

Table 294. DHW Tank Insulation—Ambient Temperature (°F)

Climate zone	Water heater location: unconditioned space ³⁵⁵			Water heater location: conditioned space ³⁵⁶		
	Annual	Peak seasonal		Annual	Peak seasonal	
		Summer	Winter		Summer	Winter
Zone 1: Amarillo	65.5	106.0	32.0	71.7	73.2	69.7
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 295. 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
40	104	89	83	79	92	92
50	108	93	86	82	95	95
60	128	110	103	98	113	114
80	144	124	116	110	128	128
120	184	159	148	141	163	163

Deemed Summer Demand Savings Tables

Table 296. DHW Tank Insulation—Summer Peak Demand 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
40	0.0030	0.0026	0.0026	0.0037	0.0026	0.0102

³⁵⁵ 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).

³⁵⁶ Average ambient temperatures for conditioned space were taken from the 2020 US Energy Information Administration Residential Energy Consumption Survey (RECS), tables hc7.8 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 summer and winter peak months from the Texas peak definition in Volume 1.

Tank volume	Unconditioned					Conditioned
	Amarillo	Dallas	Houston	Corpus Christi	El Paso	All zones
50	0.0032	0.0027	0.0027	0.0038	0.0027	0.0106
60	0.0038	0.0032	0.0032	0.0046	0.0032	0.0126
80	0.0042	0.0036	0.0036	0.0051	0.0036	0.0142
120	0.0054	0.0046	0.0046	0.0066	0.0046	0.0181

Deemed Winter Demand Savings Tables

Table 297. DHW Tank Insulation—Winter Peak Demand 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
40	0.0191	0.0170	0.0161	0.0141	0.0172	0.0109
50	0.0199	0.0176	0.0167	0.0147	0.0178	0.0113
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
120	0.0340	0.0301	0.0286	0.0251	0.0305	0.0194

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.³⁵⁷

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)

³⁵⁷ DEER READI (Remote Ex-Ante Database Interface). <http://www.deeresources.com/index.php/readi>.

- 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 298. 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.
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:

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

Equation 78

Where:

$$U_{pre} = \frac{1}{2.03} = 0.49 \text{ Btu/hr} \cdot \text{sq. ft.} \cdot \text{°F}^{358}$$

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

$$R_{insulation} = \text{R-value of installed insulation}$$

$$A = \text{Pipe surface area insulated in square feet } (\pi DL) \text{ with } L \text{ (length) and } D \text{ (pipe diameter) in feet. The maximum length allowable for insulation is 6 feet; if the pipe area is unknown, use the following table.}$$

Table 299. DHW Pipe Insulation—Estimated Pipe Surface Area

Nominal pipe diameter (inches)	Outside pipe diameter (inches)	Pipe surface area (square feet) ³⁵⁹
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)"

³⁵⁸ 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.

³⁵⁹ 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 .

T_{pipe}	=	Average pipe water temperature [°F]; default ³⁶⁰ = 120
$T_{ambient,annual}$	=	Average annual ambient temperature [°F] (see Table 300)
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. ³⁶¹
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 300)
$CF_{S/W}$	=	Seasonal peak coincidence factor ³⁶² = 1

Table 300. DHW Pipe Insulation—Ambient Temperature (°F)

Climate zone	Water heater location: unconditioned space ³⁶³			Water heater location: conditioned space ³⁶⁴		
	Annual	Peak seasonal		Annual	Peak seasonal	
		Summer	Winter		Summer	Winter
Zone 1: Amarillo	65.5	106.0	32.0	71.7	73.2	69.7
Zone 2: Dallas	73.1	108.1	42.0			
Zone 3: Houston	76.3	108.2	46.0			

³⁶⁰ 120°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.

³⁶¹ Default values based on median recovery efficiency of residential water heaters by fuel type in the AHRI database, at <http://www.ahrinet.org>.

³⁶² Coincidence factor of 1 assumes that a constant tank and near tank piping temperature is maintained across all hours of the year.

³⁶³ 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).

³⁶⁴ Average ambient temperatures for conditioned space were taken from the 2020 US Energy Information Administration Residential Energy Consumption Survey (RECS), tables hc7.8 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 summer and winter peak months from the Texas peak definition in Volume 1.

Climate zone	Water heater location: unconditioned space ³⁶³			Water heater location: conditioned space ³⁶⁴		
	Annual	Peak seasonal		Annual	Peak seasonal	
		Summer	Winter		Summer	Winter
Zone 4: Corpus Christi	78.4	103	55.0			
Zone 5: El Paso	71.8	108	41.1			

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.³⁶⁵

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

³⁶⁵ DEER READI (Remote Ex-Ante Database Interface). <http://www.deeresources.com/index.php/readi>.

- 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)

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 301. 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.³⁶⁶ 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.³⁶⁷

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.

³⁶⁶ DOE maximum flow rate for faucet aerators.

https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=40.

³⁶⁷ <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:

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

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 ³⁶⁸
t	=	Average time in minutes of hot water usage per person per day; default = 2.34 min/person/day ³⁶⁹
$T_{faucet,avg}$	=	Average faucet temperature [°F] ³⁷⁰ = 88
$T_{supply,annual}$	=	Average annual supply water temperature [°F] (see Table 302)
FPH	=	Average number of faucets per household = 3.99 faucets ³⁷¹

³⁶⁸ Occupants per home for Texas from US Census Bureau, "Persons Per Household, 2016-2020". <https://www.census.gov/quickfacts/fact/table/TX,US/PST045221>.

³⁶⁹ 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.

³⁷⁰ 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.

³⁷¹ 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 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/>.

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.³⁷²

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 [ΔkW]

$$= \frac{\rho \times C_P \times (GPM_{Base} - GPM_{Low}) \times N \times t \times (T_{faucet,avg} - T_{supply,seasonal})}{FPH \times RE \times 3,412} \times CF_{S/W}$$

Equation 81

Where:

$T_{supply,seasonal}$ = Seasonal supply water temperature [$^{\circ}F$] (Table 302)

$CF_{S/W}$ = Seasonal peak coincidence factor (Table 303)

Table 302. Faucet Aerators—Water Mains Temperature ($^{\circ}F$)³⁷³

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

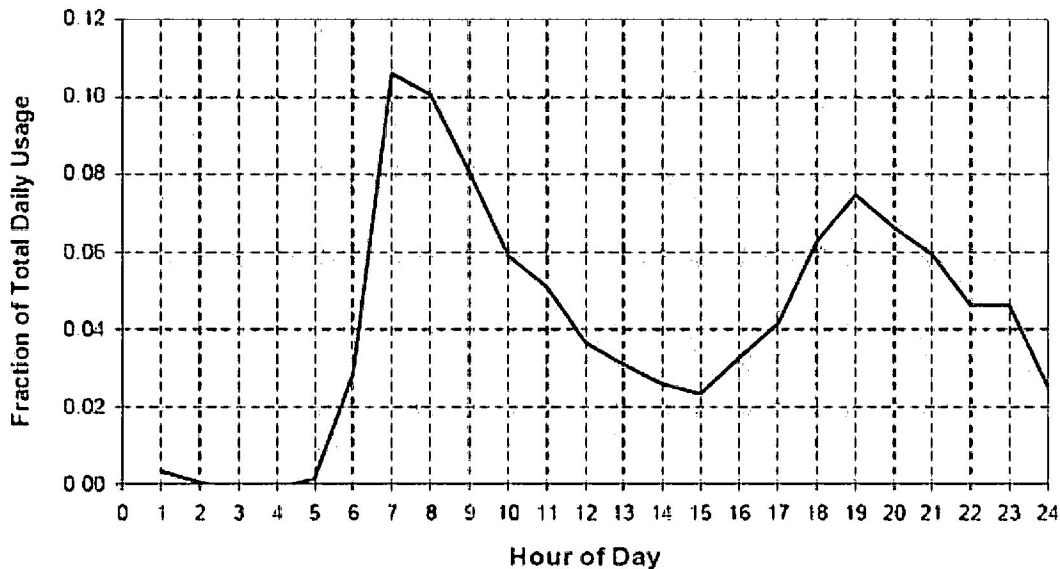
³⁷² Default values based on median recovery efficiency of residential water heaters by fuel type in the AHRI database, <https://www.ahridirectory.org/>.

