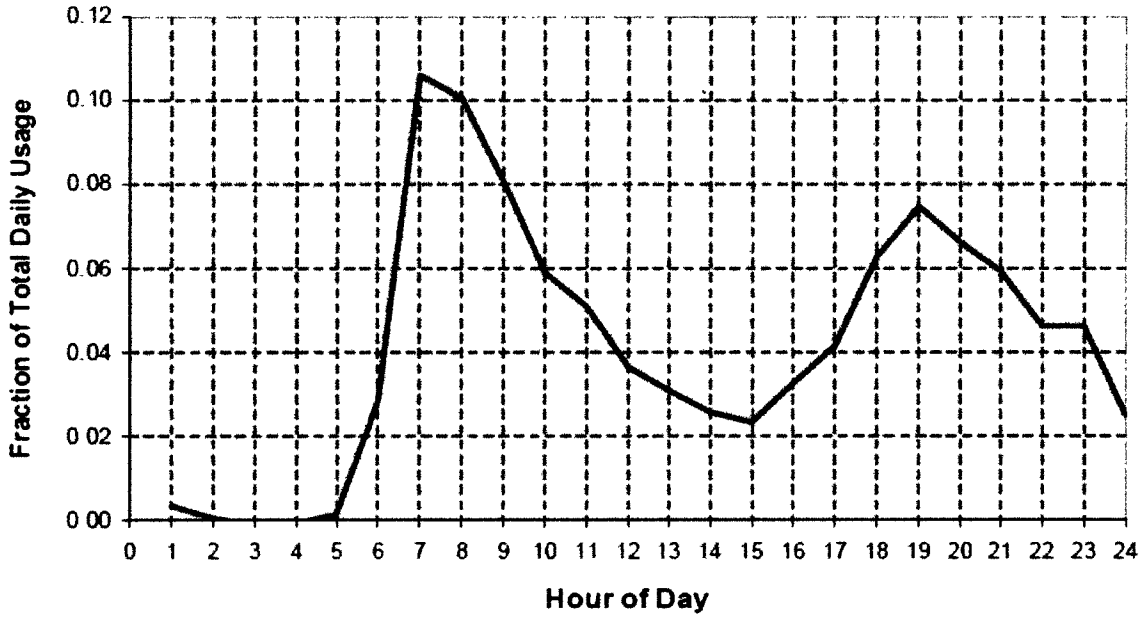

Source: Building America Performance Analysis Procedures for Existing Homes

Figure 2-7: Shower, Bath, and Sink Hot Water Use Profile

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, Appendix B: Peak Demand Reduction Documentation for further details on peak demand savings and methodology.

Additional Calculators and Tools

This section is not applicable.

Measure Life and Lifetime Savings

The estimated useful life (EUL) of a low-flow showerhead is established at 10 years.

This value is consistent with the EUL reported in the 2014 California Database for Energy Efficiency Resources (DEER).[203]

Program Tracking Data & 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:

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

References and Efficiency Standards

Petitions and Rulings

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

Relevant Standards and Reference Sources

This section is not applicable.

[203] 2014 California Database for Energy Efficiency Resources. http://www.deeresources.com/index.php/deer2013-update-for-2014-codes.

Document Revision History

Table 2-261: Low-Flow Showerheads Revision History

TRM Version	Date	Description of Change
v1.0	11/25/2013	TRM v1.0 origin
v2.0	4/18/2014	TRM v2.0 update. Minor edits to language.
v2.1	1/30/2015	TRM v2.1 update. No revision.
v3.0	4/10/2015	TRM v3.0 update. No revision.
v3.1	11/05/2015	TRM v3.1 update. Provided clarification that savings are to be awarded per showerhead. Supplemented reference for water heater set point temperature.
v4.0	10/10/2016	Updated methodology to calculate energy and demand savings.

2.4.3 Water Heater Pipe Insulation Measure Overview

TRM Measure ID: R-WH-PI

Market Sector: Residential

Measure Category: Water Heating

Applicable Building Types: Single-family, duplex and triplex; Multifamily; Manufactured

Fuels Affected: Electricity

Decision/Action Type(s): Retrofit

Program Delivery Type(s): Prescriptive

Deemed Savings Type: Deemed Savings Calculations

Savings Methodology: Engineering Algorithms and Estimates

Measure Description

This measure requires the installation of pipe insulation on un-insulated water heater pipes that are served by an electric water heater.

Eligibility Criteria

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

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

Table 2-262: Water Heater Pipe Insulation – Applicability

Application Type	Applicable	Notes
Retrofit	Y	Savings cannot be claimed in conjunction with the installation of a new water heater.
New Construction	N	

Baseline Condition

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

Table 2-263: Water Heater Pipe Insulation – Baseline Standard

Baseline
Un-insulated hot water pipes

High-Efficiency Condition

The efficiency standard requires an insulation thickness R-3. The International Residential Code (IRC) 2009 section N1103.3: Mechanical system piping insulation requires R-3 insulation.

Table 2-264: Water Heater Pipe Insulation – Efficiency Standard

Efficiency Standard
Minimum insulation of R-3

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

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Energy Savings Algorithms

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

$$\textit{Energy savings per year} = (U_{pre} - U_{post}) \times A \times (T_{pipe} - T_{ambient\ annual}) \times \left(\frac{1}{RE}\right) \times \frac{Hours_{Total}}{conversion\ factor}$$

Equation 78

Where:

U_{pre}[204] = $\frac{1}{2.03} = 0.49\ ^{Btu}/_{hr \cdot sq.ft. \cdot °F}$

U_{post} = $\frac{1}{2.03 + R_{Insulation}}$

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

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

[204] 2.03 is the R-value representing the film coefficients between water and the inside of the pipe, and between the surface and air. Mark's Standard Handbook for Mechanical Engineers, 8th edition.

Table 2-265: Estimated Pipe Surface Area

Pipe Diameter (inches)	Pipe Surface Area (square feet)[205]
0.5	0.16 x required input "Pipe Length insulated (feet)"
0.75	0.23 x required input "Pipe Length insulated (feet)"
1.0	0.29 x required input "Pipe Length insulated (feet)"

$T_{pipe}(°F)$ = *120°F*[206]

$T_{ambientannual}$ *(°F)* = *Ambient annual temperature (see Table 2-266)*

RE = *Recovery Efficiency (or in the case of heat pump water heaters, COP). If unknown, use 0.98 as a default for electric resistance water heaters or 2.2 for heat pump water heaters.*[207]

$Hours_{Total}$ = *8,760 hr. per year*

Conversion factor = *3,412 Btu per kWh*

Demand Savings Algorithms

Pipe Insulation Demand Savings (kW)

$$= (U_{pre} - U_{post}) \times A \times (T_{Pipe} - T_{ambient\ seasonal}) \times \left(\frac{1}{RE}\right) \times \frac{1}{conversion\ factor}$$

Equation 79

Where:

$T_{ambientseasonal}(°F)$ = *Ambient seasonal temperature (see Table 2-266)*

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

Nominal Diameter (inches)	Outside Diameter (inches)	Factor to Calculate Pipe Area
0.5	0.625	0.16
0.75	0.875	0.23
1.0	1.125	0.29

[206] 120°F represents the assumed water heater setpoint. New York Department of Public Service recommends using water heater setpoint as a default value, see "New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs" October 2010, page 102.

Data collection discussed in Appendix D of the EM&V team's Annual Statewide Portfolio Report for Program Year 2014-Volume 1, Project Number 40891 (August 2015), also supports a default value of 120°F.

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

Table 2-266: Ambient Temperatures per Climate Zone

Climate Zone		Ambient Temperature (°F)					
		Water Heater Location: Unconditioned Space*			Water Heater Location: Conditioned Space**		
		Annual	Peak Seasonal		Annual	Peak Seasonal	
			Summer	Winter		Summer	Winter
1	Panhandle	65.5	106	32			
2	North	73.1	108.1	42			
3	South	76.3	108.2	46	72.7	75.1	69.3
4	Valley	78.4	103	55			
5	West	71.8	108	41.1			

* Average ambient temperatures were taken from TMY3 data, with a 7°F increase in winter and an 11°F increase in summer based on ASHRAE 152 Heating System & Cooling System Location Temperatures (Garage).
** Weighted average reported thermostat set points from RECS. Times associated with these set points are assumed to be the same as those assumed by ENERGY STAR®: http://www.energystar.gov/index.cfm?c=thermostats.pr_thermostats_guidelines.

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, Appendix B: Peak Demand Reduction Documentation for further details on peak demand savings and methodology.

Additional Calculators and Tools

This section is not applicable.

Measure Life and Lifetime Savings

The estimated useful life (EUL) of water heater pipe insulation installed for an electric water heater is established at 13 years.

This value is consistent with the EUL reported in the 2014 California Database for Energy Efficiency Resources (DEER).[208]

Program Tracking Data & 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:

- The climate zone
- The R-value of the installed insulation
- Recovery Efficiency (RE) or COP, if available
- Pipe length insulated (feet)
- The pipe surface area insulated in square feet (at least the pipe diameter in inches)

References and Efficiency Standards

Petitions and Rulings

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

Relevant Standards and Reference Sources

This section is not applicable.

Document Revision History

Table 2-267: Water Heater Pipe Insulation Revision History

TRM Version	Date	Description of Change
v1.0	11/25/2013	TRM v1.0 origin
v2.0	4/18/2014	TRM v2.0 update. Minor edits to language.
v2.1	1/30/2015	TRM v2.1 update. No revision.
v3.0	4/10/2015	TRM v3.0 update. No revision.
v3.1	11/05/2015	TRM v3.1 update. Supplemented reference for water heater set point temperature.
v4.0	10/10/2016	TRM v4.0 update: No revision

[208] 2014 California Database for Energy Efficiency Resources. http://www.deeresources.com/index.php/deer2013-update-for-2014-codes.

2.4.4 Water Heater Tank Insulation Measure Overview

TRM Measure ID: R-WH-WJ

Market Sector: Residential

Measure Category: Water Heating

Applicable Building Types: Single-family, duplex and triplex; Multifamily; Manufactured

Fuels Affected: Electricity

Decision/Action Type(s): Retrofit

Program Delivery Type(s): Prescriptive

Deemed Savings Type: Deemed Savings Calculations

Savings Methodology: Engineering Algorithms and Estimates

Measure Description

This measure requires the installation of tank insulation on un-insulated water heater tanks that are served by an electric water heater.

Eligibility Criteria

Water heaters meeting the National Appliance Energy Conservation Act standards with respect to insulation and standby loss requirements are not eligible for this measure. To ensure compliance, the contractor shall inspect the build date listed on the existing water heater label and verify that the listed build date is before 1991.

Water heater pipe insulation is a residential retrofit measure. New construction and water heater replacements are not eligible for this measure, because they must meet current code requirements. In order to be awarded these deemed savings, the fuel type of the water heater must be electricity.

Table 2-268: Water Heater Tank Insulation – Applicability

Application Type	Applicable
Retrofit	Y
New Construction	N

Baseline Condition

The baseline is assumed to be a typical electric water heater with no insulation.

High-Efficiency Condition

There is no minimum insulation requirement. Manufacturer's instructions on the water heater jacket and the water heater itself should be followed. Thermostat and heating element access panels must be left uncovered.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Energy Savings Algorithms

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

$$Energy\ savings\ per\ year = (U_{pre} - U_{post}) \times A \times (T_{tank} - T_{ambient\ annual}) \times \left(\frac{1}{RE}\right) \times \frac{Hours_{Total}}{conversion\ factor}$$

Equation 80

Where:

U_{pre} = *1/ (5) Btu/hr. sq.ft. °F*

U_{post} = *1/ (5+*$R_{Insulation}$*)*

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

A = *Tank surface area insulated in square feet* (πDL) *with L (length) and D (tank diameter) in feet. If the tank area is not known, use Table 2-269.*

Table 2-269: Estimated Tank Area

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

* Tank area was obtained from a survey of electric water heater manufacturer data. Dimensions for each tank size were collected and averaged to determine a typical square footage of each size water heater. Accessed April 2013: http://www.hotwater.com/water-heaters/residential/conventional/electric/promax/standard/. Accessed April 2013: http://www.whirlpoolwaterheaters.com/products/electric-water-heaters/es40r92-45d/.

$T_{tank}(°F)$ = *Average temperature of the tank, default use 120°F*[209]

$T_{ambientannual}$ *(°F)* = *Ambient annual temperature (see Table 2-270)*

RE = *Recovery Efficiency (or in the case of heat pump water heaters, COP). If unknown, use 0.98 as a default for electric resistance water heaters or 2.2 for heat pump water heaters.*[210]

$Hours_{Total}$ = *8,760 hours per year*

Conversion factor = *3,412 Btu per kWh*

Demand Savings Algorithms

Tank Insulation Demand Savings (kW)

$$= (U_{pre} - U_{post}) \times A \times (T_{Tank} - T_{ambient\ seasonal}) \times \frac{1}{RE} \times \frac{1}{conversion\ factor}$$

Equation 81

Where:

$T_{ambientseasonal}(°F)$ = *Ambient seasonal temperature (see Table 2-270)*

Table 2-270: Ambient Temperatures per Climate Zone

Climate Zone		Ambient Temperature (°F)					
		Water Heater Location: Unconditioned Space			Water Heater Location: Conditioned Space		
		Annual	Peak Seasonal		Annual	Peak Seasonal	
			Summer	Winter		Summer	Winter
1	Panhandle	65.5	106	32			
2	North	73.1	108.1	42			
3	South	76.3	108.2	46	72.7	75.1	69.3
4	Valley	78.4	103	55			
5	West	71.8	108	41.1			

* Average ambient temperatures were taken from TMY3 data, with a 7°F increase in winter and an 11°F increase in summer based on ASHRAE 152 Heating System & Cooling System Location Temperatures (Garage).
** Weighted average reported thermostat set points from RECS. Times associated with these set points assumed to be the same as those assumed by ENERGY STAR®: http://www.energystar.gov/index.cfm?c=thermostats.pr_thermostats_guidelines.

[209] 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.

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

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

Refer to Volume 1, Appendix B: Peak Demand Reduction Documentation for further details on winter peak demand savings and methodology.

Claimed Peak Demand Savings

Refer to Volume 1, Appendix B: Peak Demand Reduction Documentation for further details on peak demand savings and methodology.

Additional Calculators and Tools

This section is not applicable.

Measure Life and Lifetime Savings

The estimated useful life (EUL) for storage water heater tank insulation is established at 7 years.

This value is consistent with the EUL reported in the 2014 California Database for Energy Efficiency Resources (DEER).[211]

Program Tracking Data & 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:

- The climate zone
- Recovery Efficiency (RE) or COP, if available
- The R-value of the installed insulation
- Tank surface area insulated in square feet (πDL) with L (length) and D (tank diameter) in feet; if unable to determine tank area, tank volume must be recorded.

[211] 2014 California Database for Energy Efficiency Resources. http://www.deeresources.com/index.php/deer2013-update-for-2014-codes.

