Table 290. Solar DHW—Water Heater Consumption (Gal/Year) [352]

Climate zone	Number of bedrooms			
	1	2	3	4
Zone 1: Amarillo	15,476	20,171	24,866	29,561
Zone 2: Dallas	14,778	19,244	23,710	28,177
Zone 3: Houston	14,492	18,864	23,236	27,608
Zone 4: Corpus Christi	14,213	18,494	22,775	27,056
Zone 5: El Paso	14,905	19,412	23,920	28,427

Table 291. Solar DHW—Water Mains Temperature (°F)[353]

Climate zone	$T_{supply,annual}$	$T_{supply,seasonal}$	
		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

Demand Savings Algorithm

$$Peak\ Demand\ Savings\ [\Delta kW] = \frac{\rho \times C_p \times GPY \times (T_{setpoint} - T_{supply,seasonal}) \times \left(\frac{1}{UEF_{pre}} - \frac{1}{SUEF_{post}}\right)}{365 \times 3{,}412} \times CF_{S/W}$$

Equation 75

Where:

$T_{supply,seasonal}$ = *Seasonal supply water temperature [°F] (see Table 291)*

$CF_{S/W}$ = *Summer/winter peak coincidence factor (see Table 292)*

[352] Building America Research Benchmark Definition. December 2009, p 13. Available online: http://www.nrel.gov/docs/fy10osti/47246.pdf.

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

Table 292. Solar DHW—Coincidence Factors[354]

Climate zone	Summer	Winter
Zone 1: Amarillo	0.042	0.067
Zone 2: Dallas	0.039	0.068
Zone 3: Houston	0.041	0.070
Zone 4: Corpus Christi	0.041	0.065
Zone 5: El Paso	0.036	0.067

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 15 years, as specified in the California Database of Energy Efficiency Resources (DEER) READI tool for EUL ID WtrHt-SWH.[355]

[354] Probability weighted peak load factors are calculated according to the method in Section 4 of the Texas TRM Vol 1 using data from Building America Performance Analysis Procedures for Existing Homes, page 18, Figure 4: Combined Domestic Hot Water Use Profile. https://www.nrel.gov/docs/fy06osti/38238.pdf.

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

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 bedrooms (not required for upstream/midstream program delivery)
- Solar DHW quantity
- Manufacturer and model number of new solar water heater
- Baseline volume (gallons), FHR, and UEF
- New solar water heater volume (gallons), FHR, and SUEF
- 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. 22241, Item 62. Petition by Frontier Energy for Approval of Second Set of Deemed Savings Estimates. Public Utility Commission of Texas.
- Docket No. 27903. Order Adopting New §25.184 as Approved at the August 21, 2003, Open Meeting and Submitted to the Secretary of State. 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 293. Solar DHW—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. No revision.
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.

TRM version	Date	Description of change
v7.0	10/2019	TRM v7.0 update. No revision.
v8.0	10/2020	TRM v8.0 update. Updated algorithms and coincidence factors.
v9.0	10/2021	TRM v9.0 update. Updated EUL reference.
v10.0	10/2022	TRM v10.0 update. Verified compliance with ENERGY STAR Version 4.0 Requirements. Updated documentation requirements.
v11.0	10/2023	TRM v11.0 update. Incorporated updated ENERGY STAR specification v5.0. Updated documentation requirements.
v12.0	10/2024	TRM v12.0 update. Clarified use of high efficiency ratings.

2.4.4 Water Heater Tank Insulation Measure Overview

TRM Measure ID: R-WH-TI

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 requires the installation of tank wrap insulation on an uninsulated water heater tank.

Eligibility Criteria

Water heater tank insulation is a residential retrofit measure. New construction and water heater replacements are not eligible for this measure because they must meet current code requirements. Tank insulation must be installed on an uninsulated electric resistance water heater.

To be eligible for this measure, water heaters must have been installed prior to April 16, 2015. Water heaters manufactured after this date are compliant with the current federal standard[356] and are built with a thicker tank with a higher baseline R-value. Modern water heaters are expected to be rated at a minimum of R-24.[357,358]

[356] "Energy Conservation Program for Consumer Products: Energy Conservation Standards for Residential Water Heaters, Direct Heating Equipment, and Pool Heaters". Effective 6/15/2010 with compliance starting 5/16/2015. https://www.federalregister.gov/documents/2010/04/16/2010-7611/energy-conservation-program-energy-conservation-standards-for-residential-water-heaters-direct.

[357] "Do-It-Yourself Savings Project: Insulate Water Heater Tank," U.S. Department of Energy. https://www.energy.gov/energysaver/do-it-yourself-savings-project-insulate-water-heater-tank.

[358] "Water Heating Products," Air-Conditioning, Heating, and Refrigeration Institute (AHRI). https://www.ahrinet.org/scholarships-education/education/homeowners/save-energy/water-heating-products.

Baseline Condition

The baseline is assumed to be a typical electric water heater with no insulation. The baseline tank is assumed to be one to two inches thick with an assumed R-value of approximately R-8 per inch.[359]

High-Efficiency Condition

The high-efficiency condition is a water heater tank wrap or insulated blanket with an R-value of at least 8.

The manufacturer's instructions on the water heater jacket and the water heater itself should be followed. Thermostat and heating element access panels must be left uncovered.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Energy Savings Algorithms

Hot water tank insulation energy savings are calculated using the following formula:

$$Energy\ Savings\ [\Delta kWh] = \frac{\left(U_{pre} - U_{post}\right) \times A \times \left(T_{tank} - T_{ambient,annual}\right) \times hours}{RE \times 3{,}412}$$

Equation 76

Where:

R_{pre}	=	*Uninsulated tank R-value = 12 [sq. ft. °F hr/Btu][360]*
R_{post}	=	*Tank insulation R-value = 12 + 8 = 20 = [sq. ft. °F hr/Btu]*
U_{pre}	=	*1 / R_{pre} = 1 / 12 = 0.083 [Btu/hr sq. ft. °F]*
U_{post}	=	*1 / R_{post} = 1 / 20 = 0.05 [Btu/hr sq. ft. °F]*
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 294*

[359] "Energy Conservation Program for Consumer Products: Energy Conservation Standards for Water Heaters", Section V. Analytical Results and Conclusion, subsection C. Lessening of Utility or Performance of Products. Effective 1/20/2004. https://www.federalregister.gov/documents/2001/01/17/01-1081/energy-conservation-program-for-consumer-products-energy-conservation-standards-for-water-heaters.

[360] Baseline storage tank assembly is assumed to have thermal performance of R12, assuming an average tank thickness of 1-2 inches (average 1.5) and an approximate R-value of R-8 per inch.

