leakage reduction provides the CFM_{50} reduction input required to estimate air infiltration measure deemed savings with the equations in Measure 2.3.1.

Table 159. Attic Encapsulation—Prototypical Home Characteristics

Shell characteristic	CFM_{50} reduction	Source
Air Infiltration Reduction from Attic Encapsulation (without Blower Door Testing)	18% reduction	Mean reduction achieved via attic encapsulation according to ACCA Manual J, 8th Edition, Section 21-14[237]

Deemed Energy Savings Tables (Infiltration Reduction Component)

Annual energy savings are provided by the space heating equipment type combined with refrigerated cooling. Savings are specified per home based on a deemed 18 percent infiltration reduction. Homes without refrigerated cooling are not eligible to claim these savings.

Table 160. Attic Encapsulation—Deemed Annual Energy Savings for Infiltration Reduction Component: 18% Air Infiltration Reduction (kWh/home)

Climate zone	Heating type		
	Gas ~~heat~~/ no heat	Electric resistance	Heat pump
Zone 1: Panhandle	135.0	874.5	385.8
Zone 2: North	209.2	600.3	315.5
Zone 3: South	161.9	469.5	259.6
Zone 4: Valley	179.7	411.9	262.9
Zone 5: West~~*~~	64.3	524.7	226.5

[237] Section 21-14 of ACCA Manual J states that, "…a foam encapsulated attic eliminates ceiling leakage to the outdoors (~~i.e.~~ i.e., to a vented attic), which means that the reduction in infiltration Cfm may range from 3 to 30 percent, with an 18 percent mean, as noted above". See Air Conditioning Contractors of America. Manual J, 8th Edition Version 2.10. Nov. 2011, p. 188.

Deemed Summer Demand Savings Tables (Infiltration Reduction Component)

Summer demand savings are specified per home based on a deemed 18 percent infiltration reduction. Homes without refrigerated cooling are not eligible to claim these savings.

Table 161. Attic Encapsulation—Deemed Summer Demand Savings for Infiltration Reduction Component: 18% Air Infiltration Reduction (kW/home)

Climate zone	Refrigerated air kW/home
Zone 1: Panhandle	0.088
Zone 2: North	0.117
Zone 3: South	0.117
Zone 4: Valley	0.098
Zone 5: West*	0.056

Deemed Winter Demand Savings Tables (Infiltration Reduction Component)

Winter demand savings are provided by space heating equipment types. Savings are specified per home based on a deemed 18 percent infiltration reduction.

Table 162. Attic Encapsulation—Deemed Winter Demand Savings for the Infiltration Reduction Component: 18% Air Infiltration Reduction (kW/home)

Climate zone	Heating type		
	Gas / no heat	Electric resistance	Heat pump
Zone 1: Panhandle	0	0.404	0.235
Zone 2: North	0	0.548	0.304
Zone 3: South	0	0.476	0.244
Zone 4: Valley	0	0.342	0.158
Zone 5: West*	0	0.161	0.066

Example Deemed Savings Calculation

Example 1. A contractor seals the attic and adds R-38 insulation to the underside of the roof to a home with 900 square feet of conditioned space below the treated attic in climate zone 3 with refrigerated air and a gas furnace, which has existing ceiling insulation estimated at R-7. No blower door testing is performed.

Insulation Component Savings:

$$Energy\ Savings/ft^2, Insulation\ to\ R-30 = 0.46 + 0.03 = 0.49\ kWh/ft^2$$

$$Energy\ Savings, Insulation\ to\ R-38 =$$

$$\{0.49 + [(4x10^{-3} + 2.97x10^{-4}) \times (38-30)]\} \times 900 = 471.9\ kWh$$

$$Summer\ Demand\ Savings, Insulation\ to\ R-38 =$$

$$\{5.51 \times 10^{-4} + [5.92 \times 10^{-6}\ x\ (38-30)]\} \times 900 = 0.54\ kW$$

$$Winter\ Demand\ Savings, Insulation\ to\ R-38 =$$

$$\{2.91 \times 10^{-5} + [2.19x10^{-7} \times (38-30)]\} \times 900 = 0.03\ kW$$

Infiltration Reduction Component Savings:

$$Energy\ Savings, 18\%\ Infiltration\ Reduction = 161.9\ kWh$$

$$Summer\ Demand\ Savings, 18\%\ Infiltration\ Reduction = 0.12\ kW$$

$$Winter\ Demand\ Savings, 18\%\ Infiltration\ Reduction = 0$$

Measure Savings:

$$Energy\ Savings = 471.9 + 161.9 = 633.8\ kWh$$

$$Summer\ Demand\ Savings = 0.54 + 0.12 = 0.66\ kW$$

$$Winter\ Demand\ Savings = 0.03 + 0 = 0.03\ kW$$

Example 2. A contractor seals the attic and adds R-30 insulation to the underside of the roof to a home with 1,200 square feet of conditioned space below the treated attic in climate zone 4 with an air-source heat pump in which existing ceiling insulation is demonstrated to be R-9. Blower door testing performed before and after measure implementation demonstrated a 750 CFM_{50} reduction in leakage rate.

Insulation Component Savings:

$$Energy\ Savings = (0.18 + 0.13)\ \times\ 1{,}200 = 372\ kWh$$

$$Summer\ Demand\ Savings = (1.79\ \times\ 10^{-4})\ \times\ 1{,}200 = 0.21\ kW$$

$$Winter\ Demand\ Savings = (1.57\ \times\ 10^{-4})\ \times\ 1{,}200 = 0.19\ kW$$

Infiltration Reduction Component Savings:

$$Energy\ Savings, 750\ CFM_{50}\ Infiltration\ Reduction =$$

$$750 \times (0.39 \times 1 + 0.21) = 450\ kWh$$

$$Summer\ Demand\ Savings, 750\ CFM_{50}\ Infiltration\ Reduction =$$

$$750 \times (2.24x10^{-4} \times 1) = 0.17\ kW$$

$$Winter\ Demand\ Savings, 750\ CFM_{50}\ Infiltration\ Reduction =$$

$$750 \times (3.60x10^{-4}) = 0.27\ kW$$

Measure Savings:

$$Energy\ Savings =\ 372\ +\ 450 = 822\ kWh$$

$$Summer\ Demand\ Savings = 0.21 + 0.17 = 0.38\ kW$$

$$Winter\ Demand\ Savings = 0.19 +\ 0.27 = 0.46\text{-}kW$$

Claimed Peak Demand Savings

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

Additional Calculators and Tools

Not applicable.

Measure Life and Lifetime Savings

According to the GDS Associates Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures (2007),[238] the Estimated Useful Life is 25 years for ceiling insulation. The measure life specified for ceiling insulation is also appropriate for attic encapsulation.

Program Tracking Data and Evaluation Requirements

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

- Climate zone
- Base R-value of original insulation
- R-value of installed insulation
- Cooling type (evaporative cooling, central refrigerated cooling, room air conditioner, none)
- Heating type (central gas, portable gas, central electric resistance, portable electric resistance, heat pump, none)
    - Additional documentation is required to validate electric resistance heat (e.g., nameplate photo, utility inspection, or other evaluator-approved approach); sampling is allowed for multifamily complexes
- Square footage of conditioned space directly below the treated attic
- Indicate whether blower door testing was performed and whether air infiltration reduction component savings are claimed in this measure or separately using the Air Infiltration measure
- Only for homes with a reported baseline R-value that is less than R-5:
    - Two pictures: 1) a picture showing the entire attic floor, and 2) a close-up picture of a ruler that shows the measurement of the depth of the insulation

      Note: The second photo type is required for each area of insulation where there are varying R-values less than R-5. Additionally, both photo types are required for all separate attic/ceiling areas, even when the installed R-value is the same.

References and Efficiency Standards

Petitions and Rulings

- 10/2017

[238] GDS Associates Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures (2007). http://library.cee1.org/sites/default/files/library/8842/CEE_Eval_MeasureLife StudyLightsandHVACGDS_1Jun2007.pdf.

Relevant Standards and Reference Sources

Not applicable.

Document Revision History

Table 163. Residential Attic Encapsulation Revision History

TRM version	Date	Description of change
v4.0	10/10/2016	TRM v4.0 origin.
v5.0	10/2017	TRM v5.0 update. Incorporated alternative savings path that includes savings for infiltration reduction.
v6.0	11/2018	TRM v6.0 update. Removed closed cell recommendation.
v7.0	11/2019	TRM v7.0 update. Incorporated EM&V guidance memo.
v8.0	10/2020	TRM v8.0 update. Updated savings tables. Added space heat adjustment factor and electric resistance documentation requirement.
v9.0	10/2021	TRM v9.0 update. Updated savings tables for < R-5 baseline category. ~~Clarified application of adjustment factors for space heating and cooling.~~

2.3.4 Wall Insulation Measure Overview

TRM Measure ID: R-BE-WI

Market Sector: Residential

Measure Category: Building Envelope

Applicable Building Types: Single-family, multifamily, manufactured

Fuels Affected: Electricity and gas

Decision/Action Type(s): Retrofit

Program Delivery Type(s): Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: Building simulation modeling

Measure Description

Wall insulation is added to the walls surrounding conditioned space in existing homes, either by removing wall enclosures and applying batt or spray insulation or by otherwise filling (e.g., blowing in loose insulation) the cavity space between studs in the walls of existing homes. Walls may be either 2x4 or 2x6 construction. Savings are estimated for filling the wall cavities of 2x4 or 2x6 walls with fiberglass batts, cellulose, or closed-cell spray foam and are presented per square foot of treated wall area (gross wall area less window and door area).

Eligibility Criteria

Cooling savings in this measure apply to customers with central or mini-split electric refrigerated air conditioning in their homes, or to customers in TRM climate zones 1 and 5 who have evaporative cooling systems. Homes must be centrally heated with either a furnace (gas or electric resistance) or a heat pump to claim heating savings. Customers who participate in hard-to-reach (HTR) or low-income (LI) programs are eligible to claim reduced heating savings for homes heated with gas or electric resistance space heaters by applying an adjustment to deemed savings that is specified for that heat type. Customers participating in HTR or LI programs are also eligible to claim reduced cooling savings for homes cooled by one or more room air conditioners by applying an adjustment to deemed savings that is specified for homes with central refrigerated air.

Refer to the Baseline Condition section below for eligibility criteria regarding the pre-retrofit level of wall insulation.

Baseline Condition

The baseline is ~~considered to be~~ a house with little or no wall insulation in the wall cavity. For those homes for which a minimal level of insulation is encountered, the baseline is established at R-4. This baseline should be used to represent homes for which installed insulation covers a very limited amount of the wall area to be treated, is significantly degraded, and/or is less than an inch thick. Homes with more than this base level of insulation are not eligible for the measure.

Baseline homes may have either 2x4 or 2x6 construction.

Electric resistance heating baselines may refer to residences heated by a centralized forced-air furnace or by individual space heaters.[239] Space heating primarily refers to electric baseboard zonal heaters controlled by thermostats or to portable plug-load heaters.[240] Electric resistance heat controlled by a wall thermostat is eligible to claim the deemed savings presented in this measure. Homes with portable space heaters may be eligible for reduced savings as described in the Deemed Energy and Summer/Winter Demand Savings Tables sections.

High-Efficiency Condition

The standard throughout Texas for adding wall insulation to an existing wall cavity is R-13, as prescribed by the United States Department of Energy (DOE) and Texas Department of Housing and Community Affairs (TDHCA) programs. The standard is achieved by filling a 2x4 wall cavity with fiberglass batt or cellulose insulation, which typically provides an R-value per inch (thickness) of between 3 and 4 $hr \cdot ft^2 \cdot °F/Btu$. Other wall insulation materials may be used, such as closed-cell spray foam, which approximately provides R-6 per inch.

As such, deemed savings are provided for insulating 2x4 and 2x6 walls to the levels presented in Table 164~~Table 164~~:

Table 164. Wall Insulation—High-Efficiency Condition R-Values for 2x4 and 2x6 Walls

Insulation material	2x4 wall	2x6 wall
Fiberglass batt or cellulose	R-13	R-17
Closed-cell spray foam	R-21	R-33

Wall insulation reduces the ventilation rate in the home, and therefore, a post-installation blower door test must be conducted. Results must comply with the minimum final ventilation rate discussed in the High-Efficiency Condition~~High-Efficiency Condition~~ section found in the Air Infiltration section of this document. This requirement applies to retrofits implemented under the HTR and RSOP programs.

[239] Electric Resistance Heating: https://www.energy.gov/energysaver/home-heating-systems/electric-resistance-heating.
[240] Portable Heaters: https://www.energy.gov/energysaver/home-heating-systems/portable-heaters.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Calibrated simulation modeling was used to develop these deemed savings values. Specifically, these deemed savings estimates were developed using BEopt 2.6, running EnergyPlus 8.4 as the underlying simulation engine. To model this measure, the prototype home models for each climate zone were modified as follows: the default R-11 insulation was reduced to either R-0 or R-4.

The model runs calculated energy use for the prototypical home prior to the installation of the wall insulation measure. Next, change-case models were run to calculate energy use with the wall insulation measure in place.

Table 165. Wall Insulation—Prototypical Home Characteristics, Climate Zones 1-4

Shell characteristic	Value	Source
Base wall insulation	R-0 R-4	BEopt estimates wall assembly R-value for uninsulated walls to be 3.6 for 2x4 construction and 3.7 for 2x6 construction. Assembly R-values for R-4 walls are 6.7 and 7.1 for 2x4 and 2x6 construction, respectively. Listed base levels are for the insulation material only.
Change wall insulation 2x4 wall	R-13 R-21	For retrofit with fiberglass batt/cellulose and closed-cell spray foam, respectively.
Change wall insulation 2x6 wall	R-17 R-33	EF or retrofit with fiberglass batt/cellulose and closed-cell spray foam, respectively.

Deemed Energy Savings Tables

Savings are presented separately for insulating 2x4 wall construction and homes with 2x6 walls. Annual energy savings are the sum of cooling and heating savings for the appropriate equipment types.

For customers who participate in hard-to-reach (HTR) or low-income (LI) programs, cooling savings may be claimed for homes cooled by one or more room air conditioners by multiplying the appropriate cooling value in Table 166~~Table 166~~ through Table 169~~Table 169~~ by a factor of 0.6. ~~Similarly~~Similarly, for HTR/LI customers, heating savings may be claimed for homes with electric resistance space heaters serving as the primary heating source by multiplying appropriate heating values in Table 166~~Table 166~~ through Table 169~~Table 169~~ by a factor of 0.24.[241]

[241] This factor was derived based on expected capacity reduction assuming 1200 sq. ft. (historical analysis of HTR participants) x 0.35 BTU/sq. ft. = 42,000 BTU for central electric furnaces and two 1,500-watt portable heaters per home rated at 5,100 BTU/heater. Taking the ratio of portable to furnace capacity yields 10,200 ÷ 42,000 = 0.24.

2x4 Walls

Table 166~~Table 166~~ presents the deemed energy savings values for insulating 2x4 walls to R-13 for all five Texas climate zones.

Table 166. Wall Insulation—Deemed Annual Energy Savings, Insulation of 2x4 Walls to R- 13 (kWh/sq. ft.)

Climate zone	~~Base case wall insulation~~Baseline R-value	Cooling savings		Heating savings		
		Refrigerated air	Evaporative cooling	Gas	Electric resistance	Heat pump
Climate zone 1: Panhandle	Uninsulated	0.50	0.17	0.18	3.96	1.67
Climate zone 2: North		0.85	N/A	0.09	2.44	0.99
Climate zone 3: South		0.90	N/A	0.07	1.67	0.66
Climate zone 4: Valley		0.53	N/A	0.04	1.19	0.45
Climate zone 5: West		0.76	0.29	0.09	2.40	0.98
Climate zone 1: Panhandle	R-4	0.18	0.06	0.07	1.52	0.64
Climate zone 2: North		0.32	N/A	0.04	0.93	0.38
Climate zone 3: South		0.33	N/A	0.03	0.64	0.25
Climate zone 4: Valley		0.19	N/A	0.01	0.45	0.17
Climate zone 5: West		0.28	0.11	0.03	0.92	0.37

Table 167 presents the deemed energy savings values for insulating 2x4 walls to R-21 for all five Texas climate zones.

Table 167. Wall Insulation—Deemed Annual Energy Savings, Insulation of 2x4 Walls to R-21 (kWh/sq. ft.)

Climate zone	Baseline R-value~~Base case wall insulation~~	Cooling savings		Heating savings		
		Refrigerated air	Evaporative cooling	Gas	Electric resistance	Heat pump
Climate zone 1: Panhandle	Uninsulated	0.56	0.18	0.20	4.44	1.87
Climate zone 2: North		0.95	N/A	0.10	2.73	1.11
Climate zone 3: South		1.01	N/A	0.08	1.88	0.74
Climate zone 4: Valley		0.59	N/A	0.04	1.33	0.50
Climate zone 5: West		0.85	0.33	0.10	2.69	1.09
Climate zone 1: Panhandle	R-4	0.24	0.08	0.09	2.00	0.84
Climate zone 2: North		0.42	N/A	0.05	1.23	0.50
Climate zone 3: South		0.43	N/A	0.03	0.84	0.33
Climate zone 4: Valley		0.26	N/A	0.02	0.59	0.22

Climate zone 5: West		0.37	0.14	0.05	1.20	0.49

2x6 Walls

Table 168~~Table 168~~ presents the deemed energy savings values for insulating 2x6 walls to R-17 for all five Texas climate zones.

Table 168. Wall Insulation – Deemed Annual Energy Savings, Insulation of 2x6 Walls to R-17 (kWh/sq. ft.)

Climate zone	Baseline R-value~~Base case wall insulation~~	Cooling savings		Heating Savings		
		Refrigerated air	Evaporative cooling	Gas	Electric resistance	Heat pump
Climate zone 1: Panhandle	Uninsulated	0.53	0.18	0.19	4.27	1.80
Climate zone 2: North		0.91	N/A	0.10	2.63	1.07
Climate zone 3: South		0.97	N/A	0.08	1.81	0.71
Climate zone 4: Valley		0.56	N/A	0.04	1.27	0.48
Climate zone 5: West		0.81	0.31	0.10	2.58	1.05
Climate zone 1: Panhandle	R-4	0.22	0.07	0.08	1.81	0.76
Climate zone 2: North		0.38	N/A	0.04	1.11	0.45
Climate zone 3: South		0.39	N/A	0.03	0.76	0.30
Climate zone 4: Valley		0.23	N/A	0.02	0.53	0.20
Climate zone 5: West		0.33	0.13	0.04	1.08	0.44

Table 169 presents the deemed energy savings values for insulating 2x6 walls to R-33 for all five Texas climate zones.

Table 169. Wall Insulation—Deemed Annual Energy Savings, Insulation of 2x6 Walls to R-33 (kWh/sq. ft.)

Climate zone	Baseline R-value~~Base case wall insulation~~	Cooling savings		Heating savings		
		Refrigerated air	Evaporative cooling	Gas	Electric resistance	Heat pump
Climate zone 1: Panhandle	Uninsulated	0.59	0.20	0.22	4.79	2.01
Climate zone 2: North		1.01	N/A	0.11	2.94	1.20
Climate zone 3: South		1.07	N/A	0.09	2.02	0.80
Climate zone 4: Valley		0.62	N/A	0.04	1.42	0.54
Climate zone 5: West		0.90	0.35	0.11	2.88	1.17
Climate zone 1: Panhandle	R-4	0.28	0.09	0.11	2.33	0.98
Climate zone 2: North		0.48	N/A	0.05	1.42	0.58
Climate zone 3: South		0.49	N/A	0.04	0.98	0.38
Climate zone 4: Valley		0.29	N/A	0.02	0.67	0.25
Climate zone 5: West		0.42	0.16	0.05	1.38	0.56

Deemed Summer Demand Savings Tables

For customers who participate in HTR/LI programs, cooling savings may be claimed for homes cooled by one or more room air conditioners by multiplying the appropriate cooling value in Table 170~~Table 170~~ through Table 173~~Table 173~~ by a factor of 0.6.