References and Efficiency Standards

Petitions and Rulings

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

Relevant Standards and Reference Sources

This section is not applicable.

Document Revision History

Table 2-271: Water Heater Tank Insulation Revision History

TRM Version	Date	Description of Change
v1.0	11/25/2013	TRM v1.0 origin
v2.0	4/18/2014	TRM v2.0 update. Minor edits to language.
v2.1	1/30/2015	TRM v2.1 update. No revision.
v3.0	4/10/2015	TRM v3.0 update. No revision.
v3.1	11/05/2015	TRM v3.1 update. Supplemented reference for water heater set point temperature.

2.4.5 Water Heater Installation – Electric Tankless and Fuel Substitution Measure Overview

TRM Measure ID: R-WH-WH

Market Sector: Residential

Measure Category: Water Heating

Applicable Building Types: Single-family, duplex and triplex; Multifamily; Manufactured

Fuels Affected: Electricity and gas

Decision/Action Type(s): Replace-on-Burnout, Early Retirement, New Construction

Program Delivery Type(s): Prescriptive

Deemed Savings Type: Deemed Savings Calculations

Savings Methodology: Engineering Algorithms and Estimates

Measure Description

This measure involves installing a new electric tankless or gas-fueled water heater (storage or tankless) in place of an electric storage water heater.[212]

Eligibility Criteria

This measure involves installing a gas storage, gas tankless (instantaneous), or electric tankless water heater in place of an electric storage water heater, and which meets all the additional requirements described below. HPWHs are not eligible for installation through this measure (see separate Heat Pump Water Heater measure). Currently, there are no conventional, electrically fueled storage units that sufficiently exceed the new federal standard to merit inclusion as an efficient condition in these deemed savings; therefore, deemed savings are only calculated for new gas storage, gas tankless, and electric tankless systems. Electric tankless water heaters may only replace systems with tanks less than 55 gallons. For the installation of an electric water heater with a tank size greater than 55 gallons, please refer to the Heat Pump Water Heater measure.

These deemed savings are for water heater replacements installed as a replace-on-burnout, new construction, or early retirement measure. However, savings are calculated under the assumption of replace-on-burnout or new construction. Savings may be awarded for installations in newly constructed homes where customer and utility representatives provide

[212] Previous versions of this measure included an incentive for installing high-efficiency conventional (electric resistance) storage water heaters. Increments to the federal standard for electric storage water heaters went into effect on April 16, 2015, eliminating the feasibility of continuing to provide deemed savings for these units.

written indication that an electric storage water heater would otherwise have been installed, along with relevant design documentation showing an electric storage water heater.

Table 2-272: Water Heater Replacement – Applicability

Application Type	Applicable
Replace-on-Burnout	Y
Early Retirement	Y
New Construction	Y*

* Subject to documentation requirements described above.

Baseline Condition

For most installations, the baseline condition is an electric storage water heater with baseline efficiency determined by tank size according to the amended federal energy efficiency standards for residential water heaters with tank sizes from 20 to 120 gallons, which took effect April 16, 2015, as published in 10 CFR Part 430.32 of the Federal Register (seeTable 2-272).[213]

Table 2-273: Water Heater Replacement – Baseline

Rated Storage Volume	Energy Factor*
≥ 20 gal and ≤ 55 gal	$0.960 - (0.0003 * V_s)$
> 55 gal and ≤ 120 gal	$2.057 - (0.00113 * V_s)$

*V_s is the volume of the water heater storage tank.

The new DOE efficiency standard effectively requires HPWHs (assuming electric water heating) for electric storage water heaters with tank size greater than 55 gallons. As such, electric water heaters with tanks greater than 55 gallons are not eligible for this measure. Instead, see the Heat Pump Water Heater measure. Furthermore, gas water heaters greater than 55 gallons must use HPWH baseline consumption to calculate savings, as shown in the deemed savings provided at the end of this measure.

For smaller systems, the baseline technology remains an electric storage water heater with electric resistance as the primary heat source. This baseline assumes a replace-on-burnout scenario.

High-Efficiency Condition

For water heater replacement and fuel substitution, the new unit must meet the following federal minimum energy factor shown in Table 2-274. Water heaters must be installed in accordance with local code requirements.

Table 2-274 shows storage water heater energy factors for common tank volumes.

[213] *10 CFR Part 430.32 Energy and water conservation standards and their effective dates.* Accessed February 2014. Available online: http://www.gpo.gov/fdsys/pkg/CFR-2012-title10-vol3/pdf/CFR-2012-title10-vol3-sec430-32.pdf.

Table 2-274: Water Heater Replacement – Efficiency Standards

Energy Source	Tank Volume (unit being replaced)	Standard Energy Factor
Electric Tankless	≥ 20 gal and ≤ 55 gal	0.98*
	> 55 gal	N/A*
Gas Tankless	≥ 20 gal	$0.82 - 0.0019 \times V_s$
Gas Storage	≥ 20 gal and ≤ 55 gal	$0.675 - 0.0015 \times V_s$
	> 55 gal	$0.8012 - 0.00078 \times V_s$

* The lowest energy factor associated with an electric tankless water heater in the AHRI database was 0.98 as of March 2014. http://www.ahridirectory.org/ahridirectory/pages/home.aspx.

** V_s is the rated storage volume of the new water heater.

Table 2-275: Storage Water Heater Energy Factors for Common Tank Volumes (not exhaustive)

Fuel Type	Tank Volume (Gallons)			
	30	40	50	80
Baseline – Electric Storage	0.951	0.948	0.945	1.967*
Efficiency Standard – Gas Storage	0.630	0.615	0.600	0.739

* Baseline value from the Heat Pump Water Heater measure.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

All deemed savings values are calculated using the following standard algorithms for water heating. These algorithms assume a replace-on-burnout or new construction scenario, but may be used to award savings for early retirement projects.

Electric Tankless Water Heater

Energy Savings Algorithm

$$kWh_{savings} = \frac{\rho \times C_p \times GPY \times (T_{setpoint} - T_{supply,annual}) \times \left(\frac{1}{EF_{pre}} - \frac{1}{EF_{post}}\right)}{3{,}412}$$

Equation 82

Where:

ρ = Water density (= 8.33 lbs/gallons)

C_p = Specific heat of water (= 1 Btu/lb·°F)

GPY = Estimated annual hot water use in gallons/year, specified by number of bedrooms in the home (see Table 2-275)

Table 2-276: Water Heater Consumption (gal/year)*

Climate Zone		Number of Bedrooms			
		1	2	3	4
1	Panhandle	15,476	20,171	24,866	29,561
2	North	14,778	19,244	23,710	28,177
3	South	14,492	18,864	23,236	27,608
4	Valley	14,213	18,494	22,775	27,056
5	West	14,905	19,412	23,920	28,427

* Building America Research Benchmark Definition. December 2009. Available online: http://www.nrel.gov/docs/fy10osti/47246.pdf.

$T_{SetPoint}$ = Water heater set point (= 120°F)[214]

$T_{Supply,ann}$ = Annual average mains temperature from Table 2-276

EF_{pre} = Baseline energy factor (see Table 2-275 or calculate per Table 2-273)[215]

EF_{post} = Energy factor of new water heater

$3{,}412$ = Constant to convert from Btu to kWh

Table 2-277: Water Mains Temperature*

Climate Zone		Water Mains Temperature (°F)		
		$T_{supply,annual}$	$T_{supply,seasonal}$	
			Summer	Winter
1	Panhandle	62.9	73.8	53.7
2	North	71.8	84.0	60.6
3	South	74.7	84.5	65.5
4	Valley	77.2	86.1	68.5
5	West	70.4	81.5	60.4

* Based on TMY3 dataset: http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/.

[214] 120°F represents the assumed water heater setpoint. The New York Department of Public Service recommends using the water heater setpoint as a default value, see "New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs." Page 99. October 2010. The data collection discussed in Appendix D of the EM&V team's Annual Statewide Portfolio Report for Program Year 2014-Volume 1, Project Number 40891 (August 2015) also supports a default value of 120°F.

[215] Note that for efficient water heater installations in newly-constructed homes, the baseline energy factor is the efficiency of the electric storage water heater that would otherwise have been installed, according to appropriate design documentation.

Demand Savings Algorithm

$$kW_{savings,summer} = Ratio_{daily\ gal}^{summer\ peak\ gal} \frac{\rho \times C_p \times GPY \times (T_{setpoint} - T_{supply,summer}) \times \left(\frac{1}{EF_{pre}} - \frac{1}{EF_{post}}\right)}{365 \times 3{,}412}$$

Equation 83

$$kW_{savings,winter} = Ratio_{daily\ gal}^{winter\ peak\ gal} \frac{\rho \times C_p \times GPY \times (T_{setpoint} - T_{supply,winter}) \times \left(\frac{1}{EF_{pre}} - \frac{1}{EF_{post}}\right)}{365 \times 3{,}412}$$

Equation 84

Where:

$Ratio_{dailygal}^{Sumpeakgal}$ = Ratio of hot water use during the typical summer peak hour (4:00 p.m. to 5:00 p.m.) to daily hot water use (= 0.0436)

$Ratio_{dailygal}^{Winpeakgal}$ = Ratio of average hot water use during the winter peak hour (7:00 a.m. to 8:00 a.m.) to daily hot water use (= 0.0794)

$T_{Supply,sum}$ = Summer average water mains temperature (see Table 2-276)

$T_{Supply,win}$ = Winter average water mains temperature (see Table 2-276)

Gas Storage or Tankless Water Heater (Fuel Substitution)

Energy and demand savings awarded for replacing an electric water heater with a gas storage or gas tankless water heater are equal to the consumption of the unit replaced.

For gas storage water heaters with a tank size greater than 55 gallons, or gas tankless water heaters replacing a unit greater than 55 gallons, the appropriate baseline is a HPWH. The baseline consumption values are calculated using the federal standard baseline condition specified in the Heat Pump Water Heater measure. Savings for gas water heaters larger than 55 gallons are shown in Table 2-278 through Table 2-281.

Energy Savings Algorithm for Units Less than 55 Gallons

$$kWh_{savings} = \frac{\rho \times C_p \times GPY \times (T_{setpoint} - T_{supply,annual}) \times \left(\frac{1}{EF_{pre}}\right)}{3{,}412}$$

Equation 85

Demand Savings Algorithm for Units Less than 55 Gallons

$$\text{SummerkW}_{\text{savings}} = \text{Ratio}_{\text{daily gal}}^{\text{summer peak gal}} \times \frac{\rho \times C_p \times \text{GPY} \times (T_{\text{setpoint}} - T_{\text{supply,summer}}) \times \left(\frac{1}{EF_{\text{pre}}}\right)}{365 \times 3{,}412}$$

Equation 86

$$\text{WinterkW}_{\text{savings}} = \text{Ratio}_{\text{daily gal}}^{\text{winter peak gal}} \times \frac{\rho \times C_p \times \text{GPY} \times (T_{\text{setpoint}} - T_{\text{supply,winter}}) \times \left(\frac{1}{EF_{\text{pre}}}\right)}{365 \times 3{,}412}$$

Equation 87

Examples

Example 1. An old 40-gallon electric water heater in a two-bedroom home in Dallas is replaced with a new, tankless electric water heater with an energy factor of 0.99.

$$\text{kWh}_{\text{savings}} = \frac{\left[8.33 \times 1 \times 19{,}244 \times (120 - 71.8) \times \left(\frac{1}{0.948} - \frac{1}{0.99}\right)\right]}{3{,}412} = 101 \text{ kWh}$$

$$\text{kW}_{\text{savings,summer}} = 0.0436 \frac{\left[8.33 \times 1 \times 19{,}244 \times (120 - 84) \times \left(\frac{1}{0.948} - \frac{1}{0.99}\right)\right]}{365 \times 3{,}412} = 0.01 \text{ kW}$$

$$\text{kW}_{\text{savings,winter}} = 0.0794 \frac{\left[8.33 \times 1 \times 19{,}244 \times (120 - 60.6) \times \left(\frac{1}{0.948} - \frac{1}{0.99}\right)\right]}{365 \times 3{,}412} = 0.03 \text{ kW}$$

Example 2. An old 30-gallon electric water heater in a one-bedroom house in El Paso is replaced with a new gas storage water heater with an energy factor of 0.65.

$$\text{kWh}_{\text{savings}} = \frac{\left[8.33 \times 1 \times 14{,}905 \times (120 - 70.4) \times \left(\frac{1}{0.951}\right)\right]}{3{,}412} = 1{,}898 \text{ kWh}$$

$$\text{kW}_{\text{savings,summer}} = 0.0436 \times \frac{\left[8.33 \times 1 \times 14{,}905 \times (120 - 81.5) \times \left(\frac{1}{0.951}\right)\right]}{365 \times 3{,}412} = 0.18 \text{ kW}$$

$$\text{kW}_{\text{savings,winter}} = 0.0794 \times \frac{\left[8.33 \times 1 \times 14{,}905 \times (120 - 60.4) \times \left(\frac{1}{0.951}\right)\right]}{365 \times 3{,}412} = 0.50 \text{ kW}$$

Example 3. An old electric water heater in a two-bedroom house in Corpus Christi is replaced with a new 65-gallon gas storage water heater in a home with gas heat.

$$\text{kWh}_{\text{savings}} = 1{,}246 \text{ kWh}$$

$$\text{kW}_{\text{savings,summer}} = 0.19 \text{ kW}$$

$$\text{kW}_{\text{savings,winter}} = 0.38 \text{ kW}$$

Deemed Energy Savings Tables

Energy savings for gas water heaters with tanks greater than 55 gallons (or gas tankless units replacing a unit greater than 55 gallons) are provided in Table 2-278.

Table 2-278: HPWH Baseline Energy Consumption (kWh) for Gas Water Heaters with > 55 Gallon Tanks

Climate Zone	Tank Size (Gal)	Water Heater Location/Heat Type			
		Conditioned Space			Unconditioned Space
		Gas	Electric Resistance	Heat Pump	
1	55 - 64	1,873	1,059	1,520	1,830
	65 - 74	2,137	1,303	1,775	2,102
	75 +	2,403	1,550	2,033	2,378
2	55 - 64	1,553	984	1,306	1,396
	65 - 74	1,762	1,180	1,509	1,604
	75 +	1,973	1,378	1,715	1,814
3	55 - 64	1,467	906	1,223	1,249
	65 - 74	1,659	1,087	1,411	1,435
	75 +	1,853	1,270	1,600	1,623
4	55 - 64	1,382	1,050	1,238	1,135
	65 - 74	1,558	1,219	1,411	1,304
	75 +	1,736	1,390	1,586	1,474
5	55 - 64	1,585	1,015	1,338	1,457
	65 - 74	1,803	1,219	1,549	1,674
	75 +	2,022	1,426	1,763	1,893

Deemed Summer Demand Savings Tables

Summer demand savings for gas water heaters with tanks greater than 55 gallons (or gas tankless units replacing a unit greater than 55 gallons) are provided in Table 2-279.

