Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Estimated Hot Water Usage Reduction

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

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

Equation 79

Where:

SHFR	=	*Showerhead flow rate, gallons per minute (gpm) (see Table 281)*
BWC$_P$	=	*Behavioral waste, minutes per shower (see Table 281)*
n_S	=	*Number of showers per person per day (see Table 281)*
365	=	*Constant to convert days to years (see Table 281)*
n_O	=	*Number of occupants per home (see Table 281)*
n_{SH}	=	*Number of showerheads per home (see Table 281)*

Applying the formula to the values from Table 281 returns the following values for baseline behavioral waste in gallons per showerhead per year:

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

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

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

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

Gallons of hot water saved per year can be found by multiplying the baseline behavioral waste gallons per year by the percent of hot water from Table 281.

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

Equation 80

Where:

HW% = *Hot water percentage (see Table 281)*

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

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

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

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

Table 281. 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)[329]	0.783			
Showers/person/day[330]	0.6			
Occupants per home[331]	2.86			
Showerheads/home[332]	1.72			
Behavioral waste/showerhead/year (gal)	713	570	499	428
Percent hot water[333]	80-85%, or 82.5% on average			
Hot water saved/year (gal)	588	470	412	353

Energy Savings Algorithms

Energy savings for this measure are calculated as follows:

$$Energy\ Savings\ per\ TSRV = \frac{\rho \times C_P \times V \times (T_{SetPoint} - T_{SupplyAverage})}{RE \times Conversion\ Factor}$$

Equation 81

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

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

[331] Occupants per home for Texas from US Census Bureau, "Persons per household, 2014-2018". Accessed August 2020. https://www.census.gov/quickfacts/TX.

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

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

Where:

ρ	=	*Water density, 8.33 lbs/gallon*
C_P	=	*Specific heat of water, 1 Btu/lb°F*
V	=	*Gallons of hot water saved per year per showerhead (see Table 281)*
$T_{SetPoint}$	=	*Water heater setpoint: 120°F* [334]
T_{Supply}	=	*Average supply water temperature (see Table 282)*
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, 2.2 for heat pump water heaters, or 0.8 for gas hot water heaters.* [335]
ConversionFactor	=	*3,412 Btu/kWh for electric or 100,000 Btu/therm for gas*

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.

$$Demand\ Savings\ per\ TSRV = \frac{\rho \times C_P \times V \times (T_{SetPoint} - T_{Supply,Seasonal})}{RE \times Conversion\ Factor \times 365} \times CF$$

Equation 82

Where:

$T_{SupplySeasonal}$	=	*Seasonal supply water temperature (see Table 282)*
CF	=	*Peak coincidence factor (see Table 283)*

[334] 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.

[335] 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.

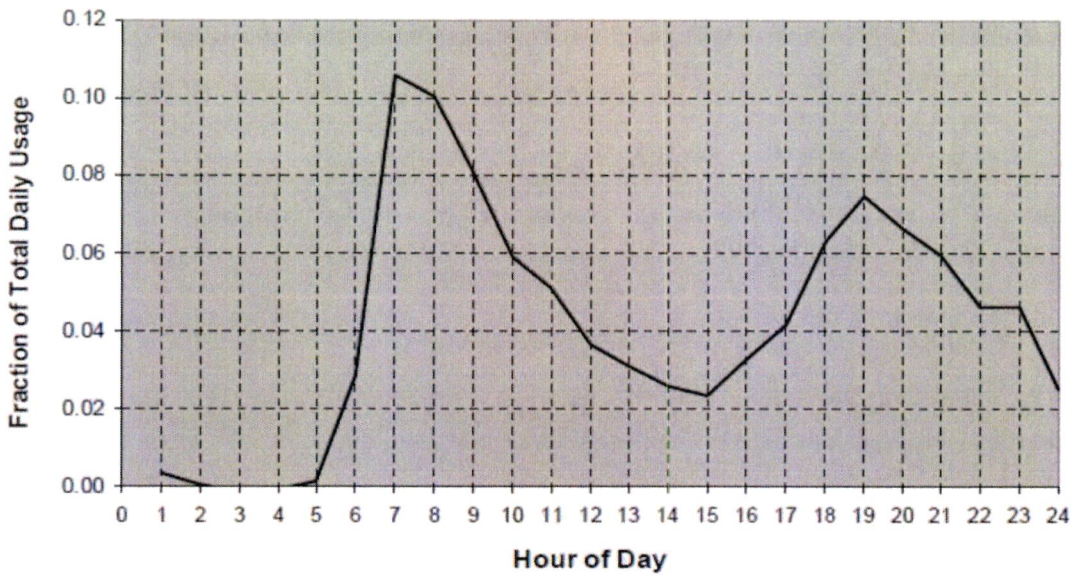
Table 282. Showerhead TSRVs – Water Mains Temperatures

Climate zone	Water Mains Temperature (°F)[336]		
		$T_{SupplySeasonal}$	
	$T_{SupplyAverage}$	Summer	Winter
Climate zone 1: Panhandle	62.9	73.8	53.7
Climate zone 2: North	71.8	84.0	60.6
Climate zone 3: South	74.7	84.5	65.5
Climate zone 4: Valley	77.2	86.1	68.5
Climate zone 5: West	70.4	81.5	60.4

Table 283. Water Fixture Peak Demand Ratios

Climate Zones	Summer	Winter
Climate Zone 1: Panhandle	0.039	0.073
Climate Zone 2: North	0.035	0.075
Climate Zone 3: South	0.038	0.080
Climate Zone 4: Valley	0.038	0.068
Climate Zone 5: West	0.028	0.069

Figure 10. Showerhead TSRVs – Shower, Bath, and Sink Hot Water Use Profile[337]



Source: Building America Performance Analysis Procedures for Existing Homes.

[336] Based on typical meteorological year (TMY) dataset for TMY3: http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/.

[337] 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) for this measure is established at 10 years.

This value is consistent with the EUL reported for a low-flow showerhead in the 2014 California Database for Energy Efficiency Resources (DEER).[338]

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
- DHW 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)

[338] 2014 California Database for Energy Efficiency Resources. http://www.deeresources.com/index.php/deer2013-update-for-2014-codes.

Document Revision History

Table 284. Residential Showerhead Temperature Sensitive Restrictor Valves 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.

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, gas

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) [339] 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. To use these deemed savings, the fuel type of the water heater must be electricity or gas.

Baseline Condition

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

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

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

measure is installed in conjunction with a low-flow showerhead, refer to the Low-flow Showerheads measure and claim additional savings as outlined in that measure.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Estimated Hot Water Usage Reduction

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

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

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

Equation 83

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

Equation 84

Where:

$\%WUE_{SH}$	=	*Showerhead percentage of warm-up events (see Table 285)*
$\%WUE_{TS}$	=	*Tub spout percentage of warm-up events (see Table 285)*
SHFR	=	*Showerhead flow rate, gallons per minute (gpm) (see Table 285)*
TSFR	=	*Tub spout flow rate, gallons per minute (gpm) (see Table 285)*
BWC_P	=	*Behavioral waste, minutes per shower (see Table 285)*
n_S	=	*Number of showers per person per day (see Table 285)*
365	=	*Constant to convert days to years (see Table 285)*
n_O	=	*Number of occupants per home (see Table 285)*
n_{SH}	=	*Number of showerheads per home (see Table 285)*

Applying the formula to the values from Table 285 returns the following values:

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

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

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

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

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

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

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

Equation 85

Where:

DLR = *Diverter leakage rate (gpm) (see Table 285)*

t_S = *Shower time (min/shower) (see Table 285)*

Applying the formula to the values from Table 285 returns the following values:

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

Part 3: To determine gallons of water saved per year can be found by multiplying the total waste by the percent of hot water from Table 285.

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

Equation 86

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 285)*

$HW\%_{D}$ = *Diverter hot water percentage (see Table 285)*

Applying the formula to the values from Table 285 returns the following values:

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

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

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

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

Table 285. Tub Spout/Showerhead TSRVs – Hot Water Usage Reduction

Description	Part 1—Behavioral Waste		Part 2—Diverter Leakage	Part 3—Total
	Showerhead Warm-up	Tub spout Warm-up		
Baseline showerhead flow rate (gpm)	1.5, 1.75, 2.0, or 2.5			N/A
Tub spout flow rate (gpm)[340]	N/A	5.0		N/A
Percent of warm-up events[341]	60%	40%		N/A
Average behavioral waste (minutes per shower)[342]		0.783		N/A
Average diverter leakage rate (gpm)[343]		N/A	0.80	N/A
Average shower time (minutes per shower)[344]		N/A	7.8	N/A
Showers/person/day[345]				0.60
Occupants/home[346]				2.86
Showerheads/home[347]				1.72
Gallons behavioral waste. per tub spout/showerhead per year (1.5 gpm)	257	570	2,272	3,099

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

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

[342] 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.

[343] Average diverter leak rate from (Taitem 2011) Taitem Tech Tip – Leaking Shower Diverters.

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

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

[346] Occupants per home for Texas from US Census Bureau, Texas, "Persons per household, 2007-2011." Accessed January 2013 http://quickfacts.census.gov/qfd/states/48000.html.

[347] Showerheads per home assumed to be equal to the number of full bathrooms per home, taken from 2015 RECS, Table HC2.8. https://www.eia.gov/consumption/residential/data/2015/#structural.

Description	Part 1—Behavioral Waste		Part 2—Diverter Leakage	Part 3—Total
	Showerhead Warm-up	Tub spout Warm-up		
Gallons behavioral waste per tub spout/showerhead per year (1.75 gpm)	299			3,142
Gallons behavioral waste per tub spout/showerhead per year (2.0 gpm)	342			3,185
Gallons behavioral waste per tub spout/showerhead per year (2.5 gpm)	428			3,270
Percent hot water[348]	80-85%, or 82.5% average		73.7%	N/A
Gallons hot water saved per year (1.5 gpm)	N/A			2,357
Gallons hot water saved per year (1.75 gpm)	N/A			2,392
Gallons hot water saved per year (2.0 gpm)	N/A			2,427
Gallons hot water saved per year (2.5 gpm)	N/A			2,498

Energy Savings Algorithms

Energy savings for this measure are calculated as follows:

$$Energy\ Savings\ per\ TS\ System = \frac{\rho \times C_P \times V \times (T_{SetPoint} - T_{SupplyAverage})}{RE \times Conversion\ Factor}$$

Equation 87

Where:

ρ = *Water density, 8.33 lbs/gallon*

C_P = *Specific heat of water, 1 Btu/lb°F*

V = *Gallons of hot water saved per year per showerhead (see Table 285)*

$T_{SetPoint}$ = *Water heater setpoint: 120°F* [349]

T_{Supply} = *Average supply water temperature (see Table 286)*

[348] Average percent 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.

[349] 120°F represents the assumed water heater setpoint. New York Department of Public Service recommends using water heater setpoint as a default value, see "New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs" October 2010, page 99.
Data collection discussed in Appendix D of the EM&V team's Annual Statewide Portfolio Report for Program Year 2014-Volume 1, Project Number 40891 (August 2015), also supports a default value of 120°F.