2x4 Walls

Table 170 presents the deemed summer demand savings values for insulating 2x4 walls to R-13 for all five Texas climate zones.

Table 170. Wall Insulation—Deemed Summer Demand Savings, Insulation of 2x4 Walls to R-13 (kW/sq. ft.)

Climate zone	Baseline R-value~~Base case wall insulation~~	Cooling type	
		Refrigerated air	Evaporative cooling
Climate zone 1: Panhandle	Uninsulated	6.41E-04	2.40E-04
Climate zone 2: North		7.32E-04	N/A
Climate zone 3: South		8.50E-04	N/A
Climate zone 4: Valley		4.17E-04	N/A
Climate zone 5: West		6.52E-04	2.00E-04

Climate zone	Baseline R-value Base-case wall insulation	Cooling type	
		Refrigerated air	Evaporative cooling
Climate zone 1: Panhandle	R-4	2.35E-04	9.16E-05
Climate zone 2: North		2.70E-04	N/A
Climate zone 3: South		3.02E-04	N/A
Climate zone 4: Valley		1.55E-04	N/A
Climate zone 5: West		2.43E-04	7.40E-05

Table 171 presents the deemed summer demand savings values for insulating 2x4 walls to R-13 for all five Texas climate zones.

Table 171. Wall Insulation—Deemed Summer Demand Savings, Insulation of 2x4 Walls to R-21 (kW/sq. ft.)

Climate zone	Baseline R-value Base-case wall insulation	Cooling type	
		Refrigerated air	Evaporative cooling
Climate zone 1: Panhandle	Uninsulated	7.34E-04	2.66E-04
Climate zone 2: North		8.16E-04	N/A
Climate zone 3: South		9.55E-04	N/A
Climate zone 4: Valley		4.69E-04	N/A
Climate zone 5: West		7.32E-04	2.23E-04
Climate zone 1: Panhandle	R-4	3.29E-04	1.18E-04
Climate zone 2: North		3.55E-04	N/A
Climate zone 3: South		4.08E-04	N/A
Climate zone 4: Valley		2.07E-04	N/A
Climate zone 5: West		3.24E-04	9.68E-05

2x6 Walls

Table 172 presents the deemed summer demand savings values for insulating 2x6 walls to R-17 for all five Texas climate zones.

Table 172. Wall Insulation—Deemed Summer Demand Savings, Insulation of 2x6 Walls to R-17 (kW/sq. ft.)

Climate zone		Cooling type	
		Refrigerated air	Evaporative cooling
Climate zone 1: Panhandle	Uninsulated	8.00E-04	2.59E-04
Climate zone 2: North		7.87E-04	N/A
Climate zone 3: South		9.20E-04	N/A
Climate zone 4: Valley		4.56E-04	N/A
Climate zone 5: West		8.06E-04	2.14E-04
Climate zone 1: Panhandle	R-4	2.88E-04	1.06E-04
Climate zone 2: North		3.19E-04	N/A
Climate zone 3: South		3.67E-04	N/A
Climate zone 4: Valley		1.88E-04	N/A
Climate zone 5: West		2.91E-04	8.44E-05

Table 173 presents the deemed summer demand savings values for insulating 2x6 walls to R-33 for all five Texas climate zones.

Table 173. Wall Insulation—Deemed Summer Demand Savings, Insulation of 2x6 Walls to R-33 (kW/sq. ft.)

Climate zone		Cooling type	
		Refrigerated air	Evaporative cooling
Climate zone 1: Panhandle	Uninsulated	7.76E-04	2.83E-04
Climate zone 2: North		8.77E-04	N/A
Climate zone 3: South		1.02E-03	N/A
Climate zone 4: Valley		5.08E-04	N/A
Climate zone 5: West		7.80E-04	2.38E-04
Climate zone 1: Panhandle	R-4	3.64E-04	1.30E-04
Climate zone 2: North		4.09E-04	N/A
Climate zone 3: South		4.64E-04	N/A
Climate zone 4: Valley		2.40E-04	N/A
Climate zone 5: West		3.65E-04	1.08E-04

Deemed Winter Demand Savings

For customers who participate in HTR/LI programs, heating savings may be claimed for homes with electric resistance space heaters serving as the primary heating source by multiplying appropriate heating values in Table 174~~Table 174~~ through Table 177~~Table 177~~by a factor of 0.24.[242]

[242] This factor was derived based on expected capacity reduction assuming 1200 sq. ft. (historical analysis of HTR participants) x 0.35 BTU/sq. ft. = 42,000 BTU for central electric furnaces and two 1,500-watt portable heaters per home rated at 5,100 BTU/heater. Taking the ratio of portable to furnace capacity yields 10,200 ÷ 42,000 = 0.24.

2x4 Walls

Table 174 presents the deemed winter demand savings values for insulating 2x4 walls to R-13 for all five Texas climate zones.

Table 174. Wall Insulation—Deemed Winter Demand Savings, Insulation of 2x4 Walls to R-13 (kW/sq. ft.)

Climate zone	Baseline R-value~~Base case wall insulation~~	Gas heat	Electric resistance	Heat pump
Climate zone 1: Panhandle	Uninsulated	6.93E-05	1.71E-03	8.78E-04
Climate zone 2: North		6.66E-05	1.96E-03	1.30E-03
Climate zone 3: South		7.49E-05	1.48E-03	8.39E-04
Climate zone 4: Valley		4.28E-05	1.22E-03	5.78E-04
Climate zone 5: West		2.06E-05	6.78E-04	2.84E-04
Climate zone 1: Panhandle	R-4	2.58E-05	6.20E-04	3.19E-04
Climate zone 2: North		2.46E-05	7.32E-04	4.94E-04
Climate zone 3: South		2.61E-05	5.50E-04	3.20E-04
Climate zone 4: Valley		1.61E-05	4.51E-04	2.13E-04
Climate zone 5: West		6.23E-06	2.23E-04	9.39E-05

Table 175 presents the deemed winter demand savings values for insulating 2x4 walls to R-21 for all five Texas climate zones.

Table 175. Wall Insulation—Deemed Winter Demand Savings, Insulation of 2x4 Walls to R-17 (kW/sq. ft.)

Climate zone	Baseline R-value~~Base case wall insulation~~	Gas heat	Electric resistance	Heat pump
Climate zone 1: Panhandle	Uninsulated	7.69E-05	1.89E-03	9.75E-04
Climate zone 2: North		7.41E-05	2.18E-03	1.46E-03
Climate zone 3: South		8.19E-05	1.65E-03	9.40E-04
Climate zone 4: Valley		4.78E-05	1.36E-03	6.41E-04
Climate zone 5: West		2.24E-05	7.37E-04	3.10E-04
Climate zone 1: Panhandle	R-4	3.34E-05	8.06E-04	4.16E-04
Climate zone 2: North		3.20E-05	9.57E-04	6.50E-04
Climate zone 3: South		3.31E-05	7.19E-04	4.21E-04
Climate zone 4: Valley		2.11E-05	5.88E-04	2.77E-04
Climate zone 5: West		8.01E-06	2.83E-04	1.20E-04

2x6 Walls

Table 176 presents the deemed winter demand savings values for insulating 2x6 walls to R-17 for all five Texas climate zones.

Table 176. Wall Insulation—Deemed Winter Demand Savings, Insulation of 2x6 Walls to R-17 (kW/sq. ft.)

Climate zone	Baseline R-value~~Base case wall insulation~~	Gas heat	Electric resistance	Heat pump
Climate zone 1: Panhandle	Uninsulated	6.99E-05	1.76E-03	9.09E-04
Climate zone 2: North		7.01E-05	2.07E-03	1.40E-03
Climate zone 3: South		7.86E-05	1.57E-03	9.10E-04
Climate zone 4: Valley		4.58E-05	1.29E-03	6.08E-04
Climate zone 5: West		1.84E-05	6.24E-04	2.64E-04
Climate zone 1: Panhandle	R-4	2.68E-05	6.93E-04	3.58E-04
Climate zone 2: North		2.84E-05	8.49E-04	5.84E-04
Climate zone 3: South		2.96E-05	6.40E-04	3.82E-04
Climate zone 4: Valley		1.90E-05	5.19E-04	2.41E-04
Climate zone 5: West		5.59E-06	2.06E-04	8.81E-05

Table 177~~Table 177~~ presents the deemed winter demand savings values for insulating 2x6 walls to R-33 for all five Texas climate zones.

Table 177. Wall Insulation—Deemed Winter Demand Savings, Insulation of 2x6 Walls to R-33 (kW/sq. ft.)

Climate zone	Baseline R-value~~Base case wall insulation~~	Gas heat	Electric resistance	Heat pump
Climate zone 1: Panhandle	Uninsulated	7.66E-05	1.95E-03	1.00E-03
Climate zone 2: North		7.77E-05	2.31E-03	1.56E-03
Climate zone 3: South		8.62E-05	1.75E-03	1.02E-03
Climate zone 4: Valley		5.11E-05	1.43E-03	6.73E-04
Climate zone 5: West		1.96E-05	6.66E-04	2.82E-04
Climate zone 1: Panhandle	R-4	3.35E-05	8.76E-04	4.53E-04
Climate zone 2: North		3.60E-05	1.08E-03	7.44E-04
Climate zone 3: South		3.72E-05	8.17E-04	4.92E-04
Climate zone 4: Valley		2.43E-05	6.59E-04	3.06E-04
Climate zone 5: West		6.87E-06	2.48E-04	1.06E-04

Example Deemed Savings Calculation

Example 1. A home with uninsulated 2x4 walls in climate zone 1 with evaporative cooling and an electric resistance furnace insulates 750 square feet to R-13 with fiberglass batt insulation.

$$kWh\ savings = (0.17 + 3.96) \times 750 = 3{,}091.5\ kWh$$

$$Summer\ kW\ savings = 2.40 \times 10^{-4} \times 750 = 0.18\ kW$$

$$Winter\ kW\ savings = 1.71 \times 10^{-3} \times 750 = 1.28\ kW$$

Example 2. A home in climate zone 4 with uninsulated 2x6 walls with a central air conditioning unit and a gas furnace insulates 500 square feet to R-17 with closed-cell spray foam.

$$kWh\ savings = (0.56 + 0.04) \times 500 = 300.0\ kWh$$

$$Summer\ kW\ savings = 4.56 \times 10^{-4} \times 500 = 0.23\ kW$$

$$Winter\ kW\ savings = 4.58 \times 10^{-5} \times 500 = 0.02\ kW$$

Claimed Peak Demand Savings

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

Additional Calculators and Tools

Not applicable.

Measure Life and Lifetime Savings

According to the GDS Associates Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures (2007), the Estimated Useful Life is 25 years for wall insulation.

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
- Cooling type (evaporative cooling, central refrigerated cooling, room air conditioner, none)
- Heating type (central gas, portable gas, central electric resistance, portable electric resistance, heat pump, none)
    - Additional documentation is required to validate electric resistance heat (e.g., nameplate photo, utility inspection, or other evaluator-approved approach); sampling is allowed for multifamily complexes

- Square footage of retrofitted wall area (gross wall area excluding window and door area)

References and Efficiency Standards

Petitions and Rulings

- Docket No. 22241, Item 58. Petition by Frontier Energy for Approval of Second Set of Deemed Savings Estimates. Public Utility Commission of Texas.
- Docket No. 22241, Item 62. Petition by Frontier Energy for Approval of Second Set of Deemed Savings Estimates. Public Utility Commission of Texas.
- Docket No. 41070. Petition of El Paso Electric Company to Approve Revisions to Residential and Commercial Deemed Savings Based on Climate Data Specific to El Paso, Texas. Public Utility Commission of Texas.

Relevant Standards and Reference Sources

Not applicable.

Document Revision History

Table 178. -Residential Wall 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. Added detail on methodology and model characteristics.
v2.1	1/30/2015	TRM v2.1 update. No revision.
v3.0	4/10/2015	TRM v3.0 update. Multiplier provided to adjust cooling side savings for homes with evaporative cooling due to lower energy usage and demand associated with evaporative coolers relative to refrigerated air. Climate Zone 2 savings values awarded for Climate Zone 5 homes with heat pumps.
v3.1	11/05/2015	TRM v3.1 update. Provided example savings calculations.
v4.0	8/31/2016	TRM v4.0 update. Updated energy and demand savings per new prototype energy simulation models. Added separate savings for 2x4 and 2x6 wall framing and for homes with central AC versus evaporative cooling. Added a two-tier baseline definition of R-0 and R-4.
v5.0	10/2017	TRM v5.0 update. Make an explicit allowance for cellulose insulation.
v6.0	11/2018	TRM v6.0 update. No revision.
v7.0	10/2019	TRM v7.0 update. No revision.
v8.0	10/2020	TRM v8.0 update. Added space heat adjustment factor and electric resistance documentation requirement.
v9.0	10/2021	TRM v9.0 update. No revision.

2.3.5 Floor Insulation Measure Overview

TRM Measure ID: R-BE-FI

Market Sector: Residential

Measure Category: Building envelope

Applicable Building Types: Single-family, multifamily, manufactured

Fuels Affected: Electricity and gas

Decision/Action Type(s): Retrofit

Program Delivery Type(s): Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: Building simulation modeling

Measure Description

Floor insulation is installed on the underside of floor areas sitting below conditioned space. Typically, it is installed in ventilated crawlspaces. Savings are presented per square foot of treated floor area.

Eligibility Criteria

Cooling savings in this measure apply to customers with central or mini-split electric refrigerated air conditioning in their homes, or to customers in TRM climate zones 1 and 5 who have evaporative cooling systems. Homes must be centrally heated with either an electric resistance furnace or a heat pump to claim heating savings. Customers who participate in hard-to-reach (HTR) or low-income (LI) programs are eligible to claim reduced heating savings for homes heated with electric resistance space heaters by applying an adjustment to deemed savings that is specified for that heat type. Customers participating in HTR or LI programs are also eligible to claim reduced cooling savings for homes cooled by one or more room air conditioners by applying an adjustment to deemed savings that is specified for homes with central refrigerated air.

Homes with gas heating are disqualified for adding floor insulation since this may result in an energy penalty due to floors not getting cooled from the ground during summer.

Baseline Condition

The baseline is ~~considered to be~~ a house with pier and beam construction and no floor insulation against the floor of the conditioned area.

Electric resistance heating baselines may refer to residences heated by a centralized forced-air furnace or by individual space heaters.[243] Space heating primarily refers to electric baseboard zonal heaters controlled by thermostats or to portable plug-load heaters.[244] Electric resistance heat controlled by a wall thermostat is eligible to claim the deemed savings presented in this measure. Homes with portable space heaters may be eligible for reduced savings as described in the Deemed Energy and Summer/Winter Demand Savings Tables sections.

High-Efficiency Condition

A floor insulation level of R-19 is recommended for site-built homes throughout Texas as prescribed by DOE and Texas Department of Housing and Community Affairs (TDHCA) programs. Batt insulation is recommended in most cases and must have the vapor barrier installed facing up and against the floor or conditioned area. Insulation should be attached or secured so that it can reasonably be expected to remain in place for at least 10 years.

Typical floor construction depth of manufactured homes usually does not allow R-19 batt to be installed within the floor joists, so R-15 loose-fill insulation is recommended by TDHCA.

A minimum of 24-inch clearance from the bottom of the insulation to the ground is required by the Occupational Safety and Health Association (OSHA).

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Calibrated simulation modeling was used to develop these deemed savings values.

Savings values for the deemed savings estimates for this measure were developed using demand and energy savings calculated using BEopt 2.6, running Energy Plus 8.1 as the underlying simulation engine. To model this measure, the prototype home models for each climate zone were modified as follows: slab foundation was replaced with a crawlspace. A 5/8" thick wood floor is also specified.

The model runs calculated energy use for the prototypical home prior to the installation of the floor insulation measure. Next, change-case models were run to calculate energy use with the floor insulation measure in place.

[243] Electric Resistance Heating: https://www.energy.gov/energysaver/home-heating-systems/electric-resistance-heating.
[244] Portable Heaters: https://www.energy.gov/energysaver/home-heating-systems/portable-heaters.

Table 179. Floor Insulation—Prototypical Home Characteristics

Shell characteristic	Value	Source
Foundation	Crawlspace	Skirting around the perimeter is assumed uninsulated and vented. The ground under the home is assumed to be bare, without any type of moisture barrier.
Base Floor Insulation	R-3.1	BEopt default for floor assembly, assuming 5/8" thick hardwood floor without carpet or another type of covering.
Change Floor Insulation	R-19 (except for manufactured housing, R-15)	Efficiency measure - retrofit insulation level as required by DOE and Texas Department of Housing and Community Affairs programs in Texas. Due to the typical floor joists depths found in manufactured housing, TDHCA recommends R-15 loose-fill insulation for manufactured housing and other non-site-built homes.

Deemed Energy Savings Tables

Table 180 through Table 184 present energy savings on a kWh per square foot of insulation installed basis for all five Texas climate zones. Annual energy savings are the sum of cooling and heating savings for the appropriate equipment types.

For customers who participate in hard-to-reach (HTR) or low-income (LI) programs, cooling savings may be claimed for homes cooled by one or more room air conditioners by multiplying the appropriate cooling value in Table 180~~Table 180~~ through Table 183~~Table 183~~ by a factor of 0.6. ~~Similarly~~Similarly, for HTR/LI customers, heating savings may be claimed for homes with electric resistance space heaters serving as the primary heating source by multiplying appropriate heating values in Table 180~~Table 180~~ through Table 183~~Table 183~~ by a factor of 0.24.[245]

Table 180. Floor Insulation—Climate Zone 1: Panhandle Region—Deemed Annual Energy Savings (kWh/sq. ft.)

Home type	Cooling savings		Heating savings	
	Refrigerated air	Evaporative cooling	Electric resistance	Heat pump
Site-built Home	-0.13	-0.07	1.72	0.68
Manufactured Home	-0.11	-0.06	1.52	0.60

[245] This factor was derived based on expected capacity reduction assuming 1200 sq. ft. (historical analysis of HTR participants) x 0.35 BTU/sq. ft. = 42,000 BTU for central electric furnaces and two 1,500-watt portable heaters per home rated at 5,100 BTU/heater. Taking the ratio of portable to furnace capacity yields 10,200 ÷ 42,000 = 0.24.

Table 181. Floor Insulation – Climate Zone 2: North Region—Deemed Annual Energy Savings (kWh/sq. ft.)

Home type	Cooling savings		Heating savings	
	Refrigerated air	Evaporative cooling	Electric resistance	Heat pump
Site-built Home	-0.12	-	0.96	0.38
Manufactured Home	-0.10	-	0.85	0.33

Table 182. Floor Insulation—Climate Zone 3: South Region—Deemed Annual Energy Savings (kWh/sq. ft.)

Home type	Cooling savings		Heating savings	
	Refrigerated air	Evaporative cooling	Electric resistance	Heat pump
Site-built Home	-0.12	-	0.63	0.24
Manufactured Home	-0.10	-	0.56	0.21

Table 183. Floor Insulation—Climate Zone 4: Valley Region—Deemed Annual Energy Savings (kWh/sq. ft.)

Home type	Cooling savings		Heating savings	
	Refrigerated air	Evaporative cooling	Electric resistance	Heat pump
Site-built Home	-0.07	-	0.40	0.15
Manufactured Home	-0.06	-	0.35	0.13

Table 184. Floor Insulation—Climate Zone 5: West Region—Deemed Annual Energy Savings (kWh/sq. ft.)