³⁷³ 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 303. 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 3. Faucet Aerators—Shower, Bath, and Sink Hot Water Use Profile³⁷⁴



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.

³⁷⁴ 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.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
- 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.

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

Document Revision History

Table 304. 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 2.0 gallons 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,³⁷⁶ while the US Environmental Protection Agency (EPA) WaterSense Program has implemented efficiency standards for showerheads requiring a maximum flow rate of 2.0 GPM.³⁷⁷

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.

³⁷⁶ http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/37.

³⁷⁷ <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:

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

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 ³⁷⁸
t	=	Average time in minutes of hot water usage per person per day; default = 7.8 min/person/day ³⁷⁹
$T_{shower,avg}$	=	Average shower temperature [°F] ³⁸⁰ = 101
$T_{supply,annual}$	=	Average annual supply water temperature [°F] (see Table 305)
SPH	=	Average number of showerheads per household = 1.80 showerheads 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.

³⁸⁰ Cadmus and Opinion Dynamics Evaluation Team, "Memorandum: Showerhead and Faucet Aerator Meter Study." Prepared for Michigan Evaluation Working Group.

³⁸¹ Showerheads per home assumed to be equal to the number of full bathrooms per home as specified in the 2020 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/>.

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 heaters³⁸²

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.

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

Equation 83

Where:

T_{supply,seasonal} = Seasonal supply water temperature [°F] (see Table 305)

CF_{S/W} = Seasonal peak coincidence factor (see Table 306)

Table 305. Low-Flow Showerheads—Water Mains Temperature (°F)³⁸³

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

³⁸² 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.

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 306. 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

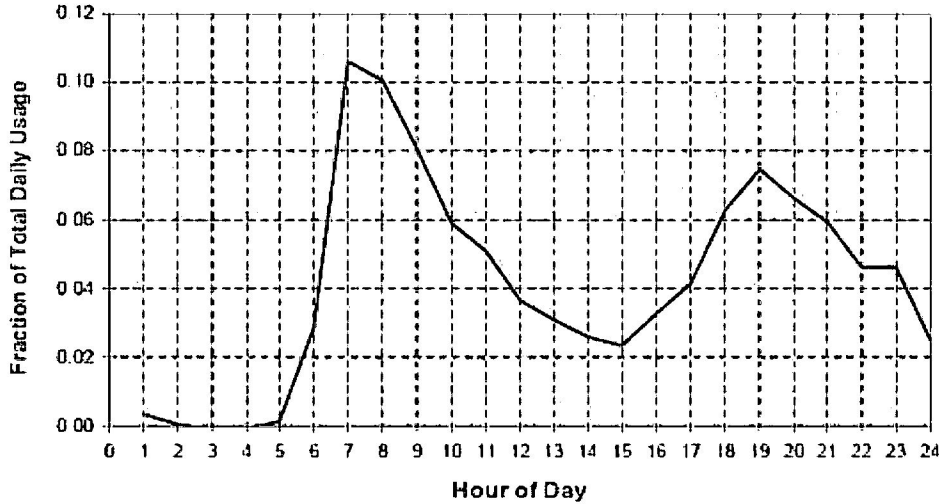


Figure 4. Low-Flow Showerheads—Shower, Bath, and Sink Hot Water Use Profile³⁸⁴

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.

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-Shrhd.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 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.

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

Document Revision History

Table 307. 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)³⁸⁶ 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.

³⁸⁶ 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:

$$\text{Annual Showerhead Behavioral Waste} = SHFR \times BW \times n_s \times 365 \times \frac{n_o}{n_{SH}}$$

Equation 84

Where:

<i>SHFR</i>	=	<i>Showerhead flow rate, gallons per minute [gpm] (see Table 308)</i>
<i>BW</i>	=	<i>Behavioral waste, minutes per shower (see Table 308)</i>
<i>n_s</i>	=	<i>Number of showers per person per day (see Table 308)</i>
<i>365</i>	=	<i>Constant to convert days to years (see Table 308)</i>
<i>n_o</i>	=	<i>Number of occupants per home (see Table 308)</i>
<i>n_{SH}</i>	=	<i>Number of showerheads per home (see Table 308)</i>

Applying the formula to the values from Table 308 returns the following values for baseline behavioral waste in gallons per showerhead per year:

$$\text{Showerhead (2.5 GPM): } 2.5 \times 0.783 \times 0.6 \times 365 \times \frac{2.86}{1.80} = 681 \text{ gal}$$

$$\text{Showerhead (2.0 GPM): } 2.0 \times 0.783 \times 0.6 \times 365 \times \frac{2.86}{1.80} = 545 \text{ gal}$$

$$\text{Showerhead (1.75 GPM): } 1.75 \times 0.783 \times 0.6 \times 365 \times \frac{2.86}{1.80} = 477 \text{ gal}$$

$$\text{Showerhead (1.5 GPM): } 1.5 \times 0.783 \times 0.6 \times 365 \times \frac{2.86}{1.80} = 409 \text{ gal}$$

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 308.

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

Equation 85

Where:

$$\text{HW\%} = \text{Hot water percentage (see Table 308)}$$

$$\text{Gallons of hot water saved per year (2.5 GPM): } 681 \times 0.825 = 562 \text{ gal}$$

$$\text{Gallons of hot water saved per year (2.0 GPM): } 545 \times 0.825 = 450 \text{ gal}$$

$$\text{Gallons of hot water saved per year (1.75 GPM): } 477 \times 0.825 = 393 \text{ gal}$$

$$\text{Gallons of hot water saved per year (1.5 GPM): } 409 \times 0.825 = 337 \text{ gal}$$

Table 308. 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) ³⁸⁷	0.783			
Showers/person/day ³⁸⁸	0.6			
Occupants per home ³⁸⁹	2.83			
Showerheads/home ³⁹⁰	1.80			
Behavioral waste/showerhead/year (gal)	681	545	477	409
Percent hot water ³⁹¹	80-85%, or 82.5% average			
Hot water saved/year (gal)	562	450	393	337

Energy Savings Algorithms

Energy savings for this measure are calculated as follows:

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

Equation 86

³⁸⁷ “Disaggregating Residential Shower Warm-Up Waste”, Sherman, Troy. August 2014. Derived by dividing average behavioral waste time (47 seconds) by 60 seconds.

³⁸⁸ Cadmus and Opinion Dynamics Evaluation Team, “Memorandum: Showerhead and Faucet Aerator Meter Study”. Prepared for Michigan Evaluation Working Group. June 2013.

³⁸⁹ Occupants per home for Texas from US Census Bureau, “Persons per household, 2016-2020”. https://www.census.gov/quickfacts/fact/table/TX_US/PST045221.

³⁹⁰ Showerheads per home assumed to be equal to the number of full bathrooms per home. Bathroom counts extracted from the 2020 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/>.

³⁹¹ “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 308)
$T_{setpoint}$	=	Water heater setpoint temperature [°F] ³⁹² = 120
$T_{supply,annual}$	=	Average annual supply water temperature [°F] (see Table 309)
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.

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

Equation 87

Where:

$T_{supply,seasonal}$	=	Seasonal supply water temperature [°F] (see Table 309)
$CF_{S/W}$	=	Seasonal peak coincidence factor (see Table 310)

³⁹² 120°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.