Table 2-279: HPWH Baseline Summer Demand (kW) for Gas Heaters with > 55 Gallon Tanks

Climate Zone	Tank Size (gal)	Water Heater Location	
		Conditioned Space	Unconditioned Space
1	55 - 64	0.19	0.14
	65 - 74	0.21	0.16
	75 +	0.23	0.18
2	55 - 64	0.13	0.08
	65 - 74	0.14	0.09
	75 +	0.16	0.1
3	55 - 64	0.13	0.08
	65 - 74	0.15	0.1
	75 +	0.16	0.11
4	55 - 64	0.12	0.08
	65 - 74	0.14	0.09
	75 +	0.15	0.1
5	55 - 64	0.13	0.09
	65 - 74	0.14	0.1
	75 +	0.16	0.11

Deemed Winter Demand Savings Tables

Winter demand savings for gas water heaters with tanks greater than 55 gallons (or gas tankless units replacing a unit greater than 55 gallons) are provided in Table 2-280.

Table 2-280: HPWH Baseline Winter Demand (kW) for Gas Water Heaters with > 55 Gallon Tanks

Climate Zone	Tank Size (gal)	Water Heater Location/Heat Type			
		Conditioned Space			Unconditioned Space
		Gas	Electric Resistance	Heat Pump	
1	55 - 64	0.40	0.13	0.28	0.44
	65 - 74	0.46	0.19	0.34	0.51
	75 +	0.52	0.24	0.40	0.57
2	55 - 64	0.36	0.1	0.25	0.38
	65 - 74	0.41	0.15	0.30	0.44
	75 +	0.47	0.2	0.35	0.50
3	55 - 64	0.33	0.07	0.22	0.38
	65 - 74	0.38	0.11	0.26	0.44
	75 +	0.43	0.16	0.31	0.50
4	55 - 64	0.28	0.04	0.18	0.38
	65 - 74	0.33	0.08	0.22	0.44
	75 +	0.37	0.12	0.26	0.50
5	55 - 64	0.33	0.08	0.22	0.38
	65 - 74	0.38	0.12	0.27	0.44
	75 +	0.43	0.16	0.31	0.50

Claimed Peak Demand Savings

Refer to Volume 1, Appendix B: Peak Demand Reduction Documentation for further details on peak demand savings and methodology.

Additional Calculators and Tools

This section is not applicable.

Measure Life and Lifetime Savings

The average EULs for installed equipment are: 20 years for a tankless water heater (gas or electric) and 11 years for a high efficiency gas water heater.

These values are consistent with the EULs reported in the 2014 California DEER.[216]

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 at the site
- Volume of the replacement water heater (gallons, zero if tankless)
- Volume of the existing water heater (gallons)
- Energy factor of the replacement water heater
- Number of bedrooms
- Form signed by customer and utility representative indicating planned electric storage water heater installation (New Construction only)
- Design documents indicating planned electric storage water heater installation (New Construction only)

References and Efficiency Standards

Petitions and Rulings

This section is not applicable.

Relevant Standards and Reference Sources

This section is not applicable.

[216] 2014 California Database for Energy Efficiency Resources. http://www.deeresources.com/index.php/deer-versions/deer2013-update-for-2014-codes.

Document Revision History

Table 2-281: Water Heater Installation – Electric Tankless and Fuel Substitution Revision History

TRM Version	Date	Description of Change
v1.0	11/25/2013	TRM v1.0 origin
v2.0	04/18/2014	TRM v2.0 update. Updated measure to require electric tankless rather than electric storage water heater installation for non-fuel-switching option. Updated by Frontier Associates, March 2014, based on new federal standards.
v2.1	01/30/2015	TRM v2.1 update. Updated to reflect that new construction permitted to claim savings subject to documentation requirements, and that gas-fueled tankless water heaters are eligible for installation.
v3.0	04/10/2015	TRM v3.0 update. Amended fuel substitution savings to reflect the full consumption of the electric unit being replaced. Revised demand savings for installing an electric tankless unit to reflect daily usage patterns.
v3.1	11/05/2015	TRM v3.1 update. Clarified baseline for water heaters greater than 55 gallons.
v4.0	10/10/2016	TRM v4.0 update. Updated HPWH baseline usage for gas storage water heaters larger than 55 gallons.

2.4.6 Heat Pump Water Heater Measure Overview

TRM Measure ID: R-WH-HW

Market Sector: Residential

Measure Category: Water Heating

Applicable Building Types: Single-family, duplex and triplex; Multifamily; Manufactured

Fuels Affected: Electricity and gas

Decision/Action Type(s): Replace-on-Burnout

Program Delivery Type(s): Prescriptive

Deemed Savings Type: Deemed Savings Values (Lookup Tables)

Savings Methodology: Engineering Algorithms and Estimates

Measure Description

The residential heat pump water heater (HPWH) measure involves the installation of an integrated or "drop-in" ENERGY STAR® HPWH. Deemed savings values are presented on a per-unit basis. Deemed savings variables include storage tank volume and HPWH installation location (in conditioned or unconditioned space). In addition, this measure accounts for the interactive air-conditioning energy savings and heating penalty associated with the HPWH when installed inside conditioned space.[217]

These deemed savings are calculated using the federal standards effective April 16, 2015. For measures installed prior to this date, utilities may, at their discretion, use the savings found in the Technical Reference Manual v.1.0 Implementation Guide (see http://www.texasefficiency.com/index.php/regulatory-filings/deemed-savings).

Eligibility Criteria

This measure applies to residential, electric, storage-type water heaters with storage capacities between 40 and 80 gallons. Heat pump add-ons to existing storage water heaters are ineligible. The measure does not apply to the replacement of gas water heaters.

These deemed savings are for Heat Pump Water Heaters installed as a replace-on-burnout measure or as an early retirement measure in existing homes. However, savings are calculated under the assumption of replace-on-burnout.

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[217] Because the latest manufacturer standards effectively require heat pump water heaters (assuming electric water heating) for residential units with storage tank size greater than 55 gallons. As such, interactive effects are essentially the same for base and change case systems, so they are ignored.

Table 2-282: Heat Pump Water Heaters – Applicability

Application Type	Applicable	Notes
Replace-on-Burnout	Y	For replacement of electric storage water heater
Early Retirement	Y	Awarded savings calculated for replace-on-burnout
New Construction	N	

Baseline Condition

The baseline condition is an electric storage water heater (EWH) with baseline efficiency determined by tank size based on the amended federal energy efficiency standards for residential water heaters with tank sizes 20 – 120 gallons, as published in 10 CFR Part 430.32 of the Federal Register:[218]

Table 2-283: Federal Standard for Residential Water Heaters

Rated Storage Volume	Energy Factor
≥ 20 gal and ≤ 55 gal	$0.960 - (0.0003 * V_s)$
> 55 gal and ≤ 120 gal	$2.057 - (0.00113 * V_s)$

Application of this equation provides the following baseline efficiency levels for electric storage water heaters.

Table 2-284: Heat Pump Water Heaters –
Minimum Required Energy Factors for Post-2004 Water Heaters

Tank Size (Gallons)			
40	50	60	80
0.948	0.945	1.989	1.967

The new DOE efficiency standard effectively requires heat pump water heaters (assuming electric water heating) for storage water heaters with tank size greater than 55 gallons. As such, the baseline technology for water heaters with tanks greater than 55 gallons is a heat pump water heater. For smaller systems, the baseline technology remains an electric storage water heater with electric resistance as the primary heat source. This baseline assumes a replace-on-burnout scenario.

[218] *10 CFR Part 430.32 Energy and water conservation standards and their effective dates*. Online. Available: http://www.gpo.gov/fdsys/pkg/CFR-2012-title10-vol3/pdf/CFR-2012-title10-vol3-sec430-32.pdf. Accessed February 2014.

High-Efficiency Condition

The efficient condition (i.e., equipment eligible to receive an incentive through a program) is a heat pump water heater that meets ENERGY STAR® qualifications.[219] Heat pump water heaters depend on adequate ventilation for proper functioning, including adequate space for both inlet and outlet air flow, and should be installed in spaces in which temperature does not drop below a certain level. The Department of Energy recommends installation in locations that remain above 40°F year-round, and provide a minimum of 1,000 cubic feet of air space around the water heater.[220]

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Four basic variables specify the appropriate deemed demand and energy savings values for a given project:

- The climate zone
- The HPWH tank size
- The HPWH installed location (Conditioned vs. Unconditioned Space)
- For HPWH installations in conditioned space, the building heating type (electric resistance, air-source heat pump, or gas furnace)

Deemed savings are estimated using an energy factor (EF) of 2.4. This EF is the average efficiency of ENERGY STAR® HPWHs as of February 2014.[221]

[219] ENERGY STAR® Requirements (as of February 2014): HPWH must have a maximum current rating of 24 amperes, voltage no greater than 250 volts, and a transfer of thermal energy from one temperature to a higher temperature level for the purpose of heating water. Unit must have "integrated" or "drop-in" configuration. EF ≥ 2.0, first-hour rating (FHR) ≥ 50 gallons/hour, Warranty ≥ 6 years on sealed systems, Safety UL 174 & UL 1995.

[220] Heat Pump Water Heaters. Department of Energy, May 2012. Online. Available. http://energy.gov/energysaver/articles/heat-pump-water-heaters. Accessed: February 22, 2013.

[221] As of February 2014, the ENERGY STAR® products list includes thirty residential heat pump water heaters with energy factors ranging from 2.2 to 2.75.

Deemed Energy Savings Tables

Deemed savings are developed for heat pump water heaters in four size ranges: 40-49 gallon, 50-59 gallons, 60-79 gallons, and 80 or more gallon sizes. These sizes correspond to the four basic sizes of HPWHs commercially available at the time these deemed savings were developed, according to review of manufacturer data provided on the ENERGY STAR® and AHRI websites. Table 2-285 presents the deemed saving tables for five Texas climate zones. This table assumes a replace-on-burnout scenario, but may be used to award savings for early retirement projects.

Table 2-285: Residential HPWH Deemed Annual Energy Savings (kWh)

Climate Zone		HPWH Tank Size Range (Gallons)	Conditioned Space			Unconditioned Space
			Gas	Heat Pump	Elec. Resistance	
1	Panhandle	40-49	1,805	1,464	1,020	1,645
		50-59	2,084	1,737	1,284	1,916
		60-79	308	308	308	320
		80+	394	394	394	409
2	North	40-49	1,533	1,294	982	1,362
		50-59	1,759	1,516	1,199	1,585
		60-79	243	243	243	245
		80+	310	310	310	313
3	South	40-49	1,449	1,213	906	1,273
		50-59	1,657	1,417	1,105	1,481
		60-79	223	223	223	219
		80+	285	285	285	280
4	Valley	40-49	1,393	1,253	1,070	1,193
		50-59	1,587	1,445	1,260	1,387
		60-79	204	204	204	199
		80+	260	260	260	255
5	West	40-49	1,554	1,315	1,003	1,409
		50-59	1,788	1,544	1,227	1,639
		60-79	253	253	253	255
		80+	324	324	324	326

Deemed Summer Demand Savings Tables

Table 2-286 presents the deemed summer demand savings for heat pump water heaters across the five Texas climate zones.

Table 2-286: Residential HPWH Deemed Summer Demand Savings (kW)

Climate Zone		HPWH Tank Size Range (Gallons)	Conditioned Space	Unconditioned Space
1	Panhandle	40-49	0.26	0.22
		50-59	0.30	0.25
		60-79	0.04	0.03
		80+	0.04	0.04
2	North	40-49	0.20	0.16
		50-59	0.22	0.18
		60-79	0.02	0.02
		80+	0.03	0.03
3	South	40-49	0.19	0.15
		50-59	0.22	0.18
		60-79	0.02	0.02
		80+	0.03	0.03
4	Valley	40-49	0.18	0.14
		50-59	0.21	0.17
		60-79	0.02	0.02
		80+	0.03	0.02
5	West	40-49	0.21	0.17
		50-59	0.24	0.20
		60-79	0.03	0.02
		80+	0.03	0.03

Deemed Winter Demand Savings Tables

Table 2-287 presents the deemed winter demand savings for heat pump water heaters across the five Texas climate zones.

Table 2-287: Residential HPWH Deemed Winter Demand Savings (kW)

Climate Zone		HPWH Tank Size Range (Gallons)	Conditioned Space			Unconditioned Space
			Gas	Heat Pump	Electric Resistance	
1	Panhandle	40-49	0.45	0.32	0.00	0.41
		50-59	0.52	0.39	0.22	0.48
		60-79	0.08	0.08	0.08	0.09
		80+	0.11	0.11	0.11	0.12
2	North	40-49	0.39	0.27	0.00	0.37
		50-59	0.46	0.33	0.16	0.43
		60-79	0.07	0.07	0.07	0.08
		80+	0.09	0.09	0.09	0.10
3	South	40-49	0.35	0.23	0.00	0.34
		50-59	0.41	0.28	0.12	0.39
		60-79	0.07	0.07	0.07	0.07
		80+	0.08	0.08	0.08	0.09
4	Valley	40-49	0.33	0.20	0.00	0.32
		50-59	0.38	0.25	0.09	0.37
		60-79	0.06	0.06	0.06	0.06
		80+	0.08	0.08	0.08	0.08
5	West	40-49	0.39	0.27	0.00	0.37
		50-59	0.46	0.33	0.16	0.43
		60-79	0.07	0.07	0.07	0.08
		80+	0.09	0.09	0.09	0.10

Claimed Peak Demand Savings

Refer to Volume 1, Appendix B: Peak Demand Reduction Documentation for further details on peak demand savings and methodology.

Additional Calculators and Tools

This section is not applicable.

Measure Life and Lifetime Savings

The Estimated Useful Life for this measure is 13 years. This EUL is consistent with the judgment of the American Council for an Energy-Efficient Economy as listed on its website.[222]

Program Tracking Data & 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:

- The climate zone
- The approximate volume of the replacement heat pump water heater tank in gallons
- The baseline energy factor (EF)
- The EF of the replacement water heater
- Water heater type (e.g., heat pump, electric resistance)
- The installed location (conditioned vs. unconditioned space)
- For heat pump water heater installations in conditioned space, the building heating type (electric resistance, air-source heat pump, or gas furnace)

References and Efficiency Standards

Petitions and Rulings

This section is not applicable.

Relevant Standards and Reference Sources

This section is not applicable.

[222] Water Heating. American Council for an Energy Efficient Economy. Online. Available: http://www.aceee.org/consumer/water-heating. Accessed: September 2011.

Document Revision History

Table 2-288: Heat Pump Water Heater Revision History

TRM Version	Date	Description of Change
v1.0	11/25/2013	TRM v1.0 origin
v2.0	04/18/2014	TRM v2.0 update. Updated by Frontier Associates, March 2014, based on new federal standards.
v2.1	01/30/2015	TRM v2.1 update. No revision.
v3.0	04/10/2015	TRM v3.0 update. No revision.
v3.1	11/05/2015	TRM v3.1 update. No revision.
v4.0	10/10/2016	TRM v4.0 update. Consolidated table formats.