Home type	Cooling savings		Heating savings	
	Refrigerated air	Evaporative cooling	Electric resistance	Heat pump
Site-built Home	-0.16	-0.07	1.10	0.43
Manufactured Home	-0.13	-0.06	0.97	0.38

Deemed Summer Demand Savings Tables

Table 185 through Table 189 present the deemed summer demand savings (kW) for all five Texas climate zones.

For customers who participate in HTR/LI programs, cooling savings may be claimed for homes cooled by one or more room air conditioners by multiplying the appropriate cooling value in Table 185~~Table 185~~ through Table 189~~Table 189~~ by a factor of 0.6.

Table 185. Floor Insulation—Climate Zone 1: Panhandle Region—Deemed Summer Demand Savings (kW/sq. ft.)

Home type	Refrigerated air	Evaporative cooling
Site-built Home	6.17E-06	-1.52E-05
Manufactured Home	5.48E-06	-1.30E-05

Table 186. Floor Insulation—Climate Zone 2: North Region—Deemed Summer Demand Savings (kW/sq. ft.)

Home type	Refrigerated air	Evaporative cooling
Site-built Home	3.10E-05	-
Manufactured Home	2.75E-05	-

Table 187. Floor Insulation—Climate Zone 3: South Region—Deemed Summer Demand Savings (kW/sq. ft.)

Home type	Refrigerated air	Evaporative cooling
Site-built Home	3.36E-05	-
Manufactured Home	2.77E-05	-

Table 188. Floor Insulation—Climate Zone 4: Valley Region—Deemed Summer Demand Savings (kW/sq. ft.)

Home type	Refrigerated air	Evaporative cooling
Site-built Home	3.58E-05	-
Manufactured Home	3.07E-05	-

Table 189. Floor Insulation—Climate Zone 5: West Region—Deemed Summer Demand Savings (kW/sq. ft.)

Home type	Refrigerated air	Evaporative cooling
Site-built Home	6.29E-06	-1.34E-06
Manufactured Home	8.30E-07	1.85E-07

Deemed Winter Demand Savings Tables

Table 190 through Table 194 present the deemed winter demand savings for all five Texas climate zones.

For customers who participate in HTR/LI programs, heating savings may be claimed for homes with electric resistance space heaters serving as the primary heating source by multiplying appropriate heating values in Table 190~~Table 190~~ through Table 194~~Table 194~~ by a factor of 0.24.[246]

Table 190. Floor Insulation—Climate Zone 1: Panhandle Region—Deemed Winter Demand Savings (kW/sq. ft.)

Home type	Electric resistance	Heat pump
Site-built Home	5.23E-04	2.55E-04
Manufactured Home	4.62E-04	2.25E-04

[246] This factor was derived based on expected capacity reduction assuming 1200 sq. ft. (historical analysis of HTR participants) x 0.35 BTU/sq. ft. = 42,000 BTU for central electric furnaces and two 1,500-watt portable heaters per home rated at 5,100 BTU/heater. Taking the ratio of portable to furnace capacity yields 10,200 ÷ 42,000 = 0.24.

Table 191. Floor Insulation—Climate Zone 2: North Region—Deemed Winter Demand Savings (kW/sq. ft.)

Home type	Electric resistance	Heat pump
Site-built Home	5.19E-04	2.88E-04
Manufactured Home	4.56E-04	2.50E-04

Table 192. Floor Insulation—Climate Zone 3: South Region—Deemed Winter Demand Savings (kW/sq. ft.)

Home type	Electric resistance	Heat pump
Site-built Home	4.22E-04	2.03E-04
Manufactured Home	3.64E-04	1.74E-04

Table 193. Floor Insulation—Climate Zone 4: Valley Region—Deemed Winter Demand Savings (kW/sq. ft.)

Home type	Electric resistance	Heat pump
Site-built Home	3.51E-04	1.53E-04
Manufactured Home	3.02E-04	1.31E-04

Table 194. Floor Insulation—Climate Zone 5: West Region—Deemed Winter Demand Savings (kW/sq. ft.)

Home Type	Electric Resistance	Heat Pump
Site-built Home	3.54E-04	1.44E-04
Manufactured Home	3.19E-04	1.30E-04

Example Deemed Savings Calculation

Example 1. A manufactured home in Climate Zone 5 with evaporative cooling and an electric resistance furnace insulates 500 square feet.

$$kWh\ savings = (-0.06 + 0.97) \times 500 = 455.0\ kWh$$

$$Summer\ kW\ savings = 1.85 \times 10^{-7} \times 500 = 0.00\ kW$$

$$Winter\ kW\ savings = 3.19 \times 10^{-4} \times 500 = 0.16\ kW$$

Example 2. A site-built home in Climate Zone 2 with an air-source heat pump insulates 825 square feet.

$$kWh\ savings = (-0.12 + 0.38) \times 825 = 214.5\ kWh$$

$$Summer\ kW\ savings = 3.10 \times 10^{-5} \times 825 = 0.03\ kW$$

$$Winter\ kW\ savings = 2.88 \times 10^{-4} \times 825 = 0.24\ kW$$

Claimed Peak Demand Savings

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

Additional Calculators and Tools

Not applicable.

Measure Life and Lifetime Savings

According to the GDS Associates Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures (2007), the Estimated Useful Life is 25 years for floor insulation.

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: The climate zone

- Climate zone
- Cooling type (evaporative cooling, central refrigerated cooling, room air conditioner, none)
- Heating type (central gas, portable gas, central electric resistance, portable electric resistance, heat pump, none)
    - Additional documentation is required to validate electric resistance heat (e.g., nameplate photo, utility inspection, or other evaluator-approved approach); sampling is allowed for multifamily complexes
- Home type (site built or manufactured)
- Square footage of installed insulation

References and Efficiency Standards

Petitions and Rulings

- Docket No. 22241, Item 62. Petition by Frontier Energy for Approval of Second Set of Deemed Savings Estimates. Public Utility Commission of Texas.
- Docket No. 41070. Petition of El Paso Electric Company to Approve Revisions to Residential and Commercial Deemed Savings Based on Climate Data Specific to El Paso, Texas. Public Utility Commission of Texas.

Relevant Standards and Reference Sources

Not applicable.

Document Revision History

Table 195. Residential Floor 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. Added detail on methodology and model characteristics.
v2.1	1/30/2015	TRM v2.1 update. No revision.
v3.0	4/10/2015	TRM v3.0 update. Multiplier provided to adjust cooling side savings for homes with evaporative cooling due to lower energy usage and demand associated with evaporative coolers relative to refrigerated air. Climate Zone 2 savings values awarded for Climate Zone 5 homes with heat pumps.
v3.1	11/05/2015	TRM v3.1 update. Provided example savings calculations.
v4.0	10/10/2016	TRM v4.0 update. Updated energy and demand savings per new prototype energy simulation models. Added separate savings for homes with evaporative cooling. Disqualified homes with gas heating for adding floor insulation.
v5.0	10/2017	TRM v5.0 update. Added an explicit reference to mini-split technology.
v6.0	11/2018	TRM v6.0 update. No revision.
v7.0	10/2019	TRM v7.0 update. No revision.
v8.0	10/2020	TRM v8.0 update. Added space heat adjustment factor and electric resistance documentation requirement.
v9.0	10/2021	TRM v9.0 update. No revision.

2.3.6 ENERGY STAR® Windows Measure Overview

TRM Measure ID: R-BE-EW

Market Sector: Residential

Applicable Building Types: Single-family, multifamily, manufactured

Measure Category: Building envelope

Fuels Affected: Electricity and gas

Decision/Action Type(s): Retrofit

Program Delivery Type(s): Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: Building simulation modeling

Measure Description

ENERGY STAR® windows savings are calculated on a per square foot of window basis, inclusive of frame and sash.

Eligibility Criteria

Cooling savings in this measure apply to customers with central or mini-split electric refrigerated air conditioning in their homes, or to customers in TRM climate zones 1 and 5 who have evaporative cooling systems. Homes must be centrally heated with either a furnace (gas or electric resistance) or a heat pump to claim heating savings. Customers who participate in hard-to-reach (HTR) or low-income (LI) programs are eligible to claim reduced heating savings for homes heated with gas or electric resistance space heaters by applying an adjustment to deemed savings that is specified for that heat type. Customers participating in HTR or LI programs are also eligible to claim reduced cooling savings for homes cooled by one or more room air conditioners by applying an adjustment to deemed savings that is specified for homes with central refrigerated air.

Baseline

There are two base cases: single-pane and double-pane windows. In both cases, a metal frame is specified. Estimated U-Values and SHGCs for baseline windows are presented in Table 196.

Electric resistance heating baselines may refer to residences heated by a centralized forced-air furnace or by individual space heaters.[247] Space heating primarily refers to electric baseboard zonal heaters controlled by thermostats or to portable plug-load heaters.[248] Electric resistance heat controlled by a wall thermostat is eligible to claim the deemed savings presented in this

[247] Electric Resistance Heating: https://www.energy.gov/energysaver/home-heating-systems/electric-resistance-heating.
[248] Portable Heaters: https://www.energy.gov/energysaver/home-heating-systems/portable-heaters.

measure. Homes with portable space heaters may be eligible for reduced savings as described in the Deemed Energy and Summer/Winter Demand Savings Tables sections.

Table 196. ENERGY STAR® Windows—Baseline Window Specification

Number of panes	U-factor Btu/(h·ft²·°F)	Solar heat gain coefficient (SHGC)
1	1.16	0.76
2	0.76	0.67

High-Efficiency Condition

For a window to qualify for these deemed savings, it must meet the relevant ENERGY STAR® criteria for the location in the state where the window is to be installed. Table 197 lists the ENERGY STAR® specifications for windows as of January 1, 2015. 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 197. ENERGY STAR® Windows—High-Efficiency Specification effective January 2015

US region, ENERGY STAR®	U-factor Btu/(h·ft²·°F)	Solar heat gain coefficient (SHGC)
North-Central	≤ 0.30	≤ 0.40
South-Central	≤ 0.30	≤ 0.25
Southern	≤ 0.40	≤ 0.25

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Deemed savings values have been estimated using calibrated simulation models. Base case homes were fitted with single-pane and double-pane windows: change case homes were equipped with windows meeting the appropriate ENERGY STAR window specification for the location in which the window was to be installed. The climate zones in the ENERGY STAR® windows specification were mapped to the Texas TRM climate zones as shown in Table 198.

Table 198. ENERGY STAR® Windows—TRM and ENERGY STAR® Climate Zones

Texas TRM climate zones	US region, ENERGY STAR® windows
Climate zone 1: Panhandle	North-Central
Climate zone 2: North	South-Central
Climate zone 3: South	Southern
Climate zone 4: Valley	Southern
Climate zone 5: West	South-Central

Deemed Energy Savings Tables

Table 199~~Table 199~~ and Table 200 present the energy savings (kWh) for the five Texas climate zones. Annual energy savings are the sum of cooling and heating savings for the appropriate equipment types.

For customers who participate in hard-to-reach (HTR) or low-income (LI) programs, cooling savings may be claimed for homes cooled by one or more room air conditioners by multiplying appropriate cooling values in Table 199~~Table 199~~ and Table 200~~Table 200~~ by a factor of 0.6. ~~Similarly~~Similarly, for HTR/LI customers, heating savings may be claimed for homes with electric resistance space heaters serving as the primary heating source by multiplying appropriate heating values in Table 199~~Table 199~~ and Table 200~~Table 200~~ by a factor of 0.24.[249]

Table 199. ENERGY STAR® Windows—Replacing Single-Pane Windows, Deemed Annual Energy Savings (kWh/sq. ft.)

Climate zone	Cooling savings		Heating savings		
	Refrigerated air	Evaporative cooling	Gas	Electric resistance	Heat pump
Climate zone 1: Panhandle	2.83	0.98	0.29	6.70	3.16
Climate zone 2: North	5.42	-	0.10	3.09	1.45
Climate zone 3: South	5.32	-	0.02	0.77	0.41
Climate zone 4: Valley	5.97	-	0.02	0.82	0.34
Climate zone 5: West	5.67	1.90	0.00	0.99	0.69

Table 200. ENERGY STAR® Windows—Replacing Double-Pane Windows Deemed Annual Energy Savings (kWh/sq. ft.)

Climate zone	Cooling savings		Heating savings		
	Refrigerated air	Evaporative cooling	Gas	Electric resistance	Heat pump
Climate zone 1: Panhandle	2.03	0.72	0.18	4.15	2.00
Climate zone 2: North	4.11	-	0.04	1.47	0.76
Climate zone 3: South	3.96	-	-0.01	-0.21	0.01
Climate zone 4: Valley	4.45	-	0.00	-0.01	0.02
Climate zone 5: West	4.24	1.46	-0.03	-0.18	0.16

[249] This factor was derived based on expected capacity reduction assuming 1200 sq. ft. (historical analysis of HTR participants) x 0.35 BTU/sq. ft. = 42,000 BTU for central electric furnaces and two 1,500-watt portable heaters per home rated at 5,100 BTU/heater. Taking the ratio of portable to furnace capacity yields 10,200 ÷ 42,000 = 0.24.

Deemed Summer Demand Savings Tables

Table 201 and Table 202 presents the summer demand savings (kW) for the five Texas climate zones.

For customers who participate in HTR/LI programs, cooling savings may be claimed for homes cooled by one or more room air conditioners by multiplying appropriate cooling values in Table 201~~Table 201~~ and Table 202~~Table 202~~ by a factor of 0.6.

Table 201. ENERGY STAR® Windows—Replacing Single-Pane Windows, Deemed Summer Demand Savings (kW/sq. ft.)

Climate zone	Refrigerated air	Evaporative cooling
Climate zone 1: Panhandle	3.09E-03	1.16E-03
Climate zone 2: North	3.89E-03	-
Climate zone 3: South	3.51E-03	-
Climate zone 4: Valley	2.99E-03	-
Climate zone 5: West	3.86E-03	1.05E-03

Table 202. ENERGY STAR® Windows—Replacing Double-Pane Windows, Deemed Summer Demand Savings (kW/sq. ft.)

Climate zone	Refrigerated air	Evaporative cooling
Climate zone 1: Panhandle	2.08E-03	8.36E-04
Climate zone 2: North	2.80E-03	-
Climate zone 3: South	2.40E-03	-
Climate zone 4: Valley	2.15E-03	-
Climate zone 5: West	2.76E-03	8.09E-04

Deemed Winter Demand Savings Tables

Table 203 and Table 204 presents the winter demand savings (kW) for the five Texas climate zones.

For customers who participate in HTR/LI programs, heating savings may be claimed for homes with electric resistance space heaters serving as the primary heating source by multiplying appropriate heating values in Table 203~~Table 203~~ and Table 204~~Table 204~~ by a factor of 0.24.[250]

[250] This factor was derived based on expected capacity reduction assuming 1200 sq. ft. (historical analysis of HTR participants) x 0.35 BTU/sq. ft. = 42,000 BTU for central electric furnaces and two 1,500-watt portable heaters per home rated at 5,100 BTU/heater. Taking the ratio of portable to furnace capacity yields 10,200 ÷ 42,000 = 0.24.

Table 203. ENERGY STAR® Windows—Replacing Single-Pane Windows, Deemed Winter Demand Savings by Heat Type (kW/sq. ft.)

Climate zone	Gas	Electric resistance	Heat pump
Climate zone 1: Panhandle	2.01E-04	4.98E-03	2.43E-03
Climate zone 2: North	1.77E-04	4.73E-03	2.74E-03
Climate zone 3: South	6.89E-05	1.78E-03	3.11E-04
Climate zone 4: Valley	4.78E-05	1.65E-03	6.68E-04
Climate zone 5: West	2.83E-05	1.10E-03	5.00E-04

Table 204. ENERGY STAR® Windows—Replacing Double-Pane Windows, Deemed Winter Demand Savings by Heat Type (kW/sq. ft.)

Climate zone	Gas	Electric resistance	Heat pump
Climate zone 1: Panhandle	1.32E-04	3.30E-03	1.64E-03
Climate zone 2: North	1.12E-04	3.16E-03	1.89E-03
Climate zone 3: South	2.33E-05	6.68E-04	3.58E-06
Climate zone 4: Valley	1.53E-05	5.62E-04	2.34E-04
Climate zone 5: West	1.31E-05	5.84E-04	2.76E-04

Example Deemed Savings Calculation

Example 1. A home in Climate Zone 1 with evaporative cooling and an electric resistance furnace replaces 125 square feet of single-pane windows with ENERGY STAR® windows.

$$kWh\ savings = (0.98\ +\ 6.70)\ \times\ 125 = 960\ kWh$$

$$Summer\ kW\ savings = 1.16x10^{-3}\ \times\ 125 = 0.15\ kW$$

$$Winter\ kW\ savings = 4.98x10^{-3}\ \times\ 125 = 0.62\ kW$$

Example 2. A home in climate zone 5 with a central air conditioning unit and a gas furnace replaces 250 square feet of double-pane windows with ENERGY STAR® windows.

$$kWh\ savings = \big(4.24 + (-0.03)\big)\ \times\ 250 = 1{,}052.5\ kWh$$

$$Summer\ kW\ savings = 2.76\ \times\ 10^{-3}\ \times\ 250 = 0.69\ kW$$

$$Winter\ kW\ savings = 1.31\ \times\ 10^{-5}\ \times\ 250 = 0.00\ kW$$

Claimed Peak Demand Savings

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

Additional Calculators and Tools

Not applicable.

Measure Life and Lifetime Savings

According to the GDS Associates Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures (2007), the Estimated Useful Life is 25 years for ENERGY STAR® windows[251].

Program Tracking Data and Evaluation Requirements

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

- Climate zone
- Cooling type (evaporative cooling, central refrigerated cooling, room air conditioner, none)
- Heating type (central gas, portable gas, central electric resistance, portable electric resistance, heat pump, none)
    - Additional documentation is required to validate electric resistance heat (e.g., nameplate photo, utility inspection, or other evaluator-approved approach); sampling is allowed for multifamily complexes
- Area of ENERGY STAR® windows installed
- Proof of purchase – with date of purchase and quantity
    - Alternative: photo of unit installed or another pre-approved method of installation verification.

References and Efficiency Standards

Petitions and Rulings

- Docket No. 22241, Item 48. Petition by Frontier Energy for Approval of Second Set of Deemed Savings Estimates. Public Utility Commission of Texas.
- Docket No. 27903. Order Adopting New §25.184 as Approved at the August 21, 2003, Open Meeting and Submitted to the Secretary of State. Public Utility Commission of Texas.

Relevant Standards and Reference Sources

Not applicable.

[251] "Measure Life Report: Residential and Commercial Industrial Lighting and HVAC Measures," The New England State Program Working Group (SPWG). June 2007. https://library.cee1.org/sites/default/files/library/8842/CEE_Eval_MeasureLifeStudyLights&HVACGDS_1Jun2007.pdf.

Document Revision History

Table 205. Residential ENERGY STAR® Windows 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. Multiplier provided to adjust cooling side savings for homes with evaporative cooling due to lower energy usage and demand associated with evaporative coolers relative to refrigerated air. Climate Zone 2 savings values awarded for Climate Zone 5 homes.
v3.1	11/05/2015	TRM v3.1 update. Provided example savings calculations. Consolidated table formats.
v4.0	10/10/2016	TRM v4.0 update. Updated energy and demand savings per new prototype energy simulation models. Added separate savings for homes with evaporative cooling.
v5.0	10/2017	TRM v5.0 update. Added explicit reference to mini-split technology
v6.0	11/2018	TRM v6.0 update. No revision.
v7.0	10/2019	TRM v7.0 update. Updated documentation requirements.
v8.0	10/2020	TRM v8.0 update. Added space heat adjustment factor and electric resistance documentation requirement.
v9.0	10/2021	TRM v9.0 update. No revision.