RE = *Recovery Efficiency (or in the case of heat pump water heaters, COP). If unknown, use 0.98 as a default for electric resistance water heaters, 2.2 for heat pump water heaters, or 0.8 for gas hot water heaters.* [350]

ConversionFactor = *3,412 Btu/kWh for electric or 100,000 Btu/therm for gas*

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.

$$Demand\ Savings\ per\ TS\ System = \frac{\rho \times C_P \times V \times (T_{SetPoint} - T_{Supply,Seasonal})}{RE \times Conversion\ Factor \times 365} \times CF$$

Equation 88

Where:

$T_{SupplySeasonal}$ = *Seasonal supply water temperature (see Table 286)*

CF = *Peak coincidence factor (see Table 287)*

Table 286. Tub Spout/Showerhead TSRVs – Water Mains Temperature

Climate zone	Water mains temperature (°F)[351]		
	$T_{SupplyAverage}$	$T_{SupplySeasonal}$	
		Summer	Winter
Climate zone 1: Panhandle	62.9	73.8	53.7
Climate zone 2: North	71.8	84.0	60.6
Climate zone 3: South	74.7	84.5	65.5
Climate zone 4: Valley	77.2	86.1	68.5
Climate zone 5: West	70.4	81.5	60.4

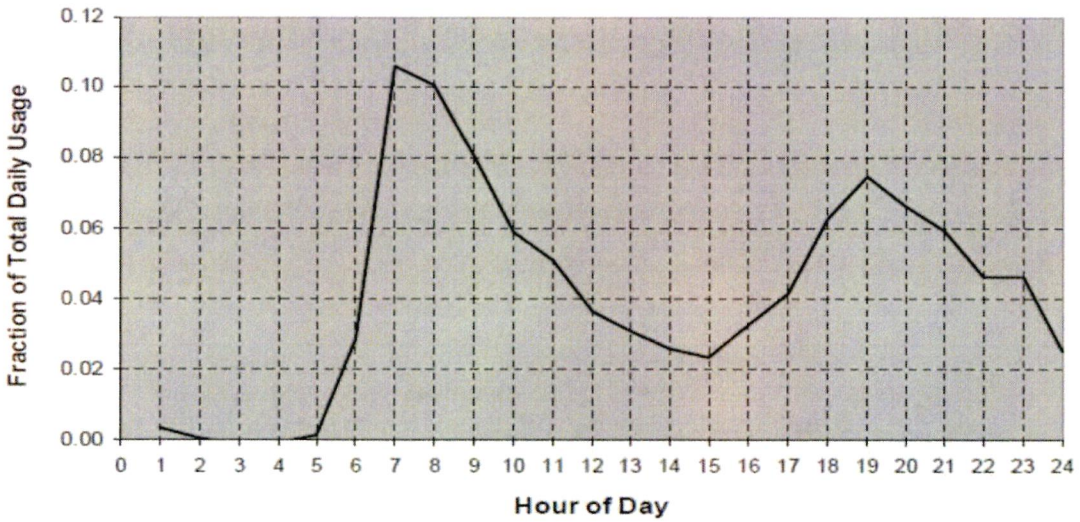
[350] Default values based on median recovery efficiency of residential water heaters by fuel type in the AHRI database, at http://cafs.ahrinet.org/gama_cafs/sdpsearch/search.jsp?table=CWH.

[351] Based on typical meteorological year (TMY) dataset for TMY3: http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/.

Table 287. Tub Spout/Showerhead TSRVs – Peak Coincidence Factors

Climate Zones	Summer	Winter
Climate Zone 1: Panhandle	0.039	0.073
Climate Zone 2: North	0.035	0.075
Climate Zone 3: South	0.038	0.080
Climate Zone 4: Valley	0.038	0.068
Climate Zone 5: West	0.028	0.069

Figure 11. Tub Spout/Showerhead TSRVs – Shower, Bath, and Sink Hot Water Use Profile[352]



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.

[352] 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) for this measure is established at 10 years.

This value is consistent with the EUL reported for a low-flow showerhead in the 2014 California Database for Energy Efficiency Resources (DEER).[353]

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

Document Revision History

Table 288. Residential Tub Spout and Showerhead Temperature Sensitive Restrictor Valves 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.

[353] 2014 California Database for Energy Efficiency Resources. http://www.deeresources.com.

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

Table 289 displays the ENERGY STAR® requirements for eligible ceiling fans as of June 16, 2018. These values are subject to updates in ENERGY STAR® specifications; energy efficiency service providers are expected to comply with the latest ENERGY STAR® specification.[354]

[354] ENERGY STAR® Ceiling Fan Specification: https://www.energystar.gov/products/lighting_fans/ceiling_fans/ceiling_fans_key_product_criteria.

Table 289. ENERGY STAR® Ceiling 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 290. ENERGY STAR® Ceiling Fan 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 291. ENERGY STAR® Ceiling Fan Light Kit Efficacy Requirements

Type	Minimum efficacy (lumens/W)	Minimum light output (lumens)
Shipped with ENERGY STAR certified light bulbs	65.0	N/A
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.[355] Default values were taken directly from the ENERGY STAR® Ceiling Fan Savings Calculator, unless otherwise specified.

$$kWh_{savings} = (kWh_{baseline} - kWh_{ES})_{fan} + (kWh_{baseline} - kWh_{ES})_{lgt} \times IEF_E$$

Equation 89

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

Equation 90

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

Equation 91

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

Equation 92

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

Equation 93

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

Equation 94

Where:

$kWh_{baseline}$ = *Non-ENERGY STAR® baseline energy usage*

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

IEF_E = *Energy Interactive Effects Factor from Table 292 assuming heating/cooling unknown*[356]

[355] ENERGY STAR® Ceiling Fan Savings Calculator (updated September 2013). https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/save-energy/purchase-energy-saving-products.

[356] The assumed energy interactive effects factors are taken from the residential lighting measure.

$W_{Lgt,baseline}$	=	*Conventional lighting total wattage = 115 W (160 W default value from ENERGY STAR® calculator reduced to comply with EISA 2007 baseline wattages)*[357]
$W_{Lgt,ES}$	=	*Actual wattage of installed ENERGY STAR® lighting; assume one high-efficiency 32 W lamp*
$W_{Fan,baseline}$	=	*Conventional fan motor wattage*
$W_{Fan,ES}$	=	*ENERGY STAR® fan motor wattage*
$W_{LS,MS,HS}$	=	*Fan motor wattage at low, medium, and high speed; see Table 293*
$OP_{LS,MS,HS}$	=	*Fan operating percentage at low, medium, and high speed; see Table* 294
AOH_{Lgt}	=	*Annual lighting operating hours = 803 hours/year (assuming 2.2 hours/day and 365 days/year operation)*[358]
AOH_{Fan}	=	*Annual fan operating hours = 1,095 hours/year (assuming 3.0 hours/day and 365 days/year operation)*[359]
1,000	=	*Constant to convert from W to kW*

Table 292. ENERGY STAR® Ceiling Fans—Interactive Effects Factor for Cooling Energy Savings and Heating Energy Penalties[360]

	IEF_E				
Heating/cooling type*	**Climate zone 1**	**Climate zone 2**	**Climate zone 3**	**Climate zone 4**	**Climate zone 5**
Heating/Cooling Unknown[361]	0.88	0.98	1.04	1.07	0.95

[357] Assumes a mix of 40 and 60 W incandescent lamps. EISA 2007 baseline wattages are approximately 72 percent of standard incandescent wattages.

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

[359] The assumed annual operating hours are taken from the ENERGY STAR® Light Fixture and Ceiling Fan Calculator. https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/save-energy/purchase-energy-saving-products.

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

[361] 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 293. Ceiling Fan 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

Table 294. Ceiling Fan 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).

$$kW_{savings} = kW_{Fan} + kW_{Lgt}$$

Equation 95

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

Equation 96

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

Equation 97

Where:

kW_{Fan} = *Fan demand savings*

CF_{Fan} = *Fan motor coincidence factor = 0.446*

kW_{Lgt} = *Lighting demand savings*

CF_{Lgt} = *Lighting coincidence factor (Table 295)*

IEF_D = *Demand Interactive Effects Factor from Table 296 assuming heating/cooling unknown*[362]

Table 295. ENERGY STAR® Ceiling Fans—Lighting Coincidence Factors[363]

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 296. ENERGY STAR® Ceiling Fans—Interactive Effects Factor for Cooling Demand Savings and Heating Demand Penalties[364]

$IEF_{D,summer}$					
Heating/cooling type*	Climate Zone 1	Climate Zone 2	Climate Zone 3	Climate Zone 4	Climate Zone 5
Heating/cooling unknown[365]	1.39	1.28	1.58	1.20	1.38
$IEF_{D,winter}$					
Heating/cooling type*	Climate Zone 1	Climate Zone 2	Climate Zone 3	Climate Zone 4	Climate Zone 5
Heating/cooling unknown[366]	0.76	0.72	0.73	0.75	0.80

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

[363] See Volume 1, Section 4.

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

[365] 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.

[366] 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 Energy Savings Tables

Table 297. Ceiling Fans Deemed Energy Savings

Deemed energy svings (kWh/Year)				
Climate zone 1: Amarillo	Climate zone 2: Dallas	Climate zone 3: Houston	Climate zone 4: Corpus Christi	Climate zone 5: El Paso
69.8	76.5	80.5	82.5	74.5

Deemed Summer Demand Savings Tables

Table 298. Ceiling Fans Deemed Demand Savings - Summer

Deemed summer 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
0.011	0.010	0.013	0.010	0.008

Deemed Winter Demand Savings Tables

Table 299. Ceiling Fans Deemed Demand Savings - Winter

Deemed winter 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
0.022	0.018	0.017	0.021	0.028

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.[367]

[367] 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.

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
- The number of installed ENERGY STAR® ceiling fan and light kits
- 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.

Relevant Standards and Reference Sources

The applicable version of the ENERGY STAR® specifications and requirements for ceiling fans.

Document Revision History

Table 300. Residential ENERGY STAR® 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.

TRM version	Date	Description of change
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.

2.5.2 ENERGY STAR® Clothes Washers Measure Overview

TRM Measure ID: R-AP-CW

Market Sector: Residential

Measure Category: Appliances

Applicable Building Types: Single-family, multifamily, manufactured

Fuels Affected: Electricity

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

Program Delivery Type(s): Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: Engineering algorithms and estimates

Measure Description

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

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

Eligibility Criteria

Not applicable.

Baseline Condition

Effective January 1, 2018, the baseline is the Department of Energy (DOE) minimum efficiency standard[368] 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 consistent with the ENERGY STAR® appliance calculator.

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

Table 301. Federal Standard for Clothes Washers

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

High-Efficiency Condition

The table below displays the ENERGY STAR® Final Version 8.0 requirements for eligible clothes washers effective February 5, 2018, with early certification available starting May 5, 2017.[369] These values are subject to updates in ENERGY STAR® specifications; energy efficiency service providers are expected to comply with the latest ENERGY STAR® requirements.

Table 302. ENERGY STAR® Specifications for Residential Clothes Washers

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

[369] Available for download at: https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Final%20Version%208.0%20Clothes%20Washer%20Partner%20Commitments%20and%20Eligibility%20Criteria.pdf.

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.[370] 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.

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

Equation 98

Baseline Unit

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

Equation 99

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

Equation 100

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

Equation 101

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

Equation 102

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

Equation 103

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*

[370] ENERGY STAR® Appliance Savings Calculator (updated October 2016). https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/save-energy/purchase-energy-saving-products.