Table 294. DHW Tank Insulation—Estimated Tank Area[361]

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

T_{tank}	=	*Average tank water temperature [°F]; default = 120°F* [362]
$T_{ambient,annual}$	=	*Average annual ambient temperature [°F] (see Table 295)*
RE	=	*Recovery efficiency; default = 0.98 for electric resistance water heaters*[363]
hours	=	*8,760 hours per year*
3,412	=	*Constant to convert from Btu to kWh*

Demand Savings Algorithms

$$Peak\ Demand\ Savings\ [\Delta kW] = \frac{(U_{pre} - U_{post}) \times A \times (T_{tank} - T_{ambient,seasonal}) \times CF_{S/W}}{RE \times 3{,}412}$$

Equation 77

Where:

$T_{ambient,seasonal}$	=	*Seasonal ambient temperature [°F] (see Table 295)*
$CF_{S/W}$	=	*Seasonal peak coincidence factor*[364] *= 1*

[361] Tank area was obtained from a survey of electric water heater manufacturer data from A.O. Smith and Whirlpool conducted in 2013. Dimensions for each tank size were collected and averaged to determine typical square footage of each size water heater.

[362] 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), supports a default value of 120°F.

[363] Default based on median recovery efficiency of residential water heaters by fuel type in the AHRI database, at http://www.ahrinet.org.

[364] Coincidence factor of 1 assumes that a constant tank temperature is maintained across all hours of the year.

Table 295. DHW Tank Insulation—Ambient Temperature (°F)

Climate zone	Water heater location: unconditioned space[365]			Water heater location: conditioned space[366]		
	Annual	Peak seasonal		Annual	Peak seasonal	
		Summer	Winter		Summer	Winter
Zone 1: Amarillo	65.5	106.0	32.0	71.7~~71.8~~	73.2~~73.9~~	69.7~~69.6~~
Zone 2: Dallas	73.1	108.1	42.0			
Zone 3: Houston	76.3	108.2	46.0			
Zone 4: Corpus Christi	78.4	103.0	55.0			
Zone 5: El Paso	71.8	108.0	41.1			

Deemed Energy Savings Tables

Table 296. DHW Tank Insulation—Energy Savings

Tank volume	Unconditioned					Conditioned
	Amarillo	Dallas	Houston	Corpus Christi	El Paso	All zones
30	83	71	67	63	73	74~~73~~
40	104	89	83	79	92	92
50	108	93	86	82	95	95
60	128	110	103	98	113	114~~113~~
80	144	124	116	110	128	128
120	184	159	148	141	163	163

[365] Average ambient temperatures for unconditioned space were taken from TMY3 data, with a 7°F increase in winter and an 11°F increase in summer based on ASHRAE 152 Heating System and Cooling System Location Temperatures (Garage).

[366] Average ambient temperatures for conditioned space were taken from the 2020 US Energy Information Administration Residential Energy Consumption Survey (RECS), tables hc7.~~8~~9 and hc6.8. Summer and winter indoor temperature averages are weighted by the number of homes. Annual temperature is weighted by the number of days from the ~~average of~~ summer and winter peak months from the Texas peak definition in Volume 1~~weighted by number of days~~.

Deemed Summer Demand Savings Tables

Table 297. DHW Tank Insulation—Summer Peak Demand~~Energy~~ Savings

Tank volume	Unconditioned					Conditioned
	Amarillo	Dallas	Houston	Corpus Christi	El Paso	All zones
30	0.0024	0.0021	0.0021	0.0030	0.0021	0.0081~~0.0080~~
40	0.0030	0.0026	0.0026	0.0037	0.0026	0.0102~~0.0100~~
50	0.0032	0.0027	0.0027	0.0038	0.0027	0.0106~~0.0104~~
60	0.0038	0.0032	0.0032	0.0046	0.0032	0.0126~~0.0124~~
80	0.0042	0.0036	0.0036	0.0051	0.0036	0.0142~~0.0140~~
120	0.0054	0.0046	0.0046	0.0066	0.0046	0.0181~~0.0178~~

Deemed Winter Demand Savings Tables

Table 298. DHW Tank Insulation—Winter Peak Demand~~Energy~~ Savings

Tank volume	Unconditioned					Conditioned
	Amarillo	Dallas	Houston	Corpus Christi	El Paso	All zones
30	0.0153	0.0136	0.0129	0.0113	0.0137	0.0087~~0.0088~~
40	0.0191	0.0170	0.0161	0.0141	0.0172	0.0109~~0.0110~~
50	0.0199	0.0176	0.0167	0.0147	0.0178	0.0113~~0.0114~~
60	0.0236	0.0209	0.0199	0.0175	0.0212	0.0135
80	0.0266	0.0236	0.0224	0.0197	0.0239	0.0152~~0.0153~~
120	0.0340	0.0301	0.0286	0.0251	0.0305	0.0194~~0.0195~~

Claimed Peak Demand Savings

Refer to Volume 1, Section 4.

Additional Calculators and Tools

Not applicable.

Measure Life and Lifetime Savings

The estimated useful life (EUL) is 7 years, as specified in the California Database of Energy Efficiency Resources (DEER) READI tool for EUL ID WtrHt-TankIns-Elec.[367]

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

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
- Water heater location (conditioned, unconditioned)
- Tank volume (30, 40, 50, 60, 80, 120)
- The R-value of the installed tank insulation
- Water heater model number and manufacture date

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.

Document Revision History

Table 299. DHW Tank Insulation—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. Supplemented reference for water heater setpoint temperature.
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	11/2019	TRM v7.0 update. No revision.

TRM version	Date	Description of change
v8.0	10/2020	TRM v8.0 update. Updated ambient temperatures.
v9.0	10/2021	TRM v9.0 update. Updated EUL reference.
v10.0	10/2022	TRM v10.0 update. Updated documentation requirements.
v11.0	10/2023	TRM v11.0 update. Clarified baseline and added deemed savings. Updated documentation requirements.
v12.0	10/2024	TRM v12.0 update. Updated ambient temperatures and deemed savings.

2.4.5 Water Heater Pipe Insulation Measure Overview

TRM Measure ID: R-WH-PI

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 requires the installation of pipe insulation on uninsulated water heater pipes that are served by an electric water heater.

Eligibility Criteria

Water heaters plumbed with heat traps are not eligible to receive incentives for this measure. It is recommended that the installer (or contractor) checks to see if the water heater heat trap works properly before declaring the water heater ineligible.

Water heater pipe insulation is a residential retrofit measure. New construction and retrofits involving the installation of new water heaters are not eligible for this measure, because they must meet current code requirements. To use these deemed savings, the fuel type of the water heater must be electricity.

Baseline Condition

The baseline is assumed to be a typical electric water heater with no heat traps and no insulation on water heater pipes.

High-Efficiency Condition

The efficiency standard requires an insulation thickness R-3. The International Residential Code (IRC) 2018 section N1103.4: Mechanical system piping insulation requires R-3 insulation.