2.4.7 Water Heater Replacement – Solar Water Heating Measure Overview

TRM Measure ID: R-WH-WS

Market Sector: Residential

Measure Category: Water Heating

Applicable Building Types: Single-family, duplex and triplex; Multifamily; Manufactured

Fuels Affected: Electricity

Decision/Action Type(s): Replace-on-Burnout

Program Delivery Type(s): Prescriptive

Deemed Savings Type: Deemed Savings Values

Savings Methodology: Engineering Algorithms and Estimates

Measure Description

Solar water heating deemed savings values are calculated based on the Solar Rating and Certification Corporation's (SRCC) test for solar water heaters (test OG-300).

Eligibility Criteria

These deemed savings are for solar water heaters installed as a replace-on-burnout measure or as an early retirement measure in existing homes. However, savings are calculated under the assumption of replace-on-burnout.

Baseline Condition

This section is not applicable.

High-Efficiency Condition

Only solar water heaters meeting the SRCC OG-300 standard (based on tank size and final Solar Energy Factor-SEF) qualify for these deemed savings estimates.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Solar water heating values are on a per-unit basis. Deemed savings variables include tank volume and installed-unit Solar Energy Factor (SEF) as rated in the Solar Rating and Certification Corporation (SRCC) "Summary of SRCC Certified Solar Collector and Water Heating System Ratings." The Solar Energy Factor (SEF) is determined under SRCC's Operating Guideline 300, "Operating Guidelines and Minimum Standards for Certifying Solar Water Heating Systems" and was developed as a means to compare solar water heating systems with conventional water heating systems rated with an Energy Factor (EF) and listed in the Gas Appliance Manufacturers Association Directory of Certified Water Heating Products.

Both EF and SEF are based on the same environmental and hot water use conditions used in the DOE Test Procedures for Water Heaters. The only significant difference is that the DOE test does not specify solar radiation. So SRCC uses a 1500 Btu/sq.ft./day solar radiation profile – a value typical of Sunbelt states (note - the annual average solar radiation for Dallas is 1533 Btu/sq.ft./day. (Information on the SRCC can be found at http://www.solar-rating.org/.)

Examples

A passive Sun Earth CP-40 with a SEF of 1.4 would consume 2133 kWh (2987/1.4), saving 1323 kWh compared to a baseline 50-gallon water heater that consumes 3458 kWh (values based on Frontier data).

An active Heliotype HP 410 G 80 with a SEF of 2.0 would consume 1494 kWh (2987/2), saving 1965 kWh compared to the baseline 50-gallon water heater.

Use SRCC OG-300 Test to obtain SEF

SRCC = Solar Rating and Certification Corporation

OG-300 = test standard for SWH systems

SEF = Solar Energy Factor

Calculate kWh Savings

$$kWh\ savings = standard\ load \times \left(1 - \frac{EF}{SEF}\right) = (3{,}458) \times \left(1 - \frac{0.864}{2}\right) = 1{,}965kWh$$

Deemed Energy Savings Tables

The following table presents the energy savings for solar water heaters based on tank size and final Solar Energy Factor (SEF).

Table 2-289: Solar Water Heating Energy Savings (kWh)

Water Heating Replacements – Solar Water Heating Energy Savings			
Approximate Volume (gal)	**80**	**50**	**30**
Baseline (DOE Standard) EF	**0.82**	**0.86**	**0.89**
SRCC OG-300 Solar Energy Factor	**Energy Savings (kWh)**		
1.0	637	471	368
1.1	909	743	640
1.2	1,135	969	866
1.3	1,326	1,160	1,057
1.4	1,490	1,324	1,221
1.5	1,633	1,467	1,364
1.6	1,757	1,591	1,488
1.7	1,867	1,701	1,598
1.8	1,965	1,799	1,696
1.9	2,052	1,886	1,783
2.0	2,131	1,965	1,862
2.1	2,202	2,036	1,933
2.2	2,266	2,100	1,997
2.3	2,325	2,159	2,056
2.4	2,379	2,213	2,110
2.5	2,429	2,263	2,160
2.6	2,475	2,309	2,206
2.7	2,518	2,352	2,249
2.8	2,557	2,391	2,288
2.9	2,594	2,428	2,325
3.0	2,628	2,462	2,359
3.1	2,660	2,494	2,391
3.2	2,691	2,525	2,422
3.3	2,719	2,553	2,450
3.4	2,745	2,579	2,476
3.5	2,771	2,605	2,502
3.6	2,794	2,628	2,525
3.7	2,817	2,651	2,548
3.8	2,838	2,672	2,569
3.9	2,858	2,692	2,589
4.0	2,877	2,711	2,608
4.1	2,895	2,729	2,626
4.2	2,913	2,747	2,644
4.3	2,929	2,763	2,660
4.4	2,945	2,779	2,676

Water Heating Replacements – Solar Water Heating Energy Savings			
Approximate Volume (gal)	**80**	**50**	**30**
Baseline (DOE Standard) EF	**0.82**	**0.86**	**0.89**
SRCC OG-300 Solar Energy Factor	**Energy Savings (kWh)**		
4.5	2,960	2,794	2,691
4.6	2,975	2,809	2,706
4.7	2,988	2,822	2,719
4.8	3,002	2,836	2,733
4.9	3,014	2,848	2,745
5.0	3,027	2,861	2,758

Source: Tim Kerrigan, National Renewable Energy Laboratory (2001)

Deemed Summer Demand Savings Tables

The following table presents the demand savings for solar water heaters.

Table 2-290: Solar Water Heating Demand Savings (kW)

Solar Water Heating Demand Savings kW
0.42

Diversified value fully displaced during solar peak.

This value is consistent with Univ. of Texas study (0.4)

Deemed Winter Demand Savings Tables

Refer to Volume 1, Appendix B: Peak Demand Reduction Documentation for further details on winter peak demand savings and methodology.

Claimed Peak Demand Savings

Refer to Volume 1, Appendix B: Peak Demand Reduction Documentation for further details on peak demand savings and methodology.

Additional Calculators and Tools

This section is not applicable.

Measure Life and Lifetime Savings

The estimated useful life (EUL) of a solar water heater is established at 15 years.

This value is consistent with the EUL reported in the 2014 California Database for Energy Efficiency Resources (DEER).[223]

Program Tracking Data & 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:

- The approximate volume of the replacement water heater in gallons
- SRCC OG-300 Solar Energy Factor of the replacement unit

References and Efficiency Standards

Petitions and Rulings

- Docket No. 22241, Item 62. Petition by Frontier Associates for Approval of Second Set of Deemed Savings Estimates. Public Utility Commission of Texas.
- Docket No. 27903. Order Adopting New §25.184 as Approved at the August 21, 2003 Open Meeting and Submitted to the Secretary of State. Public Utility Commission of Texas.

Relevant Standards and Reference Sources

This section is not applicable.

Document Revision History

Table 2-291: Water Heater Replacement – Solar Water Heating Revision History

TRM Version	Date	Description of Change
v1.0	11/25/2013	TRM v1.0 origin
v2.0	4/18/2014	TRM v2.0 update. Minor edits to language.
v2.1	1/30/2015	TRM v2.1 update. No revision.
v3.0	4/10/2015	TRM v3.0 update. No revision.
v3.1	11/05/2015	TRM v3.1 update. No revision.
V4.0	10/10/2016	TRM v4.0 update. No revision

[223] 2014 California Database for Energy Efficiency Resources. http://www.deeresources.com/index.php/deer-versions/deer2013-update-for-2014-codes.

2.5 RESIDENTIAL: APPLIANCES

2.5.1 ENERGY STAR® Ceiling Fans Measure Overview

TRM Measure ID: R-AP-FN

Market Sector: Residential

Measure Category: Appliances

Applicable Building Types: Single-family, duplex and triplex; Multifamily; Manufactured

Fuels Affected: Electricity

Decision/Action Type(s): Replace-on-Burnout, New Construction

Program Delivery Type(s): Prescriptive

Deemed Savings Type: Deemed Savings Values

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

This section is not applicable.

Baseline Condition

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

High-Efficiency Condition

Table 2-291 displays the ENERGY STAR® requirements for eligible ceiling fans as of April 1, 2012. These values are subject to updates in ENERGY STAR® specifications; energy efficiency service providers are expected to comply with the latest ENERGY STAR® code.

Table 2-292: ENERGY STAR® Specifications for Ceiling Fans

ENERGY STAR Specifications for Ceiling Fans
1. Specification defines residential ceiling fan airflow efficiency on a performance basis: CFM of airflow per watt of power consumed by the motor and controls. Efficiency is measured on each of three speeds (low/medium/high).
2. At low speed, fans must have a minimum airflow of 1,250 CFM and an efficiency of 155 CFM/Watt
3. At medium speed, fans must have a minimum airflow of 3,000 CFM and an efficiency of 100 CFM/W.
4. At high speed, fans must have a minimum airflow of 5,000 CFM and an efficiency of 75 CFM/Watt
5. Qualifying ceiling fan models must come with a minimum 30-year motor warranty; one-year component(s) warranty; and light kit warranty specified in "ENERGY STAR® Program Requirements for Luminaires" document.[224]
6. Integral or attachable lighting, including separately sold ceiling fan light kits, must meet requirements provided in the "ENERGY STAR® Program Requirements for Luminaires" specification. [225]
7. Qualifying products must permit convenient consumer adjustment of fan speed, by means of one or more wall-mounted switch(es), a remote control, or readily accessible pull chains.

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.226 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 88

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

Equation 89

[224] ENERGY STAR® Program Requirements for Luminaires. http://www.energystar.gov/ia/partners/product_specs/program_reqs/Final_Luminaires_V1_2.pdf?6d42-c7e4.

[225] Ibid.

[226] ENERGY STAR® Ceiling Fan Savings Calculator (updated September 2013). http://www.energystar.gov/products/certified-products/detail/ceiling-fans.

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

Equation 90

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

Equation 91

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

Equation 92

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

Equation 93

Where:

$kWh_{baseline}$	=	*Non-ENERGY STAR® baseline energy usage*
kWh_{ES}	=	*ENERGY STAR® average energy usage*
IEF_E	=	*Energy Interactive Effects Factor (Table 2-292)*[227]
$W_{Lgt,baseline}$	=	*Conventional lighting total wattage = 115 W (160 W default value from ENERGY STAR® calculator reduced to comply with EISA 2007 baseline wattages)*[228]
$W_{Lgt,ES}$	=	*Actual wattage of installed ENERGY STAR® lighting; if unknown, 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 2-293*
$OP_{LS,MS,HS}$	=	*Fan operating percentage at low, medium, and high speed; see Table 2-294*
AOH_{Lgt}	=	*Annual lighting operating hours = 803 hours/year (assuming 2.2 hours/day and 365 days/year operation)*[229]
AOH_{Fan}	=	*Annual fan operating hours = 1,095 hours/year (assuming 3.0 hours/day and 365 days/year operation)*
1,000	=	*Constant to convert from W to kW*

[227] The assumed energy interactive effects factors are taken from the residential lighting measure.
[228] EISA 2007 baseline wattages are approximately 72% of standard incandescent wattages.
[229] The assumed annual operating hours are taken from the residential lighting measure.

Table 2-293: ENERGY STAR® Ceiling Fans – Interactive Effects Factor for Cooling Energy Savings and Heating Energy Penalties[230]

	IEF_E				
Heating/Cooling Type*	Climate Zone 1	Climate Zone 2	Climate Zone 3	Climate Zone 4	Climate Zone 5
Gas Heat with AC	1.06	1.13	1.17	1.15	1.12
Gas Heat with no AC	1.00	1.00	1.00	1.00	1.00
Heat Pump	0.91	1.00	1.05	1.11	0.97
Electric Resistance Heat with AC	0.65	0.80	0.90	1.00	0.75
Electric Resistance Heat with no AC	0.57	0.69	0.76	0.83	0.65
No heat with AC	1.06	1.13	1.17	1.15	1.12
Unconditioned Space	1.00	1.00	1.00	1.00	1.00
Heating/Cooling Unknown[231]	0.87	1.03	1.08	1.12	1.01
Upstream Lighting[232]	0.89	1.03	1.07	1.10	1.01

* IEF for homes with no AC are most appropriate for customers with evaporative cooling or room air conditioners.

Table 2-294: 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

[230] 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: $1 + HVAC_{savings}/Lighting_{savings}$.

[231] Calculated using IEFs from Cadmus report and weighted using TMY CDD and HDD for Texas. 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.

[232] Ibid.

Table 2-295: 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 94

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

Equation 95

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

Equation 96

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 2-319)*

IEF_D = *Demand Interactive Effects Factor (Table 2-296)*[233]

Table 2-296 ENERGY STAR® Ceiling Fans – Lighting Coincidence Factors[234]

Season	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone5: El Paso
Summer	0.060	0.053	0.063	0.059	0.032
Winter	0.277	0.232	0.199	0.267	0.357

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

[234] See Volume 1, Appendix B.

Table 2-297: ENERGY STAR® Ceiling Fans – Interactive Effects Factor for Cooling Demand Savings and Heating Demand Penalties[235]

$IEF_{D.summer}$					
Heating/Cooling Type*	Climate Zone 1	Climate Zone 2	Climate Zone 3	Climate Zone 4	Climate Zone 5
Gas Heat with AC	1.45	1.33	1.68	1.23	1.44
Gas Heat with no AC	1.00	1.00	1.00	1.00	1.00
Heat Pump	1.27	1.28	1.19	1.23	1.37
Electric Resistance Heat with AC	1.07	1.27	1.07	1.23	1.36
Electric Resistance Heat with no AC	1.00	1.00	1.00	1.00	1.00
No heat with AC	1.45	1.33	1.68	1.23	1.44
Unconditioned Space	1.00	1.00	1.00	1.00	1.00
Heating/Cooling Unknown[236]	1.24	1.43	1.46	1.51	1.37
Upstream Lighting[237]	1.20	1.36	1.39	1.43	1.31
$IEF_{D.winter}$					
Heating/Cooling Type*	Climate Zone 1	Climate Zone 2	Climate Zone 3	Climate Zone 4	Climate Zone 5
Gas Heat with AC	0.98	0.98	0.98	0.98	0.98
Gas Heat with no AC	1.00	1.00	1.00	1.00	1.00
Heat Pump	0.71	0.67	0.65	0.74	0.81
Electric Resistance Heat with AC	0.44	0.36	0.38	0.42	0.52
Electric Resistance Heat with no AC	0.44	0.36	0.38	0.42	0.52
No heat with AC	0.98	0.98	0.98	0.98	0.98
Unconditioned Space	1.00	1.00	1.00	1.00	1.00
Heating/Cooling Unknown[238]	0.75	0.80	0.83	0.85	0.81
Upstream Lighting[239]	0.78	0.83	0.85	0.86	0.83

* IEF for homes with no AC are most appropriate for customers with evaporative cooling or room air conditioners.

[235] 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: $1 + HVAC_{savings}/Lighting_{savings}$.