2.3.7 ENERGY STAR® Low-E Storm Windows Measure Overview

TRM Measure ID: R-BE-SW

Market Sector: Residential

Applicable Building Types: Single-family, multifamily, manufactured

Measure Category: Building envelope

Fuels Affected: Electricity and gas

Decision/Action Type(s): Retrofit

Program Delivery Type(s): Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: Building simulation modeling and third-party field testing

Measure Description

ENERGY STAR® storm windows are a glazing attachment added to single or double-pane windows. Storm windows are an affordable option for homes where full window replacement may be difficult. Low-emissivity (low-e) metal oxide coating decreases the summer heat gain and winter heat loss of an existing window by reducing thermal transmission. Thermal transmission is reduced as follows:

- The low-e coating acts as a selective heat mirror that reflects infrared light back outside during the summer and back onto the home during the winter.
- The marine-quality glazing and caulked or compression-sealed interface reduces air leakage and infiltration.
- The dead air space, or air barrier, created between the existing window and new storm window frame further reduces thermal transmission during both summer and winter.

The low-e coating is extremely durable and has negligible impact on visible light transmission.

Eligibility Criteria

A low-e storm window may be installed on the interior or exterior of the existing window assembly. Installation is a simple process that is often completed by residential homeowners without the assistance of professional contractors. Due to the simple installation process, low-e storm windows are sometimes installed seasonally. However, savings estimates assume windows are installed for the entire year. Therefore, windows should be permanently mounted and operable.

Cooling savings in this measure apply to customers with central or mini-split electric refrigerated air conditioning in their homes. Homes must be centrally heated with either a furnace (gas or electric resistance) or a heat pump to claim heating savings. Customers who participate in hard-to-reach (HTR) or low-income (LI) programs are eligible to claim reduced heating savings for homes heated with gas or electric resistance space heaters by applying an adjustment to

deemed savings that is specified for that heat type. Customers participating in HTR or LI programs are also eligible to claim reduced cooling savings for homes cooled by one or more room air conditioners by applying an adjustment to deemed savings that is specified for homes with central refrigerated air.

Baseline

The baseline condition is an existing single or double-pane window assembly according to manufacturer specifications. Data obtained from the 2015 Residential Energy Consumption Survey (RECS) in the West South Central region show that approximately 56% of single-family homes have single-pane windows and 44% have double-pane windows.[252]

Electric resistance heating baselines may refer to residences heated by a centralized forced-air furnace or by individual space heaters.[253] Space heating primarily refers to electric baseboard zonal heaters controlled by thermostats or to portable plug-load heaters.[254] Electric resistance heat controlled by a wall thermostat is eligible to claim the deemed savings presented in this measure. Homes with portable space heaters may be eligible for reduced savings as described in the Deemed Energy and Summer/Winter Demand Savings Tables sections.

High-Efficiency Condition

For a storm window to qualify for these deemed savings, it must be compliant with ENERGY STAR® eligibility criteria final version 1.0 for exterior and interior storm windows. Table 197~~Table 197~~ lists the specifications for the relevant ENERGY STAR® climate regions, effective September 5, 2018.

Table 206. ENERGY STAR® Low-E Storm Windows – ENERGY STAR® Specification

Region	Emissivity	Solar transmission
North-Central	≤ 0.22	Any
South-Central	≤ 0.22	≤ 0.55
Southern	≤ 0.22	≤ 0.55

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Deemed savings values have been estimated using Lawrence Berkeley National Laboratory's RESFEN building simulation models for residential fenestration.[255] The properties of low-e storm windows used in the RESFEN building models are presented in Table 207~~Table 207~~. This measure assumes equal weighting between the three low-e storm window glass options.

[252] 2015 RECS survey, Table HC2.8. https://www.eia.gov/consumption/residential/data/2015/.
[253] Electric Resistance Heating: https://www.energy.gov/energysaver/home-heating-systems/electric-resistance-heating.
[254] Portable Heaters: https://www.energy.gov/energysaver/home-heating-systems/portable-heaters.
[255] Available for download at: https://windows.lbl.gov/software/resfen.

Table 207. ENERGY STAR® Low-E Storm Windows – Window Assembly Properties[256]

Window type	Glass options	U-factor	SHGC	Air Leakage
Storm window over existing single-pane	Low-e	0.35	0.47	1.25
	Low-e with solar control	0.35	0.32	1.25
Storm window over existing double-pane	Low-e	0.26	0.43	1.25
	Low-e with solar control	0.27	0.29	1.25

Assumed building characteristics are based on a 1,700 square feet single-story and 2,800 square feet two-story residence. The modeled residence has a 15% window-to-floor-area ratio. Assumed building characteristics are presented in Table 208~~Table 208~~.

Table 208. ENERGY STAR® Low-E Storm Windows – Modeled Building Characteristics

Characteristic	Model assumption
Area	Single-story: 1,700 sq. ft. Two-story: 2,800 sq. ft.
Existing window performance[257,258]	Single pane: 0.88 U-factor, 0.61 SHGC, 2 cfm/ft^2 air ~~infiltration~~infiltration Double pane: 0.51 U-factor, 0.57 SHGC, 2 cfm/ft^2 air infiltration
Existing window area	15% of floor area
Existing window frame	Wood double-hung
Foundation	Slab on-grade
Insulation	Newer construction: IECC 2006 based on climate zone Older construction: See RESFEN 6 documentation
HVAC efficiency	Newer construction: 13 SEER, 7.7 HSPF, 0.8 AFUE for IECC climate zones 1-3 and 0.9 AFUE for IECC climate zones 4-8 Older construction: 10 SEER, 6.8 HSPF, 0.78 AFUE

Deemed Energy Savings Tables

Table 199~~Table 199~~ and Table 200 present the energy savings (kWh) for the five Texas climate zones. Annual energy savings are the sum of cooling and heating savings for the appropriate equipment types.

For customers who participate in hard-to-reach (HTR) or low-income (LI) programs, cooling savings may be claimed for homes cooled by one or more room air conditioners by multiplying appropriate cooling values in Table 199~~Table 199~~ and Table 200~~Table 200~~ by a factor of 0.6.

[256] Averaged values from the selected products in Attachments Energy Rating Council (AERC). https://aercenergyrating.org/product-search/residential-product-search/.
[257] Culp, TD and KA Cort. "Database of Low-e Storm Window Energy Performance across U.S. Climate Zones." U.S. DOE, September 2014. https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-22864rev2.pdf.
[258] Air infiltration assumption from: "AERC 1.2: ~~hysical~~physical Test Methods for Measuring Energy Performance Properties of Fenestration Attachments." AERC, 2018. www.aercnet.org.

~~Similarly~~Similarly, for HTR/LI customers, heating savings may be claimed for homes with electric resistance space heaters serving as the primary heating source by multiplying appropriate heating values in Table 199~~Table 199~~ and Table 200~~Table 200~~ by a factor of 0.24.[259]

Savings are an average of newer and older construction baselines for retrofit applications.

Table 209. ENERGY STAR® Low-E Storm Windows – Deemed Annual Energy Savings (kWh/sq. ft.), Single-Pane Baseline

	Cooling Savings	Heating savings		
Climate zone	Refrigerated air	Gas	Electric resistance	Heat pump
Climate zone 1: Panhandle	1.49	--	15.66	5.34
Climate zone 2: North	2.52	--	6.65	2.09
Climate zone 3: South	2.49	--	4.55	1.48
Climate zone 4: Valley	3.22	--	2.82	0.80
Climate zone 5: West	2.35	--	6.00	2.06

Table 210. ENERGY STAR® Low-E Storm Windows – Deemed Annual Energy Savings (kWh/sq. ft.), Double-Pane Baseline

	Cooling Savings	Heating savings		
Climate zone	Refrigerated air	Gas	Electric resistance	Heat pump
Climate zone 1: Panhandle	1.56	--	6.23	2.35
Climate zone 2: North	2.50	--	2.46	0.88
Climate zone 3: South	2.62	--	1.84	0.67
Climate zone 4: Valley	3.21	--	1.05	0.32
Climate zone 5: West	2.37	--	1.90	0.79

Deemed Summer Demand Savings Tables

Table 201 and Table 202 present the summer demand savings (kW) for the five Texas climate zones.

For customers who participate in HTR/LI programs, cooling savings may be claimed for homes cooled by one or more room air conditioners by multiplying appropriate cooling values in Table 201~~Table 201~~ and Table 202~~Table 202~~ by a factor of 0.6.

[259] This factor was derived based on expected capacity reduction assuming 1200 sq. ft. (historical analysis of HTR participants) x 0.35 BTU/sq. ft. = 42,000 BTU for central electric furnaces and two 1,500-watt portable heaters per home rated at 5,100 BTU/heater. Taking the ratio of portable to furnace capacity yields 10,200 ÷ 42,000 = 0.24.

Table 211. ENERGY STAR® Low-E Storm Windows – Deemed Summer Demand Savings (kW/sq. ft.), Single-Pane Baseline

Climate zone	Refrigerated air
Climate zone 1: Panhandle	0.0016
Climate zone 2: North	0.0018
Climate zone 3: South	0.0016
Climate zone 4: Valley	0.0016
Climate zone 5: West	0.0016

Table 212. ENERGY STAR® Low-E Storm Windows – Deemed Summer Demand Savings (kW/sq. ft.), Double-Pane Baseline

Climate zone	Refrigerated air
Climate zone 1: Panhandle	0.0016
Climate zone 2: North	0.0017
Climate zone 3: South	0.0016
Climate zone 4: Valley	0.0016
Climate zone 5: West	0.0015

Deemed Winter Demand Savings Tables

Table 203 and Table 204 present the winter demand savings (kW) for the five Texas climate zones.

For customers who participate in HTR/LI programs, heating savings may be claimed for homes with electric resistance space heaters serving as the primary heating source by multiplying appropriate heating values in Table 203~~Table 203~~ and Table 204~~Table 204~~ by a factor of 0.24.[260]

Table 213. ENERGY STAR® Low-E Storm Windows – Deemed Winter Demand Savings (kW/sq. ft.), Single-Pane Baseline

Climate zone	Gas	Electric resistance	Heat pump
Climate zone 1: Panhandle	-	0.0116	0.0041
Climate zone 2: North	-	0.0102	0.0039
Climate zone 3: South	-	0.0105	0.0011
Climate zone 4: Valley	-	0.0057	0.0016
Climate zone 5: West	-	0.0067	0.0015

[260] This factor was derived based on expected capacity reduction assuming 1200 sq. ft. (historical analysis of HTR participants) x 0.35 BTU/sq. ft. = 42,000 BTU for central electric furnaces and two 1,500-watt portable heaters per home rated at 5,100 BTU/heater. Taking the ratio of portable to furnace capacity yields 10,200 ÷ 42,000 = 0.24.

Table 214. ENERGY STAR® Low-E Storm Windows – Deemed Winter Demand Savings (kW/sq. ft.), Double-Pane Baseline

Climate zone	Gas	Electric resistance	Heat pump
Climate zone 1: Panhandle	-	0.0050	0.0019
Climate zone 2: North	-	0.0053	0.0022
Climate zone 3: South	-	0.0039	0.0002
Climate zone 4: Valley	-	0.0019	0.0037
Climate zone 5: West	-	0.0035	0.0014

Claimed Peak Demand Savings

No load shape could be extracted from the building simulation for this measure. Due to the equivalent load shape with the existing ENERGY STAR® Windows measure, demand savings were estimated by applying the ratio of energy to demand savings from the windows measure to the modeled storm windows energy savings.

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

Additional Calculators and Tools

Not applicable.

Measure Life and Lifetime Savings

The estimated useful life (EUL) for low-e storm windows is 20 years according to the U.S. Department of Energy.[261]

Program Tracking Data and Evaluation Requirements

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

- Climate zone
- Cooling type (central refrigerated cooling, room air conditioner, none)
- Heating type (central gas, portable gas, central electric resistance, portable electric resistance, heat pump, none)
    - Additional documentation is required to validate electric resistance heat (e.g., nameplate photo, utility inspection, or other evaluator-approved approach); sampling is allowed for multifamily complexes

[261] Culp, TD and KA Cort. "Database of Low-e Storm Window Energy Performance across U.S. Climate Zones." U.S. DOE, September 2014. https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-22864rev2.pdf.

- Area of ENERGY STAR® storm windows installed
- Proof of purchase – with date of purchase and quantity
    - Alternative: photo of unit installed or another pre-approved method of installation verification.

References and Efficiency Standards

Petitions and Rulings

Not applicable.

Relevant Standards and Reference Sources

Not applicable.

Document Revision History

Table 215. ENERGY STAR® Low-E Storm Windows – Revision History

TRM version	Date	Description of change
v9.0	10/2021	TRM v9.0 origin.

~~2.3.7~~2.3.8 Solar Screens Measure Overview

TRM Measure ID: R-BE-SS

Market Sector: Residential

Measure Category: Building Envelope

Applicable Building Types: Single-family, multifamily, manufactured

Fuels Affected: Electricity and gas

Decision/Action Type(s): Retrofit

Program Delivery Type(s): Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: Building simulation modeling

Measure Description

Savings are presented for the installation of solar screens on west- and/or south-facing windows or glass doors. Deemed savings are calculated per square foot of treated window or door opening.

Eligibility Criteria

Cooling savings in this measure apply to customers with central or mini-split electric refrigerated air conditioning in their homes, or to customers in TRM climate Zones 1 and 5 who have evaporative cooling systems. The heating savings penalty applies to homes that are centrally heated with either a furnace (gas or electric resistance) or a heat pump. Customers who participate in hard-to-reach (HTR) or low-income (LI) programs are eligible to claim reduced heating savings for homes heated with gas or electric resistance space heaters by applying an adjustment to deemed savings that is specified for that heat type. Customers participating in HTR or LI programs are also eligible to claim reduced cooling savings for homes cooled by one or more room air conditioners by applying an adjustment to deemed savings that is specified for homes with central refrigerated air.

Solar screens must be installed on windows or glass doors that face west or south and receive significant direct sun exposure. Solar screens must block at least 65 percent of the solar heat gain to qualify for deemed savings.

Baseline Condition

The baseline is a single pane, clear glass, unshaded, west-, or south-facing window with a solar heat gain coefficient of 0.68. The baseline window area is assumed to be 7.5 percent of the total wall area.

Electric resistance heating baselines may refer to residences heated by a centralized forced-air furnace or by individual space heaters.[262] Space heating primarily refers to electric baseboard zonal heaters controlled by thermostats or to portable plug-load heaters.[263] Electric resistance heat controlled by a wall thermostat is eligible to claim the deemed savings presented in this measure. Homes with portable space heaters may be eligible for reduced savings as described in the Deemed Energy and Summer/Winter Demand Savings Tables sections.

High-Efficiency Condition

Solar screen material installed on south- or west-facing windows must reduce solar heat gain by at least 65 percent. Solar screens are not recommended for homes with electric resistance heat.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Deemed savings values have been estimated using calibrated simulation models. Specifically, these deemed savings estimates were developed using BEopt 2.6, running EnergyPlus 8.4 as the underlying simulation engine. A single modification was made to the prototype models for the various climate zone-HVAC type combinations to create the base case models for estimating savings for the solar screens measure. Windows facing all directions are assumed to be single-pane windows with U-values of 1.16 BTU/h-ft^2-R and solar heat gain coefficients (SHGC) of 0.76.

For the change case models, an 80 percent reduction was applied to the solar heat gain coefficient for the south- and west-facing windows.

Summer and winter peak demand savings are estimated by taking the difference in demand for the 20 hours identified from the TMY3 datasets in which the summer and winter peaks are most likely to occur, as described in TRM Volume 1 Section 4 - Peak Demand Definitions.

The model assumes the average solar screen installed blocks 80 percent of the solar heat gain attributed to the south and west-facing windows based on performance data from solar screens analyzed at sun angles of 30, 45, and 75 degrees to the window. [264]

While it is recommended that solar screens be removed during winter to allow the advantage of free heat from the sun, they are often not removed seasonally. This may be due to solar screens serving as an insect screen in addition to blocking the sun or simply that they're installed in difficult-to-reach areas such as second-floor windows. The savings estimates presented herein assume that the installed solar screens remain in place year-round.

[262] Electric Resistance Heating: https://www.energy.gov/energysaver/home-heating-systems/electric-resistance-heating.
[263] Portable Heaters: https://www.energy.gov/energysaver/home-heating-systems/portable-heaters.
[264] Performance data from Matrix, Inc., Mesa, Arizona testing facility for Phifer Wire Products' SunTex screen, blocks 80 percent of solar heat gain.

Thermal Performance Improvement

Manual J and other studies researched indicate a thermal improvement to a window with a solar screen due to reduced air infiltration. The National Certified Testing Laboratories provided a report stating a 15 percent reduction in the thermal transmittance of a single pane, ¼" clear glass window with a solar screen added to the exterior.

Another study that was conducted for NFRC indicated between a 22 percent and 4 percent improvement to the U-value of a window with a solar screen. A single pane, clear window has a 22 percent improvement with the addition of a solar screen, whereas a double pane, spectrally selective low-E window may only have a 4 percent improvement. The deemed savings models assume an average 10 percent improvement in thermal performance with the addition of a solar screen.

Window Frame

The window frame accounts for 10-30 percent[265] of the window area, and since it is opaque and blocks sunlight from entering the home, it is factored into the model. An average of 15 percent frame area was incorporated into the performance of the window.

Example Calculation

Example 1. A home in climate zone 4 with a central air conditioning unit and an electric resistance furnace installs 75 square feet of solar screens.

$$kWh\ savings = \big(6.09 + (-3.21)\big) \times 75 = 216\ kWh$$

$$Summer\ kW\ savings = 3.17 \times 10^{-3} \times 75 = 0.24\ kW$$

$$Winter\ kW\ savings = -2.32 \times 10^{-3} \times 75 = -0.17\ kW$$

Deemed Energy Savings Tables

Table 216 presents the deemed energy savings value per square foot of solar screen installed. Annual energy savings are the sum of cooling and heating savings for the appropriate equipment types.

For customers who participate in hard-to-reach (HTR) or low-income (LI) programs, cooling savings may be claimed for homes cooled by one or more room air conditioners by multiplying appropriate cooling value in Table 216~~Table 216~~ by a factor of 0.6. ~~Similarly~~Similarly, for HTR/LI customers, heating savings may be claimed for homes with electric resistance space heaters serving as the primary heating source by multiplying appropriate heating values in Table 216~~Table 216~~ by a factor of 0.24.[266]

[265] Residential Windows – A Guide to New Technologies and Energy Performance, 2000.

[266] This factor was derived based on expected capacity reduction assuming 1200 sq. ft. (historical analysis of HTR participants) x 0.35 BTU/sq. ft. = 42,000 BTU for central electric furnaces and two 1,500-watt portable heaters per home rated at 5,100 BTU/heater. Taking the ratio of portable to furnace capacity yields 10,200 ÷ 42,000 = 0.24.

Table 216. Deemed Energy (kWh) Savings per Square Foot of Solar Screen

Climate zone	Cooling savings (kWh/sq. ft.)		Heating savings (kWh/sq. ft.)		
	Refrigerated air	Evaporative cooling	Gas	Electric resistance	Heat pump
Climate zone 1: Panhandle	3.67	1.34	-0.62	-12.81	-4.54
Climate zone 2: North	5.38	-	-0.29	-7.14	-2.56
Climate zone 3: South	5.33	-	-0.16	-4.69	-1.69
Climate zone 4: Valley	6.09	-	-0.09	-3.21	-1.16
Climate zone 5: West	5.62	1.99	-0.44	-10.48	-3.81

Deemed Summer Demand Savings Tables

Table 217 presents the deemed summer peak demand savings value per square foot of solar screen installed.

For customers who participate in HTR/LI programs, cooling savings may be claimed for homes cooled by one or more room air conditioners by multiplying appropriate cooling value in Table 217~~Table 217~~ by a factor of 0.6.