$kWh_{conv,LPM}$ = *Conventional combined low-power mode energy*

$RUEC_{conv}$ = *Conventional rated unit electricity consumption = 381 kWh/year (top-loading, standard)* [371], 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 301)*

MCF = *Machine consumption factor = 20%*

WHCF = *Water heater consumption factor = 80%*

DU_{DW} = *Dryer usage in households with both a washer and a dryer = 95%*

DUF = *Dryer use factor (percentage of washer loads dried in machine) = 91%*

ENERGY STAR® Unit

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

Equation 104

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

Equation 105

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

Equation 106

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

Equation 107

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

Equation 108

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

Where:

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

$kWh_{ES,machine}$ = *ENERGY STAR® machine energy*

$kWh_{ES,WH}$ = *ENERGY STAR® water heater energy*

$kWh_{ES,dryer}$ = *ENERGY STAR® dryer energy*

$kWh_{ES,LPM}$ = *ENERGY STAR® combined low-power mode energy*

$RUEC_{ES}$ = *ENERGY STAR® rated unit electricity consumption (see Table 303)*

$kW_{ES,LPM}$ = *Combined low-power mode wattage of ENERGY STAR® unit (see Table 303)*

$IMEF_{ES}$ = *ENERGY STAR® integrated modified energy factor (Table 302)*

CAP_{ES} = *Average machine capacity (see Table 303)*

Table 303. ENERGY STAR® Clothes Washer Characteristics[372]

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)	109	2.1	0.00144

Summer Demand Savings Algorithms

$$kW_{savings} = \frac{kWh_{savings}}{AOH} \times CF$$

Equation 109

$$AOH = LPY \times d$$

Equation 110

Where:

AOH = *Annual operating hours*

CF = *Coincidence factor (Table 304)*

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

LPY = *Loads per year = 295*

d = *Average wash cycle duration = 1 hour*[373,374]

Table 304. ENERGY STAR® Clothes Washer Coincidence Factors[375]

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

Deemed Energy Savings Tables

Table 305. ENERGY STAR® Clothes Washer Energy Savings (kWh)

ENERGY STAR® clothes washer—annual energy savings			
Type	Water heater fuel type	Dryer fuel type	kWh savings
Front-loading > 2.5 ft³	Electric	Electric	394
		Gas	187
	Gas	Electric	241
		Gas	34
Top-loading > 2.5 ft³	Electric	Electric	193
		Gas	114
	Gas	Electric	102
		Gas	23
All ≤ 2.5 ft³	Electric	Electric	222
		Gas	41
	Gas	Electric	189
		Gas	8

[373] Weighted average of Consumer Reports Cycle Times for Top and Front-Loading Clothes Washers.
[374] 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.
[375] See Volume 1, Section 4.

Deemed Summer Demand Savings Tables

Table 306. ENERGY STAR® Clothes Washer Summer Peak Demand Savings (kW)

ENERGY STAR® clothes washer—summer demand savings							
Washer type	Fuel type		Summer demand savings (kW)				
	Water heater	Dryer	Climate zone 1	Climate zone 2	Climate zone 3	Climate zone 4	Climate zone 5
Front-loading > 2.5 ft^3	Electric	Electric	0.053	0.053	0.053	0.055	0.055
		Gas	0.025	0.025	0.025	0.026	0.026
	Gas	Electric	0.033	0.033	0.033	0.033	0.033
		Gas	0.005	0.005	0.005	0.005	0.005
Top-loading > 2.5 ft^3	Electric	Electric	0.026	0.026	0.026	0.027	0.027
		Gas	0.015	0.015	0.015	0.016	0.016
	Gas	Electric	0.014	0.014	0.014	0.014	0.014
		Gas	0.003	0.003	0.003	0.003	0.003
All $\leq$ 2.5 ft^3	Electric	Electric	0.030	0.030	0.030	0.031	0.031
		Gas	0.006	0.006	0.006	0.006	0.006
	Gas	Electric	0.026	0.026	0.026	0.026	0.026
		Gas	0.001	0.001	0.001	0.001	0.001

Deemed Winter Demand Savings Tables

Table 307. All Climate Zones—ENERGY STAR® Clothes Washer Winter Demand Savings (kW)

ENERGY STAR® clothes washer—winter demand savings							
Washer type	Fuel type		Winter demand savings (kW)				
	Water heater	Dryer	Climate zone 1	Climate zone 2	Climate zone 3	Climate zone 4	Climate zone 5
Front-loading > 2.5 ft³	Electric	Electric	0.057	0.057	0.057	0.059	0.052
		Gas	0.027	0.027	0.027	0.028	0.025
	Gas	Electric	0.035	0.035	0.035	0.036	0.032
		Gas	0.005	0.005	0.005	0.005	0.005
Top-loading > 2.5 ft³	Electric	Electric	0.028	0.028	0.028	0.029	0.026
		Gas	0.017	0.017	0.017	0.017	0.015
	Gas	Electric	0.015	0.015	0.015	0.015	0.014
		Gas	0.003	0.003	0.003	0.003	0.003
All ≤ 2.5 ft³	Electric	Electric	0.032	0.032	0.032	0.033	0.029
		Gas	0.006	0.006	0.006	0.006	0.005
	Gas	Electric	0.028	0.028	0.028	0.028	0.025
		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.[376]

[376] 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. Accessed 08/15/2019. https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=68&action=viewliveDownload TSD at: http://www.regulations.gov/#!documentDetail;D=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
- Number of units installed
- Type of unit (top-loading, front-loading, or compact)
- Fuel type of water heater (gas or electric)
- Fuel type of dryer (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

- The applicable version of the ENERGY STAR® specifications and requirements for clothes washers.

Document Revision History

Table 308. Residential ENERGY STAR® 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.

2.5.3 ENERGY STAR® Clothes Dryers Measure Overview

TRM Measure ID: R-AP-CD

Market Sector: Residential

Measure Category: Appliances

Applicable Building Types: Single-family, multifamily, manufactured

Fuels Affected: Electricity

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

Program Delivery Type(s): Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: Engineering algorithms and estimates

Measure Description

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

Eligibility Criteria

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

Baseline Condition

Effective January 1, 2015, the baseline is the Department of Energy (DOE) minimum federal efficiency standard[377], 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[378]. These values are consistent with the current ENERGY STAR® Appliance Savings Calculator.

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

[378] Available for download at: https://www.energystar.gov/sites/default/files/specs/Clothes%20Dryers%20Draft%202%20V1%200%20Stakeholder%20Webinar%20Final.pdf

Table 309. Federal Standard for Residential Clothes Dryers

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.[379] These values are subject to updates in ENERGY STAR® specifications; energy efficiency service providers are expected to comply with the latest ENERGY STAR® requirements.

Table 310. ENERGY STAR® Specifications for Residential Clothes Dryers

Product type	Average Capacity (ft^3)	Minimum CEF levels (lbs/kWh)
ENERGY STAR® Ventless or Vented Electric, Standard	≥ 4.4	3.93
ENERGY STAR® Ventless or Vented Electric, Compact (120V)	< 4.4	3.80
ENERGY STAR® Vented Electric, Compact (240 V)	< 4.4	3.45
ENERGY STAR® Ventless Electric, Compact (240 V)	< 4.4	2.68

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Energy Savings Algorithms

Energy savings for this measure were derived using the ENERGY STAR® Appliance Savings Calculator found on the ENERGY STAR® website.[380] 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.

[379] Available for download at: https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Final%20Version%201.1%20Clothes%20Dryers%20Specification%20-%20Program%20Commitment%20Criteria%20and%20Eligibility%20Criteria.pdf.

[380] ENERGY STAR® Appliance Savings Calculator (updated October 2016). https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/save-energy/purchase-energy-saving-products.

Table 311. Default Average Load for Clothes Dryers in Pounds

Product type	Average load (lbs)
Vented Electric, Standard	8.45
Vented Electric, Compact (120 V)	3.00
Vented Electric, Compact (240 V)	3.00
Ventless Electric, Compact (240 V)	3.00

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

Equation 111

Baseline Unit

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

Equation 112

Where:

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

$AvgLoad$ = *Average load in lbs (Table 311)*

LPY = *Loads per year = 283*

$CEF_{baseline}$ = *Amended Baseline Combined Energy Factor (See* Table 309*)*

ENERGY STAR® Unit

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

Equation 113

Where:

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

$AvgLoad$ = *Average load in lbs (See Table 311)*

LPY = *Loads per Year = 283*

CEF_{ES} = *ENERGY STAR® Minimum Combined Energy Factor (See* Table 310*)*

Demand Savings Algorithms

$$kW_{savings} = \frac{kWh_{savings}}{AOH} \times CF$$

Equation 114

Where:

AOH = *Annual operating hours = (8760 – 8463) = 297 hours*[381]

CF = *Coincidence factor (Table 312)*

Table 312. ENERGY STAR® Clothes Dryer Coincidence Factors[382]

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 313. ENERGY STAR® Clothes Dryer Energy Savings (kWh/Year)

ENERGY STAR® clothes dryer—annual energy savings		
Product type	Average capacity (ft^3)	Energy savings (kWh)
Ventless or Vented Electric, Standard	≥ 4.4	160
Ventless or Vented Electric, Compact (120V)	< 4.4	59
Vented Electric, Compact (240 V)	< 4.4	65
Ventless Electric, Compact (240 V)	< 4.4	82

[381] 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. Available for download at (last accessed August 29, 2019): https://neea.org/img/uploads/neea-clothes-dryer-field-study.pdf

[382] See Volume 1, Section 4.

Deemed Summer Demand Savings Tables

Table 314. ENERGY STAR® Clothes Dryer Summer Peak Demand Savings (kW)

ENERGY STAR® clothes dryer—summer demand savings						
Product type	Average capacity (ft^3)	Climate zone 1	Climate zone 2	Climate zone 3	Climate zone 4	Climate zone 5
Ventless or Vented Electric, Standard	≥ 4.4	0.022	0.022	0.022	0.022	0.023
Ventless or Vented Electric, Compact (120V)	< 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

Deemed Winter Demand Savings Tables

Table 315. ENERGY STAR® Clothes Dryer Winter Demand Savings (kW)

ENERGY STAR® clothes dryer—winter demand savings						
Product type	Average capacity (ft^3)	Climate zone 1	Climate zone 2	Climate zone 3	Climate zone 4	Climate zone 5
Ventless or Vented Electric, Standard	≥ 4.4	0.024	0.024	0.022	0.026	0.025
Ventless or Vented Electric, Compact (120V)	< 4.4	0.009	0.009	0.008	0.009	0.009
Vented Electric, Compact (240 V)	< 4.4	0.010	0.010	0.009	0.011	0.010
Ventless Electric, Compact (240 V)	< 4.4	0.012	0.013	0.011	0.013	0.013

Claimed Peak Demand Savings

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

Additional Calculators and Tools

Not applicable.

Measure Life and Lifetime Savings

The estimated useful life (EUL) of an ENERGY STAR® clothes dryer is established at 16 years based on the current DOE Final Rule standards for clothes dryers[383].

[383] Technical Support Document (April 2011) accessed 09/03/2019. See "Appendix 8C.Lifetime Distributions": https://www.regulations.gov/document?D=EERE-2007-BT-STD-0010-0053

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

References and Efficiency Standards

Petitions and Rulings

Not applicable.

Relevant Standards and Reference Sources

- The applicable version of the ENERGY STAR® specifications and requirements for clothes washers.

Document Revision History

Table 316. Residential ENERGY STAR® 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.

2.5.4 ENERGY STAR® Dishwashers Measure Overview

TRM Measure ID: R-AP-DW

Market Sector: Residential

Measure Category: Appliances

Applicable Building Types: Single-family, multifamily, manufactured

Fuels Affected: Electricity

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

Program Delivery Type(s): Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: Engineering algorithms and estimates

Measure Description

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

Eligibility Criteria

This measure applies to both standard and compact dishwasher types.

Baseline Condition

Effective May 30, 2013, the baseline is the Department of Energy (DOE) minimum efficiency standard[384] for dishwashers.

Table 317. Federal Standard for Dishwashers

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

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

High-Efficiency Condition

The following table displays the ENERGY STAR® Final Version 6.0 requirements for eligible dishwashers effective January 29, 2016.[385] These values are subject to updates in ENERGY STAR® specifications; energy efficiency service providers are expected to comply with the latest ENERGY STAR® requirements.

Table 318. ENERGY STAR® Specifications for Dishwashers

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

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Energy Savings Algorithms

Energy savings for this measure were derived using the ENERGY STAR® Appliance Savings Calculator found on the ENERGY STAR® website and the revised ENERGY STAR® specification in Table 318.[386] Default values were taken directly from the ENERGY STAR® 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.