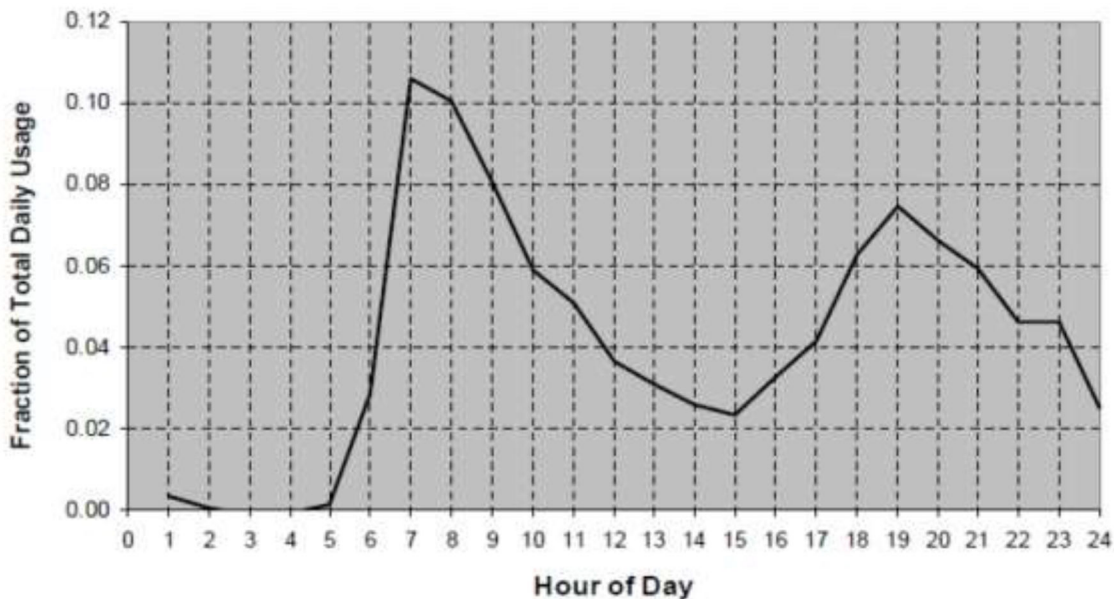
Table 309. Showerhead TSRVs—Water Mains Temperature (°F)³⁹³

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

Table 310. 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 5. Showerhead TSRVs—Shower, Bath, and Sink Hot Water Use Profile³⁹⁴



Source: Building America Performance Analysis Procedures for Existing Homes.

³⁹³ Based on typical meteorological year (TMY) dataset for TMY3 available through the National Solar Radiation Database (NSRDB) Data Viewer. <https://nslrdb.nrel.gov/data-viewer>. Data for Texas climate zones can also be accessed directly here: <https://texasefficiency.com/index.php/regulatory-filings/deemed-savings>.

³⁹⁴ 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.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
- 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.

³⁹⁵ 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 311. 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 and resulting behavioral waste and hot water saved assumptions.

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)³⁹⁶ 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.

³⁹⁶ 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:

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

Equation 88

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

Equation 89

Where:

$\%WUE_{SH}$	=	Showerhead percentage of warm-up events (see Table 312)
$\%WUE_{TS}$	=	Tub spout percentage of warm-up events (see Table 312)
SHFR	=	Showerhead flow rate, gallons per minute [gpm] (see Table 312)
TSFR	=	Tub spout flow rate, gallons per minute [gpm] (see Table 312)
BW	=	Behavioral waste, minutes per shower (see Table 312)
n_S	=	Number of showers per person per day (see Table 312)
365	=	Constant to convert days to years (see Table 312)
n_O	=	Number of occupants per home (see Table 312)
n_{SH}	=	Number of showerheads per home (see Table 312)

Applying the formula to the values from Table 312 returns the following values:

$$\text{Showerhead (1.5 GPM): } 0.6 \times \left(1.5 \times 0.783 \times 0.60 \times 365 \times \frac{2.86}{1.80} \right) = 245$$

$$\text{Showerhead (1.75 GPM): } 0.6 \times \left(1.75 \times 0.783 \times 0.60 \times 365 \times \frac{2.86}{1.80} \right) = 286$$

$$\text{Showerhead (2.0 GPM): } 0.6 \times \left(2.0 \times 0.783 \times 0.60 \times 365 \times \frac{2.86}{1.80} \right) = 327$$

$$\text{Showerhead (2.5 GPM): } 0.6 \times \left(2.5 \times 0.783 \times 0.60 \times 365 \times \frac{2.86}{1.80} \right) = 409$$

$$\text{Tub Spout (5.0 GPM): } 0.4 \times \left(5.0 \times 0.783 \times 0.60 \times 365 \times \frac{2.86}{1.80} \right) = 545$$

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

$$\text{Annual Diverter Waste} = \text{DLR} \times t_s \times n_s \times 365 \frac{\text{days}}{\text{year}} \times \frac{n_o}{n_{SH}}$$

Equation 90

Where:

DLR = Diverter leakage rate [gpm] (see Table 312)

t_s = Shower time (min/shower) (see Table 312)

Applying the formula to the values from Table 312 returns the following values:

$$\text{Diverter (0.8 GPM): } 0.8 \times 7.8 \times 0.60 \times 365 \times \frac{2.86}{1.80} = 2,171$$

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 312.

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

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 312)

*HW%*_D = Diverter hot water percentage (see Table 312)

Applying the formula to the values from Table 312 returns the following values:

$$\text{Total Annual Waste (1.5 gpm): } (245 + 545) \times 0.825 + 2,171 \times 0.737 = 2,252$$

$$\text{Total Annual Waste (1.75 gpm): } (286 + 545) \times 0.825 + 2,171 \times 0.737 = 2,286$$

$$\text{Total Annual Waste (2.0 gpm): } (327 + 545) \times 0.825 + 2,171 \times 0.737 = 2,320$$

$$\text{Total Annual Waste (2.5 gpm): } (409 + 545) \times 0.825 + 2,171 \times 0.737 = 2,387$$

Table 312. 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) ³⁹⁷	–	5.0		–
Percent of warm-up events ³⁹⁸	60%	40%		–
Average behavioral waste (minutes per shower) ³⁹⁹	0.783			–
Average diverter leakage rate (GPM) ⁴⁰⁰		–	0.80	–
Average shower time (minutes per shower) ⁴⁰¹		–	7.8	–
Showers/person/day ⁴⁰²				0.60
Occupants/home ⁴⁰³				2.83
Showersheds/home ⁴⁰⁴				1.80
Gallons behavioral waste. per tub spout/showerhead per year (1.5 GPM)	245	545	2,171	2,961
Gallons behavioral waste per tub spout/showerhead per year (1.75 GPM)	286			3,002
Gallons behavioral waste per tub spout/showerhead per year (2.0 GPM)	327			3,043

³⁹⁷ Assumption from (Sherman 2015) Calculating Savings For: Auto-Diverting Tub Spout System with ShowerStart TSV.

³⁹⁸ Percent of warm-up events from (Sherman 2014) Disaggregating Residential Shower Warm-Up Waste (Appendix B, Question 8).

³⁹⁹ 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.

⁴⁰⁰ Average diverter leak rate from (Taitem 2011) Taitem Tech Tip – Leaking Shower Diverter.

⁴⁰¹ Cadmus and Opinion Dynamics Evaluation Team, “Memorandum: Showerhead and Faucet Aerator Meter Study”. Prepared for Michigan Evaluation Working Group.

⁴⁰² Derivation of value for showers per person per day defined in the Low Flow Showerhead measure.

⁴⁰³ 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>.

⁴⁰⁴ Showerheads per home assumed to be equal to the number of full bathrooms per home, taken from 2020 RECS, Table HC2.8. <https://www.eia.gov/consumption/residential/data/2020/>.

Description	Part 1—Behavioral waste		Part 2—Diverter leakage	Part 3—Total
	SH Warm-up	TS Warm-up		
Gallons behavioral waste per tub spout/showerhead per year (2.5 GPM)	409			3,125
Percentage hot water ⁴⁰⁵	80-85%, or 82.5% average		73.7%	–
Gallons hot water saved per year (1.5 GPM)			–	2,252
Gallons hot water saved per year (1.75 GPM)			–	2,286
Gallons hot water saved per year (2.0 GPM)			–	2,320
Gallons hot water saved per year (2.5 GPM)			–	2,387

Energy Savings Algorithms

Energy savings for this measure are calculated as follows:

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

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 312)
T_{setpoint}	=	Water heater setpoint temperature ⁴⁰⁶ [°F] = 120
$T_{\text{supply,annual}}$	=	Average annual supply water temperature [°F] (see Table 313)
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

⁴⁰⁵ 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.

