM v4.0 update. No revision.
v5.0	10/2017	TRM v5.0 update. Updated footnote reference to ENERGY STAR calculator.
v6.0	11/2018	TRM v6.0 update. No revision.
v7.0	10/2019	TRM v7.0 update. Updated links and dates.
v8.0	10/2020	TRM v8.0 update. No revision.
v9.0	10/2021	TRM v9.0 update. No revision.
v10.0	10/2022	TRM v10.0 update. No revision.
v11.0	10/2023	TRM v11.0 update. No revision.

2.5.5 ENERGY STAR® Refrigerators Measure Overview

TRM Measure ID: R-AP-RF

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 refrigerators 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 20 years. To determine the remaining useful life of an existing unit, see Table 357. All retired refrigerators 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 refrigerators. To receive early retirement savings, the unit to be replaced must be functioning at the time of removal.

Newly installed refrigerators 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[441] for refrigerators, effective September 15, 2014.

[441] DOE minimum efficiency standard for residential refrigerators and freezers. http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/43.

For early retirement, the baseline for refrigerators is the annual unit energy consumption of an assumed refrigerator'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.[442] Since the federal standard effective date occurred in late 2014, existing units manufactured as of 2015 are not eligible for early retirement.

High-Efficiency Condition

The table below displays the ENERGY STAR Final Version 5.1 Requirements for eligible consumer refrigeration products effective September 15, 2014.[443] Energy efficiency service providers are expected to comply with the latest ENERGY STAR requirements.

Table 354. Refrigerators—ENERGY STAR Requirements

ENERGY STAR refrigerator		
Product type	**Volume**	**Criteria as of September 15, 2014**
Full-size refrigerators and refrigerator-freezers	7.75 cubic feet or greater	Approximately 10 percent more energy efficient than the minimum federal standard (see Table 355)

[442] 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.

[443] 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 355. Refrigerators—Formulas to Calculate the Energy Usage by Product Class[444]

Product number	Product class	Baseline energy usage federal standard as of September 15, 2014 (kWh/year)[445]	Average ENERGY STAR energy usage (kWh/year)[446]	Adjusted volume[447] (cubic feet)	Baseline energy usage (kWh/year)	ENERGY STAR energy usage (kWh/year)
3	Refrigerator freezers—automatic defrost with top-mounted freezer without an automatic icemaker	8.07 × AV + 233.7	7.26 × AV + 210.3	16.9	370.1	333.0
5	Refrigerator-freezers—automatic defrost with bottom-mounted freezer without an automatic icemaker	8.85 × AV + 317.0	7.97 × AV + 285.3	18.6	481.5	433.5
5A	Refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker with TTD ice service	9.25 × AV + 475.4	8.33 × AV + 436.3	32.1	772.1	703.5
7	Refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker with TTD ice service	8.54 × AV + 432.8	7.69 × AV + 397.9	30.4	692.1	631.4

[444] Federal standard for refrigerators and freezers. https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=37&action=viewlive. Select product classes excluded.
[445] http://www.gpo.gov/fdsys/pkg/CFR-2012-title10-vol3/pdf/CFR-2012-title10-vol3-sec430-32.pdf.
[446] Approximately ten 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.
[447] AV is calculated as a simple average across all refrigerators in the corresponding Product Class utilizing data provided by https://www.energystar.gov/productfinder/product/certified-residential-refrigerators/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 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[448]

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)

[448] 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*[449]

Table 357. Refrigerators—RUL of Replaced Unit [450]

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[451,452]	0.0
11	7.4		

[449] 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.

[450] 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.

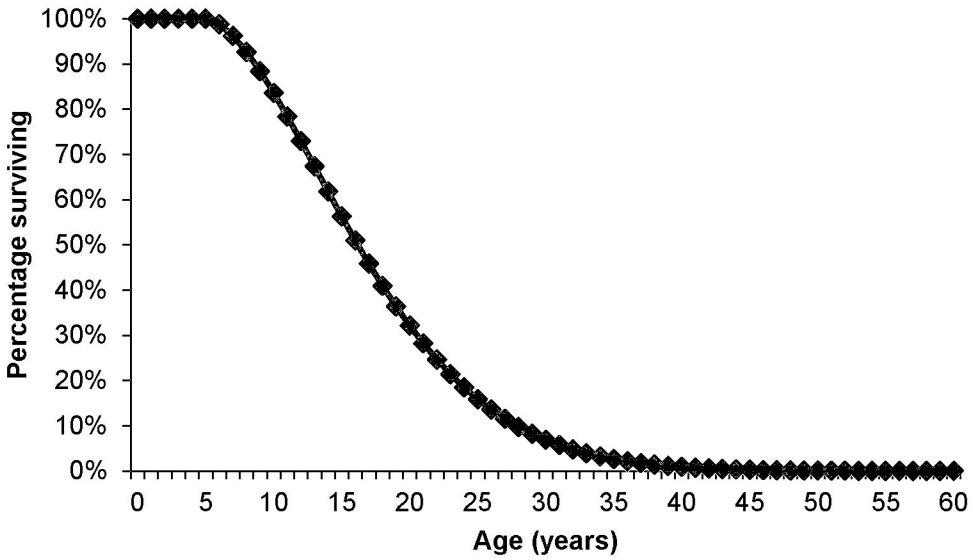
[451] RULs are capped at the 75th percentile of equipment age as determined based on DOE survival curves (see Figure 8). Systems older than this age should use the ROB baseline. See the January 2015 memo, "Considerations for early replacement of residential equipment," for further detail.