Table 217. Solar Screens—Deemed Summer Peak Demand (kW) Savings per Square Foot of Solar Screen

Climate zone	Refrigerated air	Evaporative cooling
Climate zone 1: Panhandle	2.89E-03	1.35E-03
Climate zone 2: North	3.42E-03	-
Climate zone 3: South	3.29E-03	-
Climate zone 4: Valley	3.17E-03	-
Climate zone 5: West	3.12E-03	1.07E-03

Deemed Winter Demand Savings Tables

Table 218 presents the deemed winter peak demand savings value per square foot of solar screen installed.

For customers who participate in HTR/LI programs, heating savings may be claimed for homes with electric resistance space heaters serving as the primary heating source by multiplying appropriate heating values in Table 218~~Table 218~~ by a factor of 0.24.[267]

[267] This factor was derived based on expected capacity reduction assuming 1200 sq. ft. (historical analysis of HTR participants) x 0.35 BTU/sq. ft. = 42,000 BTU for central electric furnaces and two 1,500-watt portable heaters per home rated at 5,100 BTU/heater. Taking the ratio of portable to furnace capacity yields 10,200 ÷ 42,000 = 0.24.

Table 218. Solar Screens—Deemed Winter Peak Demand (kW) Savings per Square Foot of Solar Screen

Climate zone	Gas	Electric resistance	Heat pump
Climate zone 1: Panhandle	-1.16E-04	-1.73E-03	-9.45E-04
Climate zone 2: North	-5.20E-05	-1.32E-03	-7.96E-04
Climate zone 3: South	-1.07E-04	-2.65E-03	-1.71E-03
Climate zone 4: Valley	-7.68E-05	-2.32E-03	-1.08E-03
Climate zone 5: West	-1.45E-04	-3.34E-03	-1.30E-03

Claimed Peak Demand Savings

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

Additional Calculators and Tools

Not applicable.

Measure Life and Lifetime Savings

The estimated useful life (EUL) 10 years as specified in the California Database of Energy Efficiency Resources (DEER) READI tool for EUL ID BS-WinFilm.[268] ~~of solar screens is established at 10 years.~~

~~This value is consistent with the EUL reported in the 2014 California Database for Energy Efficiency Resources (DEER).~~[269]

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
- Cooling type (evaporative cooling, central refrigerated cooling, room air conditioner, none)
- Heating type (central gas, portable gas, central electric resistance, portable electric resistance, heat pump, none)
    - Additional documentation is required to validate electric resistance heat (e.g., nameplate photo, utility inspection, or other evaluator-approved approach); sampling is allowed for multifamily complexes

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

[269] ~~2014 California Database for Energy Efficiency Resources. http://www.deeresources.com/index.php/deer2013-update-for-2014-codes.~~

- Square footage of windows or door openings treated
- Proof of purchase – with date of purchase and quantity
    - Alternative: photo of unit installed or other pre-approved method of installation verification

References and Efficiency Standards

Petitions and Rulings

- Docket No. 22241, Item 62. Petition by Frontier Energy for Approval of Second Set of Deemed Savings Estimates. Public Utility Commission of Texas.
- Docket No. 41070. Petition of El Paso Electric Company to Approve Revisions to Residential and Commercial Deemed Savings Based on Climate Data Specific to El Paso, Texas. Public Utility Commission of Texas.

Relevant Standards and Reference Sources

Not applicable.

Document Revision History

Table 219. Residential Solar Screens 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. Added detail on methodology and model characteristics. Savings awarded for south-facing windows, in addition to east- and west-facing windows.
v2.1	1/30/2015	TRM v2.1 update. No revision.
v3.0	4/10/2015	TRM v3.0 update. Multiplier provided to adjust cooling side savings for homes with evaporative cooling due to lower energy usage and demand associated with evaporative coolers relative to refrigerated air. Climate Zone 2 savings values awarded for Climate Zone 5 homes with heat pumps.
v3.1	11/05/2015	TRM v3.1 update. Provided example savings calculations.
v4.0	10/10/2016	TRM v4.0 update. Updated energy and demand savings per new prototype energy simulation models. Added separate savings for homes with evaporative cooling.
v5.0	10/2017	TRM v5.0 update. Added explicit reference to mini-split technology. Added provision for low-income and hard-to-reach customers cooled by room air conditioners to claim savings.
v6.0	11/2018	TRM v6.0 update. No revision.
v7.0	10/2019	TRM v7.0 update. Updated documentation requirements.
v8.0	10/2020	TRM v8.0 update. Added space heat adjustment factor and electric resistance documentation requirement.

TRM version	Date	Description of change
v9.0	10/2021	TRM v9.0 update. Updated EUL reference.

~~2.3.8~~2.3.9 ENERGY STAR® Cool Roofs Measure Overview

TRM Measure ID: R-BE-CR

Market Sector: Residential

Measure Category: Building Envelope

Applicable Building Types: Single-family, multifamily, manufactured

Fuels Affected: Electricity and gas

Decision/Action Type(s): Retrofit

Program Delivery Type(s): Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: Building simulation modeling

Measure Description

Reflective roofing materials reduce the overall heat load on a home by reducing the total heat energy absorbed into the building system from incident solar radiation. This reduction in total load provides space cooling energy savings during the cooling season, but reduces free heat during the heating season, so the measure saves energy in the summer but uses more energy in winter. As such, cool roofs are most beneficial in warmer climates and may not be recommended for homes where the primary heat source is electric resistance. The measure is for retrofit of existing homes.

Eligibility Criteria

Cooling savings in this measure apply to customers with central or mini-split electric refrigerated air conditioning in their homes, or to customers in TRM climate zones 1 and 5 who have evaporative cooling systems. Homes must be centrally heated with either a furnace (gas or electric resistance) or a heat pump to claim heating savings. Customers who participate in hard-to-reach (HTR) or low-income (LI) programs are eligible to claim reduced heating savings for homes heated with gas or electric resistance space heaters by applying an adjustment to deemed savings that is specified for that heat type. Customers participating in HTR or LI programs are also eligible to claim reduced cooling savings for homes cooled by one or more room air conditioners by applying an adjustment to deemed savings that is specified for homes with central refrigerated air.

Baseline Condition

The baseline condition is an existing home with a standard medium- or dark-colored roof.

Electric resistance heating baselines may refer to residences heated by a centralized forced-air furnace or by individual space heaters.[270] Space heating primarily refers to electric baseboard

[270] Electric Resistance Heating: https://www.energy.gov/energysaver/home-heating-systems/electric-resistance-heating.

zonal heaters controlled by thermostats or to portable plug-load heaters.[271] Electric resistance heat controlled by a wall thermostat is eligible to claim the deemed savings presented in this measure. Homes with portable space heaters may be eligible for reduced savings as described in the Deemed Energy and Summer/Winter Demand Savings Tables sections.

High-Efficiency Condition

The measure requires installation of roof products that have been rated by the Cool Roof Rating Council (CRRC) and demonstrate compliance with ENERGY STAR® certified roof product performance specifications for the relevant roof application. ENERGY STAR® test criteria[272] allows for products already participating in the CRRC Product Rating Program[273] to submit solar reflectance and thermal emittance product information derived from CRRC certification.

The ENERGY STAR® program classifies roofs with a slope greater than 2/12 as having a steep slope and roofs with a slope less than or equal to 2/12 as low slope roofs. ENERGY STAR® performance specifications for cool roof products for use on roofs with steep slopes and low slopes are provided in Table 220~~Table 220~~.

Table 220. Cool Roofs—ENERGY STAR® Specification[274]

Roof slope	Characteristic	Performance specification
Low Slope ≤2/12	Initial Solar Reflectance	≥ 0.65
	3-Year Solar Reflectance	≥ 0.50
High Slope > 2/12	Initial Solar Reflectance	≥ 0.25
	3-Year Solar Reflectance	≥ 0.15

The ENERGY STAR® specification for roof products will sunset effective June 1, 2022.[275] No new roof products will be certified as of June 1, 2021. At this point, ENERGY STAR® legacy or CRRC product certification will be required to demonstrate compliance with the previous ENERGY STAR® specification.

If a cool roof is installed concurrently with changes to attic insulation levels, savings should be claimed for the reflective roof according to the post-retrofit (ceiling or roof deck) insulation levels. Savings for changes in insulation levels should be claimed separately according to the ceiling insulation or attic encapsulation measures, assuming the retrofit performed meets the requirements of those measures.

[271] Portable Heaters: https://www.energy.gov/energysaver/home-heating-systems/portable-heaters.
[272] ENERGY STAR® Program Requirements for Roof Products v2.1. https://www.energystar.gov/ia/partners/product_specs/program_reqs/roofs_prog_req.pdf.
[273] CRRC Rated Products Directory: https://coolroofs.org/directory.
[274] ENERGY STAR® Roof Products Specification. https://www.energystar.gov/products/building_products/roof_products/key_product_criteria.
[275] ENERGY STAR® Roof Products Sunset Decision Memo. https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Roof%20Products%20Sunset%20Decision%20Memo.pdf.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Calibrated simulation modeling was used to develop these deemed savings values. Specifically, these deemed savings estimates were developed using BEopt 2.6, running EnergyPlus 8.4 as the underlying simulation engine. To model this measure, the prototype home models for each climate zone were modified as follows. Roof slopes were modified to reflect representative levels for the low slope and steep slope roofs. A 1/12 slope was selected for modeling low slope roofs (defined as having slope <= 2/12), and a 4/12 slope was selected for modeling steep slope roofs (slope > 2/12). Based on the performance criteria and review of the rated 3-year reflectance of rated products listed in the CRRC database, four reflectance levels were selected for modeling: 0.2, 0.4, 0.6, and 0.8, representing 20 to 80 percent reflectance.

Because of the interplay between the performance of insulation and attic/roof deck temperatures, which are directly affected by the installation of a cool roof, savings were estimated for a range of different attic insulation scenarios: a range of ceiling insulation levels from no insulation (R-0) to R-30, and two roof deck insulation levels, R-19 and R-38, were modeled. Savings for a roof deck insulation level of R-30 are provided by interpolating between the R-19 and R-38 scenarios.

These modifications are shown in Table 221~~Table 221~~.

The model runs calculated energy use for the prototypical home prior to encapsulating the attic. Change-case models were run to calculate energy use with the floor insulation measure in place with either R-30 or R-38 insulation.

Table 221. Cool Roofs—Prototypical Home Characteristics

Shell characteristic	Value	Source
Base Case Roof Material	Medium Asphalt Shingle, Reflectance = 0.15	Prototype home default
Change Case Roof Material	Medium Asphalt Shingle, Reflectance = 0.2 Reflectance = 0.4 Reflectance = 0.6 Reflectance = 0.8	Lower reflectance levels only relevant for steep slope roofs. Modeled reflectance levels reflect midpoints of ranges: 0.15 <= R < 0.3 Reflectance 0.3 <= R < 0.5 Reflectance 0.5 <= R < 0.7 Reflectance > 0.7
Roof Slope: Low-Slope Roof	1/12	Not modified between base and change cases
Roof Slope: Steep Slope Roof	4/12	Not modified between base and change cases
Ceiling (attic floor) Insulation Levels	<= R8 R9-R14 R15-R22 R-30	Not modified between base and change cases
Roof Deck (underside) Insulation Levels	R-19 R-38	Not modified between base and change cases

Deemed Energy Savings Tables

Savings are presented first for homes with ceiling insulation and subsequently for those with roof deck insulation. For customers who participate in hard-to-reach (HTR) or low-income (LI) programs, cooling savings may be claimed for homes cooled by one or more room air conditioners by multiplying appropriate cooling values in Table 222~~Table 222~~ through Table 226~~Table 226~~ by a factor of 0.6.

Homes with Ceiling Insulation

Table 222~~Table 222~~ through Table 226~~Table 226~~ present the energy savings (kWh) for installation of a reflective roof on homes with varying levels of ceiling (attic floor) insulation for the five Texas climate zones. Annual energy savings are the sum of cooling and heating savings for the appropriate equipment types. Savings are per square foot of treated roof area.

Climate Zone 1: Panhandle Region

Table 222. Cool Roofs—Climate Zone 1: Panhandle Region – Deemed Annual Energy Savings for Residential Reflective Roof Installation (kWh/sq. ft.)

Ceiling insulation R-value	Installed roof material 3-year reflectance	Cooling savings		Heating savings		
		Refrigerated air	Evaporative cooling	Gas	Electric resistance	Heat pump
Steep slope						
≤ R-8	0.15 - 0.29	0.02	0.01	0.00	-0.04	-0.01
≤ R-8	0.3 – 0.49	0.12	0.04	-0.02	-0.20	-0.07
≤ R-8	0.5 – 0.69	0.21	0.08	-0.03	-0.36	-0.14
≤ R-8	>~~=~~ 0.7	0.31	0.12	-0.05	-0.54	-0.20
R-9 to R-14	0.15 - 0.29	0.02	0.01	0.00	-0.03	-0.01
R-9 to R-14	0.3 – 0.49	0.08	0.03	-0.01	-0.13	-0.05
R-9 to R-14	0.5 – 0.69	0.15	0.06	-0.03	-0.25	-0.09
R-9 to R-14	>~~=~~ 0.7	0.22	0.08	-0.04	-0.37	-0.14
R-15 to R-22	0.15 - 0.29	0.01	0.00	0.00	-0.02	-0.01
R-15 to R-22	0.3 – 0.49	0.06	0.02	-0.01	-0.09	-0.04
R-15 to R-22	0.5 – 0.69	0.10	0.04	-0.02	-0.17	-0.06
R-15 to R-22	>~~=~~ 0.7	0.15	0.06	-0.03	-0.25	-0.10
R-30	0.15 - 0.29	0.01	0.00	0.00	-0.01	0.00
R-30	0.3 – 0.49	0.04	0.01	-0.01	-0.06	-0.02
R-30	0.5 – 0.69	0.07	0.02	-0.02	-0.11	-0.04
R-30	>~~=~~ 0.7	0.10	0.04	-0.03	-0.16	-0.06

Ceiling insulation R-value	Installed roof material 3-year reflectance	Cooling savings		Heating savings		
		Refrigerated air	Evaporative cooling	Gas	Electric resistance	Heat pump
Low slope						
≤ R-8	0.5 – 0.69	0.23	0.09	-0.03	-0.40	-0.15
≤ R-8	>= 0.7	0.34	0.13	-0.05	-0.59	-0.22
R-9 to R-14	0.5 – 0.69	0.16	0.06	-0.03	-0.27	-0.10
R-9 to R-14	>= 0.7	0.23	0.09	-0.04	-0.41	-0.15
R-15 to R-22	0.5 – 0.69	0.11	0.04	-0.02	-0.19	-0.07
R-15 to R-22	>= 0.7	0.17	0.07	-0.03	-0.28	-0.11
R-30	0.5 – 0.69	0.08	0.03	-0.02	-0.13	-0.05
R-30	>= 0.7	0.12	0.05	-0.03	-0.19	-0.07

Climate Zone 2: North Region

Table 223. Cool Roofs—Climate Zone 2: North Region –
Deemed Annual Energy Savings for Residential Reflective Roof Installation (kWh/sq. ft.)

Ceiling insulation R-value	Installed roof material 3-year reflectance	Cooling savings (refrigerated air)	Heating savings		
			Gas	Electric resistance	Heat pump
Steep slope					
≤ R-8	0.15 - 0.29	0.04	0.00	-0.03	-0.01
≤ R-8	0.3 – 0.49	0.18	-0.01	-0.13	-0.05
≤ R-8	0.5 – 0.69	0.34	-0.01	-0.24	-0.09
≤ R-8	>= 0.7	0.50	-0.02	-0.36	-0.14
R-9 to R-14	0.15 - 0.29	0.03	0.00	-0.02	-0.01
R-9 to R-14	0.3 – 0.49	0.13	-0.01	-0.09	-0.03
R-9 to R-14	0.5 – 0.69	0.24	-0.01	-0.16	-0.06
R-9 to R-14	>= 0.7	0.35	-0.02	-0.25	-0.09
R-15 to R-22	0.15 - 0.29	0.02	0.00	-0.01	0.00
R-15 to R-22	0.3 – 0.49	0.09	0.00	-0.06	-0.02
R-15 to R-22	0.5 – 0.69	0.17	-0.01	-0.11	-0.04
R-15 to R-22	>= 0.7	0.25	-0.01	-0.17	-0.06
R-30	0.15 - 0.29	0.01	0.00	-0.01	0.00
R-30	0.3 – 0.49	0.06	0.00	-0.04	-0.02
R-30	0.5 – 0.69	0.12	-0.01	-0.07	-0.03
R-30	>= 0.7	0.18	-0.01	-0.11	-0.04

Ceiling insulation R-value	Installed roof material 3-year reflectance	Cooling savings (refrigerated air)	Heating savings		
			Gas	Electric resistance	Heat pump
Low slope					
≤ R-8	0.5 – 0.69	0.37	-0.01	-0.27	-0.10
≤ R-8	≥ 0.7	0.55	-0.02	-0.40	-0.15
R-9 to R-14	0.5 – 0.69	0.26	-0.01	-0.19	-0.07
R-9 to R-14	≥ 0.7	0.39	-0.02	-0.28	-0.10
R-15 to R-22	0.5 – 0.69	0.19	-0.01	-0.13	-0.05
R-15 to R-22	≥ 0.7	0.28	-0.01	-0.19	-0.07
R-30	0.5 – 0.69	0.14	-0.01	-0.08	-0.03
R-30	≥ 0.7	0.20	-0.01	-0.13	-0.05

Climate Zone 3: South Region

Table 224. Cool Roofs—Climate Zone 3: South Region –
Deemed Annual Energy Savings for Residential Reflective Roof Installation (kWh/sq. ft.)

Ceiling insulation R-value	Installed roof material 3-year reflectance	Cooling savings (refrigerated air)	Heating savings		
			Gas	Electric resistance	Heat pump
Steep slope					
≤ R-8	0.15 - 0.29	0.04	0.00	-0.02	-0.01
≤ R-8	0.3 – 0.49	0.20	0.00	-0.10	-0.04
≤ R-8	0.5 – 0.69	0.37	-0.01	-0.18	-0.07
≤ R-8	≥ 0.7	0.55	-0.01	-0.28	-0.10
R-9 to R-14	0.15 - 0.29	0.03	0.00	-0.01	-0.01
R-9 to R-14	0.3 – 0.49	0.14	0.00	-0.07	-0.03
R-9 to R-14	0.5 – 0.69	0.26	-0.01	-0.13	-0.05
R-9 to R-14	≥ 0.7	0.39	-0.01	-0.19	-0.07
R-15 to R-22	0.15 - 0.29	0.02	0.00	-0.01	0.00
R-15 to R-22	0.3 – 0.49	0.10	0.00	-0.05	-0.02
R-15 to R-22	0.5 – 0.69	0.18	-0.01	-0.09	-0.03
R-15 to R-22	≥ 0.7	0.27	-0.01	-0.13	-0.05
R-30	0.15 - 0.29	0.01	0.00	-0.01	0.00
R-30	0.3 – 0.49	0.06	0.00	-0.03	-0.01
R-30	0.5 – 0.69	0.12	-0.01	-0.06	-0.02
R-30	≥ 0.7	0.18	-0.01	-0.08	-0.03

Ceiling insulation R-value	Installed roof material 3-year reflectance	Cooling savings (refrigerated air)	Heating savings		
			Gas	Electric resistance	Heat pump
Low slope					
≤ R-8	0.5 – 0.69	0.42	-0.01	-0.21	-0.08
≤ R-8	>= 0.7	0.62	-0.01	-0.31	-0.12
R-9 to R-14	0.5 – 0.69	0.30	-0.01	-0.14	-0.05
R-9 to R-14	>= 0.7	0.44	-0.01	-0.21	-0.08
R-15 to R-22	0.5 – 0.69	0.21	-0.01	-0.10	-0.04
R-15 to R-22	>= 0.7	0.31	-0.01	-0.15	-0.06
R-30	0.5 – 0.69	0.14	-0.01	-0.07	-0.03
R-30	>= 0.7	0.22	-0.01	-0.10	-0.04

Climate Zone 4: Valley Region

Table 225. Cool Roofs—Climate Zone 4: Valley Region –
Deemed Annual Energy Savings for Residential Reflective Roof Installation (kWh/sq. ft.)