⁴⁰⁶ 120°F represents the assumed water heater setpoint. New York Department of Public Service recommends using water heater setpoint as a default value, see “New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs” October 2010, page 99. Data collection discussed in Appendix D of the EM&V team’s Annual Statewide Portfolio Report for Program Year 2014-Volume 1, Project Number 40891 (August 2015), also supports a default value of 120°F.

Demand Savings Algorithms

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

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

Equation 93

Where:

$T_{\text{supply,seasonal}}$ = Seasonal supply water temperature [°F] (see Table 313)

$CF_{S/W}$ = Peak coincidence factor (see Table 314)

Table 313. Tub Spout/Showerhead TSRVs—Water Mains Temperature (°F)⁴⁰⁷

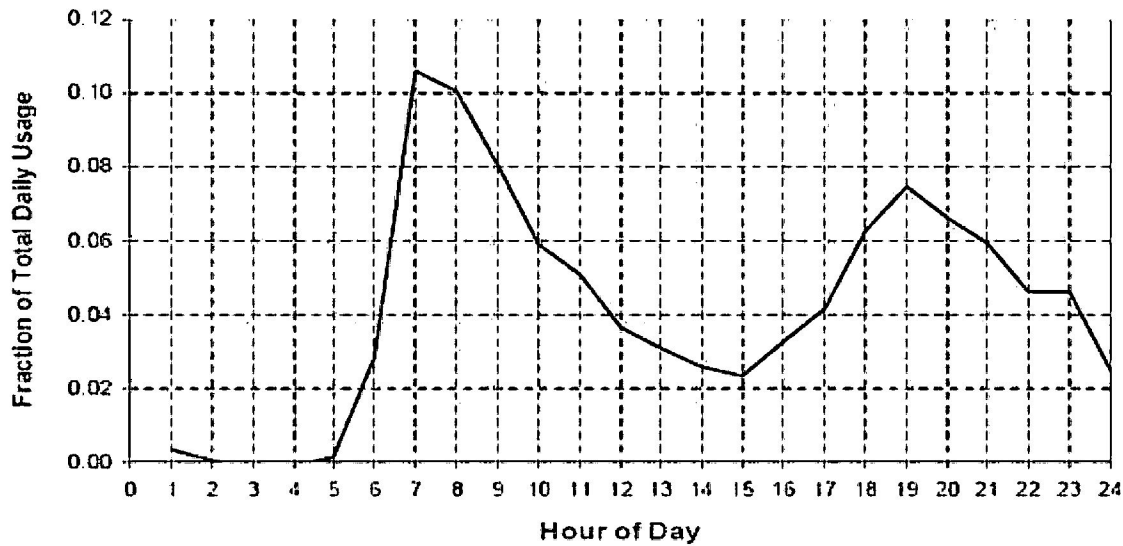
Climate zone	$T_{\text{SupplyAverage}}$	$T_{\text{SupplySeasonal}}$	
		Summer	Winter
Zone 1: Amarillo	62.9	73.8	53.7
Zone 2: Dallas	71.8	84.0	60.6
Zone 3: Houston	74.7	84.5	65.5
Zone 4: Corpus Christi	77.2	86.1	68.5
Zone 5: El Paso	70.4	81.5	60.4

Table 314. 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

⁴⁰⁷ 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 6. Tub Spout/Showerhead TSRVs—Shower, Bath, and Sink Hot Water Use Profile⁴⁰⁸



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.

⁴⁰⁸ 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.⁴⁰⁹

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 315. 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 and resulting behavioral waste and hot water saved assumptions.

⁴⁰⁹ 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

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

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 316

Table 316. DHW Temperature Setback—Estimated Tank Area⁴¹⁰

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 tank⁴¹¹ (Btu/Hr·°F·ft²)

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

T_{post} = Water heater setpoint [°F]⁴¹² = 120

8,760 = Total hours per year

RE = Recovery efficiency of electric hot water heater = 0.98⁴¹³

3,412 = Constant to convert from Btu to kWh

⁴¹⁰ Texas TRM Vol 2, 2.4.4 Water Heater Tank Insulation, Table 316.

⁴¹¹ If unknown, assume R-5 ($U = 1/5$).

⁴¹² 120°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.

⁴¹³ 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

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

Equation 95

Where:

$$CF_s = \text{Summer peak coincidence factor} = 1.0$$

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 years⁴¹⁴.

⁴¹⁴ 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 317. 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, 2018.⁴¹⁵ Energy efficiency service providers are expected to comply with the latest ENERGY STAR requirements.

⁴¹⁵ 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%20Program%20Requirements%200%200.pdf>.

Table 318. 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 319. Ceiling Fans—Efficiency Requirements

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

Table 320. 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.⁴¹⁶ Default values were taken directly from the ENERGY STAR Ceiling Fan Savings Calculator, unless otherwise specified.

⁴¹⁶ ENERGY STAR Ceiling Fan Savings Calculator (updated September 2013).
https://www.energystar.gov/sites/default/files/asset/document/light_fixture_ceiling_fan_calculator.xlsx.

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

Equation 96

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

Equation 97

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

Equation 98

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

Equation 99

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

Equation 100

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

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 321 assuming heating/cooling unknown⁴¹⁷
- $W_{\text{Lgt,baseline}}$ = Conventional lighting total wattage = 58 W (160 W default value from ENERGY STAR calculator reduced to comply with EISA 2007 45 lumens/watt backstop)⁴¹⁸
- $W_{\text{Lgt,ES}}$ = Actual wattage of installed ENERGY STAR lighting; assume one high-efficiency 32 W lamp
- $W_{\text{Fan,baseline}}$ = Conventional fan motor wattage
- $W_{\text{Fan,ES}}$ = ENERGY STAR fan motor wattage
- $W_{\text{LS/MS/HS}}$ = Fan motor wattage at low, medium, and high speed; see Table 322

⁴¹⁷ The assumed energy interactive effects factors are taken from the residential lighting measure.

⁴¹⁸ 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 323
- AOH_{Lgt} = Annual lighting operating hours = 803 hours/year (assuming 2.2 hours/day and 365 days/year operation)⁴¹⁹
- AOH_{Fan} = Annual fan operating hours = 1,095 hours/year (assuming 3.0 hours/day and 365 days/year operation)⁴²⁰
- 1,000 = Constant to convert from W to kW

Table 321. Ceiling Fans—Interactive Effects Factor for Cooling Energy Savings and Heating Energy Penalties⁴²¹

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 ⁴²²	0.88	0.98	1.04	1.07	0.95

Table 322. 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

⁴¹⁹ The assumed annual operating hours are taken from the residential lighting measure.

⁴²⁰ The assumed annual operating hours are taken from the previously cited ENERGY STAR Light Fixture and Ceiling Fan Calculator.

⁴²¹ 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: $1 + \text{HVAC}_{\text{savings}} / \text{Lighting}_{\text{savings}}$.

⁴²² 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 323. 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).

$$Peak\ Demand\ Savings\ [\Delta kW] = kW_{Fan} + kW_{Lgt} \tag{Equation 102}$$

$$kW_{Fan} = \frac{W_{Fan,baseline} - W_{Fan,ES}}{1,000} \times CF_{Fan} \tag{Equation 103}$$

$$kW_{Lgt} = \frac{W_{Lgt,baseline} - W_{Lgt,ES}}{1,000} \times CF_{Lgt,S/W} \times IEF_{D,S/W} \tag{Equation 104}$$

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 324)
- $IEF_{D,S/W}$ = Demand interactive effects factor from Table 325 assuming heating/cooling unknown⁴²³

⁴²³ The assumed demand interactive effects factors are taken from the residential lighting measure.

Table 324. Ceiling Fans—Lighting Coincidence Factors⁴²⁴

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 325. Ceiling Fans—Interactive Effects Factor for Cooling Demand Savings and Heating Demand Penalties⁴²⁵

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 ⁴²⁶	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 ⁴²⁷	0.76	0.72	0.73	0.75	0.80

Deemed Energy Savings Tables

Table 326. 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 327. 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

⁴²⁴ See Volume 1, Section 4.