[452] 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[453]



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.

[453] 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} = *968 kWh/Year*[454]

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:

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

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

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.

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[454] 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.

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	224
	Bottom freezer	5: Refrigerator-freezers—automatic defrost with a bottom-mounted freezer without an automatic icemaker	48	200
Yes	Bottom freezer	5A: Refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker with TTD ice service	69	147
	Side-by-side	7: Refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker with TTD ice service	61	130
Unknown or average refrigerator[455]			44	205

[455] 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	0.028	0.028	0.028	0.028	0.028
	Bottom freezer	5: Refrigerator-freezers—automatic defrost with bottom-mounted freezer without an automatic icemaker	0.025	0.025	0.025	0.025	0.025
Yes	Bottom freezer	5A: Refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker with TTD ice service	0.016	0.016	0.016	0.016	0.016
	Side-by-side	7: Refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker with TTD ice service	0.019	0.018	0.019	0.018	0.018
Unknown or average refrigerator			0.026	0.026	0.026	0.026	0.025

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	0.024	0.025	0.024	0.024	0.025
	Bottom freezer	5: Refrigerator-freezers—automatic defrost with bottom-mounted freezer without an automatic icemaker	0.021	0.022	0.021	0.021	0.022
Yes	Bottom freezer	5A: Refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker with TTD ice service	0.014	0.014	0.014	0.014	0.014
	Side-by-side	7: Refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker with TTD ice service	0.016	0.016	0.015	0.016	0.016
Unknown or average refrigerator			0.022	0.023	0.022	0.022	0.023

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.[456]

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.

[456] 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.

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[457] for freezers, effective September 15, 2014.

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.[458]

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[457] 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.

[458] 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.

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."[459]

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.[460] Energy efficiency service providers are expected to comply with the latest ENERGY STAR requirements.

Table 364. Freezers—ENERGY STAR Requirements[461]

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)

[459] 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.

[460] 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.

[461] https://www.energystar.gov/products/appliances/refrigerators/key_product_criteria.

Table 365. Freezers—Formulas to Calculate the Energy Usage by Product Class[462]

Product number	Full product name[463]	Product class	Baseline energy usage federal standard (kWh/year)[464]	Average ENERGY STAR energy usage (kWh/year)[465]	Adjusted volume[466] (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

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

[463] 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.

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

[465] 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.

[466] 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[467]

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)

[467] 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*[468]

Table 367. Freezers—RUL of Replaced Unit[469]

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[470,471]	0.0

[468] 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.

[469] 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.

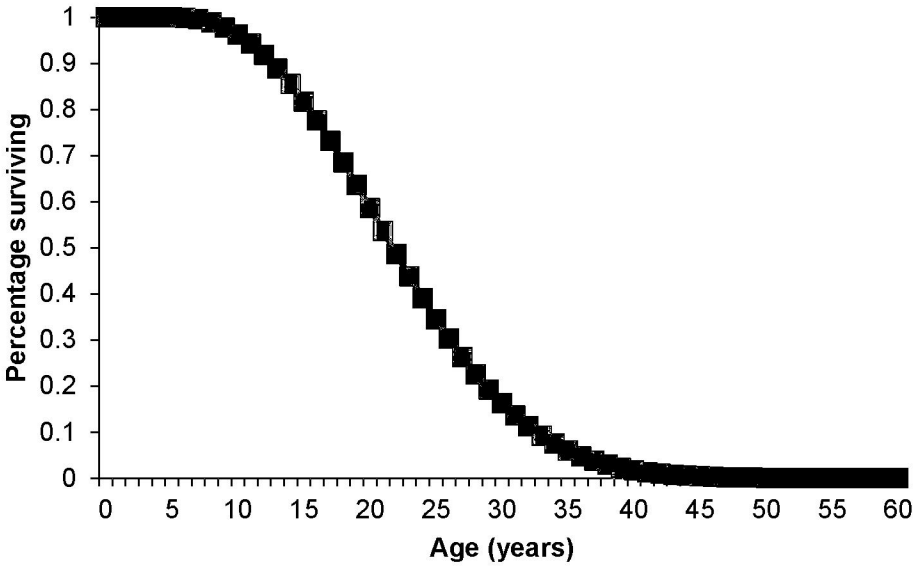
[470] RULs are capped at the 75th percentile of equipment age as determined based on DOE survival curves (see Figure 8). Systems older than this age should use the ROB baseline. See the January 2015 memo, "Considerations for early replacement of residential equipment," for further detail.