Ceiling insulation R-value	Installed roof material 3-year reflectance	Cooling savings (refrigerated air)	Heating Savings		
			Gas	Electric resistance	Heat pump
Steep slope					
≤ R-8	0.15 - 0.29	0.03	0.00	-0.01	0.00
≤ R-8	0.3 – 0.49	0.14	0.00	-0.06	-0.02
≤ R-8	0.5 – 0.69	0.26	0.00	-0.11	-0.04
≤ R-8	>= 0.7	0.38	-0.01	-0.17	-0.06
R-9 to R-14	0.15 - 0.29	0.02	0.00	-0.01	0.00
R-9 to R-14	0.3 – 0.49	0.10	0.00	-0.04	-0.02
R-9 to R-14	0.5 – 0.69	0.17	0.00	-0.08	-0.03
R-9 to R-14	>= 0.7	0.26	0.00	-0.11	-0.04
R-15 to R-22	0.15 - 0.29	0.01	0.00	-0.01	0.00
R-15 to R-22	0.3 – 0.49	0.06	0.00	-0.03	-0.01
R-15 to R-22	0.5 – 0.69	0.12	0.00	-0.05	-0.02
R-15 to R-22	>= 0.7	0.17	0.00	-0.08	-0.03
R-30	0.15 - 0.29	0.01	0.00	0.00	0.00
R-30	0.3 – 0.49	0.04	0.00	-0.02	-0.01
R-30	0.5 – 0.69	0.07	0.00	-0.03	-0.01
R-30	>= 0.7	0.11	0.00	-0.05	-0.02

Ceiling insulation R-value	Installed roof material 3-year reflectance	Cooling savings (refrigerated air)	Heating Savings		
			Gas	Electric resistance	Heat pump
Low slope					
≤ R-8	0.5 – 0.69	0.28	0.00	-0.13	-0.05
≤ R-8	≥ 0.7	0.41	-0.01	-0.19	-0.07
R-9 to R-14	0.5 – 0.69	0.19	0.00	-0.09	-0.03
R-9 to R-14	≥ 0.7	0.28	0.00	-0.13	-0.05
R-15 to R-22	0.5 – 0.69	0.13	0.00	-0.06	-0.02
R-15 to R-22	≥ 0.7	0.19	0.00	-0.08	-0.03
R-30	0.5 – 0.69	0.09	0.00	-0.04	-0.01
R-30	≥ 0.7	0.13	0.00	-0.06	-0.02

Climate Zone 5: West Region

Table 226. Cool Roofs—Climate Zone 5: West Region –
Deemed Annual Energy Savings for Residential Reflective Roof Installation (kWh/sq. ft.)

Ceiling insulation R-value	Installed roof material 3-year reflectance	Cooling savings		Heating savings		
		Refrigerated air	Evaporative cooling	Gas	Electric resistance	Heat pump
Steep slope						
≤ R-8	0.15 - 0.29	0.04	0.02	0.00	-0.04	-0.01
≤ R-8	0.3 – 0.49	0.21	0.08	-0.01	-0.20	-0.07
≤ R-8	0.5 – 0.69	0.39	0.15	-0.02	-0.38	-0.14
≤ R-8	≥ 0.7	0.58	0.23	-0.03	-0.59	-0.22
R-9 to R-14	0.15 - 0.29	0.03	0.01	0.00	-0.03	-0.01
R-9 to R-14	0.3 – 0.49	0.15	0.06	-0.01	-0.14	-0.05
R-9 to R-14	0.5 – 0.69	0.27	0.11	-0.01	-0.27	-0.10
R-9 to R-14	≥ 0.7	0.41	0.16	-0.02	-0.41	-0.15
R-15 to R-22	0.15 - 0.29	0.02	0.01	0.00	-0.02	-0.01
R-15 to R-22	0.3 – 0.49	0.10	0.04	-0.01	-0.10	-0.04
R-15 to R-22	0.5 – 0.69	0.19	0.08	-0.01	-0.18	-0.07
R-15 to R-22	≥ 0.7	0.29	0.12	-0.02	-0.28	-0.10
R-30	0.15 - 0.29	0.01	0.01	0.00	-0.01	-0.01
R-30	0.3 – 0.49	0.07	0.03	0.00	-0.06	-0.02
R-30	0.5 – 0.69	0.13	0.05	-0.01	-0.12	-0.04
R-30	≥ 0.7	0.20	0.08	-0.01	-0.18	-0.07

Ceiling insulation R-value	Installed roof material 3-year reflectance	Cooling savings		Heating savings		
		Refrigerated air	Evaporative cooling	Gas	Electric resistance	Heat pump
Low slope						
≤ R-8	0.5 – 0.69	0.45	0.18	-0.02	-0.44	-0.16
≤ R-8	≥ 0.7	0.66	0.26	-0.03	-0.68	-0.25
R-9 to R-14	0.5 – 0.69	0.32	0.13	-0.02	-0.31	-0.12
R-9 to R-14	≥ 0.7	0.47	0.19	-0.03	-0.47	-0.18
R-15 to R-22	0.5 – 0.69	0.23	0.09	-0.01	-0.21	-0.08
R-15 to R-22	≥ 0.7	0.34	0.14	-0.02	-0.32	-0.12
R-30	0.5 – 0.69	0.17	0.07	-0.01	-0.14	-0.06
R-30	≥ 0.7	0.25	0.10	-0.02	-0.22	-0.08

Homes with Roof Deck Insulation

Table 227 through Table 231 present the energy savings (kWh) for the installation of a reflective roof on homes with varying levels of roof deck insulation for the five Texas climate zones. Annual energy savings are the sum of cooling and heating savings for the appropriate equipment types. Savings are per square foot of treated roof area.

Climate Zone 1: Panhandle Region

Table 227. Cool Roofs—Climate Zone 1: Panhandle Region – Deemed Annual Energy Savings for Residential Reflective Roof Installation (kWh/sq. ft.)

Roof deck insulation R-value	Installed roof material 3-year reflectance	Cooling savings		Heating savings		
		Refrigerated air	Evaporative cooling	Gas	Electric resistance	Heat pump
Steep slope						
R-19	0.15 - 0.29	0.00	0.00	0.00	0.00	0.00
R-19	0.3 – 0.49	0.06	0.02	-0.01	-0.13	-0.05
R-19	0.5 – 0.69	0.13	0.04	-0.01	-0.28	-0.11
R-19	≥ 0.7	0.20	0.07	-0.02	-0.42	-0.16
R-30	0.15 - 0.29	0.01	0.00	0.00	-0.01	-0.01
R-30	0.3 – 0.49	0.05	0.02	-0.01	-0.12	-0.04
R-30	0.5 – 0.69	0.11	0.03	-0.01	-0.23	-0.09
R-30	≥ 0.7	0.16	0.05	-0.02	-0.35	-0.14
R-38	0.15 - 0.29	0.01	0.00	0.00	-0.02	-0.01
R-38	0.3 – 0.49	0.05	0.02	-0.01	-0.11	-0.04
R-38	0.5 – 0.69	0.09	0.03	-0.01	-0.20	-0.08
R-38	≥ 0.7	0.13	0.04	-0.02	-0.30	-0.12

Roof deck insulation R-value	Installed roof material 3-year reflectance	Cooling savings		Heating savings		
		Refrigerated air	Evaporative cooling	Gas	Electric resistance	Heat pump
Low slope						
R-19	0.5 – 0.69	0.13	0.04	-0.01	-0.27	-0.11
R-19	>= 0.7	0.20	0.07	-0.02	-0.42	-0.16
R-30	0.5 – 0.69	0.11	0.03	-0.01	-0.23	-0.09
R-30	>= 0.7	0.16	0.05	-0.02	-0.34	-0.13
R-38	0.5 – 0.69	0.09	0.03	-0.01	-0.20	-0.08
R-38	>= 0.7	0.13	0.04	-0.02	-0.29	-0.11

Climate Zone 2: North Region

Table 228. Cool Roofs—Climate Zone 2: North Region – Deemed Annual Energy Savings for Residential Reflective Roof Installation (kWh/sq. ft.)

Roof deck insulation R-value	Installed roof material 3-year reflectance	Cooling savings (refrigerated air)	Heating savings		
			Gas	Electric resistance	Heat pump
Steep slope					
R-19	0.15 - 0.29	0.00	0.00	0.00	0.00
R-19	0.3 – 0.49	0.10	0.00	-0.09	-0.03
R-19	0.5 – 0.69	0.21	-0.01	-0.18	-0.07
R-19	>= 0.7	0.32	-0.01	-0.28	-0.11
R-30	0.15 - 0.29	0.01	0.00	-0.01	-0.01
R-30	0.3 – 0.49	0.09	0.00	-0.08	-0.03
R-30	0.5 – 0.69	0.17	-0.01	-0.15	-0.06
R-30	>= 0.7	0.26	-0.01	-0.23	-0.09
R-38	0.15 - 0.29	0.02	0.00	-0.01	-0.01
R-38	0.3 – 0.49	0.08	0.00	-0.07	-0.03
R-38	0.5 – 0.69	0.14	-0.01	-0.13	-0.05
R-38	>= 0.7	0.21	-0.01	-0.19	-0.07
Low slope					
R-19	0.5 – 0.69	0.21	-0.01	-0.18	-0.07
R-19	>= 0.7	0.32	-0.01	-0.28	-0.11
R-30	0.5 – 0.69	0.17	-0.01	-0.15	-0.06
R-30	>= 0.7	0.26	-0.01	-0.23	-0.09
R-38	0.5 – 0.69	0.14	-0.01	-0.13	-0.05
R-38	>= 0.7	0.21	-0.01	-0.19	-0.07

Climate Zone 3: South Region

**Table 229. Cool Roofs—Climate Zone 3: South Region –
Deemed Annual Energy Savings for Residential Reflective Roof Installation (kWh/sq. ft.)**

Roof deck insulation R-value	Installed roof material 3-year reflectance	Cooling savings (refrigerated air)	Heating savings		
			Gas	Electric resistanceGas heat	Heat pumpGas heat
Steep slope					
R-19	0.15 - 0.29	0.00	0.00	0.00	0.00
R-19	0.3 – 0.49	0.11	0.00	-0.07	-0.03
R-19	0.5 – 0.69	0.22	-0.01	-0.14	-0.05
R-19	>= 0.7	0.34	-0.01	-0.22	-0.08
R-30	0.15 - 0.29	0.01	0.00	-0.01	0.00
R-30	0.3 – 0.49	0.09	0.00	-0.06	-0.02
R-30	0.5 – 0.69	0.19	0.00	-0.12	-0.04
R-30	>= 0.7	0.28	-0.01	-0.18	-0.07
R-38	0.15 - 0.29	0.02	0.00	-0.01	0.00
R-38	0.3 – 0.49	0.08	0.00	-0.06	-0.02
R-38	0.5 – 0.69	0.16	0.00	-0.10	-0.04
R-38	>= 0.7	0.23	-0.01	-0.15	-0.06
Low slope					
R-19	0.5 – 0.69	0.22	-0.01	-0.14	-0.06
R-19	>= 0.7	0.35	-0.01	-0.22	-0.08
R-30	0.5 – 0.69	0.19	0.00	-0.12	-0.05
R-30	>= 0.7	0.28	-0.01	-0.18	-0.07
R-38	0.5 – 0.69	0.16	0.00	-0.10	-0.04
R-38	>= 0.7	0.23	-0.01	-0.15	-0.06

Climate Zone 4: Valley Region

**Table 230. Cool Roofs—Climate Zone 4: Valley Region –
Deemed Annual Energy Savings for Residential Reflective Roof Installation (kWh/sq. ft.)**

Roof deck insulation R-value	Installed roof material 3-year reflectance	Cooling savings (refrigerated air)	Heating savings		
			Gas	Electric Resistance	Heat Pump
Steep slope					
R-19	0.15 - 0.29	0.00	0.00	0.00	0.00
R-19	0.3 – 0.49	0.09	0.00	-0.04	-0.02
R-19	0.5 – 0.69	0.17	0.00	-0.09	-0.03
R-19	>= 0.7	0.26	0.00	-0.13	-0.05
R-30	0.15 - 0.29	0.01	0.00	-0.01	0.00
R-30	0.3 – 0.49	0.08	0.00	-0.03	-0.01
R-30	0.5 – 0.69	0.14	0.00	-0.07	-0.02
R-30	>= 0.7	0.21	0.00	-0.11	-0.04

Roof deck insulation R-value	Installed roof material 3-year reflectance	Cooling savings (refrigerated air)	Heating savings		
			Gas	Electric Resistance	Heat Pump
R-38	0.15 - 0.29	0.01	0.00	-0.01	0.00
R-38	0.3 – 0.49	0.07	0.00	-0.03	-0.01
R-38	0.5 – 0.69	0.12	0.00	-0.06	-0.02
R-38	>= 0.7	0.18	0.00	-0.09	-0.03
Low slope					
R-19	0.5 – 0.69	0.23	-0.01	-0.29	-0.11
R-19	>= 0.7	0.36	-0.02	-0.46	-0.18
R-30	0.5 – 0.69	0.17	0.00	-0.16	-0.06
R-30	>= 0.7	0.26	-0.01	-0.25	-0.09
R-38	0.5 – 0.69	0.12	0.00	-0.06	-0.02
R-38	>= 0.7	0.18	0.00	-0.09	-0.03

Climate Zone 5: West Region

Table 231. Cool Roofs—Climate Zone 5: West Region –
Deemed Annual Energy Savings for Residential Reflective Roof Installation (kWh/sq. ft.)

Roof deck insulation R-value	Installed roof material 3-year reflectance	Cooling savings		Heating savings		
		Refrigerated air	Evaporative cooling	Gas	Electric Resistance	Heat Pump
Steep slope						
R-19	0.15 - 0.29	0.00	0.00	0.00	0.00	0.00
R-19	0.3 – 0.49	0.11	0.04	-0.01	-0.14	-0.05
R-19	0.5 – 0.69	0.22	0.08	-0.01	-0.28	-0.11
R-19	>= 0.7	0.35	0.12	-0.02	-0.45	-0.17
R-30	0.15 - 0.29	0.01	0.01	0.00	-0.01	-0.01
R-30	0.3 – 0.49	0.10	0.03	0.00	-0.12	-0.04
R-30	0.5 – 0.69	0.19	0.06	-0.01	-0.23	-0.09
R-30	>= 0.7	0.28	0.10	-0.01	-0.37	-0.14
R-38	0.15 - 0.29	0.02	0.01	0.00	-0.02	-0.01
R-38	0.3 – 0.49	0.09	0.03	0.00	-0.11	-0.04
R-38	0.5 – 0.69	0.16	0.05	-0.01	-0.20	-0.08
R-38	>= 0.7	0.23	0.08	-0.01	-0.31	-0.12
Low slope						
R-19	0.5 – 0.69	0.23	0.08	-0.01	-0.29	-0.11
R-19	>= 0.7	0.36	0.12	-0.02	-0.46	-0.18
R-30	0.5 – 0.69	0.19	0.06	-0.01	-0.24	-0.09
R-30	>= 0.7	0.29	0.10	-0.01	-0.38	-0.15
R-38	0.5 – 0.69	0.16	0.05	-0.01	-0.21	-0.08
R-38	>= 0.7	0.24	0.08	-0.01	-0.32	-0.12

Deemed Summer Demand Savings Tables

Savings are presented first for homes with ceiling insulation, and subsequently for those with roof deck insulation. For customers who participate in HTR/LI programs, cooling savings may be claimed for homes cooled by one or more room air conditioners by multiplying appropriate cooling values in Table 232~~Table 232~~ through Table 236~~Table 236~~ by a factor of 0.6.

Homes with Ceiling Insulation

Table 232~~Table 232~~ through Table 236~~Table 236~~ present the summer demand savings (kW) associated with the installation of a reflective roof in homes with varying levels of ceiling insulation (attic floor) for the five Texas climate zones. Savings are per square foot of treated roof area.

Climate Zone 1: Panhandle Region

Table 232. Cool Roofs—Climate Zone 1: Panhandle Region –
Deemed Summer Demand Savings for Residential Reflective Roof Installation (kW/sq. ft.)

Ceiling insulation R-value	Installed roof material 3-year reflectance	Low slope		Steep slope	
		Refrigerated air	Evaporative cooling	Refrigerated air	Evaporative cooling
≤ R-8	0.15 - 0.29	N/A	N/A	1.48 x 10-5	6.69 x 10-6
≤ R-8	0.3 – 0.49	N/A	N/A	8.09 x 10-5	4.47 x 10-5
≤ R-8	0.5 – 0.69	1.78 x 10-4	9.21 x 10-5	1.63 x 10-4	7.51 x 10-5
≤ R-8	>= 0.7	2.85 x 10-4	1.55 x 10-4	2.86 x 10-4	1.40 x 10-4
R-9 to R-14	0.15 - 0.29	N/A	N/A	6.05 x 10-6	7.93 x 10-6
R-9 to R-14	0.3 – 0.49	N/A	N/A	5.64 x 10-5	2.18 x 10-5
R-9 to R-14	0.5 – 0.69	1.17 x 10-4	5.99 x 10-5	1.08 x 10-4	4.52 x 10-5
R-9 to R-14	>= 0.7	1.92 x 10-4	9.10 x 10-5	1.90 x 10-4	9.38 x 10-5
R-15 to R-22	0.15 - 0.29	N/A	N/A	2.30 x 10-6	-8.73 x 10-7
R-15 to R-22	0.3 – 0.49	N/A	N/A	3.55 x 10-5	1.53 x 10-5
R-15 to R-22	0.5 – 0.69	7.90 x 10-5	3.73 x 10-5	7.34 x 10-5	2.74 x 10-5
R-15 to R-22	>= 0.7	1.31 x 10-4	6.28 x 10-5	1.37 x 10-4	7.50 x 10-5
R-30	0.15 - 0.29	N/A	N/A	-8.06 x 10-7	3.42 x 10-6
R-30	0.3 – 0.49	N/A	N/A	2.36 x 10-5	1.83 x 10-5
R-30	0.5 – 0.69	5.39 x 10-5	1.76 x 10-5	4.99 x 10-5	2.70 x 10-5
R-30	>= 0.7	9.25 x 10-5	4.31 x 10-5	9.56 x 10-5	5.99 x 10-5

Climate Zone 2: North Region

Table 233. Cool Roofs—Climate Zone 2: North Region –
Deemed Summer Demand Savings for Residential Reflective Roof Installation (kW/sq. ft.)

Ceiling insulation R-value	Installed roof material 3-year reflectance	Low slope	Steep slope
≤ R-8	0.15 - 0.29	N/A	2.63 x 10-5
≤ R-8	0.3 – 0.49	N/A	1.36 x 10-4

Ceiling insulation R-value	Installed roof material 3-year reflectance	Low slope	Steep slope
≤ R-8	0.5 – 0.69	2.83 x 10-4	2.64 x 10-4
≤ R-8	>= 0.7	4.10 x 10-4	4.06 x 10-4
R-9 to R-14	0.15 - 0.29	N/A	1.78 x 10-5
R-9 to R-14	0.3 – 0.49	N/A	1.02 x 10-4
R-9 to R-14	0.5 – 0.69	1.99 x 10-4	1.73 x 10-4
R-9 to R-14	>= 0.7	2.85 x 10-4	2.85 x 10-4
R-15 to R-22	0.15 - 0.29	N/A	9.26 x 10-6
R-15 to R-22	0.3 – 0.49	N/A	7.69 x 10-5
R-15 to R-22	0.5 – 0.69	1.47 x 10-4	1.23 x 10-4
R-15 to R-22	>= 0.7	2.04 x 10-4	2.15 x 10-4
R-30	0.15 - 0.29	N/A	1.34 x 10-5
R-30	0.3 – 0.49	N/A	5.58 x 10-5
R-30	0.5 – 0.69	1.01 x 10-4	8.64 x 10-5
R-30	>= 0.7	1.52 x 10-4	1.58 x 10-4

Climate Zone 3: South Region

Table 234. Cool Roofs—Climate Zone 3: South Region – Deemed Summer Demand Savings for Residential Reflective Roof Installation (kW/sq. ft.)