All visible hot water piping must be insulated. Savings are based on a maximum allowable insulation length of 6 feet of piping.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Energy Savings Algorithms

Hot water pipe insulation energy savings are calculated using the following formula:

$$Energy\ Savings\ [\Delta kWh] = \frac{(U_{pre} - U_{post}) \times A \times (T_{pipe} - T_{ambient,annual}) \times hours}{RE \times 3{,}412}$$

Equation 78

Where:

U_{pre} = $\frac{1}{2.03} = 0.49\ {}^{Btu}/_{hr \cdot sq.ft. \cdot °F}$ [368]

U_{post} = $\frac{1}{2.03 + R_{Insulation}}\ {}^{Btu}/_{hr \cdot sq.ft. \cdot °F}$

$R_{Insulation}$ = *R-value of installed insulation*

A = *Pipe surface area insulated in square feet* (πDL) *with L (length) and D (pipe diameter) in feet. The maximum length allowable for insulation is 6 feet; if the pipe area is unknown, use the following table.*

Table 300. DHW Pipe Insulation—Estimated Pipe Surface Area

Nominal pipe diameter (inches)	Outside pipe diameter (inches)	Pipe surface area (square feet)[369]
0.5	0.625	0.16 x required input "Pipe Length insulated (feet)"
0.75	0.875	0.23 x required input "Pipe Length insulated (feet)"
1.0	1.125	0.29 x required input "Pipe Length insulated (feet)"

T_{pipe} = *Average pipe water temperature [°F]; default*[370] *= 120*

[368] 2.03 is the R-value representing the film coefficients between water and the inside of the pipe, and between the surface and air. Mark's Standard Handbook for Mechanical Engineers, 8th edition.

[369] Factors used in the calculation for pipe area were determined by using the outside diameter of the pipe in inches, converting it to feet, and multiplying by π.

[370] 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 102.
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.

$T_{ambient,annual}$	=	*Average annual ambient temperature [°F] (see Table 301)*
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.*[371]
hours	=	*8,760 hours per year*

Demand Savings Algorithms

$$Peak\ Demand\ Savings\ [\Delta kW] = \frac{(U_{pre} - U_{post}) \times A \times (T_{pipe} - T_{ambient,seasonal}) \times CF_{S/W}}{RE \times 3{,}412}$$

Equation 79

Where:

$T_{ambient,seasonal}$	=	*Seasonal ambient temperature [°F] (see Table 301)*
$CF_{S/W}$	=	*Seasonal peak coincidence factor*[372] *= 1*

Table 301. DHW Pipe Insulation—Ambient Temperature (°F)

Climate zone	Water heater location: unconditioned space[373]			Water heater location: conditioned space[374]		
	Annual	Peak seasonal		Annual	Peak seasonal	
		Summer	Winter		Summer	Winter
Zone 1: Amarillo	65.5	106.0	32.0	71.7~~71.8~~	73.2~~73.9~~	69.7~~69.6~~
Zone 2: Dallas	73.1	108.1	42.0			
Zone 3: Houston	76.3	108.2	46.0			
Zone 4: Corpus Christi	78.4	103	55.0			
Zone 5: El Paso	71.8	108	41.1			

[371] Default values based on median recovery efficiency of residential water heaters by fuel type in the AHRI database, at http://www.ahrinet.org.

[372] Coincidence factor of 1 assumes that a constant tank and near tank piping temperature is maintained across all hours of the year.

[373] Average ambient temperatures for unconditioned space were taken from TMY3 data, with a 7°F increase in winter and an 11°F increase in summer based on ASHRAE 152 Heating System and Cooling System Location Temperatures (Garage).

[374] Average ambient temperatures for conditioned space were taken from the 2020 US Energy Information Administration Residential Energy Consumption Survey (RECS), tables hc7.~~8~~9 and hc6.8. Summer and winter indoor temperature averages are weighted by the number of homes. Annual temperature is weighted by the number of days from the ~~average of~~ summer and winter peak months from the Texas peak definition in Volume 1~~weighted by number of days~~.

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 13 years, as specified in the California Database of Energy Efficiency Resources (DEER) READI tool for EUL ID WtrHt-WH-PipeIns-Elec.[375]

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
- Water heater location (conditioned, unconditioned)
- The R-value of the installed insulation
- Recovery efficiency (RE) or COP, if available
- Pipe length insulated (feet)
- The pipe surface area insulated in square feet (at least the pipe diameter in inches)

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

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.

Document Revision History

Table 302. DHW Pipe Insulation—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. Supplemented reference for water heater setpoint temperature.
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	11/2019	TRM v7.0 update. No revision.
v8.0	10/2020	TRM v8.0 update. Updated ambient temperatures.
v9.0	10/2021	TRM v9.0 update. Updated EUL reference.
v10.0	10/2022	TRM v10.0 update. Updated documentation requirements.
v11.0	10/2023	TRM v11.0 update. No revision.
v12.0	10/2024	TRM v12.0 update. Updated ambient temperatures.

2.4.6 Faucet Aerators Measure Overview

TRM Measure ID: R-WH-FA

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 involves installing aerators on kitchen and bathroom water faucets as a retrofit measure.

Eligibility Criteria

The savings values are per faucet aerator installed. It is not a requirement that all faucets in a home be treated for the deemed savings to be applicable.

These deemed savings are for residential, retrofit or new construction, and installations of kitchen and bathroom faucet aerators. To be awarded these deemed savings, the fuel type of the water heater must be electricity.

Baseline Condition

The 2.2 gallon per minute (GPM) baseline faucet flow rate is based on the Department of Energy (DOE) maximum flow rate standard.[376] The deemed savings assume that the existing faucet aerators have a minimum flow rate of 2.2 GPM. The US EPA WaterSense specification for faucet aerators is 1.5 GPM.[377]

High-Efficiency Condition

Aerators that have been defaced to make the flow rating illegible are not eligible for replacement. For direct install programs, all aerators removed shall be collected by the contractor and held for possible inspection by the utility until all inspections for invoiced installations have been completed.

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[376] DOE maximum flow rate for faucet aerators. https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=40.

[377] https://www.epa.gov/watersense/bathroom-faucets.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Energy Savings Algorithms

The deemed savings, for any faucet aerator change case using aerators with flow rates of 1.5 GPM or lower, are calculated as follows:

$$Energy\ Savings\ per\ aerator\ [\Delta kWh] = \frac{\rho \times C_P \times (GPM_{Base} - GPM_{Low}) \times N \times t \times 365 \times \left(T_{faucet,avg} - T_{supply,annual}\right)}{FPH \times RE \times 3{,}412}$$

Equation 80

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 = 2.2 gallons per minute*
GPM_{Low}	=	*Post-installation flow rate of aerator, typically 1.5, 1.0, or 0.5 gallons per minute; if unknown, assume 1.5 gallons per minute*
N	=	*Average number of persons per household = 2.83 persons*[378]
t	=	*Average time in minutes of hot water usage per person per day; default = 2.34 min/person/day*[379]
$T_{faucet,avg}$	=	*Average faucet temperature [°F]*[380] *= 88*
$T_{supply,annual}$	=	*Average annual supply water temperature [°F] (see Table 303)*
FPH	=	*Average number of faucets per household = 3.99~~3.87~~ faucets*[381]

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

[379] Cadmus and Opinion Dynamics Evaluation Team, "Memorandum: Showerhead and Faucet Aerator Meter Study." Prepared for Michigan Evaluation Working Group. Derived by taking weighted average of average minutes per person per day specified for kitchens (4.5) and bathrooms (1.6) assuming 1 kitchen aerator and 2.93 bathrooms.