[236] Calculated using IEFs from Cadmus report and weighted using TMY CDD and HDD for Texas. 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.

[237] Ibid.

[238] Ibid.

[239] Ibid.

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, Appendix B: Peak Demand Reduction Documentation for further details on peak demand savings and methodology.

Additional Calculators and Tools

This section is 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.[240]

Program Tracking Data & 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:

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

[240] 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.

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 2-298: ENERGY STAR® Ceiling Fan 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 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	March 2016	TRM v3.1 March Revision update. Updated summer and winter coincidence factors.
v4.0	10/10/2016	TRM v4.0 update. Updated interactive effect values using building energy simulation.

2.5.2 ENERGY STAR® Clothes Washer Measure Overview

TRM Measure ID: R-AP-CW

Market Sector: Residential

Measure Category: Appliances

Applicable Building Types: Single-family, duplex and triplex; Multifamily; Manufactured

Fuels Affected: Electricity

Decision/Action Type(s): Replace-on-Burnout, New Construction

Program Delivery Type(s): Prescriptive

Deemed Savings Type: Deemed Savings Values

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 March 7, 2015.

Eligibility Criteria

This section is not applicable.

Baseline Condition

Effective March 7, 2015, the baseline is the Department of Energy (DOE) minimum efficiency standard[241] 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. This baseline is schedule to change again on January 1, 2018.

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

Table 2-299: Federal Standard for Clothes Washers

Product Type	Current Criteria (as of March 7, 2015)	Proposed Changes for January 1, 2018
Top-loading, Standard (1.6 ft^3 or greater capacity)	IMEF ≥ 1.29 IWF≤ 8.4	IMEF ≥ 1.57 IWF≤ 6.5

IMEF = Integrated Modified Energy Factor (ft^3/kWh/cycle)
IWF = Integrated Water Factor (gallons/cycle/ft^3)

High-Efficiency Condition

The table below displays the ENERGY STAR® Final Version 7.0 requirements for eligible clothes washers effective March 7, 2015.[242] 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 2-300: ENERGY STAR® Specifications for Residential Clothes Washers

Product Type	Current Criteria (as of March 7, 2015)
ENERGY STAR® Residential Front-loading (> 2.5 ft^3)	IMEF ≥ 2.38 IWF≤ 3.7
ENERGY STAR® Residential Top-loading (> 2.5 ft^3)	IMEF ≥ 2.06 IWF ≤ 4.3
ENERGY STAR® Residential Small or Compact (< 2.5 ft^3)	IMEF ≥ 2.07 IWF ≤ 4.2

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Energy Savings Algorithms

Energy savings for this measure were derived using the ENERGY STAR® Appliance Savings Calculator found on the ENERGY STAR® website.[243] 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® appliance calculator. The most recent TRM version should be referenced to determine the savings for this measure.

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

Equation 97

[242] Available for download at: http://www.energystar.gov/sites/default/files/specs//ENERGY%20STAR%20Final%20Version%207.0%20Clothes%20Washer%20Program%20Requirements.pdf.
[243] ENERGY STAR® Appliance Savings Calculator (updated September 2015). http://www.energystar.gov/sites/default/files/asset/document/appliance_calculator.xlsx.

Baseline Unit

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

Equation 98

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

Equation 99

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

Equation 100

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

Equation 101

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

Equation 102

Where:

$kWh_{baseline}$	=	*Federal standard baseline energy usage*
$kWh_{conv,machine}$	=	*Conventional machine energy*
$kWh_{conv,WH}$	=	*Conventional water heater energy*
$kWh_{conv,dryer}$	=	*Conventional dryer energy*
$kWh_{conv,LPM}$	=	*Conventional combined low-power mode energy*
$RUEC_{conv}$	=	*Conventional rated unit electricity consumption = 381 kWh/year (top-loading)* [244]
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*
CAP_{conv}	=	*Average machine capacity = 4.5 ft³ (top-loading)*

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

$IMEF_{FS}$ = *Federal standard integrated modified energy factor (Table 2-299)*

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 103

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

Equation 104

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

Equation 105

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

Equation 106

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

Equation 107

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 2-301)*

$kW_{ES,LPM}$ = *Combined low-power mode wattage of ENERGY STAR® unit (see Table 2-301)*

$IMEF_{ES}$ = *ENERGY STAR® integrated modified energy factor (Table 2-300)*

CAP_{ES} = *Average machine capacity (see Table 2-301)*

Table 2-301: ENERGY STAR® Clothes Washer Characteristics[245]

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

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

$$AOH = LPY \times d$$

Equation 108

Where:

AOH = *Annual operating hours*

CF = *Coincidence factor (Table 2-302)*

LPY = *Loads per year = 295*

d = *Average wash cycle duration = 1 hour*[246,247]

Table 2-302: ENERGY STAR® Clothes Washer Coincidence Factors[248]

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

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

[246] Weighted average of Consumer Reports Cycle Times for Top and Front-Loading Clothes Washers. Top: http://www.consumerreports.org/cro/appliances/laundry-and-cleaning/washing-machines/top-loading-washing-machine-ratings/ratings-overview.htm. Front: http://www.consumerreports.org/cro/appliances/laundry-and-cleaning/washing-machines/front-loading-washing-machine-ratings/ratings-overview.htm.

[247] Consumer Reports. "Top-loading washers remain more popular with Americans". April 13, 2010. Weighted average of 75% Top-Loading Clothes Washers and 25% Front-Loading Clothes Washers. http://news.consumerreports.org/home/2010/04/best-front-loaders-top-loaders-which-is-more-popular-mold-vibration-washing-machine-reviews.html. This publication is available for purchase only.

[248] See Volume 1, Appendix B.

Deemed Energy Savings Tables

Table 2-303: 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	548
	Electric	Gas	187
	Gas	Electric	396
	Gas	Gas	34
Top-loading > 2.5 ft³	Electric	Electric	397
	Electric	Gas	114
	Gas	Electric	306
	Gas	Gas	23
All ≤ 2.5 ft³	Electric	Electric	753
	Electric	Gas	203
	Gas	Electric	589
	Gas	Gas	39

Deemed Summer Demand Savings Tables

Table 2-304: 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 ft³	Electric	Electric	0.075	0.074	0.075	0.076	0.076
	Electric	Gas	0.026	0.025	0.026	0.026	0.026
	Gas	Electric	0.054	0.054	0.054	0.055	0.055
	Gas	Gas	0.005	0.005	0.005	0.005	0.005
Top-loading > 2.5 ft³	Electric	Electric	0.054	0.054	0.054	0.055	0.055
	Electric	Gas	0.016	0.015	0.016	0.016	0.016
	Gas	Electric	0.042	0.041	0.042	0.042	0.043
	Gas	Gas	0.003	0.003	0.003	0.003	0.003
All ≤ 2.5 ft³	Electric	Electric	0.103	0.102	0.103	0.105	0.105
	Electric	Gas	0.028	0.028	0.028	0.028	0.028
	Gas	Electric	0.081	0.080	0.080	0.081	0.082
	Gas	Gas	0.005	0.005	0.005	0.005	0.005

Deemed Winter Demand Savings Tables

Table 2-305: 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 ft^3	Electric	Electric	0.079	0.080	0.080	0.083	0.072
	Electric	Gas	0.027	0.027	0.027	0.028	0.025
	Gas	Electric	0.057	0.058	0.058	0.060	0.052
	Gas	Gas	0.005	0.005	0.005	0.005	0.005
Top-loading > 2.5 ft^3	Electric	Electric	0.057	0.058	0.058	0.060	0.052
	Electric	Gas	0.016	0.017	0.017	0.017	0.015
	Gas	Electric	0.044	0.045	0.045	0.046	0.040
	Gas	Gas	0.003	0.003	0.003	0.003	0.003
All ≤ 2.5 ft^3	Electric	Electric	0.108	0.110	0.110	0.113	0.099
	Electric	Gas	0.029	0.030	0.030	0.031	0.027
	Gas	Electric	0.085	0.086	0.086	0.089	0.078
	Gas	Gas	0.006	0.006	0.006	0.006	0.005

Claimed Peak Demand Savings

Refer to Volume 1, Appendix B: Peak Demand Reduction Documentation for further details on peak demand savings and methodology.

Additional Calculators and Tools

This section is 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.[249]

[249] 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 10/07/2014. http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/39. Download TSD at: http://www.regulations.gov/#!documentDetail;D=EERE-2008-BT-STD-0019-0047.

Program Tracking Data & 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 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)

References and Efficiency Standards

Petitions and Rulings

This section is not applicable.

Relevant Standards and Reference Sources

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

Document Revision History

Table 2-306: ENERGY STAR® Clothes Washer 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 Associates, 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	March 2016	Updated winter coincidence factors and winter and summer demand savings tables.
v4.0	10/10/2016	TRM v4.0 update. No revision.

2.5.3 ENERGY STAR® Dishwasher Measure Overview

TRM Measure ID: R-AP-DW

Market Sector: Residential

Measure Category: Appliances

Applicable Building Types: Single-family, duplex and triplex; Multifamily; Manufactured

Fuels Affected: Electricity

Decision/Action Type(s): Replace-on-Burnout, New Construction

Program Delivery Type(s): Prescriptive

Deemed Savings Type: Deemed Savings Values

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[250] for dishwashers.

[250] DOE minimum efficiency standard for residential dishwashers. http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/67.

Table 2-307 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

High-Efficiency Condition

The following table displays the ENERGY STAR® Final Version 6.0 requirements for eligible dishwashers effective January 29, 2016.[251] 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 2-308 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 2-308.[252] 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 109

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

Equation 110

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

[252] ENERGY STAR® Appliance Savings Calculator (updated September 2015). http://www.energystar.gov/sites/default/files/asset/document/appliance_calculator.xlsx.

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

Equation 111

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

Equation 112

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

Equation 113

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

Equation 114

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

Equation 115

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 2-307)*

$RUEC_{ES}$ = *ENERGY STAR® rated use electricity consumption = 270 kWh/year for standard and 203 kWh/year for compact (Table 2-308)*

MCF = *Machine consumption factor = 44%*

$WHCF$ = *Water heater consumption factor = 56%*

Demand Savings Algorithms

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

Equation 116

$$AOH = CPY \times d$$

Equation 117

Where:

AOH	=	*Annual operating hours*
CF	=	*Coincidence factor = (Table 2-309)*
CPY	=	*Cycles per year = 215*
d	=	*Average wash cycle duration = 2.1 hours*[253]

Table 2-309: ENERGY STAR® Dishwasher Coincidence Factors[254]

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 2-310: 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

[253] Average of Consumer Reports Cycle Times for Dishwashers. http://www.consumerreports.org/cro/appliances/kitchen-appliances/dishwashers/dishwasher-ratings/ratings-overview.htm.

[254] See Volume 1, Appendix B.

Deemed Summer Demand Savings Table

Table 2-311: 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 2-312: 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, Appendix B: Peak Demand Reduction Documentation for further details on peak demand savings and methodology.

Additional Calculators and Tools

This section is 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.[255]

[255] 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 10/07/2014. http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/67. Download TSD at: http://www.regulations.gov/#!documentDetail;D=EERE-2011-BT-STD-0060-0007.

Program Tracking Data & 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 units installed
- Type of dishwasher (standard or compact)
- Fuel type of water heater (gas or electric)

References and Efficiency Standards

Petitions and Rulings

This section is not applicable.

Relevant Standards and Reference Sources

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

Document Revision History

Table 2-313: ENERGY STAR® Dishwasher 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 Associates, 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 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 measure. Consolidated table formats.
v3.1	March 2016	Updated summer and winter coincidence factors and demand savings tables.
v4.0	10/10/2016	TRM v4.0 update. No revision.

2.5.4 ENERGY STAR® Refrigerator Measure Overview

TRM Measure ID: R-AP-RF

Market Sector: Residential

Measure Category: Appliances

Applicable Building Types: Single-family, duplex and triplex; Multifamily; Manufactured

Fuels Affected: Electricity

Decision/Action Type(s): Replace-on-Burnout, New Construction, Early Retirement

Program Delivery Type(s): Prescriptive

Deemed Savings Type: Deemed Savings Calculations

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

Utilities should refer to the January 2015 memo, "Considerations for early replacement of residential equipment,"[256] when designing programs that permit savings to be claimed for early retirement. 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 2-314. 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. In order 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.

[256] 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.

Baseline Condition

For new construction or replace-on-burnout, the baseline is the Department of Energy (DOE) minimum efficiency standard[257] for refrigerators, effective September 15, 2014.

For early retirement, the baseline for refrigerators is assumed to be the annual unit energy consumption of the refrigerator being replaced, as reported by the Association of Home Appliance Manufacturers (AHAM) refrigerator database[258] and adjusted for age according to the formula in the Energy and Demand Savings Methodology section of this measure. AHAM energy use data includes the average manufacturer reported annual kWh usage by year of production dating back to the 1970s.

Alternatively, the baseline annual energy usage of the refrigerator 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".[259]

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

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

Equation 118

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 2-313 displays the ENERGY STAR® requirements for eligible refrigerators, which went into effect 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.

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

258 AHAM Refrigerator Database. http://rfdirectory.aham.org/AdvancedSearch.aspx.

259 Alex Moore, D&R International, Ltd. "Incorporating Refrigerator Replacement into the Weatherization Assistance Program" Information Tool Kit." Department of Energy. November 19, 2001. http://www.waptac.org/data/files/Website_Docs/technical_tools/toolkit07.pdf.

Table 2-314: 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% more energy efficient than the minimum federal standard (see Table 2-313)

Configuration Codes (for Table 2-315):

BF: Bottom Freezer
SD: Refrigerator Only – Single Door
SR: Refrigerator/Freezer – Single Door
SS: Side-by-Side
TF: Top Freezer

TTD: Through the Door (Ice Maker)

A: Automatic Defrost
M: Manual Defrost
P: Partial Automatic Defrost

AV = Adjusted Volume = Fresh Volume + 1.63 x Freezer Volume (ft^3)

Table 2-315: Formulas to Calculate the ENERGY STAR® Criteria for each Refrigerator Product Category by Adjusted Volume[260]

Product Number	Product Class	Baseline Energy Usage Federal Standard as of Sept 15, 2014 (kWh/year)[261]	Average ENERGY STAR® Energy Usage (kWh/year)[262]	Configuration(s)	Ice (Y/N)	Defrost
1, 2	Refrigerator-freezers—manual or partial automatic defrost	7.99 × AV + 225.0	7.19 × AV + 202.5	SS, TF, BF, SR	Y, N	M, P
1A	Refrigerator-only—manual defrost	6.79 × AV + 193.6	6.11 × AV + 174.2	SD	Y, N	M
3	Refrigerator freezers—automatic defrost with top-mounted freezer without an automatic icemaker	8.07 × AV + 233.7	7.26 × AV + 210.3	TF	N	A
3-BI	Built-in refrigerator-freezers—automatic defrost with top-mounted freezer without an automatic icemaker	9.15 × AV + 264.9	8.24 × AV + 238.4	TF	N	A
3I	Refrigerator-freezers—automatic defrost with top-mounted freezer with an automatic ice maker without TTD ice service	8.07 × AV + 317.7	7.26 × AV + 294.3	TF	N	A
3I-BI	Built-in refrigerator-freezers—automatic defrost with top-mounted freezer without an automatic ice maker with TTD ice service	9.15 × AV + 348.9	8.24 × AV + 322.4	TF	N	A
3A	Refrigerator-only—automatic defrost	7.07 × AV + 201.6	6.36 × AV + 181.4	SD	Y, N	A

[260] 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.