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

Equation 115

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

Equation 116

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

Equation 117

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

Equation 118

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

Equation 119

[385] Available for download at: http://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Residential%20Dishwasher%20Version%206.0%20Final%20Program%20Requirements_0.pdf.

[386] ENERGY STAR® Appliance Savings Calculator (updated October 2016). https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/save-energy/purchase-energy-saving-products.

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

Equation 120

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

Equation 121

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 317)*
$RUEC_{ES}$	=	*ENERGY STAR® rated use electricity consumption = 270 kWh/year for standard and 203 kWh/year for compact (Table 318)*
MCF	=	*Machine consumption factor = 44%*
WHCF	=	*Water heater consumption factor = 56%*

Demand Savings Algorithms

$$kW_{savings} = \frac{kWh_{savings}}{AOH} \times CF$$

Equation 122

$$AOH = CPY \times d$$

Equation 123

Where:

AOH = *Annual operating hours*

CF = *Coincidence factor = (Table 319)*

CPY = *Cycles per year = 215*

d = *Average wash cycle duration = 2.1 hours*[387]

Table 319. ENERGY STAR® Dishwasher Coincidence Factors[388]

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 320. ENERGY STAR® Dishwasher Energy Savings

ENERGY STAR® dishwasher—energy savings (kWh)		
Product type	Electric water heating	Gas water heating
Standard	37	16
Compact	19	8

[387] Average of Consumer Reports Cycle Times for Dishwashers.
[388] See Volume 1, Section 4.

Deemed Summer Demand Savings Tables

Table 321. ENERGY STAR® Dishwasher Summer Peak Demand Savings (kW)

ENERGY STAR® dishwasher—summer demand savings (kW)						
Dishwasher type	Water heating fuel	Climate zone 1	Climate zone 2	Climate zone 3	Climate zone 4	Climate zone 5
Standard	Electric	0.003	0.003	0.003	0.003	0.003
	Gas	0.002	0.001	0.002	0.001	0.002
Compact	Electric	0.002	0.002	0.002	0.002	0.002
	Gas	0.001	0.001	0.001	0.001	0.001

Deemed Winter Demand Savings Tables

Table 322. ENERGY STAR® Dishwasher Winter Peak Demand Savings (kW)

ENERGY STAR® Dishwasher—Winter Demand Savings (kW)						
Dishwasher type	Water heating fuel	Climate zone 1	Climate zone 2	Climate zone 3	Climate zone 4	Climate zone 5
Standard	Electric	0.009	0.009	0.007	0.009	0.011
	Gas	0.004	0.004	0.003	0.004	0.005
Compact	Electric	0.004	0.004	0.004	0.005	0.005
	Gas	0.002	0.002	0.002	0.002	0.002

Claimed Peak Demand Savings

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

Additional Calculators and Tools

Not applicable.

Measure Life and Lifetime Savings

The estimated useful life (EUL) is established at 15 years based on the Technical Support Document for the current DOE Final Rule standards for residential dishwashers.[389]

[389] 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. Accessed 08/15/2019. https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=38&action=viewlive.

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
- Number of units installed
- 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

- The applicable version of the ENERGY STAR® specifications and requirements for dishwashers.

Document Revision History

Table 323. Residential ENERGY STAR® 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® specifications 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.

TRM version	Date	Description of change
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.

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 327. All retired refrigerators must be dismantled in an environmentally safe manner in accordance with applicable federal, state, and local regulations. The installer will provide documentation of proper disposal of refrigerators. To receive early retirement savings, the unit to be replaced must be functioning at the time of removal.

Newly installed refrigerators must meet current ENERGY STAR® efficiency levels.

Baseline Condition

For new construction or replace-on-burnout, the baseline is the Department of Energy (DOE) minimum efficiency standard[390] for refrigerators, effective September 15, 2014.

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.[391] Since the federal standard effective date occurred in late 2014, existing units manufactured as of 2015 are not eligible for early retirement.

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

[391] 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. http://www.kouba-cavallo.com/refmods.htm.

High-Efficiency Condition

Table 324 displays the ENERGY STAR® requirements for eligible refrigerators, which went into effect on September 15, 2014. These values are subject to updates in ENERGY STAR® specifications; energy efficiency service providers are expected to comply with the latest ENERGY STAR® requirements.

Table 324. ENERGY STAR® Specifications for Refrigerators

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 325)

Table 325. Formulas to Calculate the ENERGY STAR® Criteria for each Refrigerator Product Category by Adjusted Volume[392]

Product number	Product class	Baseline energy usage federal standard as of September 15, 2014 (kWh/year)[393]	Average ENERGY STAR® energy usage (kWh/year)[394]	Adjusted volume[395] (cubic feet)	Baseline energy usage (kWh/year)	ENERGY STAR® energy usage (kWh/year)
3	Refrigerator freezers—automatic defrost with top-mounted freezer without an automatic icemaker	8.07 × AV + 233.7	7.26 × AV + 210.3	16.9	370.1	333.0
5	Refrigerator-freezers—automatic defrost with bottom-mounted freezer without an automatic icemaker	8.85 × AV + 317.0	7.97 × AV + 285.3	18.6	481.5	433.5
5A	Refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker with TTD ice service	9.25 × AV + 475.4	8.33 × AV + 436.3	32.1	772.1	703.5
7	Refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker with TTD ice service	8.54 × AV + 432.8	7.69 × AV + 397.9	30.4	692.1	631.4

[392] Available for download at http://www.gpo.gov/fdsys/pkg/CFR-2012-title10-vol3/pdf/CFR-2012-title10-vol3-sec430-32.pdf. Select product classes excluded.
[393] http://www.gpo.gov/fdsys/pkg/CFR-2012-title10-vol3/pdf/CFR-2012-title10-vol3-sec430-32.pdf.
[394] Approximately 10 percent more efficient than baseline, as specified in the ENERGY STAR® Appliance Savings Calculator (updated September 2015). http://www.energystar.gov/sites/default/files/asset/document/appliance_calculator.xlsx.
[395] 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

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

Equation 124

Where:

$kWh_{baseline}$ = *Federal standard baseline energy usage (see Table 325)*

kWh_{ES} = *ENERGY STAR® average energy usage (see Table 325)*

Demand Savings Algorithms

$$kW_{savings} = \frac{kWh_{savings}}{8{,}760\ hrs} \times LSAF$$

Equation 125

Where:

LSAF = *Load Shape Adjustment Factor (see Table 326)*

Table 326. ENERGY STAR® Refrigerator Load Shape Adjustment Factors[396]

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)

[396] 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 327); if unknown, assume the age of the replaced unit is equal to the EUL resulting in a default RUL of 5.0 years*

EUL = *Estimated useful life = 16 years*

Table 327. Remaining Useful Life (RUL) of Replaced Refrigerator[397]

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[398,399]	0.0
11	7.4		

Derivation of RULs

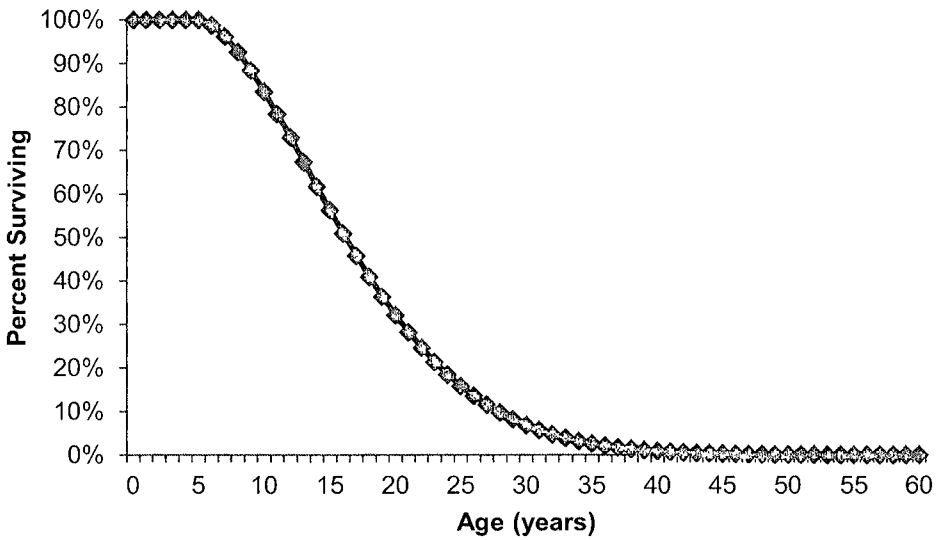
ENERGY STAR® refrigerators have an estimated useful life of 16 years. This estimate is consistent with the age at which approximately 50 percent of the refrigerators installed in a given year will no longer be in service, as described by the survival function in Figure 12.

[397] 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.

[398] RULs are capped at the 75th percentile of equipment age, 21 years, as determined based on DOE survival curves (see Figure 12). Systems older than 21 years should use the ROB baseline. See the January 2015 memo, "Considerations for early replacement of residential equipment," for further detail.

[399] 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.

Figure 12. Survival Function for ENERGY STAR® Refrigerators[400]



The method to estimate the remaining useful life (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 12. 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.

Energy Savings Algorithms

For the RUL time period:

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

Equation 126

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 127

[400] 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.

Where:

kWh_{manf} = *968 kWh/Year*[401]

$kWh_{baseline}$ = *Federal standard baseline energy usage (see Table 325)*

kWh_{ES} = *ENERGY STAR® average energy usage (see Table 325)*

Demand Savings Algorithms

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

For the RUL time period:

$$kW_{savings,ER} = \frac{kWh_{savings,ER}}{8{,}760\ hrs} \times LSAF$$

Equation 128

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

$$kW_{savings,ROB} = \frac{kWh_{savings,ROB}}{8{,}760\ hrs} \times LSAF$$

Equation 129

Where:

LSAF = *Load shape adjustment factor (Table 326)*

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.

[401] This is the weighted average of Adjusted annual unit energy consumption, derived from the MwEPA Refrigerator and Freezer Energy Rating Database (or from metering). Weights are calculated from the millions-of-households measurements obtained from the Residential Energy Consumption Survey, or RECS, (https://www.eia.gov/consumption/residential/data/2015/hc/php/hc3.6.php) corresponding to the year range classifications of refrigerators greater than 15 years old (specifically, 15-to-19-years-old and 20-or-more-years-old). Data in which refrigerators' model years were older than 1975 were excluded.

Where:

RUL = *Remaining useful life (see Table 327)*

EUL = *Estimated useful life = 16 years*[402]

Deemed Energy Savings Tables

Table 328. ENERGY STAR® Refrigerators Energy Savings (kWh) by Refrigerator Type

Through-the-door ice?	Door type	Product class	ROB savings (kWh/year)	ER savings (kWh/year)
No	Top Freezer	3: Refrigerator freezers—automatic defrost with a top-mounted freezer without an automatic icemaker	37	224
	Bottom Freezer	5: Refrigerator-freezers—automatic defrost with a bottom-mounted freezer without an automatic icemaker	48	200
Yes	Bottom Freezer	5A: Refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker with TTD ice service	69	147
	Side-by-Side	7: Refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker with TTD ice service	61	130
Unknown or Average Refrigerator[403]			44	205

[402] 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: http://www.regulations.gov/#!documentDetail;D=EERE-2008-BT-STD-0012-0128.