[380] Cadmus and Opinion Dynamics Evaluation Team, "Memorandum: Showerhead and Faucet Aerator Meter Study." Prepared for Michigan Evaluation Working Group. Derived by taking weighted average of average temperature for kitchens (93°F) and bathrooms (86°F) assuming 1 kitchen aerator and 2.93 bathrooms.
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.

[381] Faucets per home assumed to be equal to one per kitchen and each half-bath plus 1.5 per each full bathroom per home. Bathroom counts extracted from the 2020~~2015~~ Residential Energy Consumption Survey (RECS), Table HC2.8 Structural and ~~G~~geographic ~~C~~characteristics of ~~H~~homes in West South-Central ~~R~~region. https://www.eia.gov/consumption/residential/data/2020/.

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.*[382]
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.

$$Peak\ Demand\ Savings\ per\ aerator\ [\Delta kW] = \frac{\rho \times C_P \times (GPM_{Base} - GPM_{Low}) \times N \times t \times (T_{faucet,avg} - T_{supply,seasonal})}{FPH \times RE \times 3{,}412} \times CF_{S/W}$$

Equation 81

Where:

$T_{supply,seasonal}$	=	*Seasonal supply water temperature [°F] (Table 303)*
$CF_{S/W}$	=	*Seasonal peak coincidence factor (Table 304)*

Table 303. Faucet Aerators—Water Mains Temperature (°F)[383]

Climate zone	$T_{supply,avg}$	$T_{supply,seasonal}$	
		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

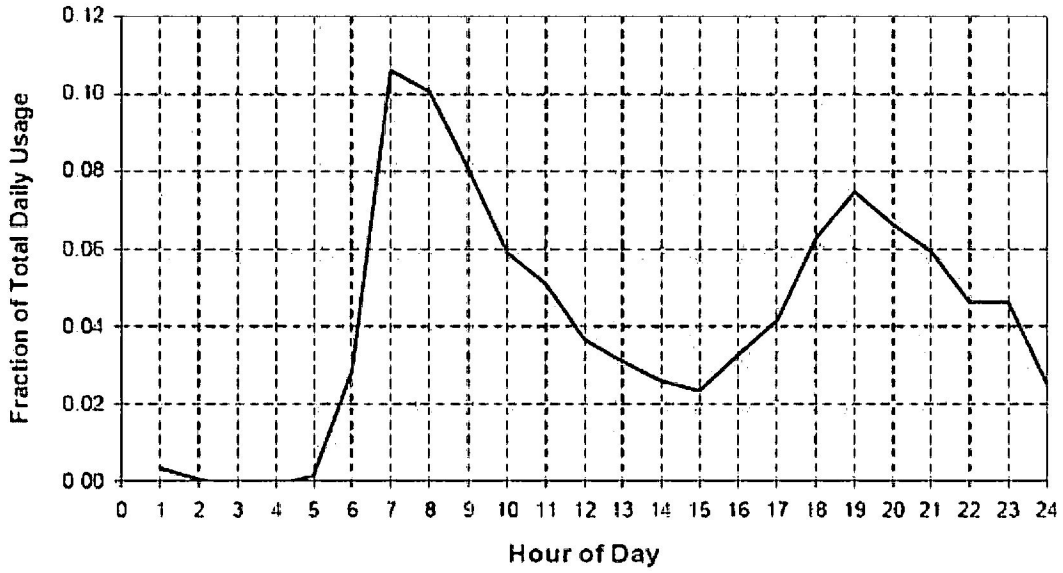
[382] Default values based on median recovery efficiency of residential water heaters by fuel type in the AHRI database, https://www.ahridirectory.org/.

[383] 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 304. Faucet Aerators—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 4. Faucet Aerators—Shower, Bath, and Sink Hot Water Use Profile[384]



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.

[384] 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-Aertr.[385]

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 faucet 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.

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

Document Revision History

Table 305. Faucet Aerators—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	10/30/2015	TRM v3.1 update. 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. 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.
v12.0	10/2024	TRM v12.0 update. Updated number of faucets per home.

2.4.7 Low-Flow Showerheads Measure Overview

TRM Measure ID: R-WH-SH

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 removing existing showerheads and installing low-flow showerheads in residences.

Eligibility Criteria

The incentive is for replacement of an existing showerhead with a new showerhead rated at or below 2.0gallons per minute (GPM). The only showerheads eligible for installation are those that are not easily modified to increase the flow rate.

These deemed savings are for showerheads installed as a retrofit or new construction measure. To be awarded these deemed savings, the fuel type of the water heater must be electricity.

Baseline Condition

Federal standards set a maximum flow rate of 2.5 GPM,[386] while the US Environmental Protection Agency (EPA) WaterSense Program has implemented efficiency standards for showerheads requiring a maximum flow rate of 2.0 GPM.[387]

High-Efficiency Condition

In addition to meeting the baseline requirements above, existing showerheads that have been defaced to make the flow rating illegible are not eligible for replacement. All showerheads removed shall be collected by the contractor and held for possible inspection by the utility until all inspections for invoiced installations have been completed.

[386] http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/37.
[387] http://www.epa.gov/watersense/products/showerheads.html.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Energy Savings Algorithms

Energy savings for this measure are calculated as follows:

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

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*[388]
t	=	*Average time in minutes of hot water usage per person per day; default = 7.8 min/person/day*[389]
$T_{shower,avg}$	=	*Average shower temperature [°F]*[390] *= 101*
$T_{supply,annual}$	=	*Average annual supply water temperature [°F] (see Table 306)*
SPH	=	*Average number of showerheads per household = 1.80~~1.74~~ showerheads*[391]

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

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

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

[391] Showerheads per home assumed to be equal to the number of full bathrooms per home as specified in the 2020~~2009~~ Residential Energy Consumption Survey (RECS), Table HC2.8~~2.10~~ Structural and geographic characteristics of homes in West South-Central region. https://www.eia.gov/consumption/residential/data/2020/.

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*[392]
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)[393]

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

[392] 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 .