[471] 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[472]



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.

[472] 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} = *841 kWh/Year*[473]

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

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.

[473] 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.

Deemed Energy Savings Tables

Table 368. Freezers—Savings (kWh)

Freezer type	Size	ROB savings (kWh)	ER savings (kWh)
Chest	Standard (≥ 7.75 ft^3)	29	154
	Compact (< 7.75 ft^3)	22	163
Upright	Standard (≥ 7.75 ft^3)	48	130
	Compact (< 7.75 ft^3)	32	151

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)	0.020	0.019	0.019	0.019	0.019
	Compact (< 7.75 ft^3)	0.021	0.020	0.021	0.020	0.020
Upright	Standard (≥ 7.75 ft^3)	0.017	0.016	0.016	0.016	0.016
	Compact (< 7.75 ft^3)	0.019	0.019	0.019	0.019	0.019

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)	0.016	0.017	0.016	0.017	0.017
	Compact (< 7.75 ft^3)	0.017	0.018	0.017	0.018	0.018
Upright	Standard (≥ 7.75 ft^3)	0.014	0.014	0.014	0.014	0.014
	Compact (< 7.75 ft^3)	0.016	0.017	0.016	0.016	0.017

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.[474]

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

[474] 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.

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 v10.0 update. Updated early retirement age eligibility.

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:

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

Equation 144

Where:

$kWh_{existing}$	=	*Average annual energy consumption[475] (see Table 374)*
ISAF	=	*In situ adjustment factor[476] = 0.942*
PUF	=	*Part use factor[477] = 0.915*

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

Total capacity (ft^3)	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

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

[476] 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.

[477] 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[478]

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

[478] 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,[479] 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)

[479] 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.

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.[480]

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

[480] 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.[481] 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.[482] 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

[481] 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.

[482] 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[483]

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

[483] 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.[484]

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.

[484] 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.

2.5.9 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.[485]

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.[486] Therefore, multi-speed pumps must have a high-speed override capability to revert back to low speed after a period not to exceed 24 hours.

[485] 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.

[486] 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.[487] Weighted energy factor (WEF) requirements are based on rated hydraulic horsepower (hhp).

Table 384. Baseline Condition—Federal Standard Effective July 19, 2021

Pump subtype	Size class	WEF
Self-priming (inground) pool umps	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.[488] 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.[489] 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.

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

[488] 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.

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

Table 385. ENERGY STAR Pool Pumps – Energy Efficiency Level

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.[490]

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

Equation 152

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 153

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

Equation 154

Where:

PFR_{base} = *Baseline pump flow rate [gal/min] (Table 386)*

$_{W}EF_{base}$ = *Baseline pump energy factor [gal/W x hr] (Table 386)*

WEF_{ES} = *ENERGY STAR pump energy factor [gal/W x hr] (Table 387)*

hours = *Pump daily operating hours (Table 386)*

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

[490] 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 386)*
TO	=	*Turnovers per day, number of times the volume of the pool is run through the pump per day (Table 387)*
60	=	*Constant to convert between minutes and hours*
1,000	=	*Constant to convert from W to kW*

Table 386. Pool Pumps—Baseline Assumptions[491]

New pump HP	Reference HP	Reference HHP[492]	Hours[493]	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 387. Pool Pumps—ENERGY STAR Assumptions[494]

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 155

[491] 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.

[492] 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.

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

[494] 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 388)*

Table 388. Pool Pumps—Coincidence Factors[495]

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 389. Pool Pumps—Energy Savings (kWh)[496]

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	–	–

[495] 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.

[496] 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[497]

Table 390. 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 391. 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

[497] 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 392. 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 393. 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.[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 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

[498] 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 394. 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.