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

Deemed Summer Demand Savings Tables

Table 329. ENERGY STAR® Refrigerators Replace-on-Burnout Summer Demand Savings (kW) by Refrigerator Type

Through-the-door ice?	Door type	Product class	Replace-on-burnout savings (kW—summer)				
			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 330. ENERGY STAR® Refrigerators Early Retirement Summer Demand Savings (kW) by Refrigerator Type

Through-the-door ice?	Door type	Product class	Early-Retirement Savings (kW —summer)				
			Climate zone 1: Amarillo	Climate zone 2: Dallas	Climate zone 3: Houston	Climate zone 4: Corpus Christi	Climate zone 5: El Paso
No	Top Freezer	3: Refrigerator freezers—automatic defrost with top-mounted freezer without an automatic icemaker	0.028	0.028	0.028	0.028	0.028
	Bottom Freezer	5: Refrigerator-freezers—automatic defrost with bottom-mounted freezer without an automatic icemaker	0.025	0.025	0.025	0.025	0.025
Yes	Bottom Freezer	5A: Refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker with TTD ice service	0.016	0.016	0.016	0.016	0.016
	Side-by-Side	7: Refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker with TTD ice service	0.019	0.018	0.019	0.018	0.018
Unknown or Average Refrigerator			0.026	0.026	0.026	0.026	0.025

Deemed Winter Demand Savings Tables

Table 331. ENERGY STAR® Refrigerators Replace-on-burnout Winter Demand Savings (kW) by Refrigerator Type

Through-the-door ice?	Door type	Product class	Replace-on-burnout savings (kW—winter)				
			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 332. ENERGY STAR® Refrigerators Early Retirement Winter Demand Savings (kW) by Refrigerator Type

Through-the-door ice?	Door type	Product class	Early-retirement savings (kW —winter)				
			Climate zone 1: Amarillo	Climate zone 2: Dallas	Climate zone 3: Houston	Climate zone 4: Corpus Christi	Climate zone 5: El Paso
No	Top Freezer	3: Refrigerator freezers—automatic defrost with top-mounted freezer without an automatic icemaker	0.024	0.025	0.024	0.024	0.025
	Bottom Freezer	5: Refrigerator-freezers—automatic defrost with bottom-mounted freezer without an automatic icemaker	0.021	0.022	0.021	0.021	0.022
Yes	Bottom Freezer	5A: Refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker with TTD ice service	0.014	0.014	0.014	0.014	0.014
	Side-by-Side	7: Refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker with TTD ice service	0.016	0.016	0.015	0.016	0.016
Unknown or Average Refrigerator			0.022	0.023	0.022	0.022	0.023

Claimed Peak Demand Savings

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

Additional Calculators and Tools

Not applicable.

Measure Life and Lifetime Savings

The estimated useful life (EUL) is established at 16 years based on the current DOE Final Rule standards for residential refrigerators.[404]

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
- Number of units installed
- The project type of the installation (new construction, replace-on-burnout, or early retirement)
- Installed refrigerator 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.

[404] Final Rule: Standards, Federal Register, 76 FR 57516 (Sept. 15, 2011) and associated Technical Support Document. Accessed 10/10/2014. http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/43. Download TSD at: http://www.regulations.gov/#!documentDetail;D=EERE-2008-BT-STD-0012-0128.

Relevant Standards and Reference Sources

- The applicable version of the ENERGY STAR® specifications and requirements for refrigerators.

Document Revision History

Table 333. Residential ENERGY STAR® 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. LSAF updated to align with new peak demand methodology.
v3.1	11/05/2015	TRM v3.1 update. Correction to legacy LSAF. 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

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 337. All retired freezers must be dismantled in an environmentally safe manner in accordance with applicable federal, state, and local regulations. The installer will provide documentation of proper disposal of freezers. In order to receive early retirement savings, the unit to be replaced must be functioning at the time of removal.

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

Baseline Condition

For new construction or replace-on-burnout, the baseline is the Department of Energy (DOE) minimum efficiency standard[405] for freezers, effective September 15, 2014.

For early retirement, the baseline for freezers is the annual unit energy consumption of a freezer's adjusted energy usage rating based on an average of values reported by the Midwest Energy Performance Analytics (MwEPA) Refrigerator and Freezer Energy Rating Database.[406] Since the federal standard effective date occurred in late 2014, existing units manufactured as of 2015 are not eligible for early retirement.

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[405] 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.

[406] 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. http://www.kouba-cavallo.com/refmods.htm.

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."[407]

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

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

Equation 130

Where:

WH	=	*Watt-hours metered during a time period*
h	=	*Measurement time period (hours)*
8,760	=	*Hours in a year*
1,000 Watt-hours	=	*1 kWh*

High-Efficiency Condition

Table 334 displays the ENERGY STAR® requirements for eligible freezers, which went into effect on September 15, 2014. These values are subject to updates in ENERGY STAR® specifications; energy efficiency service providers are expected to comply with the latest ENERGY STAR® requirements.

Table 334. ENERGY STAR® Specifications for Freezers[408]

ENERGY STAR® freezer		
Product type	**Volume**	**Criteria as of September 15, 2014**
Freezers	7.75 cubic feet or greater	Approximately 10 percent more energy efficient than the minimum federal standard (see Table 325)
Compact Freezers	Less than 7.75 cubic feet	Approximately 10 percent more energy efficient than the minimum federal standard (see Table 325)

[407] 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.

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

Table 335. Formulas to Calculate the ENERGY STAR® Criteria for Select Freezer Product Categories by Adjusted Volume[409]

Product number	Full product name[410]	Product class	Baseline energy usage federal standard (kWh/year)[411]	Average ENERGY STAR® energy usage (kWh/year)[412]	Adjusted volume[413] (cubic feet)	Baseline energy usage (kWh/year)	ENERGY STAR® energy usage (kWh/year)
8	Upright freezers with manual defrost	Upright (Manual Defrost)	5.57 × AV + 193.7	5.01 × AV + 174.3	16.12	283.5	255.1
9	Upright freezers with automatic defrost without an automatic icemaker	Upright (Auto Defrost)	8.62 × AV + 228.3	7.76 × AV + 205.5	29.96	486.6	438.0
10	Chest freezers and all other freezers except compact freezers	Chest	7.29 × AV + 107.8	6.56 × AV + 97	25.25	291.8	262.6
16	Compact upright freezers with manual defrost	Compact Upright (Manual Defrost)	8.65 × AV + 225.7	7.79 × AV + 203.1	5.34	271.9	244.7
17	Compact upright freezers with automatic defrost	Compact Upright (Auto Defrost)	10.17 × AV + 351.9	9.15 × AV + 316.7	7.95	432.7	389.4
18	Compact chest freezers	Compact Chest	9.25 × AV + 136.8	8.33 × AV + 123.1	9.06	220.6	198.6

[409] Available for download at http://www.gpo.gov/fdsys/pkg/CFR-2012-title10-vol3/pdf/CFR-2012-title10-vol3-sec430-32.pdf. Select product classes excluded.

[410] 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.

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

[412] Approximately 10 percent more efficient than baseline, as specified in the ENERGY STAR® Appliance Savings Calculator (updated September 2015). http://www.energystar.gov/sites/default/files/asset/document/appliance_calculator.xlsx.

[413] 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

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

Equation 131

Where:

$kWh_{baseline}$ = *Federal standard baseline energy usage (see* Table 335*)*

kWh_{ES} = *ENERGY STAR® average energy usage (see* Table 335*)*

Demand Savings Algorithms

$$kW_{savings} = \frac{kWh_{savings}}{8{,}760\ hrs} \times LSAF$$

Equation 132

Where:

LSAF = *Load Shape Adjustment Factor (see* Table 336*)*

Table 336. ENERGY STAR® Freezer Load Shape Adjustment Factors[414]

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)

[414] 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 335*); if unknown, assume the age of the replaced unit is equal to the EUL resulting in a default RUL of 5.0 years.*

EUL = *Estimated useful life = 22 years*

Table 337. Remaining Useful Life (RUL) of Replaced Freezer[415]

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[416,417]	0.0

[415] 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.

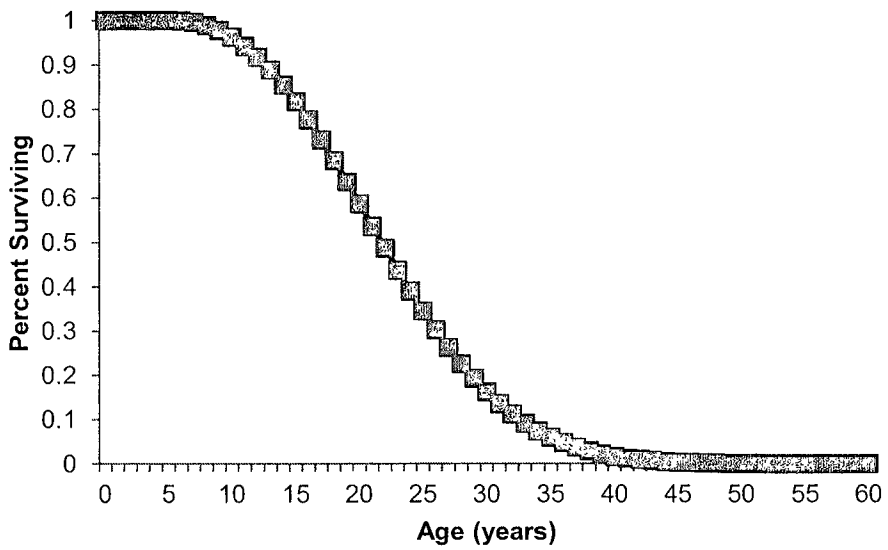
[416] RULs are capped at the 75th percentile of equipment age, 27 years, as determined based on DOE survival curves (see Figure 12). Systems older than 27 years should use the ROB baseline. See the January 2015 memo, "Considerations for early replacement of residential equipment," for further detail.

[417] 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 13.

Figure 13. Survival Function for ENERGY STAR® Freezers[418]



The method for estimating the remaining useful life (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 13. 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.

[418] 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} = *841 kWh/Year*[419]

$kWh_{baseline}$ = *Federal standard baseline energy usage (see Table 335)*

kWh_{ES} = *ENERGY STAR® average energy usage (see Table 335)*

Demand Savings Algorithms

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

For the RUL time period:

$$kW_{savings,ER} = \frac{kWh_{savings,ER}}{8{,}760\ hrs} \times LSAF$$

Equation 135

[419] This is the weighted average of adjusted annual unit energy consumption, a metric obtained from the MwEPA Refrigerator and Freezer Energy Rating Database (if from metering, substitute recorded value in lieu of this weighted average). Weights are calculated from the millions-of-households measurements obtained from RECS, (https://www.eia.gov/consumption/residential/data/2015/hc/php/hc3.6.php) corresponding to the year range classifications of freezers greater than 15 years old (specifically, 15-to-19-years-old and 20-or-more-years-old). The oldest freezers for which we had data were from 1979.

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

$$kW_{savings,ROB} = \frac{kWh_{savings,ROB}}{8{,}760\ hrs} \times LSAF$$

Equation 136

Where:

LSAF = *Load shape adjustment factor (Table 336)*

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.

Where:

RUL = *Remaining Useful Life (see Table 327)*

EUL = *Estimated Useful Life = 22 years*[420]

Deemed Energy Savings Tables

Table 338. ENERGY STAR® Freezers Energy Savings (kWh) by Freezer Type

Freezer type	Size	ROB savings (kWh/year)	ER savings (kWh/year)
Chest	Standard (≥ 7.75 ft³)	29	154
	Compact (< 7.75 ft³)	22	163
Upright	Standard (≥ 7.75 ft³)	48	130
	Compact (< 7.75 ft³)	32	151

[420] 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: http://www.regulations.gov/#!documentDetail;D=EERE-2008-BT-STD-0012-0128.