[393] 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

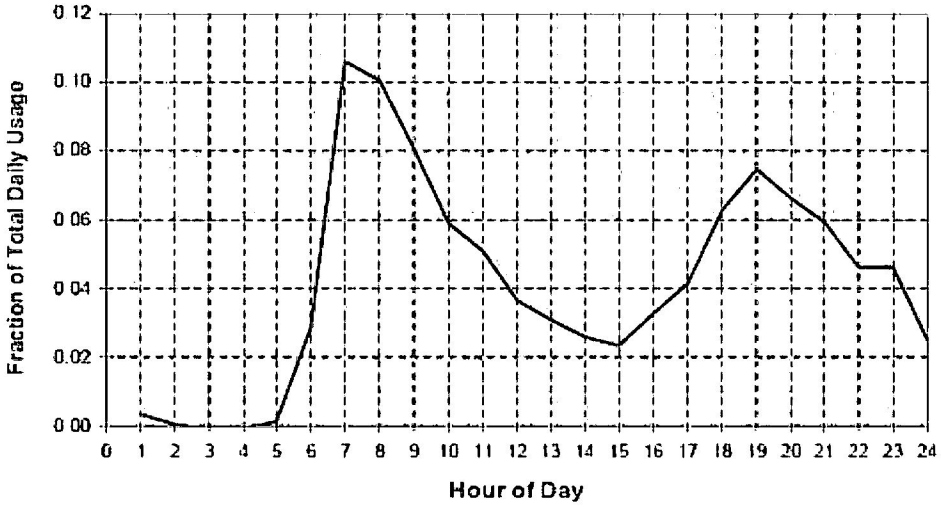


Figure 5. Low-Flow Showerheads—Shower, Bath, and Sink Hot Water Use Profile[394]

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.

[394] 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.[395]

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.

[395] 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.
v12.0	10/2024	TRM v12.0 update. Updated number of showerheads per home.

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)[396] 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.

[396] 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)[397]				0.783
Showers/person/day[398]				0.6
Occupants per home[399]				2.83
Showerheads/home[400]				1.80~~1.72~~
Behavioral waste/showerhead/year (gal)	713	570	499	428
Percent hot water[401]				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:

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

Equation 86

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

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

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

[400] Showerheads per home assumed to be equal to the number of full bathrooms per home. Bathroom counts extracted from the 2020~~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/2020/~~https://www.eia.gov/consumption/residential/data/2015/#structural~~.

[401] "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][402] = 120*
$T_{supply,annual}$	=	*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)*

[402] 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.

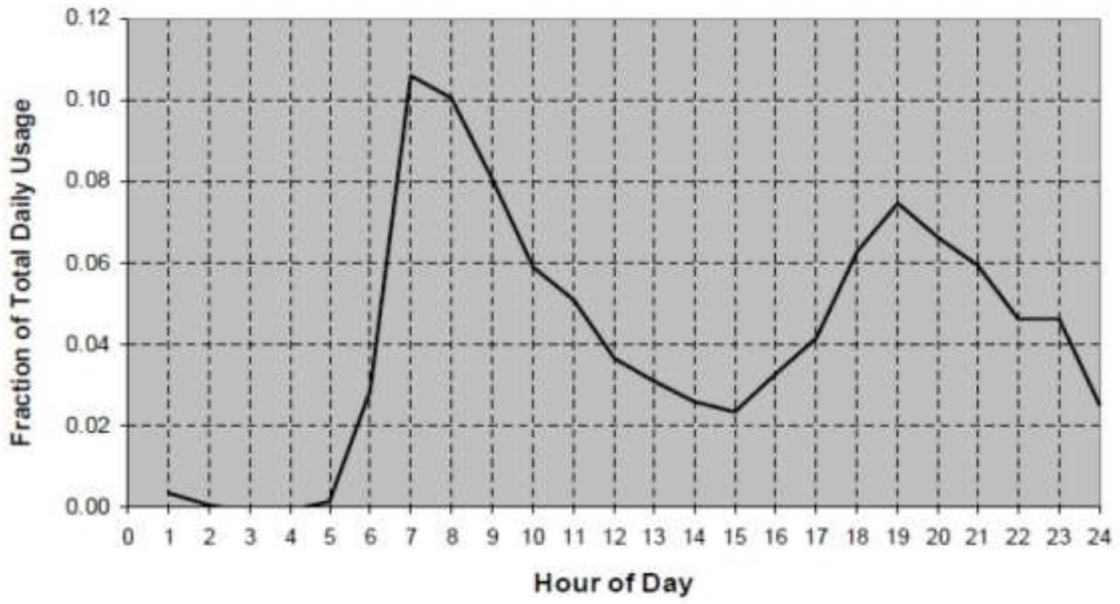
Table 310. Showerhead TSRVs—Water Mains Temperature (°F)[403]

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[404]



Source: Building America Performance Analysis Procedures for Existing Homes.

[403] 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.

[404] 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.[405]

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.

[405] 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.
v12.0	10/2024	TRM v12.0 update. Updated number of showerheads per home.

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) [406] 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.

[406] 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)[407]	–	5.0		–
Percent of warm-up events[408]	60%	40%		–
Average behavioral waste (minutes per shower)[409]		0.783		–
Average diverter leakage rate (GPM)[410]		–	0.80	–
Average shower time (minutes per shower)[411]		–	7.8	–
Showers/person/day[412]				0.60
Occupants/home[413]				2.83
Showerheads/home[414]				1.80~~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

[407] Assumption from (Sherman 2015) Calculating Savings For: Auto-Diverting Tub Spout System with ShowerStart TSV.
[408] Percent of warm-up events from (Sherman 2014) Disaggregating Residential Shower Warm-Up Waste (Appendix B, Question 8).
[409] 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.
[410] Average diverter leak rate from (Taitem 2011) Taitem Tech Tip – Leaking Shower Diverters.
[411] Cadmus and Opinion Dynamics Evaluation Team, "Memorandum: Showerhead and Faucet Aerator Meter Study". Prepared for Michigan Evaluation Working Group.
[412] Derivation of value for showers per person per day defined in the Low Flow Showerhead measure.
[413] 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.
[414] Showerheads per home assumed to be equal to the number of full bathrooms per home, taken from 2020~~2015~~ RECS, Table HC2.8. https://www.eia.gov/consumption/residential/data/2020/~~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 (2.0 GPM)	342			3,185
Gallons behavioral waste per tub spout/showerhead per year (2.5 GPM)	428			3,270
Percentage hot water[415]	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:

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

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 [416] [°F] = 120*

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

[415] 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.

[416] 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.