⁴²⁵ See Table 321.

⁴²⁶ 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.

⁴²⁷ 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 328. 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 2010.⁴²⁸

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.

⁴²⁸ 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 329. 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 standard⁴²⁹ 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, 2024.⁴³⁰ This standard will transition the efficiency metric from an integrated modified energy factor (IMEF) to an energy efficiency ratio (EER). However, compliance is not required until March 1, 2028.

⁴²⁹ DOE minimum efficiency standard for residential clothes washers.
https://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/39.

⁴³⁰ New DOE final rule.
<https://www.energy.gov/eere/buildings/consumer-clothes-washers>.

Table 330. Clothes Washers—Federal Standard

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

High-Efficiency Condition

Eligible equipment must be compliant with the current ENERGY STAR v8.1 specification, effective February 5, 2018.⁴³¹ Qualified products must meet the minimum requirements from Table 331.

Table 331. Clothes Washers—ENERGY STAR Requirements

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

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Energy Savings Algorithms

Energy savings for this measure were derived using the ENERGY STAR Appliance Savings Calculator found on the ENERGY STAR website.⁴³² 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.

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

Equation 105

⁴³¹ ENERGY STAR Program Requirements Product Specification for Clothes Washers. <https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Final%20Version%208.0%20Clothes%20Washer%20Partner%20Commitments%20and%20Eligibility%20Criteria.pdf>.

⁴³² ENERGY STAR Appliance Savings Calculator (updated October 2016). The previously cited URL is no longer available, but a copy of the calculator can be provided upon request.

Baseline Unit

$$kWh_{baseline} = kWh_{conv,machine} + kWh_{conv,WH} + kWh_{conv,dryer} + kWh_{conv,LPM} \quad \text{Equation 106}$$

$$kWh_{conv,machine} = MCF \times RUEC_{conv} \times \frac{LPY}{RLPY} \quad \text{Equation 107}$$

$$kWh_{conv,WH} = WHCF \times RUEC_{conv} \times \frac{LPY}{RLPY} \quad \text{Equation 108}$$

$$kWh_{conv,LPM} = kW_{conv,LPM} \times (8,760 - LPY) \quad \text{Equation 109}$$

$$kWh_{conv,dryer} = \left[\left(\frac{Cap_{conv}}{IMEF_{FS}} \times LPY \right) - \left(RUEC_{conv} \times \frac{LPY}{RLPY} \right) - kWh_{conv,LPM} \right] \times \frac{DU}{DUF} \quad \text{Equation 110}$$

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) ⁴³³ , 163 kWh/year top-loading, compact)
LPY	=	Loads per year = 295
$RLPY$	=	Reference loads per year = 392
$kW_{conv,LPM}$	=	Combined low-power mode wattage of conventional unit = 0.00115 kW (top-loading, standard), 0.00144 kW (top-loading, compact)
Cap_{conv}	=	Average machine capacity = 4.5 ft ³ (top-loading, standard), 2.1 ft ³ (top-loading, compact)
$IMEF_{FS}$	=	Federal standard integrated modified energy factor (Table 330)

⁴³³ This value is taken from the ENERGY STAR appliance calculator and corresponds with the federal standard after March 7, 2015.

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

ENERGY STAR Unit

$$kWh_{ES} = kWh_{ES,machine} + kWh_{ES,WH} + kWh_{ES,dryer} + kWh_{ES,LPM} \quad \text{Equation 111}$$

$$kWh_{ES,machine} = MCF \times RUEC_{ES} \times \frac{LPY}{RLPY} \quad \text{Equation 112}$$

$$kWh_{ES,WH} = WHCF \times RUEC_{ES} \times \frac{LPY}{RLPY} \quad \text{Equation 113}$$

$$kWh_{ES,LPM} = kW_{ES,LPM} \times (8,760 - LPY) \quad \text{Equation 114}$$

$$kWh_{ES,dryer} = \left[\left(\frac{Cap_{ES}}{IMEF_{ES}} \times LPY \right) - \left(RUEC_{ES} \times \frac{LPY}{RLPY} \right) - kWh_{ES,LPM} \right] \times \frac{DU}{DUF} \quad \text{Equation 115}$$

Where:

<i>kWh_{ES}</i>	=	<i>ENERGY STAR average energy usage</i>
<i>kWh_{ES,machine}</i>	=	<i>ENERGY STAR machine energy</i>
<i>kWh_{ES,WH}</i>	=	<i>ENERGY STAR water heater energy</i>
<i>kWh_{ES,dryer}</i>	=	<i>ENERGY STAR dryer energy</i>
<i>kWh_{ES,LPM}</i>	=	<i>ENERGY STAR combined low-power mode energy</i>
<i>RUEC_{ES}</i>	=	<i>ENERGY STAR rated unit electricity consumption (see Table 332)</i>
<i>kW_{ES,LPM}</i>	=	<i>Combined low-power mode wattage of ENERGY STAR unit (see Table 332)</i>
<i>IMEF_{ES}</i>	=	<i>ENERGY STAR integrated modified energy factor (see Table 331)</i>
<i>Cap_{ES}</i>	=	<i>Average machine capacity (see Table 332)</i>

Table 332. Clothes Washers—ENERGY STAR Characteristics⁴³⁴

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 333)
- LPY = Loads per year = 295
- d = Average wash cycle duration = 1 hour^{435,436}

Table 333. Clothes Washers—Coincidence Factors⁴³⁷

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

⁴³⁴ This value is taken from the ENERGY STAR appliance calculator and corresponds with the ENERGY STAR specification after March 7, 2015.

⁴³⁵ Weighted average of Consumer Reports Cycle Times for Top and Front-Loading Clothes Washers.

⁴³⁶ 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.

⁴³⁷ See Volume 1, Section 4.

Deemed Energy Savings Tables

Table 334. 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 335. Clothes Washers—Summer Peak Demand Savings (kW)

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

Deemed Winter Demand Savings Tables

Table 336. 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.⁴³⁸

⁴³⁸ The median lifetime was calculated using the survival function outlined in the DOE Technical Support Document. Final Rule: Standards, Federal Register, 77 FR 32308 (May 31, 2012) and associated Technical Support Document. https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=68&action=viewlive. Download TSD at: <https://www.regulations.gov/document/EERE-2008-BT-STD-0019-0047>.

Program Tracking Data and Evaluation Requirements

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

- Climate zone or county
- Unit quantity
- Manufacturer and model number
- Type of unit (top-loading, front-loading, or compact)
- DHW fuel type (gas or electric)
- Dryer fuel type (gas or electric)
- Proof of purchase – with date of purchase and quantity
 - Alternative: photo of unit installed or another pre-approved method of installation verification

References and Efficiency Standards

Petitions and Rulings

Not applicable.

Relevant Standards and Reference Sources

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

Document Revision History

Table 337. Clothes Washers—Revision History

TRM version	Date	Description of change
v1.0	11/25/2013	TRM v1.0 origin.
v2.0	4/18/2014	TRM v2.0 update. Updated by Frontier Energy, March 2014, based on new federal standards.
v2.1	1/30/2015	TRM v2.1 update. New ENERGY STAR standards incorporated.
v3.0	4/10/2015	TRM v3.0 update. Updated EUL to align with median lifetime. New peak savings calculated according to revised peak definition.
v3.1	11/05/2015	TRM v3.1 update. New ENERGY STAR algorithms and default assumptions incorporated.
v3.1	3/28/2016	TRM v3.1 March revision. Updated winter coincidence factors and winter and summer demand savings tables.
v4.0	10/10/2016	TRM v4.0 update. No revision.

TRM version	Date	Description of change
v5.0	10/2017	TRM v5.0 update. Updated baseline IMEF to reflect changes in Federal Standard. Updated Front Load Washer IMEF to reflect changes in ENERGY STAR Specification. Added baseline for compact units to reflect Federal Standard for compact washers.
v6.0	11/2018	TRM v6.0 update. No revision.
v7.0	11/2019	TRM v7.0 update. Updated links and dates.
v8.0	10/2020	TRM v8.0 update. No revision.
v9.0	10/2021	TRM v9.0 update. General reference checks and text edits. Updated deemed savings tables to match savings algorithms and ENERGY STAR calculator.
v10.0	10/2022	TRM v10.0 update. No revision.
v11.0	10/2023	TRM v11.0 update. No revision.
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 standard⁴³⁹, 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, 2024.⁴⁴⁰ However, compliance is required on and after March 1, 2028.