Deemed Summer Demand Savings Tables

Table 339. ENERGY STAR® Freezers Replace-on-Burnout Summer Demand Savings (kW) by Freezer Type

Freezer type	Product class	Replace-on-burnout savings (kW—summer)				
		Climate zone 1: Amarillo	Climate zone 2: Dallas	Climate zone 3: Houston	Climate zone 4: Corpus Christi	Climate zone 5: El Paso
Chest	Standard (≥ 7.75 ft³)	0.004	0.004	0.004	0.004	0.004
	Compact (< 7.75 ft³)	0.003	0.003	0.003	0.003	0.003
Upright	Standard (≥ 7.75 ft³)	0.006	0.006	0.006	0.006	0.006
	Compact (< 7.75 ft³)	0.004	0.004	0.004	0.004	0.004

Table 340. ENERGY STAR® Freezers Early Retirement Summer Demand Savings (kW) by Freezer Type

Freezer type	Product class	Early-retirement savings (kW—summer)				
		Climate zone 1: Amarillo	Climate zone 2: Dallas	Climate zone 3: Houston	Climate zone 4: Corpus Christi	Climate zone 5: El Paso
Chest	Standard (≥ 7.75 ft³)	0.020	0.019	0.019	0.019	0.019
	Compact (< 7.75 ft³)	0.021	0.020	0.021	0.020	0.020
Upright	Standard (≥ 7.75 ft³)	0.017	0.016	0.016	0.016	0.016
	Compact (< 7.75 ft³)	0.019	0.019	0.019	0.019	0.019

Deemed Winter Demand Savings Tables

Table 341. ENERGY STAR® Freezers Replace-on-Burnout Winter Demand Savings (kW) by Freezer Type

Freezer type	Product class	Replace-on-burnout savings (kW—winter)				
		Climate zone 1: Amarillo	Climate zone 2: Dallas	Climate zone 3: Houston	Climate zone 4: Corpus Christi	Climate zone 5: El Paso
Chest	Standard (≥ 7.75 ft^3)	0.003	0.003	0.003	0.003	0.003
	Compact (< 7.75 ft^3)	0.002	0.002	0.002	0.002	0.002
Upright	Standard (≥ 7.75 ft^3)	0.005	0.005	0.005	0.005	0.005
	Compact (< 7.75 ft^3)	0.003	0.003	0.003	0.003	0.003

Table 342. ENERGY STAR® Freezers Early Retirement Winter Demand Savings (kW) by Freezer Type

Freezer type	Product class	Early-retirement savings (kW—winter)				
		Climate zone 1: Amarillo	Climate zone 2: Dallas	Climate zone 3: Houston	Climate zone 4: Corpus Christi	Climate zone 5: El Paso
Chest	Standard (≥ 7.75 ft^3)	0.016	0.017	0.016	0.017	0.017
	Compact (< 7.75 ft^3)	0.017	0.018	0.017	0.018	0.018
Upright	Standard (≥ 7.75 ft^3)	0.014	0.014	0.014	0.014	0.014
	Compact (< 7.75 ft^3)	0.016	0.017	0.016	0.016	0.017

Claimed Peak Demand Savings

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

Additional Calculators and Tools

Not applicable.

Measure Life and Lifetime Savings

The estimated useful life (EUL) is established at 22 years based on the current DOE Final Rule standards for residential freezers.[421]

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
- Number of units installed
- The project type of the installation (new construction, replace-on-burnout, or early retirement)
- Installed freezer type (upright or chest)
- Installed freezer size (standard, i.e. ≥ 7.75 ft^3, or compact, i.e. < 7.75 ft^3)
- Photograph demonstrating functionality of existing equipment and/or customer responses to survey questionnaire documenting the condition of the replaced unit and their motivation for measure replacement for early retirement eligibility determination (early retirement only)
- The installer will provide documentation of proper disposal of freezers in accordance with applicable federal, state, and local regulations. (early retirement only)

References and Efficiency Standards

Petitions and Rulings

Not applicable.

[421] Final Rule: Standards, Federal Register, 76 FR 57516 (Sept. 15, 2011) and associated Technical Support Document. Accessed 09/03/2019. https://www.ecfr.gov/cgi-bin/text-idx?SID=48f64e166fe3561666f871e521996e13&mc=true&node=se10.3.430_132&rgn=div8. Download TSD at: http://www.regulations.gov/#!documentDetail;D=EERE-2008-BT-STD-0012-0128.

Relevant Standards and Reference Sources

The applicable version of the ENERGY STAR® specifications and requirements for freezers.

Document Revision History

Table 343. Residential ENERGY STAR® 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. Updated early retirement age eligibility.

2.5.7 ENERGY STAR® Pool Pumps Measure Overview

TRM Measure ID: R-AP-PP

Market Sector: Residential

Measure Category: Appliances

Applicable Building Types: Single-family, multifamily, manufactured

Fuels Affected: Electricity

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

Program Delivery Type(s): Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: Engineering algorithms and estimates

Measure Description

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

Eligibility Criteria

This measure applies to all residential applications of in-ground pools or above-ground pools. Pools that serve multiple tenants in a common area are not eligible for this measure. Ineligible pump products include waterfall, integral cartridge filter, integral sand filter, storable electric spa, and rigid electric spa[422].

Multi-speed pool pumps are an alternative to variable speed pumps. The multi-speed pump uses an induction motor that functions as two motors in one, with full-speed and half-speed options. Multi-speed pumps may enable significant energy savings. However, if the half-speed motor is unable to complete the required water circulation task, the larger motor will operate exclusively. Having only two speed-choices limits the ability of the pump motor to fine-tune the flow rates required for maximum energy savings.[423] Therefore, multi-speed pumps must have a high-speed override capability to revert back to low speed after a period not to exceed 24 hours.

Baseline Condition

The baseline condition is a 1 to 3 horsepower (hp) standard efficiency single-speed pool pump.

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[422] These product types are excluded by the ENERGY STAR® specifications. https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Final%20Version%203.0%20Pool%20Pumps%20Specification.pdf. Accessed July 2020.

[423] Hunt, A. and Easley, S., 2012, "*Measure Guideline: Replacing Single-Speed Pool Pumps with Variable Speed Pumps for Energy Savings.*" Building America Retrofit Alliance (BARA), U.S. U.S. DOE. May 2012. http://www.nrel.gov/docs/fy12osti/54242.pdf Accessed July 2020.

High-Efficiency Condition

The high-efficiency condition is a 1 to 3 hp ENERGY STAR® certified variable speed pump (VSP) or ENERGY STAR® certified multi-speed pool pump.

Energy and Demand Savings Methodology

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

Savings Algorithms and Input Variables

Energy Savings Algorithms

Energy savings for this measure were derived using the ENERGY STAR® Pool Pump Savings Calculator with Texas selected as the applicable location, so Texas-specific assumptions were used.[424]

$$kWh_{Savings} = kWh_{conv} - kWh_{ES}$$

Equation 137

Where:

kWh_{conv} = *Conventional single-speed pool pump energy (kWh)*

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

Algorithms to calculate the above parameters are defined as:

$$kWh_{conv} = \frac{PFR_{conv} \times 60 \times hours \times days}{EF_{conv} \times 1000}$$

Equation 138

$$kWh_{ES} = \frac{gal \times turn_{day} \times days}{EF_{ES}}$$

Equation 139

Where:

hours = *Pump daily operating hours (Table 344)*

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

PFRconv = *Conventional single-speed pump flow rate [gal/min] (Table 344)*

[424] The ENERGY STAR® Pool Pump Savings Calculator, updated February 2013, can be found on the ENERGY STAR® website at: https://www.energystar.gov/products/certified-products/detail/pool-pumps.

EFconv	=	*Conventional single-speed pump energy factor [gal/W·hr] (Table 344)*
EF_{ES}	=	*ENERGY STAR® pump energy factor [gal/W·hr] (Table 344)*
60	=	*Constant to convert between minutes and hours*
1,000	=	*Constant to convert from kilowatts to watts*

Table 344. Conventional Pool Pumps Assumptions[425]

Rated pump HP (new)	Hours[426]	PFR_{conv}(gal/min)	EF_{conv} (gal/W·h)
≤ 1.25	9.1062	75.5000	2.5131
1.25 < hp ≤ 1.75		78.1429	2.2677
1.75 < hp ≤ 2.25		88.6667	2.2990
2.25 < hp ≤ 2.75		93.0910	2.1812
2.75 < hp ≤ 3		101.6667	1.9987

Table 345. ENERGY STAR® Pool Pumps Assumptions[427]

Rated pump HP (new)	Gallons	EF_{ES} (gal/W·h)	Turnovers/day
≤ 1.25	22,000	8.7	1.9
1.25 < hp ≤ 1.75		8.9	1.9
1.75 < hp ≤ 2.25		9.3	2.2
2.25 < hp ≤ 2.75		7.4	2.3
2.75 < hp ≤ 3		7.1	2.5

Demand Savings Algorithms

$$kW_{Savings} = \frac{kWh_{conv} - kWh_{ES}}{hours} \times \frac{DF}{days}$$

Equation 140

[425] Conventional pump PFR and EF values are taken from pump curves found in the ENERGY STAR® Pool Pump Savings Calculator.

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

[427] ENERGY STAR® values are taken from default inputs and pump curves found in the ENERGY STAR® Pool Pump Savings Calculator.

Where:

hours = *Pump daily operating hours (Table 345)*

DF = *Demand Factor (Table 346)*

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

Table 346. Demand Factors[428]

Climate zone	Summer DF	Winter DF
1	0.258	-0.002
2	0.329	0.025
3	0.276	0.108
4	0.266	0.036
5	0.497	-0.143

Deemed Energy Savings Tables

Table 347. ENERGY STAR® Variable Speed Pool Pump Energy Savings[429]

Rated pump hp (new)	kWh savings
≤ 1.25	4,238
1.25 < hp ≤ 1.75	5,158
1.75 < hp ≤ 2.25	5,792
2.25 < hp ≤ 2.75	6,015
2.75 < hp ≤ 3	7,317

Deemed Summer Demand Savings Tables[430]

Table 348. ENERGY STAR® Variable Speed Pool Pump Summer Demand Savings

Rated pump HP (new)	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
≤ 1.25	0.329	0.419	0.352	0.339	0.634
1.25 < hp ≤ 1.75	0.401	0.510	0.429	0.413	0.771
1.75 < hp ≤ 2.25	0.450	0.573	0.481	0.463	0.866
2.25 < hp ≤ 2.75	0.468	0.595	0.500	0.481	0.900
2.75 < hp ≤ 3	0.569	0.724	0.608	0.586	1.094

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

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

[430] Ibid.

Deemed Winter Demand Savings Tables

Table 349. ENERGY STAR® Variable Speed Pool Pump Winter Demand Savings

Rated pump HP (new)	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
≤ 1.25	(0.002)	0.032	0.138	0.046	(0.182)
1.25 < hp ≤ 1.75	(0.003)	0.039	0.168	0.056	(0.222)
1.75 < hp ≤ 2.25	(0.003)	0.043	0.189	0.062	(0.249)
2.25 < hp ≤ 2.75	(0.003)	0.045	0.196	0.065	(0.259)
2.75 < hp ≤ 3	(0.004)	0.055	0.239	0.079	(0.315)

Claimed Peak Demand Savings

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

Additional Calculators and Tools

ENERGY STAR® Pool Pump Savings Calculator, updated May 2020, can be found on the ENERGY STAR® website at https://www.energystar.gov/productfinder/downloads/Pool_Pump_Calculator_2020.05.05_FINAL.xlsx

Measure Life and Lifetime Savings

According to DEER 2014, the estimated useful life for this measure is 10 years.[431]

Program Tracking Data and Evaluation Requirements

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

For all projects collect:

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

[431] Database for Energy Efficient Resources (2014). http://www.deeresources.com/.

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

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

References and Efficiency Standards

Petitions and Rulings

Not applicable.

Relevant Standards and Reference Sources

- The applicable version of the ENERGY STAR® specifications and requirements for pool pumps.

Document Revision History

Table 350. Residential ENERGY STAR® Pool Pumps Revision History

TRM version	Date	Description of change
v5.0	10/2017	TRM v5.0 origin.
v6.0	11/2018	TRM v6.0 update. No revision.
v7.0	10/2019	TRM v7.0 update. Updated eligibility to include above ground pool pumps now eligible for ENERGY STAR® certification. Acknowledged the forthcoming ENERGY STAR® version 2.0.
v8.0	10/2020	TRM v8.0 update. Incorporated ENERGY STAR® version 2.0 updated deemed savings.