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 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)[417]

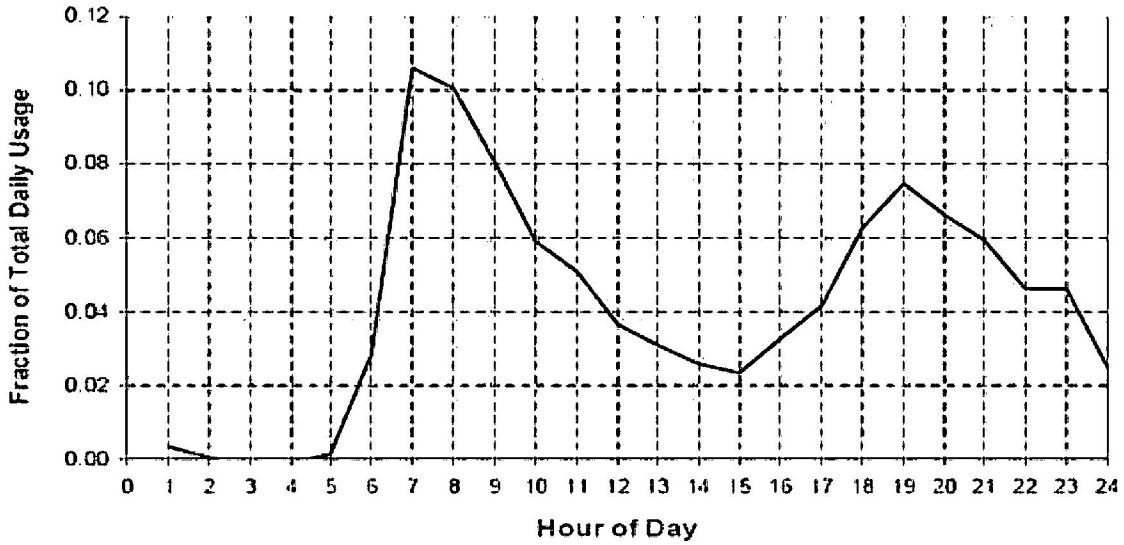
Climate zone	$T_{SupplyAverage}$	$T_{SupplySeasonal}$	
		Summer	Winter
Zone 1: Amarillo	62.9	73.8	53.7
Zone 2: Dallas	71.8	84.0	60.6
Zone 3: Houston	74.7	84.5	65.5
Zone 4: Corpus Christi	77.2	86.1	68.5
Zone 5: El Paso	70.4	81.5	60.4

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

[417] 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[418]



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.

[418] 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.[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
- 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.
v12.0	10/2024	TRM v12.0 update. Updated number of showerheads per home.

[419] 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[420]

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*[421] *(Btu/Hr·°F·ft²)*

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

T_{post} = *Water heater setpoint [°F]*[422] *= 120*

8,760 = *Total hours per year*

RE = *Recovery efficiency of electric hot water heater = 0.98*[423]

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

[420] Texas TRM Vol 2, 2.4.4 Water Heater Tank Insulation, Table 317.
[421] If unknown, assume R-5 (U = 1/5).
[422] 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.
[423] 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[424].

[424] 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.
v12.0	10/2024	TRM v12.0 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.[425] Energy efficiency service providers are expected to comply with the latest ENERGY STAR requirements.

[425] 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.[426] Default values were taken directly from the ENERGY STAR Ceiling Fan Savings Calculator, unless otherwise specified.

[426] 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*[427]
$W_{Lgt,baseline}$	=	*Conventional lighting total wattage = 58 W (160 W default value from ENERGY STAR calculator reduced to comply with EISA 2007 45 lumens/watt backstop)*[428]
$W_{Lgt,ES}$	=	*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*

[427] The assumed energy interactive effects factors are taken from the residential lighting measure.
[428] 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)*[429]

AOH_{Fan} = *Annual fan operating hours = 1,095 hours/year (assuming 3.0 hours/day and 365 days/year operation)*[430]

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

Table 322. Ceiling Fans—Interactive Effects Factor for Cooling Energy Savings and Heating Energy Penalties[431]

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[432]	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

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

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

[431] 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: $1 + HVAC_{savings}/Lighting_{savings}$.

[432] 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*[433]

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

Table 325. Ceiling Fans—Lighting Coincidence Factors[434]

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[435]

$IEF_{D,S}$					
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[436]	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[437]	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

[434] See Volume 1, Section 4.
[435] See Table 322.
[436] 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.
[437] 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.[438]

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.

[438] 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.
v12.0	10/2024	TRM v12.0 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[439] 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.

The DOE has published a Federal Register notice of Direct Final Rule pertaining to energy conservation standards for residential clothes washers, effective July 15, 2024.[440] This standard will transition the efficiency metric from IMEF to EER. However, compliance is not required until March 1, 2028.

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

[440] New DOE final rule. https://www.energy.gov/eere/buildings/consumer-clothes-washers.

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

~~**Table 331. Clothes Washers—Federal Standard**~~

~~Product type~~	~~Current criteria as of July 15, 2024~~
~~Top-loading, standard (1.6 ft^3 or greater capacity)~~	~~EER ≥ 4.27~~ ~~WER ≥ 0.57~~
~~Top-loading, compact (less than 1.6 ft^3 capacity)~~	~~EER ≥ 3.79~~ ~~WER ≥ 0.29~~

High-Efficiency Condition

Eligible equipment must be compliant with the current~~The table below displays the~~ ENERGY STAR ~~Final Version~~ v8.1 specification~~Requirements for eligible clothes washers~~, effective February 5, 2018.[441] Qualified products must meet the minimum requirements from Table 332~~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

[441] ENERGY STAR Program Requirements Product Specification for Clothes Washers ~~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.

Energy savings for this measure were derived using the ENERGY STAR Appliance Savings Calculator found on the ENERGY STAR website.[442] 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

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)* [443]*, 163 kWh/year top-loading, compact)*
LPY	=	*Loads per year = 295*

[442] 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.

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

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 ft^3 (top-loading, standard), 2.1 ft^3 (top-loading, compact)*
$IMEF_{FS}$	=	*Federal standard integrated modified energy factor (Table 331)*
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[444]

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* [445,446]

444 This value is taken from the ENERGY STAR appliance calculator and corresponds with the ENERGY STAR specification after March 7, 2015.

445 Weighted average of Consumer Reports Cycle Times for Top and Front-Loading Clothes Washers.

446 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.

Table 334. Clothes Washers—Coincidence Factors[447]

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

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

[447] See Volume 1, Section 4.

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					
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.[448]

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.

[448] 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.

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.
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.
v12.0	10/2024	TRM v12.0 update. Clarified upcoming federal standard. Incorporated latest ENERGY STAR specification.

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[449], 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.

The DOE has published a new final rule effective July 10, 2024.[450] However, compliance is required on and after March 1, 2028.

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

[450] DOE updated federal standard: https://www.energy.gov/eere/buildings/consumer-clothes-dryers.

Table 339. Clothes Dryers—Current 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

~~**Table 339. Clothes Dryers—Updated Federal Standard (As of March 1,2028)**~~

Product type	Average capacity (ft^3)	Minimum CEF levels (lbs/kWh)
~~Vented electric, standard~~	~~≥ 4.4~~	~~3.73~~
~~Vented electric, compact (120 V)~~	~~< 4.4~~	~~3.61~~
~~Vented electric, compact (240 V)~~	~~< 4.4~~	~~3.27~~
~~Ventless electric, compact (240 V)~~	~~< 4.4~~	~~2.55~~

High-Efficiency Condition

The table below displays the ENERGY STAR Final Version 1.1 Requirements for eligible clothes dryers effective January 1, 2015.[451] Energy efficiency service providers are expected to comply with the latest ENERGY STAR requirements.