⁴³⁹ DOE minimum efficiency standard for residential clothes dryers.

<https://www.regulations.gov/document?D=EERE-2007-BT-STD-0010-0050>.

⁴⁴⁰ DOE updated federal standard: <https://www.energy.gov/eere/buildings/consumer-clothes-dryers>.

Table 338. 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

High-Efficiency Condition

The table below displays the ENERGY STAR Final Version 1.1 Requirements for eligible clothes dryers effective January 1, 2015.⁴⁴¹ Energy efficiency service providers are expected to comply with the latest ENERGY STAR requirements.

Table 339. Clothes Dryers—ENERGY STAR Requirements

Product type	Heat type	Average capacity (ft ³)	Minimum CEF levels (lbs/kWh)	Average CEF from QPL ⁴⁴²
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 electric, compact (240 V)		< 4.4	3.45	4.97
ENERGY STAR ventless or vented electric, standard	Hybrid heat Pump	< 4.4	3.93	5.11

⁴⁴¹ 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>

⁴⁴² ENERGY STAR Clothes Dryers Qualified Product Listing (QPL).

<https://www.energystar.gov/productfinder/product/certified-clothes-dryers/results>

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.⁴⁴³ 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 340. 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)	
Ventless electric, compact (240 V)	

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

Equation 118

Baseline Unit

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

Equation 119

Where:

- kWh_{baseline} = Federal standard baseline energy usage
- AvgLoad = Average load in lbs (Table 340)
- LPY = Loads per year = 283
- CEF_{baseline} = Baseline combined energy factor (see Table 338)

ENERGY STAR Unit

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

Equation 120

⁴⁴³ 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.

Where:

kWh_{ES} = ENERGY STAR average energy usage

CEF_{ES} = ENERGY STAR minimum combined energy factor (see Table 339)

Demand Savings Algorithms

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

Equation 121

Where:

AOH = Annual operating hours = (8,760 – 8,463) = 297 hours⁴⁴⁴

$CF_{S/W}$ = Seasonal peak coincidence factor (Table 341)

Table 341. Clothes Dryers—Coincidence Factors⁴⁴⁵

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 342. 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
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
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

⁴⁴⁴ 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>.

⁴⁴⁵ See Volume 1, Section 4.

Deemed Summer Demand Savings Tables

Table 343. 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	0.024	0.024	0.024	0.024	0.025
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 344. 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.⁴⁴⁶

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 ($\geq 4.4 \text{ ft}^3/\text{standard}$ or $< 4.4 \text{ ft}^3/\text{compact}$)
- 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.

⁴⁴⁶ 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 345. 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 standard⁴⁴⁷ for dishwashers.

Table 346. 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, 2027.⁴⁴⁸ The baseline will be updated at that time to reflect the current federal standard.

⁴⁴⁷ DOE minimum efficiency standard for residential dishwashers.

https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=38&action=vi ewlive.

⁴⁴⁸ DOE minimum efficiency standard for residential dishwashers.

<https://www.regulations.gov/document/EERE-2019-BT-STD-0039-0065>.

High-Efficiency Condition

The following table displays the ENERGY STAR Final Version 7.0 Requirements for eligible dishwashers effective July 19, 2023.⁴⁴⁹ Energy efficiency service providers are expected to comply with the latest ENERGY STAR requirements.

Table 347. Dishwashers—ENERGY STAR Requirements

Product type	Annual energy use (kWh/year)	Water consumption (gallons/cycle)
Standard (≥ 8 place settings + 6 serving pieces)	≤ 240	≤ 3.2
Compact (< 8 place settings + 6 serving pieces)	≤ 155	≤ 2.0

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 347.⁴⁵⁰ 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.

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

Equation 122

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

Equation 123

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

Equation 124

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

Equation 125

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

Equation 126

⁴⁴⁹ ENERGY STAR Dishwashers Final Version 7.0 Program Requirements.

<https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Version%207.0%20Residential%20Dishwasher%20Final%20Specification.pdf>.

⁴⁵⁰ ENERGY STAR Appliance Savings Calculator (updated October 2016). The previously cited URL is no longer available, but a copy of the calculator can be provided upon request.

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

Equation 127

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

Equation 128

Where:

$kWh_{baseline}$	=	Federal standard baseline energy usage
kWh_{ES}	=	ENERGY STAR average energy usage
$kWh_{conv,machine}$	=	Conventional machine energy
$kWh_{conv,WH}$	=	Conventional water heater energy
$kWh_{ES,machine}$	=	ENERGY STAR machine energy
$kWh_{ES,WH}$	=	ENERGY STAR water heater energy
$RUEC_{conv}$	=	Conventional rated use electricity consumption = 307 kWh/year for standard and 222 kWh/year for compact (Table 346)
$RUEC_{ES}$	=	ENERGY STAR rated use electricity consumption = 270 kWh/year for standard and 203 kWh/year for compact (Table 347)
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 348)
CPY	=	Cycles per year = 215
d	=	Average wash cycle duration = 2.1 hours ⁴⁵¹

⁴⁵¹ Average of consumer reports cycle times for dishwashers.

Table 348. Dishwashers—Coincidence Factors⁴⁵²

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 349. Dishwashers—Energy Savings (kWh)

Product type	Electric DHW	Gas DHW
Standard	67	29
Compact		

Deemed Summer Demand Savings Tables

Table 350. 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	0.006	0.006	0.006	0.006	0.006
	Gas	0.003	0.003	0.003	0.003	0.003
Compact	Electric	0.006	0.006	0.006	0.006	0.006
	Gas	0.003	0.003	0.003	0.003	0.003

Deemed Winter Demand Savings Tables

Table 351. 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	0.016	0.015	0.013	0.017	0.019
	Gas	0.007	0.007	0.006	0.007	0.008
Compact	Electric	0.016	0.015	0.013	0.017	0.019
	Gas	0.007	0.007	0.006	0.007	0.008

Claimed Peak Demand Savings

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

⁴⁵² See Volume 1, Section 4.

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.⁴⁵³

Program Tracking Data and Evaluation Requirements

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

- Climate zone or county
- Unit quantity
- Manufacturer and model number
- Type of dishwasher (standard or compact)
- Fuel type of water heater (gas or electric)
- Proof of purchase – with date of purchase and quantity
 - Alternative: photo of unit installed or another pre-approved method of installation verification

References and Efficiency Standards

Petitions and Rulings

Not applicable.

Relevant Standards and Reference Sources

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

⁴⁵³ The median lifetime was calculated using the survival function outlined in the DOE Technical Support Document. Final Rule: Standards, Federal Register, 77 FR 31918 (May 30, 2012) and associated Technical Support Document.
https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=38&action=viewlive.

Document Revision History

Table 352. 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 356. 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 standard⁴⁵⁴ 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.⁴⁵⁵ The baseline will be updated at that time to reflect the current federal standard.

⁴⁵⁴ DOE minimum efficiency standard for residential refrigerators and freezers.

http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/43.

⁴⁵⁵ 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.⁴⁵⁶ 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, 2014.⁴⁵⁷ Energy efficiency service providers are expected to comply with the latest ENERGY STAR requirements.

Table 353. 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 354)

⁴⁵⁶ 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>.