Ceiling insulation R-value	Installed roof material 3-year reflectance	Low slope	Steep slope
≤ R-8	0.15 - 0.29	N/A	2.38 x 10-5
≤ R-8	0.3 – 0.49	N/A	1.33 x 10-4
≤ R-8	0.5 – 0.69	2.76 x 10-4	2.72 x 10-4
≤ R-8	>= 0.7	4.64 x 10-4	4.28 x 10-4
R-9 to R-14	0.15 - 0.29	N/A	1.55 x 10-5
R-9 to R-14	0.3 – 0.49	N/A	1.07 x 10-4
R-9 to R-14	0.5 – 0.69	2.12 x 10-4	2.03 x 10-4
R-9 to R-14	>= 0.7	3.30 x 10-4	3.11 x 10-4
R-15 to R-22	0.15 - 0.29	N/A	1.75 x 10-5
R-15 to R-22	0.3 – 0.49	N/A	7.56 x 10-5
R-15 to R-22	0.5 – 0.69	1.53 x 10-4	1.44 x 10-4
R-15 to R-22	>= 0.7	2.37 x 10-4	2.26 x 10-4
R-30	0.15 - 0.29	N/A	9.44 x 10-6

Ceiling insulation R-value	Installed roof material 3-year reflectance	Low slope	Steep slope
R-30	0.3 – 0.49	N/A	5.11 x 10-5
R-30	0.5 – 0.69	1.09 x 10-4	9.65 x 10-5
R-30	>= 0.7	1.75 x 10-4	1.64 x 10-4

Climate Zone 4: Valley Region

Table 235. Cool Roofs—Climate Zone 4: Valley Region – Deemed Summer Demand Savings for Residential Reflective Roof Installation (kW/sq. ft.)

Ceiling insulation R-value	Installed roof material 3-Year reflectance	Low Slope	steep slope
≤ R-8	0.15 - 0.29	N/A	1.46 x 10-5
≤ R-8	0.3 – 0.49	N/A	6.97 x 10-5
≤ R-8	0.5 – 0.69	1.22 x 10-4	1.23 x 10-4
≤ R-8	>= 0.7	2.02 x 10-4	2.01 x 10-4
R-9 to R-14	0.15 - 0.29	N/A	6.80 x 10-6
R-9 to R-14	0.3 – 0.49	N/A	4.15 x 10-5
R-9 to R-14	0.5 – 0.69	7.62 x 10-5	7.37 x 10-5
R-9 to R-14	>= 0.7	1.26 x 10-4	1.28 x 10-4
R-15 to R-22	0.15 - 0.29	N/A	4.71 x 10-6
R-15 to R-22	0.3 – 0.49	N/A	2.55 x 10-5
R-15 to R-22	0.5 – 0.69	4.24 x 10-5	4.39 x 10-5
R-15 to R-22	>= 0.7	7.33 x 10-5	7.94 x 10-5
R-30	0.15 - 0.29	N/A	2.50 x 10-6
R-30	0.3 – 0.49	N/A	1.01 x 10-5
R-30	0.5 – 0.69	2.41 x 10-5	2.04 x 10-5
R-30	>= 0.7	4.01 x 10-5	4.77 x 10-5

Climate Zone 5: West Region

Table 236. Cool Roofs—Climate Zone 5: West Region – Deemed Summer Demand Savings for Residential Reflective Roof Installation (kW/sq. ft.)

Ceiling insulation R-value	Installed roof material 3-year reflectance	Low slope		Steep slope	
		Refrigerated air	Evaporative cooling	Refrigerated air	Evaporative cooling
≤ R-8	0.15 - 0.29	N/A	N/A	2.72 x 10-5	8.96 x 10-6
≤ R-8	0.3 – 0.49	N/A	N/A	1.27 x 10-4	6.00 x 10-5
≤ R-8	0.5 – 0.69	3.06 x 10-4	1.34 x 10-4	2.59 x 10-4	1.38 x 10-4
≤ R-8	>= 0.7	4.77 x 10-4	2.05 x 10-4	3.97 x 10-4	1.78 x 10-4

Ceiling insulation R-value	Installed roof material 3-year reflectance	Low slope		Steep slope	
		Refrigerated air	Evaporative cooling	Refrigerated air	Evaporative cooling
R-9 to R-14	0.15 - 0.29	N/A	N/A	1.25 x 10-5	9.26 x 10-6
R-9 to R-14	0.3 – 0.49	N/A	N/A	8.24 x 10-5	5.30 x 10-5
R-9 to R-14	0.5 – 0.69	2.07 x 10-4	1.00 x 10-4	1.73 x 10-4	8.86 x 10-5
R-9 to R-14	>= 0.7	3.27 x 10-4	1.44 x 10-4	2.60 x 10-4	1.22 x 10-4
R-15 to R-22	0.15 - 0.29	N/A	N/A	6.16 x 10-6	3.73 x 10-6
R-15 to R-22	0.3 – 0.49	N/A	N/A	6.18 x 10-5	4.40 x 10-5
R-15 to R-22	0.5 – 0.69	1.50 x 10-4	7.63 x 10-5	1.24 x 10-4	6.49 x 10-5
R-15 to R-22	>= 0.7	2.42 x 10-4	1.11 x 10-4	1.88 x 10-4	8.86 x 10-5
R-30	0.15 - 0.29	N/A	N/A	6.64 x 10-6	5.65 x 10-7
R-30	0.3 – 0.49	N/A	N/A	4.77 x 10-5	2.87 x 10-5
R-30	0.5 – 0.69	1.01 x 10-4	5.91 x 10-5	8.81 x 10-5	5.07 x 10-5
R-30	>= 0.7	1.80 x 10-4	8.50 x 10-5	1.32 x 10-4	6.75 x 10-5

Homes with Roof Deck Insulation

Table 237~~Table 237~~ through Table 241~~Table 241~~ present the summer demand savings (kW) associated with the installation of a reflective roof in homes with varying levels of roof deck for the five Texas climate zones. Savings are per square foot of treated roof area.

Climate Zone 1: Panhandle Region

Table 237. Cool Roofs—Climate Zone 1: Panhandle Region – Deemed Summer Demand Savings for Residential Reflective Roof Installation (kW/sq. ft.)

Roof deck insulation R-value	Installed roof material 3-year reflectance	Low slope		Steep slope	
		Refrigerated air	Evaporative cooling	Refrigerated air	Evaporative cooling
R-19	0.15 - 0.29	N/A	N/A	-	-
R-19	0.3 – 0.49	N/A	N/A	2.67 x 10-5	7.62 x 10-6
R-19	0.5 – 0.69	5.56 x 10-5	1.84 x 10-5	5.35 x 10-5	1.55 x 10-5
R-19	>= 0.7	9.88 x 10-5	7.61 x 10-6	8.81 x 10-5	1.52 x 10-5
R-30	0.15 - 0.29	N/A	N/A	3.37 x 10-6	3.42 x 10-6
R-30	0.3 – 0.49	N/A	N/A	1.97 x 10-5	7.38 x 10-6
R-30	0.5 – 0.69	3.21 x 10-5	9.13 x 10-6	3.06 x 10-5	1.25 x 10-5
R-30	>= 0.7	6.91 x 10-5	8.48 x 10-6	5.94 x 10-5	1.60 x 10-5
R-38	0.15 - 0.29	N/A	N/A	5.82 x 10-6	5.90 x 10-6

Roof deck insulation R-value	Installed roof material 3-year reflectance	Low slope		Steep slope	
		Refrigerated air	Evaporative cooling	Refrigerated air	Evaporative cooling
R-38	0.3 – 0.49	N/A	N/A	1.46 x 10-5	7.20 x 10-6
R-38	0.5 – 0.69	1.50 x 10-5	2.38 x 10-6	1.40 x 10-5	1.04 x 10-5
R-38	>= 0.7	4.75 x 10-5	9.12 x 10-6	3.85 x 10-5	1.66 x 10-5

Climate Zone 2: North Region

Table 238. Cool Roofs—Climate Zone 2: North Region – Deemed Summer Demand Savings for Residential Reflective Roof Installation (kW/sq. ft.)

Roof deck insulation R-value	Installed roof material 3-year reflectance	Low slope	Steep slope
		Refrigerated air	Refrigerated air
R-19	0.15 - 0.29	N/A	5.45 x 10-5
R-19	0.3 – 0.49	N/A	9.02 x 10-5
R-19	0.5 – 0.69	7.41 x 10-5	1.21 x 10-4
R-19	>= 0.7	1.16 x 10-4	5.18 x 10-6
R-30	0.15 - 0.29	N/A	2.22 x 10-5
R-30	0.3 – 0.49	N/A	5.01 x 10-5
R-30	0.5 – 0.69	4.37 x 10-5	7.67 x 10-5
R-30	>= 0.7	7.41 x 10-5	3.37 x 10-5
R-38	0.15 - 0.29	N/A	-1.31 x 10-6
R-38	0.3 – 0.49	N/A	2.10 x 10-5
R-38	0.5 – 0.69	2.16 x 10-5	4.44 x 10-5
R-38	>= 0.7	N/A	5.45 x 10-5

Climate Zone 3: South Region

Table 239. Cool Roofs—Climate Zone 3: South Region – Deemed Summer Demand Savings for Residential Reflective Roof Installation (kW/sq. ft.)

Roof deck insulation R-value	Installed roof material 3-year reflectance	Low slope	Steep slope
		Refrigerated air	Refrigerated air
R-19	0.15 - 0.29	N/A	-
R-19	0.3 – 0.49	N/A	4.30 x 10-5
R-19	0.5 – 0.69	9.43 x 10-5	9.42 x 10-5
R-19	>= 0.7	1.32 x 10-4	1.21 x 10-4
R-30	0.15 - 0.29	N/A	-1.46 x 10-6
R-30	0.3 – 0.49	N/A	2.60 x 10-5

Roof deck insulation R-value	Installed roof material 3-year reflectance	Low slope	Steep slope
		Refrigerated air	Refrigerated air
R-30	0.5 – 0.69	7.13 x 10-5	6.50 x 10-5
R-30	>= 0.7	8.56 x 10-5	8.46 x 10-5
R-38	0.15 - 0.29	N/A	-2.53 x 10-6
R-38	0.3 – 0.49	N/A	1.37 x 10-5
R-38	0.5 – 0.69	5.46 x 10-5	4.37 x 10-5
R-38	>= 0.7	5.19 x 10-5	5.82 x 10-5

Climate Zone 4: Valley Region

Table 240. Cool Roofs—Climate Zone 4: Valley Region – Deemed Summer Demand Savings for Residential Reflective Roof Installation (kW/sq. ft.)

Roof deck insulation R-value	Installed roof material 3-year reflectance	Low slope	Steep slope
		Refrigerated air	Refrigerated air
R-19	0.15 - 0.29	N/A	-
R-19	0.3 – 0.49	N/A	3.38 x 10-5
R-19	0.5 – 0.69	4.44 x 10-5	5.01 x 10-5
R-19	>= 0.7	7.43 x 10-5	7.37 x 10-5
R-30	0.15 - 0.29	N/A	3.36 x 10-6
R-30	0.3 – 0.49	N/A	2.68 x 10-5
R-30	0.5 – 0.69	2.09 x 10-5	3.56 x 10-5
R-30	>= 0.7	5.33 x 10-5	5.29 x 10-5
R-38	0.15 - 0.29	N/A	5.81 x 10-6
R-38	0.3 – 0.49	N/A	2.17 x 10-5
R-38	0.5 – 0.69	3.83 x 10-6	2.51 x 10-5
R-38	>= 0.7	3.80 x 10-5	3.78 x 10-5

Climate Zone 5: West Region

Table 241. Cool Roofs—Climate Zone 5: West Region – Deemed Summer Demand Savings for Residential Reflective Roof Installation (kW/sq. ft.)

Roof deck insulation R-value	Installed roof material 3-year reflectance	Low slope		Steep slope	
		Refrigerated air	Evaporative cooling	Refrigerated air	Evaporative cooling
R-19	0.15 - 0.29	N/A	N/A	-	-
R-19	0.3 – 0.49	N/A	N/A	3.64 x 10-5	2.24 x 10-5
R-19	0.5 – 0.69	8.11 x 10-5	2.76 x 10-5	8.95 x 10-5	4.42 x 10-5
R-19	>= 0.7	1.33 x 10-4	2.30 x 10-5	1.35 x 10-4	4.44 x 10-5

Roof deck insulation R-value	Installed roof material 3-year reflectance	Low slope		Steep slope	
		Refrigerated air	Evaporative cooling	Refrigerated air	Evaporative cooling
R-30	0.15 - 0.29	N/A	N/A	6.66 x 10-6	1.11 x 10-6
R-30	0.3 – 0.49	N/A	N/A	3.01 x 10-5	5.29 x 10-6
R-30	0.5 – 0.69	5.61 x 10-5	1.09 x 10-5	6.63 x 10-5	1.83 x 10-5
R-30	>= 0.7	1.13 x 10-4	1.29 x 10-5	1.05 x 10-4	2.23 x 10-5
R-38	0.15 - 0.29	N/A	N/A	1.15 x 10-5	1.91 x 10-6
R-38	0.3 – 0.49	N/A	N/A	2.55 x 10-5	-7.15 x 10-6
R-38	0.5 – 0.69	3.79 x 10-5	-1.22 x 10-6	4.95 x 10-5	-5.19 x 10-7
R-38	>= 0.7	9.92 x 10-5	5.60 x 10-6	8.40 x 10-5	6.29 x 10-6

Deemed Winter Demand Savings Tables

Savings are presented first for homes with ceiling insulation, and subsequently for those with roof deck insulation. For customers who participate in HTR/LI programs, heating savings may be claimed for homes with electric resistance space heaters serving as the primary heating source by multiplying appropriate heating values in Table 242 through Table 246 by a factor of 0.24.[276]

Homes with Ceiling Insulation

Table 242~~Table 242~~ through Table 246~~Table 246~~ present the winter demand savings (kW) associated with the installation of a reflective roof in homes with varying levels of ceiling insulation (attic floor) for the five Texas climate zones. Savings are per square foot of treated roof area.

Climate Zone 1: Panhandle Region

Table 242. Cool Roofs—Climate Zone 1: Panhandle Region – Deemed Winter Demand Savings for Residential Reflective Roof Installation (kW/sq. ft.)

Ceiling insulation R-value	Installed roof material 3-year reflectance	Low slope			Steep slope		
		Gas Heat	Electric resistance	Heat pump	Gas heat	Electric resistance	Heat pump
≤ R-8	0.15 - 0.29	N/A	N/A	N/A	-1.01 x 10-6	-9.53 x 10-6	-4.74 x 10-6
≤ R-8	0.3 – 0.49	N/A	N/A	N/A	-4.25 x 10-6	-4.66 x 10-5	-2.12 x 10-5
≤ R-8	0.5 – 0.69	1.52 x 10-6	-9.25 x 10-5	-4.52 x 10-5	-5.04 x 10-6	-8.62 x 10-5	-4.15 x 10-5
≤ R-8	>= 0.7	-9.01 x 10-6	-1.34 x 10-4	-6.68 x 10-5	-2.13 x 10-5	-1.24 x 10-4	-5.82 x 10-5

[276] This factor was derived based on expected capacity reduction assuming 1200 sq. ft. (historical analysis of HTR participants) x 0.35 BTU/sq. ft. = 42,000 BTU for central electric furnaces and two 1,500-watt portable heaters per home rated at 5,100 BTU/heater. Taking the ratio of portable to furnace capacity yields 10,200 ÷ 42,000 = 0.24.

Ceiling insulation R-value	Installed roof material 3-year reflectance	Low slope			Steep slope		
		Gas Heat	Electric resistance	Heat pump	Gas heat	Electric resistance	Heat pump
R-9 to R-14	0.15 - 0.29	N/A	N/A	N/A	-8.59 x 10-7	-7.63 x 10-6	-3.69 x 10-6
R-9 to R-14	0.3 – 0.49	N/A	N/A	N/A	-3.68 x 10-6	-3.63 x 10-5	-1.55 x 10-5
R-9 to R-14	0.5 – 0.69	-1.04 x 10-7	-7.28 x 10-5	-3.43 x 10-5	-1.49 x 10-5	-6.73 x 10-5	-3.07 x 10-5
R-9 to R-14	>= 0.7	-6.86 x 10-6	-1.05 x 10-4	-4.98 x 10-5	-2.11 x 10-5	-9.83 x 10-5	-4.57 x 10-5
R-15 to R-22	0.15 - 0.29	N/A	N/A	N/A	-8.96 x 10-7	-5.40 x 10-6	-2.51 x 10-6
R-15 to R-22	0.3 – 0.49	N/A	N/A	N/A	-3.85 x 10-6	-2.60 x 10-5	-1.08 x 10-5
R-15 to R-22	0.5 – 0.69	-1.72 x 10-6	-5.26 x 10-5	-2.47 x 10-5	-1.19 x 10-5	-4.80 x 10-5	-2.15 x 10-5
R-15 to R-22	>= 0.7	-9.72 x 10-7	-7.65 x 10-5	-3.64 x 10-5	-1.44 x 10-5	-7.05 x 10-5	-3.23 x 10-5
R-30	0.15 - 0.29	N/A	N/A	N/A	-8.09 x 10-7	-3.58 x 10-6	-1.64 x 10-6
R-30	0.3 – 0.49	N/A	N/A	N/A	-1.08 x 10-5	-1.73 x 10-5	-7.31 x 10-6
R-30	0.5 – 0.69	-5.10 x 10-6	-3.52 x 10-5	-1.58 x 10-5	-1.54 x 10-5	-3.12 x 10-5	-1.36 x 10-5
R-30	>= 0.7	-3.71 x 10-6	-5.35 x 10-5	-2.58 x 10-5	-2.10 x 10-5	-4.64 x 10-5	-2.11 x 10-5

Climate Zone 2: North Region

Table 243. Cool Roofs—Climate Zone 2: North Region – Deemed Winter Demand Savings for Residential Reflective Roof Installation (kW/sq. ft.)