Table 340. Clothes Dryers—ENERGY STAR Requirements

Product type	Heat Type	Average Capacity (ft3)	Minimum CEF levels (lbs/kWh)	Average CEF from QPL[452]
ENERGY STAR ventless or vented electric, standard	Electric	≥ 4.4	3.93	4.01
ENERGY STAR ventless or vented electric, compact (120 V)		< 4.4	3.80	3.80
ENERGY STAR vented electric, compact (240 V)		< 4.4	3.45	3.45
ENERGY STAR ventless electric, compact (240 V)		< 4.4	2.68	2.68
ENERGY STAR ventless or vented electric, standard	Heat Pump	≥ 4.4	3.93	8.65
ENERGY STAR ventless or vented electric, compact (120 V)		< 4.4	3.80	6.37
ENERGY STAR ventless~~ed~~ electric, compact (240 V)		< 4.4	3.45	4.97

[451] 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.

[452] ENERGY STAR Clothes Dryers Qualified Product Listing (QPL). https://www.energystar.gov/productfinder/product/certified-clothes-dryers/results.

ENERGY STAR ventless or vented electric, standard~~compact (240 V)~~	Hybrid Heat Pump	< 4.4	3.93	5.11

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.[453] 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.

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)*

[453] 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.

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*[454]

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

Table 342. Clothes Dryers—Coincidence Factors[455]

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	Heat Type	Average capacity (ft^3)	Energy savings (kWh)
Ventless or vented electric, standard	Electric	≥ 4.4	172~~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

[454] 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.

[455] See Volume 1, Section 4.

Product type	Heat Type	Average capacity (ft^3)	Energy savings (kWh)
Ventless or vented electric, standard	Heat Pump	≥ 4.4	492
Ventless or vented electric, compact (120 V)		< 4.4	149
Ventless electric, compact (240 V)		< 4.4	140
Ventless or vented electric standard	Hybrid Heat Pump	< 4.4	301

Deemed Summer Demand Savings Tables

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

Product type	Heat 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	Electric	≥ 4.4	0.0242	0.0242	0.0242	0.0242	0.0253
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
Ventless or vented electric, standard	Heat Pump	≥ 4.4	0.067	0.067	0.067	0.068	0.070
Ventless or vented electric, compact (120 V)		< 4.4	0.020	0.020	0.020	0.020	0.021
Ventless electric, compact (240 V)		< 4.4	0.019	0.019	0.019	0.019	0.020
Ventless or vented electric standard	Hybrid Heat Pump	< 4.4	0.041	0.041	0.041	0.041	0.043

Deemed Winter Demand Savings Tables

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

Product type	Heat 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	Electric	≥ 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
Ventless or vented electric, standard	Heat Pump	≥ 4.4	0.074	0.075	0.068	0.080	0.078
Ventless or vented electric, compact (120 V)		< 4.4	0.023	0.023	0.021	0.024	0.024
Ventless electric, compact (240 V)		< 4.4	0.021	0.021	0.020	0.023	0.022
Ventless or vented electric standard	Hybrid Heat Pump	< 4.4	0.046	0.046	0.042	0.049	0.048

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.[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
- Manufacturer and model number
- Type of unit (vented or ventless)
- Capacity (≥ 4.4 ft^3/standard or < 4.4 ft^3/compact)
- Heating type (electric, heat pump, hybrid heat pump)
- Proof of purchase – including date of purchase and quantity
    - Alternative: photo of unit installed or another pre-approved method of installation verification

References and Efficiency Standards

Petitions and Rulings

Not applicable.

Relevant Standards and Reference Sources

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

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

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.
v12.0	10/2024	TRM v12.0 update. Clarified upcoming federal standard. Added heat pump dryer savings tier.

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[457] 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

The DOE issued an updated direct final rule effective August 22, 2024. However, compliance with the amended federal standard is not required until April 23, 2027.[458] The baseline will be updated at that time to reflect the current federal standard.

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

[458] DOE minimum efficiency standard for residential dishwashers. https://www.regulations.gov/document/EERE-2019-BT-STD-0039-0065.

~~Table 347. Dishwashers—Federal Standard~~

~~Product type~~	~~Annual energy use (kWh/year)~~	~~Water consumption (gallons/cycle)~~
~~Standard (≥ 8 place settings)~~	~~≤ 223~~	~~≤ 3.3~~
~~Compact (< 8 place settings)~~	~~≤ 174~~	~~≤ 3.1~~

High-Efficiency Condition

The following table displays the ENERGY STAR Final Version 7.0~~6.0~~ Requirements for eligible dishwashers effective July 19, 2023~~January 29, 2016~~.[459] 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)	≤ 240~~270~~	≤ 3.2~~3.5~~
Compact (< 8 place settings + 6 serving pieces)	≤ 155~~203~~	≤ 2.0~~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.[460] 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

[459] ENERGY STAR Dishwashers Final Version 7.0~~6.0~~ Program Requirements. https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Version%207.0%20Residential%20Dishwasher%20Final%20Specification.pdf.~~https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Residential%20Dishwasher%20Version%206.0%20Final%20Program%20Requirements.pdf.~~

[460] 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.

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

Equation 124

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

Equation 125

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

Equation 126

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

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*[461]

Table 349. Dishwashers—Coincidence Factors[462]

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	67~~37~~	29~~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	0.00~~63~~	0.00~~63~~	0.00~~63~~	0.00~~63~~	0.00~~63~~
	Gas	0.00~~32~~	0.00~~31~~	0.00~~32~~	0.00~~31~~	0.00~~32~~
Compact	Electric	0.00~~62~~	0.00~~62~~	0.00~~62~~	0.00~~62~~	0.00~~62~~
	Gas	0.00~~31~~	0.00~~31~~	0.00~~31~~	0.00~~31~~	0.00~~31~~

[461] Average of consumer reports cycle times for dishwashers.
[462] See Volume 1, Section 4.

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	0.01609	0.01509	0.01307	0.01709	0.0191
	Gas	0.0074	0.0074	0.0063	0.0074	0.0085
Compact	Electric	0.01604	0.01504	0.01304	0.01705	0.01905
	Gas	0.0072	0.0072	0.0062	0.0072	0.0082

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.[463]

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

[463] 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.

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 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.
v12.0	10/2024	TRM v12.0 update. Clarified upcoming federal standard. Incorporated latest ENERGY STAR specification.

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[464] for refrigerators, effective September 15, 2014.

The DOE issued an updated direct final rule effective June 13, 2024. However, compliance with the new amended standard is not required until either January 31, 2029 or January 31, 2030 depending on product class.[465] The baseline will be updated at that time to reflect the current federal standard.

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

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

For early retirement, the baseline for 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.[466] 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.[467] 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)

[466] 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.