⁴⁵⁷ 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 354. Refrigerators—Formulas to Calculate the Energy Usage by Product Class⁴⁵⁸

Product number	Product class	Baseline energy usage federal standard as of September 15, 2014 (kWh/year) ⁴⁵⁹	Average ENERGY STAR energy usage (kWh/year) ⁴⁶⁰	Adjusted volume ⁴⁶¹ (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	$8.07 \times AV + 233.7$	$7.26 \times AV + 210.3$	16.9	370.1	333.0
5	Refrigerator-freezers—automatic defrost with bottom-mounted freezer without an automatic icemaker	$8.85 \times AV + 317.0$	$7.97 \times AV + 285.3$	18.6	481.5	433.5
5A	Refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker with TTD ice service	$9.25 \times AV + 475.4$	$8.33 \times AV + 436.3$	32.1	772.1	703.5
7	Refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker with TTD ice service	$8.54 \times AV + 432.8$	$7.69 \times AV + 397.9$	30.4	692.1	631.4

⁴⁵⁸ Federal standard for refrigerators and freezers.

https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=37&action=viewlive. Select product classes excluded.

⁴⁵⁹ <http://www.gpo.gov/fdsys/pkg/CFR-2012-title10-vol3/pdf/CFR-2012-title10-vol3-sec430-32.pdf>.

⁴⁶⁰ 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.

⁴⁶¹ 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

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

Equation 131

Where:

kWh_{baseline} = Federal standard baseline energy usage (see Table 354)

kWh_{ES} = ENERGY STAR average energy usage (see Table 354)

Demand Savings Algorithms

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

Equation 132

Where:

$CF_{S/W}$ = Seasonal coincidence factor (see Table 355)

Table 355. Refrigerators—Coincidence Factors⁴⁶²

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).

⁴⁶² 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 356); 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 years⁴⁶³

Table 356. Refrigerators—RUL of Replaced Unit⁴⁶⁴

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 ^{465,466}	0.0
11	7.4		

⁴⁶³ 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>.

⁴⁶⁴ 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.

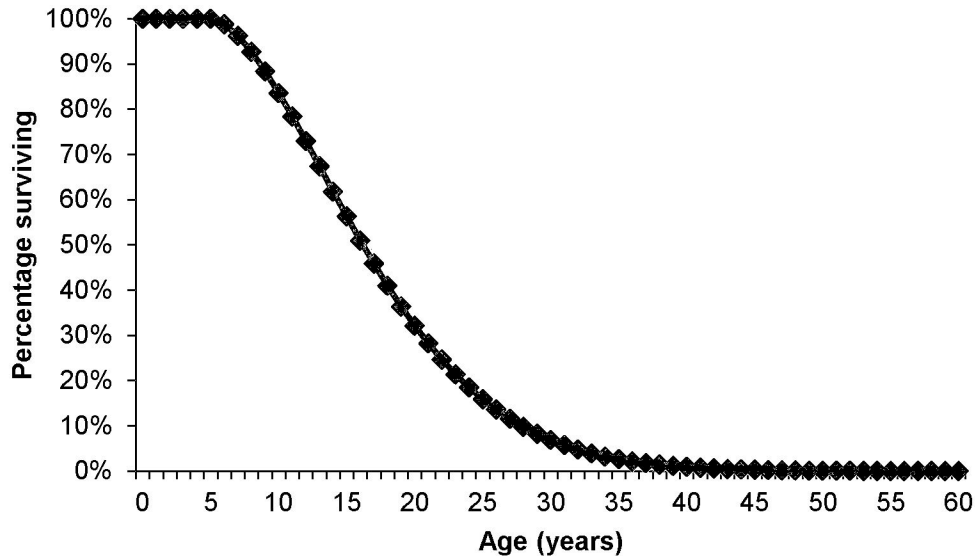
⁴⁶⁵ RULs are capped at the 75th percentile of equipment age as determined based on DOE survival curves (see Figure 7). Systems older than this age should use the ROB baseline. See the January 2015 memo, “Considerations for early replacement of residential equipment,” for further detail.

⁴⁶⁶ 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 7.

Figure 7. Refrigerators—Survival Function⁴⁶⁷



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 7. 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.

⁴⁶⁷ 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:

$$kWh_{manf} = 940 \text{ kWh/Year}^{468}$$

Demand Savings Algorithms

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

For the RUL time period:

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

Equation 135

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

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

Equation 136

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

⁴⁶⁸ 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>.

Deemed Energy Savings Tables

Table 357. Refrigerators—Energy Savings (kWh)

Through-the-door ice?	Door type	Product class	ROB savings (kWh/year)	ER savings (kWh/year)
No	Top freezer	3: Refrigerator freezers—automatic defrost with a top-mounted freezer without an automatic icemaker	37	215
	Bottom freezer	5: Refrigerator-freezers—automatic defrost with a bottom-mounted freezer without an automatic icemaker	48	191
Yes	Bottom freezer	5A: Refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker with TTD ice service	69	138
	Side-by-side	7: Refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker with TTD ice service	61	121
Unknown or average refrigerator ⁴⁶⁹			44	196

⁴⁶⁹ 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§or=aaa&juris=ca&n=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 358. 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 359. 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	0.027	0.027	0.027	0.027	0.027
	Bottom freezer	5: Refrigerator-freezers—automatic defrost with bottom-mounted freezer without an automatic icemaker	0.024	0.024	0.024	0.024	0.024
Yes	Bottom freezer	5A: Refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker with TTD ice service	0.015	0.015	0.015	0.015	0.015
	Side-by-side	7: Refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker with TTD ice service	0.018	0.017	0.017	0.017	0.017
Unknown or average refrigerator			0.025	0.025	0.025	0.025	0.024

Deemed Winter Demand Savings Tables

Table 360. 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 361. 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	0.023	0.024	0.023	0.023	0.024
	Bottom freezer	5: Refrigerator-freezers—automatic defrost with bottom-mounted freezer without an automatic icemaker	0.020	0.021	0.020	0.021	0.021
Yes	Bottom freezer	5A: Refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker with TTD ice service	0.013	0.013	0.013	0.013	0.013
	Side-by-side	7: Refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker with TTD ice service	0.015	0.015	0.015	0.015	0.015
Unknown or average refrigerator			0.021	0.022	0.021	0.021	0.022

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.⁴⁷⁰

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.

⁴⁷⁰ Final Rule: Standards, Federal Register, 76 FR 57516 (Sept. 15, 2011) and associated Technical Support Document. 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>.

Relevant Standards and Reference Sources

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

Document Revision History

Table 362. Refrigerators—Revision History

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

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 366. 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 standard⁴⁷¹ 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.⁴⁷² The baseline will be updated at that time to reflect the current federal standard.

⁴⁷¹ 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.

⁴⁷² 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.⁴⁷³ 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.”⁴⁷⁴

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

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

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, 2014.⁴⁷⁵ Energy efficiency service providers are expected to comply with the latest ENERGY STAR requirements.

⁴⁷³ 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>.

⁴⁷⁴ 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.

⁴⁷⁵ 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 363. 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 354)
Compact freezers	Less than 7.75 cubic feet	Approximately ten percent more energy efficient than the minimum federal standard (see Table 354)

Table 364. Freezers—Formulas to Calculate the Energy Usage by Product Class⁴⁷⁶

Product number	Full product name ⁴⁷⁷	Product class	Baseline energy usage federal standard (kWh/year) ⁴⁷⁸	Average ENERGY STAR energy usage (kWh/year) ⁴⁷⁹	Adjusted volume ⁴⁸⁰ (cubic feet)	Baseline energy usage (kWh/year)	ENERGY STAR energy usage (kWh/year)
8	Upright freezers with manual defrost	Upright (manual defrost)	$5.57 \times AV + 193.7$	$5.01 \times AV + 174.3$	16.12	283.5	255.1
9	Upright freezers with automatic defrost without an automatic icemaker	Upright (auto defrost)	$8.62 \times AV + 228.3$	$7.76 \times AV + 205.5$	29.96	486.6	438.0
10	Chest freezers and all other freezers except compact freezers	Chest	$7.29 \times AV + 107.8$	$6.56 \times AV + 97$	25.25	291.8	262.6
16	Compact upright freezers with manual defrost	Compact upright (manual defrost)	$8.65 \times AV + 225.7$	$7.79 \times AV + 203.1$	5.34	271.9	244.7
17	Compact upright freezers with automatic defrost	Compact upright (auto defrost)	$10.17 \times AV + 351.9$	$9.15 \times AV + 316.7$	7.95	432.7	389.4
18	Compact chest freezers	Compact chest	$9.25 \times AV + 136.8$	$8.33 \times AV + 123.1$	9.06	220.6	198.6

⁴⁷⁶ Federal standard for refrigerators and freezers.

https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=37&action=viewlive. Select product classes excluded.