[261] http://www.gpo.gov/fdsys/pkg/CFR-2012-title10-vol3/pdf/CFR-2012-title10-vol3-sec430-32.pdf.

[262] Approximately 10% 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.

Product Number	Product Class	Baseline Energy Usage Federal Standard as of Sept 15, 2014 (kWh/year)[263]	Average ENERGY STAR® Energy Usage (kWh/year)[264]	Configuration(s)	Ice (Y/N)	Defrost
3A-BI	Built-in refrigerator-only—automatic defrost	8.02 × AV + 228.5	7.22 × AV + 205.7	SD	Y, N	A
4	Refrigerator-freezers—automatic defrost with side-mounted freezer without an automatic icemaker	8.51 × AV + 297.8	7.66 × AV + 268.0	SS	N	A
4-BI	Built-in refrigerator-freezers—automatic defrost with side-mounted freezer without an automatic icemaker	10.22 × AV + 357.4	9.20 × AV + 321.7	SS	N	A
4I	Refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker without TTD ice service	8.51 × AV + 381.8	7.66 × AV + 352.0	SS	N	A
4I-BI	Built-in refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker without TTD ice service	10.22 × AV + 441.4	9.20 × AV + 405.7	SS	N	A
5	Refrigerator-freezers—automatic defrost with bottom-mounted freezer without an automatic icemaker	8.85 × AV + 317.0	7.97 × AV + 285.3	BF	N	A
5-BI	Built-in refrigerator-freezers—automatic defrost with bottom-mounted freezer without an automatic icemaker	9.40 × AV + 336.9	8.46 × AV + 303.2	BF	N	A
5I	Refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker without TTD ice service	8.85 × AV + 401.0	7.97 × AV + 369.3	BF	N	A

[263] http://www.gpo.gov/fdsys/pkg/CFR-2012-title10-vol3/pdf/CFR-2012-title10-vol3-sec430-32.pdf.

[264] Approximately 10% 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.

Product Number	Product Class	Baseline Energy Usage Federal Standard as of Sept 15, 2014 (kWh/year)[265]	Average ENERGY STAR® Energy Usage (kWh/year)[266]	Configuration(s)	Ice (Y/N)	Defrost
5I-BI	Built-in refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker without TTD ice service	9.40 × AV + 420.9	8.46 × AV + 387.2	BF	N	A
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	BF	Y	A
5A-BI	Built-in refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker with TTD ice service	9.83 × AV + 499.9	8.85 × AV + 458.3	BF	Y	A
6	Refrigerator-freezers—automatic defrost with top-mounted freezer with TTD ice service	8.40 × AV + 385.4	7.56 × AV + 355.3	TF	Y	A
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	SS	Y	A
7-BI	Built-in refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker with TTD ice service	10.25 × AV + 502.6	9.23 × AV + 460.7	SS	Y	A

[265] http://www.gpo.gov/fdsys/pkg/CFR-2012-title10-vol3/pdf/CFR-2012-title10-vol3-sec430-32.pdf.

[266] Approximately 10% 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.

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 119

Where:

$kWh_{baseline}$ = *Federal standard baseline energy usage (see Table 2-314)*

kWh_{ES} = *ENERGY STAR average energy usage (see (see Table 2-314)*

Demand Savings Algorithms

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

Equation 120

Where:

LSAF = *Load Shape Adjustment Factor (see Table 2-315)*

Table 2-316: ENERGY STAR® Refrigerator Load Shape Adjustment Factors[267]

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 (16 – RUL)

[267] See Volume 1, Appendix B.

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 Volume 3, Appendix D of this document.

Where:

RUL = *Remaining Useful Life (seeTable 2-316); 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 2-317: Remaining Useful Life (RUL) of Replaced Refrigerator

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[268,269]	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 Table 2-316.

[268] RULs are capped at the 75th percentile of equipment age, 21 years, as determined based on DOE survival curves (see Figure 2-8). 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.

[269] 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.

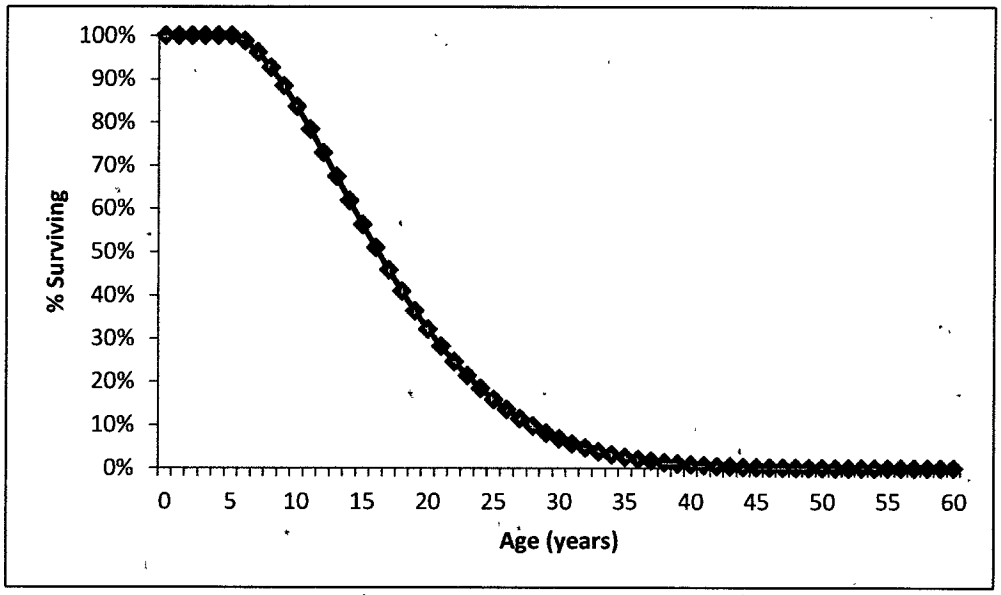

Figure 2-8: Survival Function for ENERGY STAR® Refrigerators[270]

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 2-8. The age of the refrigerator being replaced is found on the horizontal axis, and the corresponding percentage of surviving refrigerators is determined from the chart. The surviving percentage value is then divided in half, creating a new estimated useful lifetime applicable to the current unit age. Then, the age (year) that corresponds to this new percentage is read from the chart. RUL is estimated as the difference between that age and the current age of the system being replaced.

For example, assume a refrigerator being replaced is 15 years old. The corresponding % surviving value is 56%. Half of 56% is 28%. The age corresponding to 28% 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 121

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

[270] 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.

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

Equation 122

Where:

kWh_{manf} = *Annual unit energy consumption from the Association of Home Appliance Manufacturers (AHAM) refrigerator database*[271] *(or from metering)*

$kWh_{baseline}$ = *Federal standard baseline energy usage (see Table 2-314)*

kWh_{ES} = *ENERGY STAR® average energy usage (see Table 2-314)*

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 123

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 124

Where:

LSAF = *Load Shape Adjustment Factor (Table 2-315)*

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 Volume 3, Appendix D of this document.

Where:

RUL = *Remaining Useful Life (seeTable 2-316)*

EUL = *Estimated Useful Life = 16 years*[272]

[271] AHAM Refrigerator Database. http://rfdirectory.aham.org/AdvancedSearch.aspx.

[272] Department of Energy, Federal Register, 76 Final Rule 57516, Technical Support Document: 8.2.3.1 Estimated Survival Function. September 15, 2011.

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

Refer to Volume 1, Appendix B: Peak Demand Reduction Documentation for further details on winter peak demand savings and methodology.

Claimed Peak Demand Savings

Refer to Volume 1, Appendix B: Peak Demand Reduction Documentation for further details on peak demand savings and methodology.

Additional Calculators and Tools

This section is 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.[273]

Program Tracking Data & 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 units installed
- The project type of the installation (New Construction, Replace-on-Burnout, or Early Retirement)
- Installed refrigerator model number
- Product class (see Table 2-315)
- Refrigerator volume

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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.

[273] 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.

- Freezer volume
- Retired refrigerator model number (Early Retirement only)
- Retired refrigerator annual energy usage (Early Retirement only)
- Age of retired refrigerator (Early Retirement only)
- Recommended: internal temperature(s) in retired refrigerator and, if present, freezer (Early Retirement only)
- Recommended: customer responses to survey questionnaire for early retirement eligibility determination (Early Retirement only)

References and Efficiency Standards

Petitions and Rulings

This section is not applicable.

Relevant Standards and Reference Sources

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

Document Revision History

Table 2-318: ENERGY STAR® Refrigerator 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 main measure as "Early Retirement" option. Updated by Frontier Associates, 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 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	March 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 five years.

2.6 RESIDENTIAL: APPLIANCE RECYCLING

2.6.1 Refrigerator/Freezer Recycling Measure Overview

TRM Measure ID: R-AP-RR.

Market Sector: Residential

Measure Category: Appliance Recycling

Applicable Building Types: Single-family, duplex and triplex; Multifamily; Manufactured

Fuels Affected: Electricity

Decision/Action Type(s): Early Retirement

Program Delivery Type(s): Prescriptive

Deemed Savings Type: Deemed Savings Values

Savings Methodology: Engineering Algorithms and Estimates

Measure Description

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

Eligibility Criteria

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

Baseline Condition

Without program intervention, the recycled refrigerator or freezer would have remained operable on the electrical grid. As a result, the baseline condition for early retirement programs is the status quo (continued operation) and the basis for estimating energy savings is the annual

energy consumption of the refrigerator or freezer being retired (as specified in the "Energy and Demand Savings Methodology" section).

High-Efficiency Condition

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

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Energy Savings

Energy savings are calculated as follows:

$$\begin{aligned} kWh_{savings} &= kWh_{existing} \times ISAF \times PUF \\ &= 1,308 \times 0.942 \times 0.915 \\ &= 1,128\ kWh \end{aligned}$$

Equation 125

Where:

$kWh_{existing}$ = *Average annual energy consumption*[274] *= 1,308 kWh*

$ISAF$ = *In Situ Adjustment Factor*[275] *= 0.942*

PUF = *Part Use Factor*[276] *= 0.915*

[274] The Cadmus Group, Inc. "Residential Retrofit High Impact Measure Evaluation Report". Prepared for California Public Utilities Commission Energy Division. February 8, 2010. Average of DOE-Based Full-Year Unit Energy Consumption (weighted by representative utility survey participation).

[275] Ibid. Factor to account for variation between site conditions and controlled DOE testing conditions (90 °F test chamber, empty refrigerator and freezer cabinets, and no door openings). Appliances in warmer climate zones use more energy than those in cooler climate zones; utilized SCE data (highest percentage of warm climate projects) to best approximate Texas climate, p. 139-140.

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

Demand Savings

Summer peak demand savings are calculated as follows:

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

Equation 126

Where:

AOH = *Annual Operating Hours = 8,760 hours*

$LSAF$ = *Load Shape Adjustment Factor (Table 2-319)*

Table 2-319: Load Shape Adjustment Factors[277]

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

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, Appendix B: Peak Demand Reduction Documentation for further details on peak demand savings and methodology.

Additional Calculators and Tools

This section is not applicable.

[277] See Volume 1, Appendix B.

Measure Life and Lifetime Savings

Based on the KEMA Residential Refrigerator Recycling Ninth Year Retention Study,[278] the Estimated Useful Life of Refrigerator Recycling is 8 years, representing the assumed remaining useful life of the retired unit.

Program Tracking Data & 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 refrigerators/freezers replaced
- Age of removed unit
- Size (in cubic feet)
- Configuration (top freezer, bottom freezer, side-by-side, or single-door)

References and Efficiency Standards

Petitions and Rulings

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

Relevant Standards and Reference Sources

Not applicable.

Document Revision History

Table 2-320: Residential Refrigerator/Freezer Recycling Revision History

TRM Version	Date	Description of Change
v2.1	1/30/2015	TRM v2.1 origin
v3.0	4/10/2015	TRM v3.0 update. LSAF updated to align with new peak demand methodology.
v3.1	11/05/2015	TRM v3.1 update. No revision.
v3.1	March 2016	Updated summer and winter coincidence factors.
v4.0	10/10/2016	TRM v4.0 update. No revision.

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

Public Utility Commission of Texas

Texas Technical Reference Manual

Version 4.0

Volume 3: Nonresidential Measures

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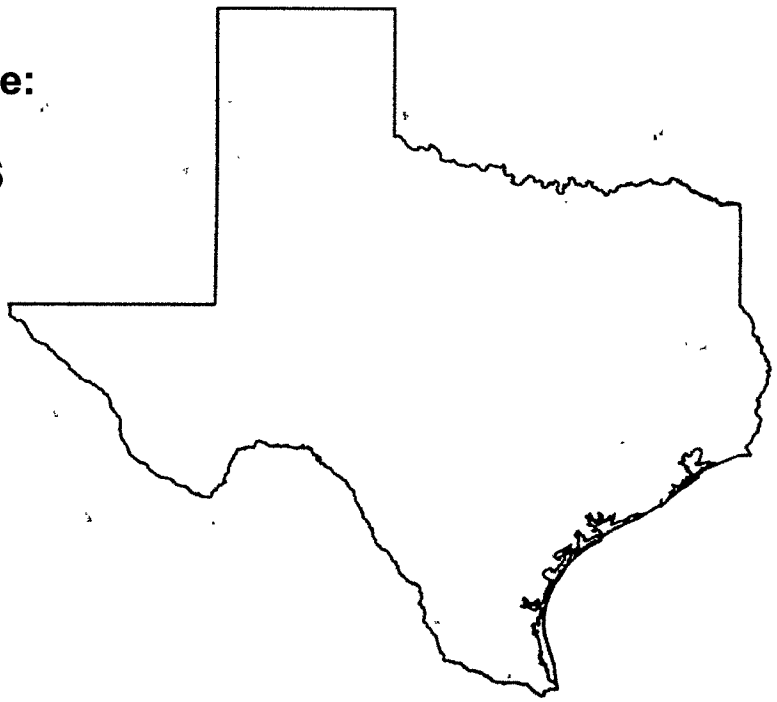
November 1, 2016



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Acknowledgements

The Technical Reference Manual is maintained by the Public Utility Commission of Texas' independent Evaluation, Monitoring and Verification (EM&V) team members—Tetra Tech, The Cadmus Group, Itron, and Johnson Consulting Group.