2.5.8 ENERGY STAR® Air Purifiers Measure Overview

TRM Measure ID: R-AP-AP

Market Sector: Residential

Measure Category: Appliances

Applicable Building Types: Single-family, multifamily, manufactured

Fuels Affected: Electricity

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

Program Delivery Type(s): Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: Engineering algorithms and estimates

Measure Description

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

Eligibility Criteria

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

Baseline Condition

The baseline condition is defined as 1.0 cfm/W for a conventional air purifier unit's efficiency, a value from EPA research conducted in 2011, as cited in the ENERGY STAR® Appliance Savings Calculator[432].

High-Efficiency Condition

The following table displays the ENERGY STAR® Final Version 1.2 requirements for eligible air purifiers effective July 1, 2004.[433,434] These values are subject to updates in ENERGY STAR® specifications; energy efficiency service providers are expected to comply with the latest ENERGY STAR® requirements.

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[432] ENERGY STAR® Appliance Savings Calculator (updated October 2016). https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/save-energy/purchase-energy-saving-products.

[433] Available for download at: https://www.energystar.gov/ia/partners/prod_development/revisions/downloads/room_aircleaners/Room_Air_Cleaners_Final_V1.2_Specification.pdf?6ec0-9f1a.

[434] Quantitative definitions of product criteria: https://www.energystar.gov/products/appliances/air_purifiers_cleaners/key_product_criteria.

Table 351. ENERGY STAR® Specifications for Air Purifiers

Product type	Clean air delivery rate (CADR)	Minimum performance requirement	Standby power requirement	Ozone production
Air Purifiers or Room Air Cleaners	≥ 50 cu ft/min	2.0 cfm/watt	2.0 W	≤ 50 ppb

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Energy Savings Algorithms

Energy savings for this measure were derived using the ENERGY STAR® Appliance Savings Calculator and the revised ENERGY STAR® specification in Table 318.[435] Default values were taken directly from the ENERGY STAR® 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.

$$kWh_{savings} = (kWh_{baseline,OP} + kWh_{baseline,SB}) - (kWh_{ES,OP} + kWh_{ES,SB})$$

Equation 141

$$kWh_{baseline,OP} = \left(\frac{CADR_{baseline}}{Eff_{baseline}}\right)/1000 \times Hours_{OP} \times Days_{OP}$$

Equation 142

$$kWh_{baseline,SB} = (8760 - Hours_{OP} \times Days_{OP}) \times W_{baseline,SB}/1000$$

Equation 143

$$kWh_{ES,OP} = \left(\frac{CADR_{ES}}{Eff_{ES}}\right)/1000 \times Hours_{OP} \times Days_{OP}$$

Equation 144

$$kWh_{ES,SB} = 8760 - Hours_{OP} \times Days_{OP} \times W_{ES,SB}/1000$$

Equation 145

Where:

$kWh_{baseline,OP}$ = *Baseline/conventional operating energy usage*

$kWh_{baseline,SB}$ = *Baseline/conventional standby energy usage*

$kWh_{ES,OP}$ = *ENERGY STAR® average operating energy usage*

[435] ENERGY STAR® Appliance Savings Calculator (updated October 2016). https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/save-energy/purchase-energy-saving-products.

$kWh_{ES,SB}$ = *ENERGY STAR® average standby energy usage*

$CADR_{baseline}$ = *Baseline unit clean air delivery rate (cu ft/min)*

$CADR_{ES}$ = *ENERGY STAR® unit clean air delivery rate (cu ft/min)*

$Eff_{baseline}$ = *Baseline clean air delivery efficiency = 1.0 cfm/watt*

Eff_{ES} = *ENERGY STAR® air delivery efficiency = 3.0 cfm/watt*

$Hours_{OP}$ = *Average hours of operation per day = 16*

$Days_{OP}$ = *Average days of operation per year = 365*

$W_{baseline,SB}$ = *Conventional model standby power = 1.0 watt*

$W_{ES,SB}$ = *ENERGY STAR® model standby power = 0.6 watts*

8760 = *Total hours per year*

Demand Savings Algorithms

$$kW_{savings} = \frac{kWh_{savings}}{Hours_{OP} \times Days_{OP}} \times CF$$

Equation 146

Where:

$Hours_{OP}$ = *Average hours of operation per day = 16*

$Days_{OP}$ = *Average days of operation per year = 365*

CF = *Coincidence factor =* (Table 352)

Table 352. ENERGY STAR® Air Purifiers Coincidence Factors[436]

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

[436] See Volume 1, Section 4.

Deemed Energy Savings Tables

Table 353. ENERGY STAR® Air Purifiers Energy Savings (kWh)

ENERGY STAR® air purifiers—energy savings (kWh)		
Dust CADR range (cu ft/min)	Dust CADR midpoint	Energy savings
51-100	75	293
101-150	125	488
151-200	175	683
201-250	225	877
> 250	275	1,072

Deemed Summer Demand Savings Tables

Table 354. ENERGY STAR® Air Purifiers Summer Peak Demand Savings (kW)

ENERGY STAR® air purifiers—summer demand savings (kW)					
CADR range (cu ft/min)	Climate zone 1: Amarillo	Climate zone 2: Dallas	Climate zone 3: Houston	Climate zone 4: Corpus Christi	Climate zone 5: El Paso
51-100	0.03	0.03	0.03	0.03	0.03
101-150	0.05	0.05	0.05	0.05	0.05
151-200	0.07	0.07	0.07	0.07	0.07
201-250	0.10	0.09	0.09	0.09	0.08
> 250	0.12	0.11	0.12	0.11	0.10

Deemed Winter Demand Savings Tables

Table 355. ENERGY STAR® Air Purifiers Winter Peak Demand Savings (kW)

ENERGY STAR® air purifiers—winter demand savings (kW)					
CADR range (cu ft/min)	Climate zone 1: Amarillo	Climate zone 2: Dallas	Climate zone 3: Houston	Climate zone 4: Corpus Christi	Climate zone 5: El Paso
51-100	0.04	0.05	0.04	0.04	0.05
101-150	0.07	0.08	0.07	0.07	0.08
151-200	0.10	0.11	0.10	0.10	0.11
201-250	0.13	0.14	0.12	0.13	0.14
> 250	0.16	0.17	0.15	0.16	0.17

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 9 years; a figure cited as obtained from the Appliance Magazine's Portrait of the U.S. Appliance Industry, 1998 on the ENERGY STAR® Appliance Savings Calculator[437].

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
- Number of units installed
- Clean air delivery rate (CADR) in cu ft/min (cfm)
- Proof of purchase – including date of purchase and quantity
    - Alternative: photo of unit installed or another pre-approved method of installation verification.

[437] ENERGY STAR® Appliance Savings Calculator (updated October 2016). https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/save-energy/purchase-energy-saving-products.

References and Efficiency Standards

Petitions and Rulings

Not applicable.

Relevant Standards and Reference Sources

- The applicable version of the ENERGY STAR® specifications and requirements for air purifiers.

Document Revision History

Table 356. Residential ENERGY STAR® Air Purifiers Revision History

TRM version	Date	Description of change
v7.0	10/2019	TRM v7.0 origin.
v8.0	10/2020	TRM v8.0 update. No revision.

2.5.9 Advanced Power Strips Measure Overview

TRM Measure ID: R-AP-PS

Market Sector: Residential

Measure Category: Appliances

Applicable Building Types: Single-family, multifamily, manufactured

Fuels Affected: Electricity

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

Program Delivery Type(s): Prescriptive

Deemed Savings Type: Deemed savings values

Savings Methodology: Engineering algorithms and estimates

Measure Description

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

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

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

Eligibility Criteria

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

Baseline Condition

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

High-Efficiency Condition

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

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

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

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

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

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

Table 357. APS – Peripheral Watt Consumption Breakdown[438]

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

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

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

Energy Savings Algorithms

Tier 1 APS

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

$$\Delta kWh = \sum \frac{W_i \times H_i}{1{,}000}$$

Equation 147

Where:

W	=	*Weighted watts per hour consumed in standby/off mode for each peripheral device (see* Table 357*)*
H	=	*Annual hours per year controlled by APS (see Table 357)*
$1{,}000$	=	*Constant to convert from watts to kilowatts*

Tier 2 APS

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

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

Equation 148

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

Equation 149

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

Equation 150

Where:

kWh_{TV}	=	*Average annual energy consumption of Tier 2 qualifying TV systems; default = 602.8 kWh*[439]
kWh_{Comp}	=	*Average annual energy consumption of Tier 2 qualifying computer systems; default = 197.9 kWh*[440]

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

ERP = *Energy reduction percentage (default = 47.5%[441])*

ISR = *In-service rate or the percentage of units rebated that are installed; default = 1.0*

Demand Savings Algorithms

Tier 1 and Tier 2 APS

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

$$\Delta kW = \sum \frac{\Delta kWh}{H} \times CF$$

Equation 151

Where:

ΔkWh = *Annual kWh energy savings calculated as defined above*

H = *Annual hours per year controlled by APS (see Table 357 for Tier 1 APS; assume 4,380 for Tier 2 APS[442])*

CF = *Coincidence Factor (see Table 358)[443]*

Table 358. APS—Coincidence Factors[444]

Season	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
Summer	0.33	0.43	0.36	0.30	0.66
Winter	0.88	0.87	0.85	0.84	0.86

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

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

[443] Derived using Electric Power Research Institute (EPRI) End Use Load Shapes for Residential TV and PC. Accessed 9/19/2018. http://loadshape.epri.com/enduse

[444] See Volume 1, Section 4.

Deemed Energy Savings Tables

Refer to Table 359 and Table 360.

Deemed Summer Demand Savings Tables

Refer to Table 359 and Table 360.

Table 359. APS—Deemed Savings for Tier 1 Residential APS

System type	Peripheral device	kWh Savings	Summer kW savings					Winter kW savings				
			Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
Home Entertainment	Audio Equipment: AV Receiver	20.4	0.0010	0.0013	0.0011	0.0009	0.0020	0.0027	0.0027	0.0026	0.0026	0.0027
	Audio Equipment: Speakers	0.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Audio Equipment: Subwoofer	3.9	0.0002	0.0003	0.0002	0.0002	0.0004	0.0005	0.0005	0.0005	0.0005	0.0005
	Media Player: BluRay	7.1	0.0003	0.0004	0.0003	0.0003	0.0006	0.0007	0.0007	0.0007	0.0007	0.0007
	Media Player: DVD	19.7	0.0008	0.0010	0.0008	0.0007	0.0015	0.0020	0.0020	0.0020	0.0020	0.0020
	Media Player: DVD-R	29.2	0.0011	0.0015	0.0012	0.0010	0.0023	0.0030	0.0030	0.0029	0.0029	0.0029
	Media Player: DVD/VCR	37.1	0.0015	0.0019	0.0016	0.0013	0.0029	0.0039	0.0039	0.0038	0.0037	0.0038
	Media Player: VCR	28.3	0.0011	0.0014	0.0012	0.0010	0.0022	0.0029	0.0029	0.0028	0.0028	0.0028
	Set-Top Box: Cable	96.4	0.0053	0.0069	0.0058	0.0048	0.0106	0.0141	0.0139	0.0136	0.0134	0.0138
	Set-Top Box: Cable with DVR	259.0	0.0142	0.0185	0.0155	0.0129	0.0284	0.0378	0.0374	0.0366	0.0361	0.0370
	Set-Top Box: Satellite	82.7	0.0050	0.0065	0.0054	0.0045	0.0099	0.0132	0.0131	0.0128	0.0126	0.0129
	Set-Top Box: Satellite with DVR	154.3	0.0092	0.0120	0.0101	0.0084	0.0185	0.0246	0.0244	0.0238	0.0235	0.0241
	Set-Top Box: Stand Alone DVR	180.3	0.0089	0.0116	0.0097	0.0081	0.0178	0.0238	0.0235	0.0230	0.0227	0.0232
	Television: CRT	10.9	0.0005	0.0007	0.0006	0.0005	0.0011	0.0014	0.0014	0.0014	0.0013	0.0014
	Television: LCD	3.4	0.0002	0.0002	0.0002	0.0002	0.0003	0.0004	0.0004	0.0004	0.0004	0.0004
	Television: Plasma	4.1	0.0002	0.0003	0.0002	0.0002	0.0004	0.0005	0.0005	0.0005	0.0005	0.0005
	Television: Projection	47.8	0.0023	0.0030	0.0025	0.0021	0.0046	0.0062	0.0061	0.0060	0.0059	0.0060