⁴⁷⁷ 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.

⁴⁷⁸ https://www.ecfr.gov/cgi-bin/text-idx?SID=48f64e166fe3561666f871e521996e13&mc=true&node=se10.3.430_132&rgn=div8.

⁴⁷⁹ 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.

⁴⁸⁰ 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

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

Equation 138

Where:

kWh_{baseline} = Federal standard baseline energy usage (see Table 364)

kWh_{ES} = ENERGY STAR average energy usage (see Table 364)

Demand Savings Algorithms

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

Equation 139

Where:

$CF_{S/W}$ = Seasonal coincidence factor (see Table 365)

Table 365. Freezers—Coincidence Factors⁴⁸¹

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)

⁴⁸¹ 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 366); 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 years⁴⁸²

Table 366. Freezers—RUL of Replaced Unit⁴⁸³

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 ^{484,485}	0.0

⁴⁸² 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>.

⁴⁸³ 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.

⁴⁸⁴ RULs are capped at the 75th percentile of equipment age as determined based on DOE survival curves (see Figure 7). 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.

⁴⁸⁵ 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 8.

Figure 8. Freezers—Survival Function⁴⁸⁶



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 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.

⁴⁸⁶ Department of Energy, Federal Register, 76 Final Rule 57516, Technical Support Document: 8.2.3.1 Estimated Survival Function. September 15, 2011.
http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/refrig_finalrule_tsd.pdf.

Energy Savings Algorithms

For the RUL time period:

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

Equation 140

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

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

Equation 141

Where:

$$kWh_{manf} = 805 \text{ kWh/Year}^{487}$$

Demand Savings Algorithms

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

For the RUL time period:

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

Equation 142

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

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

Equation 143

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

⁴⁸⁷ Existing unit consumption is derived from the MwEPA Refrigerator and Freezer Database. Consumption is weighted using appliance characteristics from the 2020 Residential Energy Consumption Survey (RECS) for units greater than 15 years old. Data was only available for units manufactured on or after 1979.
<https://www.energy.gov/scep/wap/articles/refrigerator-and-freezer-energy-rating-online-search-tool>.
<https://www.eia.gov/consumption/residential/data/2020/hc/pdf/HC%203.8.pdf>.

Deemed Energy Savings Tables

Table 367. Freezers—Savings (kWh)

Freezer type	Size	ROB savings (kWh)	ER savings (kWh)
Chest	Standard (≥ 7.75 ft ³)	29	146
	Compact (< 7.75 ft ³)	22	155
Upright	Standard (≥ 7.75 ft ³)	48	122
	Compact (< 7.75 ft ³)	32	143

Deemed Summer Demand Savings Tables

Table 368. Freezers—Replace-on-Burnout—Summer Peak Demand Savings (kW)

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

Table 369. Freezers—Early Retirement—Summer Peak Demand Savings (kW)

Freezer type	Product class	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
Chest	Standard ($\geq 7.75 \text{ ft}^3$)	0.019	0.018	0.018	0.018	0.018
	Compact ($< 7.75 \text{ ft}^3$)	0.020	0.019	0.020	0.019	0.019
Upright	Standard ($\geq 7.75 \text{ ft}^3$)	0.016	0.015	0.015	0.015	0.015
	Compact ($< 7.75 \text{ ft}^3$)	0.018	0.018	0.018	0.018	0.018

Deemed Winter Demand Savings Tables

Table 370. Freezers—Replace-on-Burnout—Winter Peak Demand Savings (kW)

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

Table 371. Freezers—Early Retirement—Winter Peak Demand Savings (kW)

Freezer type	Product class	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
Chest	Standard ($\geq 7.75 \text{ ft}^3$)	0.015	0.016	0.015	0.016	0.016
	Compact ($< 7.75 \text{ ft}^3$)	0.016	0.017	0.016	0.017	0.017
Upright	Standard ($\geq 7.75 \text{ ft}^3$)	0.013	0.013	0.013	0.013	0.013
	Compact ($< 7.75 \text{ ft}^3$)	0.015	0.016	0.015	0.015	0.016

Claimed Peak Demand Savings

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

Additional Calculators and Tools

Not applicable.

Measure Life and Lifetime Savings

The estimated useful life (EUL) is established at 22 years based on the current DOE Final Rule standards for residential freezers.⁴⁸⁸

Program Tracking Data and Evaluation Requirements

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

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

⁴⁸⁸ Final Rule: Standards, Federal Register, 76 FR 57516 (Sept. 15, 2011) and associated Technical Support Document. https://www.ecfr.gov/cgi-bin/text-idx?SID=48f64e166fe3561666f871e521996e13&mc=true&node=se10.3.430_132&rgn=div8. Download TSD at: <https://www.regulations.gov/document/EERE-2008-BT-STD-0012-0128>.

References and Efficiency Standards

Petitions and Rulings

Not applicable.

Relevant Standards and Reference Sources

Please refer to measure citations for relevant standards and reference sources

Document Revision History

Table 372. Freezers—Revision History

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

2.5.7 Refrigerator/Freezer Recycling Measure Overview

TRM Measure ID: R-AP-RR

Market Sector: Residential

Measure Category: Appliance Recycling

Applicable Building Types: Single-family, multifamily, manufactured

Fuels Affected: Electricity

Decision/Action Type(s): Early retirement

Program Delivery Type(s): Prescriptive

Deemed Savings Type: Deemed savings calculation

Savings Methodology: Engineering algorithms and estimates

Measure Description

This measure involves early retirement and recycling of an existing, full-size (7.75 ft³ or greater) refrigerator or combined refrigerator/freezer in a residential application. Savings represent the entire estimated energy consumption of the existing unit and are applicable over the estimated remaining life of the existing unit.

Eligibility Criteria

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

Baseline Condition

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

High-Efficiency Condition

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

Energy and Demand Savings Methodology

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

Savings Algorithms and Input Variables

Energy Savings Algorithms

Energy savings are calculated as follows:

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

Equation 144

Where:

kWh_{existing} = Average annual energy consumption⁴⁸⁹ (see Table 373)

ISAF = In situ adjustment factor⁴⁹⁰ = 0.942

PUF = Part use factor⁴⁹¹ = 0.915

Table 373. Refrigerator/Freezer Recycling—Average Annual Energy Consumption

Total capacity (ft ³)	Year manufactured	kWh _{existing} by freezer configuration				
		Top	Bottom	Side	Upright	Chest
< 16.5	≤ 2000	861	962	1,139	937	532
	2001-2010	556	724	747	713	435
	≥ 2011	374	483	592	449	292

⁴⁸⁹ ENERGY STAR Flip Your Fridge Calculator.

<https://www.energystar.gov/index.cfm?fuseaction=refrig.calculator>.

⁴⁹⁰ The Cadmus Group, Inc. "Residential Retrofit High Impact Measure Evaluation Report". Prepared for California Public Utilities Commission Energy Division. February 8, 2010. Factor to account for variation between site conditions and controlled DOE testing conditions (90 °F test chamber, empty refrigerator and freezer cabinets, and no door openings). Appliances in warmer climate zones use more energy than those in cooler climate zones; utilized SCE data (highest percentage of warm climate projects) to best approximate Texas climate, p. 139-140.

⁴⁹¹ Ibid. Factor to account for the number of refrigerators that were running, running part time, or not running at the time of recycling, p. 142-143 (weighted by representative utility survey participation, p. 117).

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

Demand Savings Algorithms

Summer peak demand savings are calculated as follows:

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

Equation 145

Where:

AOH = Annual operating hours = 8,760 hours

CF_{S/W} = Seasonal coincidence factor (see Table 374)

Table 374. Refrigerator/Freezer Recycling—Coincidence Factors⁴⁹²

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

⁴⁹² See Volume 1, Appendix B.