This version of the Texas Technical Reference Manual was primarily developed from program documentation and measure savings calculators used by the Texas Electric Utilities and their Energy Efficiency Services Providers (EESPs) to support their energy efficiency efforts, and original source material from petitions filed with the Public Utility Commission of Texas by the utilities, their consultants and EESPs such as Frontier Associates (TXu 1-904-705), ICF, CLEAResult and Nexant. Certain technical content and updates were added by the EM&V team to provide further explanation and direction as well as consistent structure and level of information

TRM Technical Support

Technical support and questions can be emailed to the EM&V project manager (lark.lee@tetratech.com) and PUCT staff (katie.rich@puc.texas.gov).

1. INTRODUCTION

This volume of the TRM contains the deemed savings for nonresidential measures that have been approved for use in Texas by the PUCT. This volume includes instructions regarding various savings calculators and reference sources of the information. The TRM serves as a centralized source of deemed savings values; where appropriate, Measurement & Verification (M&V) methods by measure category are noted for informational purposes only regarding the basis of projected and claimed savings.

Table 1-1 provides an overview of the nonresidential measures contained within Volume 3 and the types of deemed savings estimates available for each one. There are four types of deemed savings estimates identified:

- Point estimates that provide a single deemed savings value that correspond to a single measure or type of technology.
- Deemed saving tables that provide energy and peak savings as a function of size, capacity; building type, efficiency level, or other inputs.
- Savings algorithms that require user defined inputs that must be gathered on site and the identification of default inputs where primary data could not be collected. In many cases, these algorithms are provided as references to deemed savings tables, point estimates, or calculator explanations.
- Calculators are used by different utilities and implementers to calculate energy savings for different measures. In many cases, there are several different calculators available for a single measure. Sometimes their background calculators are similar, and in other cases, estimates can vary greatly between each calculator.

M&V methods are also used for some measures to calculate savings in the event that standard equipment is not used, or the specified building types do not apply. For some of these measures, both a simplified M&V approach and a full M&V approach may be allowed by the utility. M&V methods as a source of claimed and projected savings are noted for informational purposes only. Standardized M&V approaches that have been reviewed by the EM&V team are incorporated into Volume 4: Measurement & Verification Protocols of this TRM.

Please consult Volume I: Overview and User Guide, Section 4: Structure and Content, for details on the organization of the measure templates presented in this volume.

Table 1-1: Nonresidential Deemed Savings by Measure Category

Measure Category	Measure Description	Point Estimates	Deemed Savings Tables	Savings Algorithm	Calculator	M&V	4.0 Update
Lighting	Lighting - Lamps and Fixtures	--	--	X	X	X	Added LPD values and tracking data requirements for exterior space type Zones used in Codes and Standards.
Lighting	Lighting Controls	--	--	X	X	X	
HVAC (Cooling)	AC Tune-Up	--	--	X	--	X	TRM v4.0 origin
HVAC (Cooling)	Package and Split-System (AC and Heat Pumps)	--	--	X	X	X	Used modeling approach to update DF and EFLH for applicable building types and climate zones. Updated baseline efficiency values for split and packaged units less than 5.4 tons to be consistent with updated federal standards.
HVAC (Cooling)	Chillers	--	--	X	X	X	Used modeling approach to update DF and EFLH for applicable building types and climate zones.
HVAC (Cooling)	Package Terminal Units and Room Air Conditioners (AC and Heat Pumps)	--	--	X	X	X	
HVAC (Ventilation)	VFDs on AHU Supply Fans	--	X	X	--	--	
Building Envelope	Cool Roof	X	--	X	X	--	Clarified eligibility criteria, baseline condition, and high-efficiency condition. Added R-values for more materials to Table 2-49. Added new high performance roof calculator for use in determining energy star roof savings
Building Envelope	Window Treatments	X	--	X	X	--	
Food Service	ENERGY STAR® Combination Ovens Measure Overview	--	X	X	--	--	
Food Service	ENERGY STAR® Electric Convection Ovens	--	X	X	--	--	

Measure Category	Measure Description	Point Estimates	Deemed Savings Tables	Savings Algorithm	Calculator	M&V	4.0 Update
Food Service	ENERGY STAR® Commercial Dishwashers	--	X	X	--	--	Added high-efficiency requirements for pots, pans, and utensils
Food Service	ENERGY STAR® Commercial Electric Hot Food Holding Cabinets		X	X			
Food Service	ENERGY STAR® Kitchen Electric Fryers		X	X			
Food Service	Pre-Rinse Spray Valves		X	X			
Food Service	ENERGY STAR® Electric Steam Cookers		X	X		--	
Refrigeration	Door Heater Controls		X	X		--	Update Deemed kW_{ash} for Medium temperature cases and add kW_{ash} for Low temperature cases. Added more significant digits to the input variables a-j for equations 82 and 83.
Refrigeration	ECM Evaporator Fan Motors			X		--	Updated the methodology to incorporate the type of motor replaced and added values for both coolers and freezers
Refrigeration	Electronic Defrost Control			X		--	
Refrigeration	Evaporator Fan Controls			X		--	
Refrigeration	Night Covers for Open Refrigerated Cases		X	X		--	Added more significant digits to the input variables a-j for equations 107 and 108.
Refrigeration	High-Efficiency Solid & Glass Door Reach-in Cases			X		--	
Refrigeration	Strip Curtains for Walk-in Cooler/Freezer		X				

Measure Category	Measure Description	Point Estimates	Deemed Savings Tables	Savings Algorithm	Calculator	M&V	4.0 Update
Refrigeration	Low/No Anti-sweat Heat Glass Doors (Zero Energy Glass Doors)	--	X	X	--	--	Updated savings methodology to be consistent with the door heater controls measure.
Miscellaneous	Vending Machine Controllers	--	X	X	--	--	
Miscellaneous	Lodging Guest Room Occupancy Sensor Control	--	X	--	--	--	
Miscellaneous	Pump-Off Controller	--	X	X	--	--	
Solar Electric	Solar Photovoltaics	--	--	X	--	X	Removed deemed savings option for energy. Provided new method for calculating summer and winter demand savings and provided deemed summer and winter demand savings lookup tables.

2. NONRESIDENTIAL MEASURES

2.1 NONRESIDENTIAL: LIGHTING

2.1.1 Lamps and Fixtures Measure Overview

TRM Measure ID: NR- LT-LF

Market Sector: Commercial

Measure Category: Lighting

Applicable Building Types: All Commercial, Multifamily common areas

Fuels Affected: Electricity (Interactive HVAC effects: Electric/Gas space heating)

Decision/Action Types: Retrofit (RET) and New Construction (NC)

Program Delivery Type: Prescriptive, Custom, Direct Install

Deemed Savings Type: Deemed Savings Calculation

Savings Methodology: Calculator

Measure Description

This section provides estimates of the energy and peak savings resulting from the installation of energy efficient lamps and/or ballasts. The installation can be the result of new construction or the replacement of existing lamps and/or ballasts. This TRM Measure ID covers the following lighting technologies:

- Linear Fluorescent T5s, and High-Performance or Reduced Watt T8s. Linear fluorescent measures may also involve delamping1 with or without the use of reflectors.
- Fluorescent Electrodeless Induction lamps and fixtures
- Compact Fluorescent Lamp (CFL) screw-based lamps and hard-wired pin-based fixtures
- Pulse-start (PSMH) and Ceramic Metal Halide (CMH) lamps, and other High Intensity Discharge (HID) lamps
- Light Emitting Diode (LED) screw-based lamps and hard-wired LED fixtures

Energy and demand savings are based on operating hours, coincident-load factors, and changes in pre-existing and post-installation lighting loads as determined using an approved lighting *Standard Fixture Wattage* table (see the *Lighting Survey Form*[2]). The *Lighting Survey Form (LSF)* is one example of a calculator that is used to determine energy and demand savings. Pre and post-retrofit lighting inventories are entered and used with the pre-loaded

[1] Delamping energy savings are eligible if done in conjunction with T-8 lamp and electronic ballast retrofits.
[2] Maintained by Frontier/EUMMOT: http://texasefficiency.com/index.php/regulatory-filings/lighting.

stipulated values and algorithms needed to calculate energy and demand savings. Components of the calculator include:

- Instructions and Project Information
- Pre and Post-retrofit lighting inventories. A tab for exempt fixtures, and a description of the exemptions, is also present in this calculator.
- Fixture descriptions are selected from a Standard Fixture Wattage table.
- Factor Tables which contain stipulated operating hours, coincidence factors, and interactive HVAC factors.
- A Summary tab, where the final energy and demand calculations are displayed. The data from this tab is entered into the utility program tracking data as the claimed savings values.

Although the generic *Lighting Survey Form* calculator is available to all entities on the Texas Energy Efficiency website, several utilities have their own versions.

Eligibility Criteria

This section describes the system information and certified wattage values that must be used to estimate energy and peak savings from lighting systems installed as part of the Texas utility energy efficiency programs. The fixture codes and the demand values listed in the Table of Standard Fixture Wattages are used in calculating energy and demand savings for lighting efficiency projects. In addition, LED and linear fluorescent T8s need to be certified, as follows:

High-performance (HP) and reduced-watt (RW) T8 linear fluorescent lamps and ballasts need to be certified by the *Consortium for Energy Efficiency* (CEE). See High Efficiency Condition section for additional details.

LED lamps and fixtures must be certified and listed by at least one of the following organizations: *DesignLights Consortium (DLC)*, *ENERGY STAR®*, Lighting Design Lab (LDL), or DOE LED Lighting Facts. Links to these organizations and their certified LED equipment lists are provided on the Texas Energy Efficiency website. Additionally, at the utilities discretion, LED products may receive approval if results of independent lab testing[3] (e.g. LM-79, LM-80, TM-21, ISTMT) show the products comply with the most current version of the DLC Technical Requirements.[4]

Exempt Lighting for New Construction. Some types of new construction lighting fixtures are exempt from inclusion in the interior lighting demand savings calculation, but they are still included in the total installed lighting power calculations for a project. Exempt fixtures are those that do not provide general/ambient/area lighting, have separate control devices, and are installed in one of the following applications[5]:

1. The connected power associated with the following lighting equipment is not included in calculating total connected lighting power.

[3] DLC test lab requirements: https://www.designlights.org/content/QPL/ProductSubmit/LabTesting
[4] DLC tech. requirements: https://www.designlights.org/content/qpl/productsubmit/categoryspecifications
[5] IECC 2009, Section 505.5.1

1.1. Professional sports arena playing-field lighting.

1.2. Sleeping-unit lighting in hotels, motels, boarding houses, or similar buildings.

1.3. Emergency lighting automatically off during normal building operation.

1.4. Lighting in spaces specifically designed for use by occupants with special lighting needs including visual impairment and other medical and age-related issues.

1.5. Lighting in interior spaces that have been specifically designated as a registered interior historic landmark.

1.6. Casino gaming areas.

2. Lighting equipment used for the following shall be exempt provided that it is in addition to general lighting and is controlled by an independent control device:

   2.1. Task lighting for medical and dental purposes.

   2.2. Display lighting for exhibits in galleries, museums, and monuments.

3. Lighting for theatrical purposes, including performance, stage, film production, and video production.

4. Lighting for photographic processes.

5. Lighting integral to equipment or instrumentation and installed by the manufacturer.

6. Task lighting for plant growth or maintenance.

7. Advertising signage or directional signage.

8. In restaurant building and areas, lighting for food warming or integral to food preparation equipment.

9. Lighting equipment that is for sale.

10. Lighting demonstration equipment in education facilities.

11. Lighting approved because of safety or emergency considerations, inclusive of exit lights.

12. Lighting integral to both open and glass-enclosed refrigerator and freezer cases.

13. Lighting in retail display windows, provided the display area is enclosed by ceiling height partitions.

14. Furniture-mounted supplemental task lighting that is controlled by automatic shut off.

Baseline Condition

The baseline condition or assumed baseline efficiency used in the savings calculations depends on the decision type used for the measure. For new construction, the baseline will be based on a Lighting Power Density (LPD) in watts per square foot by building type, as specified by the relevant energy code/standard applied to a specific project. For *retrofit* applications, the baseline efficiency would typically reflect the in-situ, pre-existing equipment, with the exception of linear

fluorescent T12s and first generation T8s as explained below. Fixture wattages used for the savings calculations are determined from the Table of Standard Fixture Wattages.

Linear Fluorescent T12 Special Conditions

The U.S. Energy Policy Act of 1992 (EPACT) set energy efficiency standards that preclude certain lamps and ballasts from being manufactured or imported into the U.S. The latest standards covering general service linear fluorescents went into full effect July 2014. Under this provision, almost all 4-foot and some 8-foot T12 lamps, as well as first-generation 4-foot, 700 series T8 lamps were prohibited from manufacture. Because all lighting equipment for Texas energy efficiency programs must be EPACT compliant, including existing or baseline equipment, adjustments were made to the T12 fixtures in the Standard Fixture Wattage table. Certain T12 lamp/ballast combinations which are non-EPACT compliant are assigned EPACT demand values.

As such, 4-foot and 8-foot T12s are no longer an approved baseline technology for Texas energy efficiency programs. 4-foot and 8-foot T12s are still eligible for lighting retrofit projects, but an assumed electronic T8 baseline will be used for estimating the energy and demand savings instead of the existing T12 equipment. T12 fixtures will remain in the Standard Fixture Wattage list, but the label for these records will be changed to "T12 (T8 baseline)" and the fixture wattage for these records will be adjusted to use the adjusted fixture wattages shown in Table 2-1.

Table 2-1: Adjusted Baseline Wattages for T12 Equipment

T12 Length	Lamp Count	Revised Lamp Wattage	Revised System Wattage
48 inch – Std, HO, and VHO (4 feet)	1	32	31
	2	32	58
	3	32	85
	4	32	112
	6	32	170
	8	32	224
96 inch - Std (8 feet) 60/75W	1	59	69
	2	59	110
	3	59	179
	4	59	219
	6	59	330
	8	59	438*
96 inch-HO and VHO (8 feet) 95/110W	1	86	101
	2	86	160
	3	86	261
	4	86	319
	6	86	481
	8	86	638

T12 Length	Lamp Count	Revised Lamp Wattage	Revised System Wattage
2-foot U-Tube	1	32	32
	2	32	60
	3	32	89

* 8 lamp fixture wattage approximated by doubling 4 lamp fixture wattage.

Key: HO = high output, VHO = very high output

High-Efficiency Condition

Acceptable efficient fixture types are specified in the Table of Standard Fixture Wattages. In addition, some technologies such as LEDs must meet the additional requirements specified under Eligibility Criteria.

High-Efficiency/Performance Linear Fluorescent T8s

All 4-foot T8 post-retrofit technologies and new construction projects must use electronic ballasts manufactured after November 2014[6], and high performance T8 lamps that are on the T8 Replacment Lamp products list developed by the Consortium for Energy Efficiency (CEE) as published on its website.