[467] 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[468]

Product number	Product class	Baseline energy usage federal standard as of September 15, 2014 (kWh/year)[469]	Average ENERGY STAR energy usage (kWh/year)[470]	Adjusted volume[471] (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

[468] Federal standard for refrigerators and freezers. https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=37&action=viewlive. Select product classes excluded.
[469] http://www.gpo.gov/fdsys/pkg/CFR-2012-title10-vol3/pdf/CFR-2012-title10-vol3-sec430-32.pdf.
[470] 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.
[471] 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[472]

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

Early Retirement

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

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

[472] See Volume 1, Section 4.

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

Where:

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

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

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

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

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

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

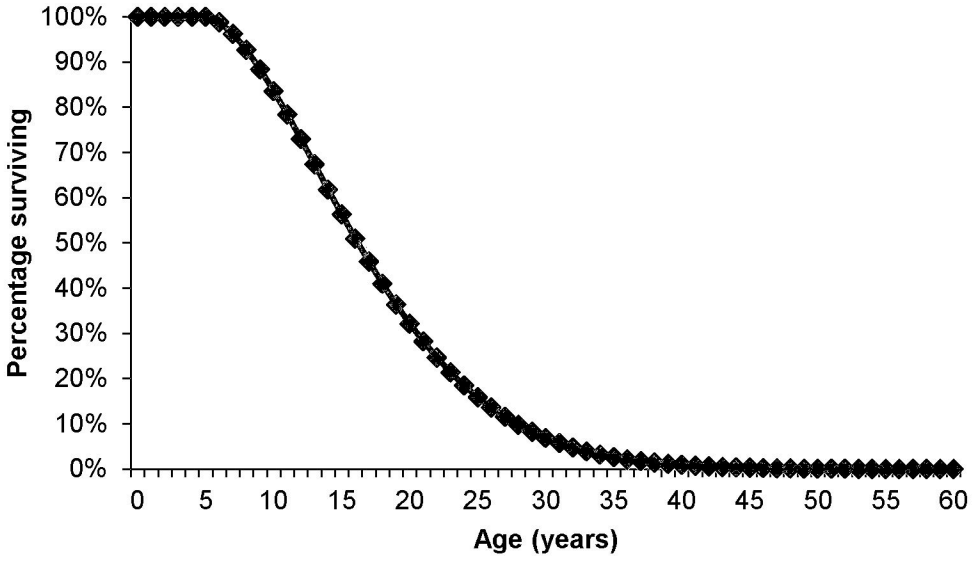
[475] RULs are capped at the 75th percentile of equipment age as determined based on DOE survival curves (see Figure 8). Systems older than this age should use the ROB baseline. See the January 2015 memo, "Considerations for early replacement of residential equipment," for further detail.

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

Derivation of RULs

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

Figure 8. Refrigerators—Survival Function[477]



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

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

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

Energy Savings Algorithms

For the RUL time period:

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

Equation 133

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

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

Equation 134

Where:

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

Demand Savings Algorithms

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

For the RUL time period:

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

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

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

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

Deemed Energy Savings Tables

Table 358. Refrigerators—Energy Savings (kWh)

Through-the-door ice?	Door type	Product class	ROB savings (kWh/year)	ER savings (kWh/year)
No	Top freezer	3: Refrigerator freezers—automatic defrost with a top-mounted freezer without an automatic icemaker	37	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[479]			44	205

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

Deemed Summer Demand Savings Tables

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

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

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

Through-the-door ice?	Door type	Product class	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
No	Top freezer	3: Refrigerator freezers—automatic defrost with top-mounted freezer without an automatic icemaker	0.028	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.[480]

Program Tracking Data and Evaluation Requirements

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

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

References and Efficiency Standards

Petitions and Rulings

Not applicable.

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

Relevant Standards and Reference Sources

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

Document Revision History

Table 363. Refrigerators—Revision History

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

2.5.6 ENERGY STAR® Freezers Measure Overview

TRM Measure ID: R-AP-FZ

Market Sector: Residential

Measure Category: Appliances

Applicable Building Types: Single-family, multifamily, manufactured

Fuels Affected: Electricity

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

Program Delivery Type(s): Prescriptive

Deemed Savings Type: Deemed savings calculation

Savings Methodology: Engineering algorithms and estimates

Measure Description

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

Eligibility Criteria

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

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

Baseline Condition

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

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

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

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

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

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

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

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

Equation 137

Where:

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

High-Efficiency Condition

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

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

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

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

Table 364. Freezers—ENERGY STAR Requirements

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

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

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

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

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

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

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

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

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

New Construction or Replace-on-Burnout

Energy Savings Algorithms

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

Equation 138

Where:

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

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

Demand Savings Algorithms

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

Equation 139

Where:

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

Table 366. Freezers—Coincidence Factors[491]

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

Early Retirement

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

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

[491] See Volume 1, Section 4.

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

Where:

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

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

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

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

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

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

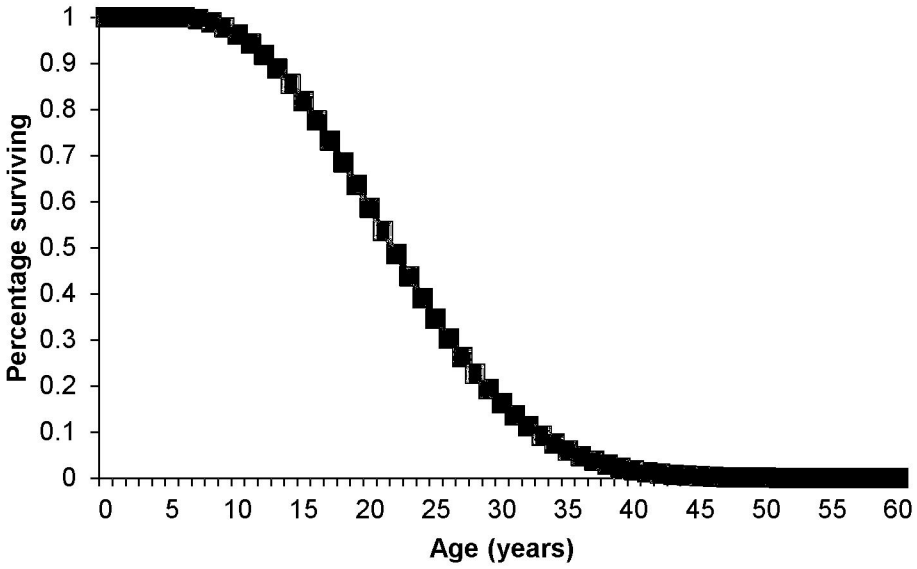
[494] RULs are capped at the 75th percentile of equipment age as determined based on DOE survival curves (see Figure 8). Systems older than this age should use the ROB baseline. See the January 2015 memo, "Considerations for early replacement of residential equipment," for further detail.

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

Derivation of RULs

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

Figure 9. Freezers—Survival Function[496]



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

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

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