System type	Peripheral device	kWh Savings	Summer kW savings					Winter kW savings				
			Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
Home Entertainment	Video Game Console: Nintendo Wii	20.6	0.0008	0.0011	0.0009	0.0007	0.0016	0.0022	0.0021	0.0021	0.0021	0.0021
	Video Game Console: Wii U	21.7	0.0009	0.0011	0.0009	0.0008	0.0017	0.0023	0.0023	0.0022	0.0022	0.0022
	Video Game Console: Playstation 2	10.9	0.0004	0.0006	0.0005	0.0004	0.0009	0.0011	0.0011	0.0011	0.0011	0.0011
	Video Game Console: Playstation 3	92.3	0.0036	0.0047	0.0040	0.0033	0.0073	0.0097	0.0096	0.0094	0.0093	0.0095
	Video Game Console: Playstation 4	124.8	0.0049	0.0064	0.0054	0.0045	0.0099	0.0131	0.0130	0.0127	0.0125	0.0128
	Video Game Console: XBOX	52.9	0.0021	0.0027	0.0023	0.0019	0.0042	0.0056	0.0055	0.0054	0.0053	0.0054
	Video Game Console: XBOX 360	88.5	0.0035	0.0046	0.0038	0.0032	0.0070	0.0093	0.0092	0.0090	0.0089	0.0091
	Video Game Console: XBOX One	154.1	0.0061	0.0079	0.0066	0.0055	0.0122	0.0162	0.0160	0.0157	0.0155	0.0159
	Home Entertainment System[445]	269.9	0.0133	0.0173	0.0145	0.0121	0.0265	0.0354	0.0350	0.0342	0.0338	0.0346

[445] Assuming Audio Equipment: AV Receiver, Media Player: Average, Set-Top Box: Average, and Video Game Console: Average.

System type	Peripheral device	kWh Savings	Summer kW savings					Winter kW savings				
			Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
Home Office	Computer: Desktop	37.5	0.0016	0.0021	0.0018	0.0015	0.0033	0.0043	0.0043	0.0042	0.0041	0.0042
	Computer: Laptop	38.2	0.0017	0.0022	0.0018	0.0015	0.0033	0.0044	0.0044	0.0043	0.0042	0.0043
	Computer Monitor: CRT	15.7	0.0008	0.0010	0.0008	0.0007	0.0015	0.0020	0.0020	0.0019	0.0019	0.0020
	Computer Monitor: LCD	8.3	0.0004	0.0005	0.0004	0.0004	0.0008	0.0011	0.0010	0.0010	0.0010	0.0010
	Computer Speakers	15.7	0.0008	0.0010	0.0008	0.0007	0.0015	0.0020	0.0020	0.0020	0.0019	0.0020
	Copier	12.9	0.0005	0.0006	0.0005	0.0005	0.0010	0.0013	0.0013	0.0013	0.0013	0.0013
	Fax Machine: Inkjet	46.2	0.0018	0.0023	0.0019	0.0016	0.0035	0.0047	0.0046	0.0045	0.0045	0.0046
	Fax Machine: Laser	19.7	0.0007	0.0010	0.0008	0.0007	0.0015	0.0020	0.0020	0.0019	0.0019	0.0019
	Printer: Inkjet	13.3	0.0005	0.0007	0.0005	0.0005	0.0010	0.0013	0.0013	0.0013	0.0013	0.0013
	Printer: Laser	37.9	0.0014	0.0019	0.0016	0.0013	0.0029	0.0038	0.0038	0.0037	0.0037	0.0037
	Scanner	18.0	0.0007	0.0009	0.0008	0.0006	0.0014	0.0018	0.0018	0.0018	0.0018	0.0018
	Home Office System[446]	87.1	0.0038	0.0049	0.0041	0.0034	0.0075	0.0100	0.0099	0.0097	0.0096	0.0098
Upstream/ Midstream	Unspecified System[447]	178.5	0.0085	0.0111	0.0093	0.0077	0.0170	0.0227	0.0224	0.0219	0.0217	0.0222

Table 360. APS—Deemed Savings for Tier 2 Residential APS

System type	kWh Savings	Summer kW savings					Winter kW savings				
		Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
Home Entertainment	286.3	0.022	0.028	0.024	0.020	0.043	0.058	0.057	0.056	0.055	0.056
Home Office	94.0	0.007	0.009	0.008	0.006	0.014	0.019	0.019	0.018	0.018	0.018
Upstream/Midstream	190.2	0.014	0.019	0.016	0.013	0.029	0.038	0.038	0.037	0.036	0.037

[446] Assuming Computer Monitor: LCD, Computer Speakers, Copier, Printer: Average, and Scanner.
[447] Average of Home Entertainment and Home Office system averages.

Claimed Peak Demand Savings

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

Additional Calculators and Tools

Not applicable.

Measure Life and Lifetime Savings

The estimated useful life (EUL) is 10 years for a Tier 1 APS, according to the 2011 NYSERDA Advanced Power Strip Research Report.[448] While Tier 2 APS is not covered by the NYSERDA report, assume the same 10-year EUL for Tier 2 APS.

Program Tracking Data and Evaluation Requirements

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

- Number of APS installed
- APS type (Tier 1 or Tier 2)
- System or peripheral type
- Climate zone
- 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

Not applicable.

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

Document Revision History

Table 361. Residential ENERGY STAR® Advanced Power Strips 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.

2.5.10 ENERGY STAR® Electric Vehicle Supply Equipment (EVSE)

TRM Measure ID: R-AP-EV

Market Sector: Residential

Measure Category: Appliance

Applicable Business Types: Single-family, manufactured

Fuels Affected: Electricity

Decision/Action Type: Retrofit, new construction

Program Delivery Type: Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: Engineering algorithms and estimates

Measure Description

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

Eligibility Criteria

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

Baseline Condition

The baseline condition is a non-ENERGY STAR qualified Level 2 EVSE.

High-Efficiency Condition

The high-efficiency EVSE must be an ENERGY STAR® qualified Level 2 EVSE.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Savings for EVSE come from efficiency gains of the ENERGY STAR equipment during operating modes when the vehicle is plugged in but not charging and when not plugged in. Deemed savings are calculated according to the following algorithms.

Energy Savings Algorithms

$$ENERGY\ STAR\ Idle\ Consumption\ [kWh] = \frac{(hr_{plug} \times W_{plug} + hr_{unplug\_C} \times W_{unplug}) \times days_C + hr_{unplug\_NC} \times W_{unplug} \times days_{NC}}{1000}$$

Equation 152

$$Baseline\ Idle\ Consumption\ [kWh] = \frac{ENERGY\ STAR\ Idle\ Consumption}{0.6}$$

Equation 153

$$Annual\ Energy\ Savings\ [kWh] = Baseline\ Idle\ Consumption - ENERGY\ STAR\ Idle\ Consumption$$

Equation 154

$$Demand\ Savings\ [kW] = Annual\ Energy\ Savings \times PLS$$

Equation 155

Where:

hrs_{plug} = *Hours per day the vehicle is plugged into the EVSE and not charging, 9.3 hr.*[449]

W_{plug} = *Wattage of the EVSE when the vehicle is plugged into the EVSE but not charging, 6.9 W.*[450]

hr_{unplug_C} = *Hours per day the vehicle is not plugged into the EVSE on a charging day, 12.3 hr.*[451]

hr_{unplug_NC} = *Hours per day the vehicle is not plugged into the EVSE on a non-charge day, 24 hr.*

W_{unplug} = *Wattage of the EVSE when the vehicle is not plugged into the EVSE, 3.3 W.*[452]

$days_C$ = *Number of charging days per year, 321.*[453]

[449] Idaho National Lab (INL) EV Project, June 2015, "Characterize the Demand and Energy Characteristics of Residential Electric Vehicle Supply Equipment," page 5. A vehicle plugged in for 11.7 hours and charging for 2.4 hours leaves 9.3 hours when it is plugged in and not charging.

[450] Average Idle Mode Input Power from ENERGY STAR certified EVSE product list as of July 13, 2020.

[451] INL; 24 hours per day minus 11.7 hours plugged in leaves 12.3 hours unplugged.

[452] Average No Vehicle Mode Input Power from ENERGY STAR certified EVSE product list as of July 13, 2020.

[453] INL, page 6, 88% of PEV owners charge every day. 365 x .88 = 321.2.

$days_{NC}$ = *Number of non-charging days per year, 44.*

1000 = *conversion from Wh to kWh*

0.6 = *Efficiency adjustment factor*[454]

Demand Savings Algorithms

$$Demand\ Savings\ [kW] = Annual\ Energy\ Savings\ \times PLS$$

Equation 156

Where:

PLS = *Probability-weighted peak load share, Table 362*

Table 362. EVSE Peak Load Share[455]

Climate zone	Summer PLS	Winter PLS
Climate zone 1: Amarillo	0.00012	0.00016
Climate zone 2: Dallas	0.00011	0.00014
Climate zone 3: Houston	0.00012	0.00011
Climate zone 4: Corpus Christi	0.00011	0.00016
Climate zone 5: El Paso	0.00009	0.00023

Deemed Energy Savings Tables

Table 363 presents the deemed annual energy savings per EVSE.

Table 363. EVSE Annual Energy Savings

Annual energy savings (kWh)
24.7

[454] ENERGY STAR Electric Vehicle Chargers Buying Guidance: "ENERGY STAR certified EV charger... on average use 40% less energy than a standard EV charger when the charger is in standby mode (i.e., not actively charging a vehicle)." https://www.energystar.gov/products/other/evse. Accessed July 2020.

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

Deemed Summer and Winter Demand Savings Tables

Table 364 presents the deemed summer and winter peak kW savings per EVSE.

Table 364. EVSE Peak Demand Savings

Climate Zone	Summer Peak kW	Winter Peak kW
Climate Zone 1: Amarillo	0.00298	0.00392
Climate Zone 2: Dallas	0.00274	0.00358
Climate Zone 3: Houston	0.00294	0.00276
Climate Zone 4: Corpus Christi	0.00283	0.00403
Climate Zone 5: El Paso	0.00222	0.00574

Claimed Peak Demand Savings

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

Additional Calculators and Tools

Not applicable.

Measure Life and Lifetime Savings

The estimated useful life (EUL) for an EVSE is assumed to be 10 years.[456]

Program Tracking Data and Evaluation Requirements

It is required that the following list of primary inputs and contextual data be specified and tracked by the program database to inform the evaluation and apply the savings properly:

- Climate zone
- EVSE make and model number
- Vehicle year, make, and model
- Estimated number of miles driven per day

References and Efficiency Standards

Petitions and Rulings

Not applicable.

[456] U.S. Department of Energy Vehicle Technologies Office, November 2015, "Costs Associated with Non-Residential Electric Vehicle Supply Equipment" p. 21. https://afdc.energy.gov/files/u/publication/evse_cost_report_2015.pdf, Accessed July 2020.