If CEE does not have efficiency guidelines for a T8 system (such as for 8-foot, 3-foot, 2-foot, and U-bend T8 products), the product must have higher light output or reduced wattage than its standard equivalent product (minimum efficacy of 75 mean lumens per watt), while also providing a CRI (color rendering index) greater than 80, and an average rated life of 24,000 hours at three hours per start. In addition, 2-foot and 3-foot ballasts must also use electronic ballasts manufactured after November 2014.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

This section describes the deemed savings methodology for both energy and demand savings for all lighting projects. The savings are calculated in separate methods for retrofit projects and new construction projects, and both are described below.

[6] Changes to the DOE Federal standards for electronic ballasts effective November 2014 met both the CEE performance specification and the NEMA Premium requirements, so CEE discontinued their specification and qualifying product lists. A legacy ballast list from January 2015 is still available.

Retrofit[7,8]:

$$Energy\ Savings = (kW_{pre} - kW_{installed}) \times Hours \times (HVAC_{energy})$$

Equation 1

$$Peak\ Summer\ Demand\ Savings = (kW_{pre} - kW_{installed}) \times CF \times (HVAC_{demand})$$

Equation 2

New Construction:

$$Energy\ Savings = \left(\frac{LPD \times FloorArea}{1000} - kW_{installed}\right) \times Hours \times (HVAC_{energy})$$

Equation 3

$$Peak\ Summer\ Demand\ Savings = \left(\frac{LPD \times FloorArea}{1000} - kW_{installed}\right) \times CF \times (HVAC_{demand})$$

Equation 4

Where:

kW_{pre}	=	*Total kW of existing measure (Fixture wattage from Standard wattage table multiplied by quantity of fixtures)*
$kW_{installed}$	=	*Total kW of retrofit measure (Fixture wattage from Standard wattage table multiplied by quantity of fixtures)*
LPD	=	*Acceptable Lighting Power Density based on building type from efficiency codes from Table 2-2 [W/ft²]*
Floor Area	=	*Floor area of the treated space where the lights were installed*
Hours	=	*Hours by building type from Table 2-4*
CF	=	*Coincidence factor by building type from Table 2-4*
$HVAC_{energy}$	=	*Energy Interactive HVAC factor by building type*
$HVAC_{demand}$	=	*Demand Interactive HVAC factor by building type*

Each of the parameters in these equations, and the approach or their stipulated values, is discussed in detail below.

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[7] For non-operating fixtures, the baseline demand may be adjusted by using values from the Standard Wattage Table. The number of non-operating fixtures will be limited to 10% of the total fixture count per facility.

[8] The energy and demand savings calculations should also account for lighting controls that are present on either the *pre* or *installed* lighting systems, and should also be adjusted for eligible rebated lighting controls on the installed lighting system. The EAF and PAF factors in the Lighting Controls measure section should be used for these calculations.

Lamp and Fixture Wattages (kW_{pre}, $kW_{installed}$)

Existing Construction: Standard Fixture Wattage Table. One example of a Table of Standard Fixture Wattages can be found in the *Lighting Survey Form* maintained on the Texas Energy Efficiency website[9]. This table is used to assign identification codes and demand values (watts) to common fixture types (fluorescent, incandescent, HID, LED, etc.) used in commercial applications. The table is subdivided into lamp types such as linear fluorescent, compact fluorescent, mercury vapor, etc., with each subdivision sorted by fixture code. Each record, or row, in the Table contains a fixture code, which serves as a unique identifier. A legend explains the rules behind the fixture codes.

Each record also includes a description of the fixture, the number of lamps, the number of ballasts if applicable, and the fixture wattage. The table wattage values for each fixture type are averages of various manufacturers' laboratory tests performed to ANSI test standards. By using standardized demand values for each fixture type, the Table simplifies the accounting procedures for lighting equipment retrofits. The table is updated periodically as new fixtures are added.

The fixture codes and the demand values listed in the watt/fixture column in the Table of Standard Fixture Wattages are used in calculating energy and demand savings for any lighting efficiency project.

For implementers interested in adding new fixtures to Frontier's lighting table, a request should be submitted to Frontier. The request should include all information required to uniquely identify the fixture type and to fix its demand, as well as other contextual information needed for the table. If possible, the request should also be supported by manufacturer's ANSI test data. Frontier then periodically releases updates of the table.

New Construction: Lighting Power Density Table. For new construction projects, the post-retrofit lighting wattages are determined as they are for the existing construction projects, from the Standard Fixture Wattage table. However, the baseline wattage is determined from the treated floor area and a lighting power density (LPD) value, which are the allowable watts per square foot of lit floor area as specified by the relevant energy code. These values for interior space types are presented in Table 2-2.

In Table 2-3 the zones used for exterior space types are:

- Zone 1: Developed areas of national parks, state parks, forest lands, and rural areas
- Zone 2: Areas predominantly consisting of residential zoning, neighborhood business districts, light industrial with limited night-time use, and residential mixed use areas
- Zone 3: All other areas
- Zone 4: High-activity commercial districts in major metropolitan areas as designated by the local land use planning authority

[9] Frontier Associates *Lighting Survey Form, Fixture Description* tab: http://www.texasefficiency.com/images/documents/lsf_2013_v8.01_250%20rows.xlsm.

Table 2-2: New Construction LPDs for Interior Space Types by Building Type[10]

Facility Type	Lighting Power Density (W/ft²)	Facility Type	Lighting Power Density (W/ft²)
Automotive Facility	0.90	Multi-Family	0.70
Convention Center	1.20	Museum	1.10
Courthouse	1.20	Office	1.00
Dining: Bar/Lounge/Leisure	1.30	Parking Garage	0.30
Dining: Cafeteria	1.40	Penitentiary	1.00
Dining: Family	1.60	Performing Arts	1.60
Dormitory	1.00	Police/Fire Stations	1.00
Exercise Center	1.00	Post Office	1.10
Gymnasium	1.10	Religious Buildings	1.30
Health Care – Clinic	1.00	Retail	1.50
Hospital	1.20	School/University	1.20
Hotel	1.00	Sports Arena	1.10
Library	1.30	Town Hall	1.10
Manufacturing	1.30	Transportation	1.00
Motel	1.00	Warehouse	0.80
Motion Picture	1.20	Workshop	1.40

Table 2-3: New Construction LPDs for Exterior Space Types

Facility Type	Lighting Power Density (W/ft²)			
	Zone 1	Zone 2	Zone 3	Zone 4
Uncovered Parking: Parking Areas and Drives	0.04	0.06	0.10	0.13
Building Grounds: Walkways ≥ 10 ft wide, Plaza Areas, and Special Feature Areas	0.14	0.14	0.16	0.20
Building Grounds: Stairways	0.75	1.00	1.00	1.00
Building Grounds: Pedestrian Tunnels	0.15	0.15	0.20	0.30
Building Entrances and Exits: Entry Canopies	0.25	0.25	0.4	0.4
Sales Canopies: Free-standing and Attached	0.60	0.60	0.80	1.00
Outdoor Sales: Open Areas	0.25	0.25	0.50	0.70
Building Facades	--	0.10	0.15	0.20
Entrances and Gatehouse Inspection Stations	0.75	0.75	0.75	0.75
Loading Areas for Emergency Vehicles	0.50	0.50	0.50	0.50

[10] Source per *Lighting Survey Form*: ANSI/ASHRAE/IESNA Standard 90.1 -2007 Table. 9.5.1, p. 62 & IECC 2009 Table. 505.5.2, p. 59.

Operating Hours (Hours) and Coincidence Factors (CFs)

Operating hours and peak demand coincidence factors are assigned by building type, as shown in Table 2-4. The building types used in this table are based on Commercial Buildings Energy Consumption Survey (CBECS)[11] building types, but have been modified for Texas.

Table 2-4: Operating Hours and Coincidence Factors by Building Type[12]

Building Type Code	Building Type Description	Operating Hours	Summer Peak CF
Educ. K-12, No Summer	Education (K-12 w/o Summer Session)	2,777	47%
Education, Summer	Education: College, University, Vocational, Day Care, and K-12 w/ Summer Session	3,577	69%
Non-24 Hour Retail	Food Sales – Non-24 Hour Supermarket/Retail	4,706	95%
24-Hr Retail	24 Hour Supermarket/Retail	6,900	95%
Fast Food	Food Service – Fast Food	6,188	81%
Sit Down Rest.	Food Service – Sit-down Restaurant	4,368	81%
Health In	Health Care (In Patient)	5,730	78%
Health Out	Health Care (Out Patient)	3,386	77%
Lodging, Common	Lodging (Hotel/Motel/Dorm), Common Area	6,630	82%
Lodging, Rooms	Lodging (Hotel/Motel/Dorm), Rooms	3,055	25%
Manufacturing	Manufacturing	5,740	73%
MF Common	Multi-family Housing, Common Areas	4,772	87%
Nursing Home	Nursing and Residential Care	4,271	78%
Office	Office	3,737	77%
Outdoor	Outdoor Lighting Photo-Controlled	3,996	0% (Winter peak = 61%)
Parking	Parking Structure	7,884	100%
Public Assembly	Public Assembly	2,638	56%
Public Order	Public Order and Safety	3,472	75%
Religious	Religious Worship	1,824	53%
Retail Non Mall/Strip	Retail (Excl. mall and strip center)	3,668	90%
Enclosed Mall	Retail (Enclosed Mall)	4,813	93%
Strip/Non-Enclosed Mall	Retail (Strip Center and non-enclosed mall)	3,965	90%
Service (Non-Food)	Service (excl. food)	3,406	90%
Non-Refrig. Warehouse	Warehouse (non-refrigerated)	3,501	77%
Refrig. Warehouse	Warehouse (refrigerated)	3,798	84%

Note: These petition-approved values listed in this table come from PUCT Docket 39146. The exception to this is the Winter Peak factor of 61% for Outdoor Lighting (see Footnote 1013). Slight variations to these are found in other calculators and program manuals. A set of comparisons of HOU and CF across utilities are found in Appendix C.

Interactive HVAC Factors (HVAC energy, demand)

[11] DOE-EIA Commercial Building Energy Consumption Survey.

[12] The operating hours and coincidence factors listed in this table have been calculated at the facility level and should be applied to the entire facility. Outdoor fixtures that are not associated with the typical building schedule may be claimed separately.

Basic lighting savings are adjusted to account for the lighting system interaction with HVAC systems in conditioned or refrigerated spaces. A reduced lighting load reduces the internal heat gain to the building, which reduces the air conditioning/cooling load but it also increases the heating load. Currently, the TRM only considers the additional cooling savings, and the heating penalty or increase in usage is ignored.

As Table 2-5 shows, four conditioned space types are used for the Texas programs. There is a single air-conditioned space type and two options for commercial refrigeration type spaces like walk-in coolers and refrigerated warehouses: Medium and Low temperature. Utility procedures state that if the actual application falls between these values, that the higher temperature value should be used. The final space type is unconditioned (or more explicitly uncooled as the focus is on cooling). In the lighting calculators, these values are typically assigned at the line-item level based on the conditioning type for the space in which the fixtures are located.

Table 2-5: Deemed Energy and Demand Interactive HVAC Factors[13]

Space Conditioning Type	Energy Interactive HVAC Factor	Demand Interactive HVAC Factor
Air Conditioned	1.05	1.10
Med. Temp Refrigeration (33 to 41°F)	1.25	1.25
Low Temp Refrigeration (-10 to 10°F)	1.30	1.30
None (Unconditioned/Uncooled)	1.00	1.00

Deemed Energy and Demand Savings Tables

This section is not applicable as these calculations are entirely dependent on site-specific parameters related to lighting system operation.

Claimed Peak Demand Savings

Refer to Volume 1, Appendix B: Peak Demand Reduction Documentation for further details on peak demand savings and methodology.

Measure Life and Lifetime Savings

The estimated useful life (EUL) values are defined for specific lighting types by the Texas petition process, and are maintained on the Texas Energy Efficiency website and are listed below[14]:

- Halogen Lamps: 1.5 years
- High Intensity Discharge Lamps: 15.5 years
- Integrated-ballast CCFL Lamps: 4.5 years
- Integrated-ballast CFL Lamps: 2.5 years

[13] PUCT Docket 39146. Table 7 (page 17) and Table 12 (page 24).
[14] PUCT Docket 36779.

- Integral LED Lamps: 9 years[15]
- Light Emitting Diode: 15 years
- Modular CFL and CCFL Fixtures: 16 years
- T8 and T5 Linear Fluorescents: 15.5 years

Program Tracking Data and Evaluation Requirements

The following primary inputs and contextual data should be specified and tracked by the program database to inform the evaluation and apply the savings properly.

- Decision/Action Type: Retrofit or NC
- Building or Space Type
- **For New Construction Only**: Lighting Power Density Factor
- **For New Construction Only**: Interior or Exterior Space Square Footage
- Conditioned Space Type: cooling equipment type, refrigerated space temperature range, heating fuel type, % heated/cooled for NC ONLY (specified per control)
- Baseline Fixture Configuration
- Baseline Lamp Wattage
- Baseline Ballast Type
- Baseline Lighting Controls
- Baseline Counts of Operating Fixtures
- Baseline Counts of Non-Operating Fixtures
- Post-Retrofit Fixture Configuration
- Post-Retrofit Lamp Wattage
- Post-Retrofit Lamp Specification Sheets
- Post-Retrofit Ballast Type
- Post-Retrofit Lighting Controls
- Post-Retrofit Counts of Operating Fixtures
- Equipment Operating Hours
- Lighting Measure Group (from Table 2-5)

[15] PUCT Docket 38023.

Lighting measure groups to be used for measure summary reports:

The lighting measure groups below must be used for reporting summarized savings of lighting measures. Higher-level groupings of lighting technologies, such as "NonLED" lighting, will not provide enough resolution for evaluation and cost effectiveness analysis. These lighting groups are consistent with the EULs defined for lighting technologies, and will ensure that the correct, approved EUL can be associated with reported lighting savings.

Table 2-6: Lighting Measure Groups to be used for Reporting Savings[16]

TRM Standard Measure Groups
T8/T5 Linear Fluorescent
Integrated-ballast CCFL Lamps
Integrated-ballast CFL Lamps
Modular CFL and CCFL Fixtures
Light Emitting Diode (LED)
Integral LED Lamp
High Intensity Discharge (HID)
Halogen

References and Efficiency Standards

Petitions and Rulings

- PUCT Docket 36779 – Describes Effective Useful Life
- PUCT Docket 39146 – Describes deemed values for energy and demand savings
- PUCT Docket 38023 – Describes LED Installation and Efficiency Standards for non-residential LED products

Relevant Standards and Reference Sources

- DOE's LED Lighting Facts showcases LED products for general illumination from manufacturers who commit to testing products and reporting performance results. http://www1.eere.energy.gov/buildings/ssl/ledlightingfacts.html. Accessed 09/19/2013.
- ENERGY STAR® requirements for Commercial LED Lighting. http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=LTG. Accessed 09/19/2013.
- Design Lights Consortium. www.designlights.org. Accessed 09/19/2013.

[16] A "Lighting Controls" lighting measure group is also used in the tracking data summary, but it is only used to report savings for *rebated, eligible* lighting controls. The savings for lighting systems with non-eligible lighting controls should use the relevant lamp type lighting measure group.