Ceiling insulation R-value	Installed roof material 3-year reflectance	Low slope			Steep slope		
		Gas heat	Electric resistance	Heat pump	Gas heat	Electric resistance	Heat pump
≤ R-8	0.15 - 0.29	N/A	N/A	N/A	4.57 x 10-6	-1.03 x 10-5	-5.30 x 10-6
≤ R-8	0.3 – 0.49	N/A	N/A	N/A	1.59 x 10-6	-4.70 x 10-5	-2.68 x 10-5
≤ R-8	0.5 – 0.69	-3.36 x 10-6	-1.19 x 10-4	-5.69 x 10-5	1.19 x 10-6	-9.33 x 10-5	-4.88 x 10-5
≤ R-8	>= 0.7	-3.79 x 10-6	-1.74 x 10-4	-8.66 x 10-5	-4.46 x 10-6	-1.43 x 10-4	-7.18 x 10-5
R-9 to R-14	0.15 - 0.29	N/A	N/A	N/A	-7.26 x 10-7	-8.09 x 10-6	-3.86 x 10-6
R-9 to R-14	0.3 – 0.49	N/A	N/A	N/A	-2.92 x 10-6	-4.23 x 10-5	-2.03 x 10-5
R-9 to R-14	0.5 – 0.69	-1.29 x 10-5	-9.30 x 10-5	-4.31 x 10-5	-3.26 x 10-6	-7.90 x 10-5	-3.76 x 10-5
R-9 to R-14	>= 0.7	-1.27 x 10-5	-1.41 x 10-4	-6.53 x 10-5	-7.53 x 10-6	-1.19 x 10-4	-5.52 x 10-5
R-15 to R-22	0.15 - 0.29	N/A	N/A	N/A	3.23 x 10-7	-5.84 x 10-6	-2.76 x 10-6
R-15 to R-22	0.3 – 0.49	N/A	N/A	N/A	-1.95 x 10-6	-3.04 x 10-5	-1.43 x 10-5
R-15 to R-22	0.5 – 0.69	-1.48 x 10-5	-6.81 x 10-5	-3.23 x 10-5	-2.74 x 10-6	-5.69 x 10-5	-2.66 x 10-5
R-15 to R-22	>= 0.7	-1.61 x 10-5	-1.02 x 10-4	-4.67 x 10-5	-3.88 x 10-7	-8.65 x 10-5	-4.05 x 10-5

Ceiling insulation R-value	Installed roof material 3-year reflectance	Low slope			Steep slope		
		Gas heat	Electric resistance	Heat pump	Gas heat	Electric resistance	Heat pump
R-30	0.15 - 0.29	N/A	N/A	N/A	-3.74 x 10-7	2.81 x 10-6	8.71 x 10-6
R-30	0.3 – 0.49	N/A	N/A	N/A	-1.78 x 10-6	-1.39 x 10-5	9.39 x 10-7
R-30	0.5 – 0.69	-3.37 x 10-6	-4.77 x 10-5	-2.23 x 10-5	-2.20 x 10-6	-3.16 x 10-5	-7.00 x 10-6
R-30	>= 0.7	-1.67 x 10-5	-7.04 x 10-5	-3.03 x 10-5	-4.41 x 10-6	-5.14 x 10-5	-1.57 x 10-5

Climate Zone 3: South Region

Table 244. Cool Roofs—Climate Zone 3: South Region – Deemed Winter Demand Savings for Residential Reflective Roof Installation (kW/sq. ft.)

Ceiling insulation R-value	Installed roof material 3-year reflectance	Low slope			Steep slope		
		Gas heat	Electric resistance	Heat pump	Gas heat	Electric resistance	Heat pump
≤ R-8	0.15 - 0.29	N/A	N/A	N/A	-7.39 x 10-7	-1.25 x 10-5	-6.46 x 10-6
≤ R-8	0.3 – 0.49	N/A	N/A	N/A	-2.67 x 10-6	-6.28 x 10-5	-3.05 x 10-5
≤ R-8	0.5 – 0.69	-4.26 x 10-6	-1.28 x 10-4	-6.54 x 10-5	-5.79 x 10-6	-1.14 x 10-4	-5.59 x 10-5
≤ R-8	>= 0.7	-4.68 x 10-6	-1.84 x 10-4	-9.11 x 10-5	-9.38 x 10-6	-1.68 x 10-4	-8.50 x 10-5
R-9 to R-14	0.15 - 0.29	N/A	N/A	N/A	-6.93 x 10-7	-9.35 x 10-6	-4.68 x 10-6
R-9 to R-14	0.3 – 0.49	N/A	N/A	N/A	-3.38 x 10-6	-4.69 x 10-5	-2.31 x 10-5
R-9 to R-14	0.5 – 0.69	-5.14 x 10-6	-9.71 x 10-5	-4.78 x 10-5	-6.46 x 10-6	-8.68 x 10-5	-4.28 x 10-5
R-9 to R-14	>= 0.7	-4.83 x 10-6	-1.41 x 10-4	-6.90 x 10-5	-1.00 x 10-5	-1.27 x 10-4	-6.19 x 10-5
R-15 to R-22	0.15 - 0.29	N/A	N/A	N/A	-7.06 x 10-7	-6.48 x 10-6	-3.22 x 10-6
R-15 to R-22	0.3 – 0.49	N/A	N/A	N/A	-3.70 x 10-6	-3.32 x 10-5	-1.62 x 10-5
R-15 to R-22	0.5 – 0.69	-5.52 x 10-6	-6.85 x 10-5	-3.34 x 10-5	-6.80 x 10-6	-6.15 x 10-5	-3.00 x 10-5
R-15 to R-22	>= 0.7	-8.06 x 10-6	-1.00 x 10-4	-4.89 x 10-5	-9.55 x 10-6	-9.10 x 10-5	-4.44 x 10-5
R-30	0.15 - 0.29	N/A	N/A	N/A	-6.32 x 10-7	-4.54 x 10-6	-2.25 x 10-6
R-30	0.3 – 0.49	N/A	N/A	N/A	-3.32 x 10-6	-2.23 x 10-5	-1.07 x 10-5
R-30	0.5 – 0.69	-5.55 x 10-6	-4.83 x 10-5	-2.35 x 10-5	-6.05 x 10-6	-4.13 x 10-5	-2.00 x 10-5
R-30	>= 0.7	-6.77 x 10-6	-7.30 x 10-5	-3.95 x 10-5	-8.39 x 10-6	-6.06 x 10-5	-2.93 x 10-5

Climate Zone 4: Valley Region

**Table 245. Cool Roofs—Climate Zone 4: Valley Region –
Deemed Winter Demand Savings for Residential Reflective Roof Installation (kW/sq. ft.)**

Ceiling insulation R-value	Installed roof material 3-year reflectance	Low slope			Steep slope		
		Gas heat	Electric resistance	Heat pump	Gas heat	Electric resistance	Heat pump
≤ R-8	0.15 - 0.29	N/A	N/A	N/A	-4.02 x 10-7	-1.19 x 10-5	-5.71 x 10-6
≤ R-8	0.3 – 0.49	N/A	N/A	N/A	-2.13 x 10-6	-5.99 x 10-5	-2.89 x 10-5
≤ R-8	0.5 – 0.69	-3.72 x 10-6	-1.20 x 10-4	-5.60 x 10-5	-3.17 x 10-6	-1.08 x 10-4	-5.08 x 10-5
≤ R-8	>= 0.7	-7.11 x 10-6	-1.79 x 10-4	-8.65 x 10-5	-4.84 x 10-6	-1.61 x 10-4	-7.59 x 10-5
R-9 to R-14	0.15 - 0.29	N/A	N/A	N/A	-6.35 x 10-7	-8.94 x 10-6	-4.36 x 10-6
R-9 to R-14	0.3 – 0.49	N/A	N/A	N/A	-1.95 x 10-6	-4.53 x 10-5	-2.21 x 10-5
R-9 to R-14	0.5 – 0.69	-3.55 x 10-6	-9.21 x 10-5	-4.40 x 10-5	-2.94 x 10-6	-8.27 x 10-5	-3.89 x 10-5
R-9 to R-14	>= 0.7	-4.77 x 10-6	-1.35 x 10-4	-6.41 x 10-5	-3.95 x 10-6	-1.23 x 10-4	-5.95 x 10-5
R-15 to R-22	0.15 - 0.29	N/A	N/A	N/A	-1.73 x 10-6	-6.16 x 10-6	-2.94 x 10-6
R-15 to R-22	0.3 – 0.49	N/A	N/A	N/A	-2.67 x 10-6	-3.25 x 10-5	-1.62 x 10-5
R-15 to R-22	0.5 – 0.69	-3.83 x 10-6	-6.74 x 10-5	-3.45 x 10-5	-3.08 x 10-6	-5.91 x 10-5	-2.83 x 10-5
R-15 to R-22	>= 0.7	-4.47 x 10-6	-9.81 x 10-5	-4.84 x 10-5	-4.19 x 10-6	-8.82 x 10-5	-4.34 x 10-5
R-30	0.15 - 0.29	N/A	N/A	N/A	-1.34 x 10-7	-4.03 x 10-6	-1.87 x 10-6
R-30	0.3 – 0.49	N/A	N/A	N/A	-9.58 x 10-7	-2.14 x 10-5	-1.03 x 10-5
R-30	0.5 – 0.69	-3.13 x 10-6	-4.69 x 10-5	-2.41 x 10-5	-2.42 x 10-6	-4.01 x 10-5	-2.00 x 10-5
R-30	>= 0.7	-3.46 x 10-6	-6.78 x 10-5	-3.32 x 10-5	-2.98 x 10-6	-5.89 x 10-5	-2.88 x 10-5

Climate Zone 5: West Region

**Table 246. Cool Roofs—Climate Zone 5: West Region –
Deemed Winter Demand Savings for Residential Reflective Roof Installation (kW/sq. ft.)**

Ceiling insulation R-value	Installed roof material 3-year reflectance	Low slope			Steep slope		
		Gas heat	Electric resistance	Heat pump	Gas heat	Electric resistance	Heat pump
≤ R-8	0.15 - 0.29	N/A	N/A	N/A	-2.41 x 10-7	-1.98 x 10-5	-7.98 x 10-6
≤ R-8	0.3 – 0.49	N/A	N/A	N/A	-4.83 x 10-6	-1.03 x 10-4	-4.14 x 10-5
≤ R-8	0.5 – 0.69	-1.33 x 10-5	-2.36 x 10-4	-9.44 x 10-5	-1.22 x 10-5	-1.99 x 10-4	-7.97 x 10-5
≤ R-8	>= 0.7	-1.47 x 10-5	-3.64 x 10-4	-1.48 x 10-4	-1.73 x 10-5	-3.11 x 10-4	-1.28 x 10-4
R-9 to R-14	0.15 - 0.29	N/A	N/A	N/A	-5.77 x 10-7	-1.35 x 10-5	-5.48 x 10-6
R-9 to R-14	0.3 – 0.49	N/A	N/A	N/A	-4.07 x 10-6	-7.56 x 10-5	-3.15 x 10-5
R-9 to R-14	0.5 – 0.69	-9.52 x 10-6	-1.70 x 10-4	-6.83 x 10-5	-9.66 x 10-6	-1.44 x 10-4	-5.76 x 10-5

Ceiling insulation R-value	Installed roof material 3-year reflectance	Low slope			Steep slope		
		Gas heat	Electric resistance	Heat pump	Gas heat	Electric resistance	Heat pump
R-9 to R-14	>= 0.7	-1.06 x 10-5	-2.73 x 10-4	-1.12 x 10-4	-1.38 x 10-5	-2.33 x 10-4	-9.66 x 10-5
R-15 to R-22	0.15 - 0.29	N/A	N/A	N/A	-4.29 x 10-7	-9.41 x 10-6	-4.20 x 10-6
R-15 to R-22	0.3 – 0.49	N/A	N/A	N/A	-3.14 x 10-6	-4.91 x 10-5	-2.00 x 10-5
R-15 to R-22	0.5 – 0.69	-7.55 x 10-6	-1.14 x 10-4	-4.66 x 10-5	-7.70 x 10-6	-9.71 x 10-5	-4.02 x 10-5
R-15 to R-22	>= 0.7	-8.94 x 10-6	-1.85 x 10-4	-7.43 x 10-5	-1.05 x 10-5	-1.55 x 10-4	-6.29 x 10-5
R-30	0.15 - 0.29	N/A	N/A	N/A	-2.85 x 10-7	-6.26 x 10-6	-2.54 x 10-6
R-30	0.3 – 0.49	N/A	N/A	N/A	-2.32 x 10-6	-3.11 x 10-5	-1.25 x 10-5
R-30	0.5 – 0.69	-5.52 x 10-6	-7.44 x 10-5	-2.95 x 10-5	-6.01 x 10-6	-5.97 x 10-5	-2.46 x 10-5
R-30	>= 0.7	-7.73 x 10-6	-1.20 x 10-4	-4.89 x 10-5	-7.78 x 10-6	-9.69 x 10-5	-3.98 x 10-5

Homes with Roof Deck Insulation

Table 247~~Table 247~~ through Table 251~~Table 251~~ present the winter demand savings (kW) associated with the installation of a reflective roof in homes with varying levels of roof deck for the five Texas climate zones. Savings are per square foot of treated roof area.

Climate Zone 1: Panhandle Region

Table 247. Cool Roofs—Climate Zone 1: Panhandle Region – Deemed Winter Demand Savings for Residential Reflective Roof Installation (kW/sq. ft.)

Roof deck insulation R-value	Installed roof material 3-year reflectance	Low slope			Steep slope		
		Gas heat	Electric resistance	Heat pump	Gas heat	Electric resistance	Heat pump
R-19	0.15 - 0.29	N/A	N/A	N/A	-	-	-
R-19	0.3 – 0.49	N/A	N/A	N/A	6.62 x 10-7	-3.75 x 10-5	-1.86 x 10-5
R-19	0.5 – 0.69	1.68 x 10-6	-6.28 x 10-5	-2.35 x 10-5	5.59 x 10-6	-7.49 x 10-5	-3.71 x 10-5
R-19	>= 0.7	-1.78 x 10-6	-9.77 x 10-5	-4.08 x 10-5	7.13 x 10-6	-1.12 x 10-4	-5.19 x 10-5
R-30	0.15 - 0.29	N/A	N/A	N/A	-1.08 x 10-7	-3.00 x 10-6	-1.52 x 10-6
R-30	0.3 – 0.49	N/A	N/A	N/A	2.49 x 10-6	-3.23 x 10-5	-1.75 x 10-5
R-30	0.5 – 0.69	-5.08 x 10-7	-5.14 x 10-5	-2.26 x 10-5	3.99 x 10-6	-6.01 x 10-5	-3.15 x 10-5
R-30	>= 0.7	-1.76 x 10-6	-7.76 x 10-5	-3.59 x 10-5	4.24 x 10-6	-8.76 x 10-5	-4.38 x 10-5
R-38	0.15 - 0.29	N/A	N/A	N/A	-1.87 x 10-7	-5.19 x 10-6	-2.62 x 10-6
R-38	0.3 – 0.49	N/A	N/A	N/A	3.82 x 10-6	-2.85 x 10-5	-1.67 x 10-5
R-38	0.5 – 0.69	-2.10 x 10-6	-4.31 x 10-5	-2.20 x 10-5	2.82 x 10-6	-4.93 x 10-5	-2.74 x 10-5
R-38	>= 0.7	-1.74 x 10-6	-6.29 x 10-5	-3.23 x 10-5	2.13 x 10-6	-6.99 x 10-5	-3.79 x 10-5

Climate Zone 2: North Region

Table 248. Cool Roofs—Climate Zone 2: North Region – Deemed Winter Demand Savings for Residential Reflective Roof Installation (kW/sq. ft.)

Roof deck insulation R-value	Installed roof material 3-year reflectance	Low slope			Steep slope		
		Gas heat	Electric resistance	Heat pump	Gas heat	Electric resistance	Heat pump
R-19	0.15 - 0.29	N/A	N/A	N/A	-	-	-
R-19	0.3 – 0.49	N/A	N/A	N/A	-1.68 x 10-6	-4.21 x 10-5	-2.13 x 10-5
R-19	0.5 – 0.69	3.73 x 10-6	-8.26 x 10-5	-3.29 x 10-5	3.93 x 10-6	-8.72 x 10-5	-4.49 x 10-5
R-19	>= 0.7	2.09 x 10-6	-1.33 x 10-4	-5.96 x 10-5	2.27 x 10-6	-1.30 x 10-4	-5.31 x 10-5
R-30	0.15 - 0.29	N/A	N/A	N/A	-7.35 x 10-8	-3.36 x 10-6	-1.70 x 10-6
R-30	0.3 – 0.49	N/A	N/A	N/A	-1.19 x 10-6	-3.52 x 10-5	-1.73 x 10-5
R-30	0.5 – 0.69	6.09 x 10-7	-6.66 x 10-5	-3.33 x 10-5	8.00 x 10-8	-6.99 x 10-5	-3.56 x 10-5
R-30	>= 0.7	-1.22 x 10-6	-1.03 x 10-4	-5.11 x 10-5	-1.19 x 10-6	-1.03 x 10-4	-4.63 x 10-5
R-38	0.15 - 0.29	N/A	N/A	N/A	-1.27 x 10-7	-5.81 x 10-6	-2.93 x 10-6
R-38	0.3 – 0.49	N/A	N/A	N/A	-8.41 x 10-7	-3.02 x 10-5	-1.44 x 10-5
R-38	0.5 – 0.69	-1.66 x 10-6	-5.49 x 10-5	-3.36 x 10-5	-2.72 x 10-6	-5.73 x 10-5	-2.88 x 10-5
R-38	>= 0.7	-3.63 x 10-6	-8.17 x 10-5	-4.49 x 10-5	-3.70 x 10-6	-8.42 x 10-5	-4.14 x 10-5

Climate Zone 3: South Region

Table 249. Cool Roofs—Climate Zone 3: South Region – Deemed Winter Demand Savings for Residential Reflective Roof Installation (kW/sq. ft.)

Roof deck insulation R-value	Installed roof material 3-year reflectance	Low slope			Steep slope		
		Gas heat	Electric resistance	Heat pump	Gas heat	Electric resistance	Heat pump
R-19	0.15 - 0.29	N/A	N/A	N/A	-	-	-
R-19	0.3 – 0.49	N/A	N/A	N/A	5.21 x 10-8	-4.60 x 10-5	-2.10 x 10-5
R-19	0.5 – 0.69	-4.82 x 10-7	-9.84 x 10-5	-5.19 x 10-5	-1.73 x 10-7	-9.69 x 10-5	-4.88 x 10-5
R-19	>= 0.7	1.47 x 10-6	-1.47 x 10-4	-7.52 x 10-5	2.13 x 10-6	-1.52 x 10-4	-8.03 x 10-5
R-30	0.15 - 0.29	N/A	N/A	N/A	2.41 x 10-8	-3.94 x 10-6	-2.10 x 10-6
R-30	0.3 – 0.49	N/A	N/A	N/A	1.86 x 10-7	-4.00 x 10-5	-1.93 x 10-5
R-30	0.5 – 0.69	-1.49 x 10-6	-8.32 x 10-5	-4.30 x 10-5	-4.20 x 10-7	-7.79 x 10-5	-4.01 x 10-5
R-30	>= 0.7	-1.30 x 10-6	-1.17 x 10-4	-6.28 x 10-5	-7.36 x 10-7	-1.19 x 10-4	-6.33 x 10-5
R-38	0.15 - 0.29	N/A	N/A	N/A	4.96 x 10-8	-6.80 x 10-6	-3.63 x 10-6
R-38	0.3 – 0.49	N/A	N/A	N/A	4.75 x 10-7	-3.56 x 10-5	-1.81 x 10-5
R-38	0.5 – 0.69	-2.23 x 10-6	-7.22 x 10-5	-3.66 x 10-5	-5.99 x 10-7	-6.41 x 10-5	-3.37 x 10-5
R-38	>= 0.7	-3.32 x 10-6	-9.52 x 10-5	-5.37 x 10-5	-2.82 x 10-6	-9.58 x 10-5	-5.09 x 10-5

Climate Zone 4: Valley Region

**Table 250. Cool Roofs—Climate Zone 4: Valley Region –
Deemed Winter Demand Savings for Residential Reflective Roof Installation (kW/sq. ft.)**

Roof deck insulation R-value	Installed roof material 3-year reflectance	Low slope			Steep slope		
		Gas heat	Electric resistance	Heat pump	Gas heat	Electric resistance	Heat pump
R-19	0.15 - 0.29	N/A	N/A	N/A	-	-	-
R-19	0.3 – 0.49	N/A	N/A	N/A	-1.53 x 10-6	-4.45 x 10-5	-2.26 x 10-5
R-19	0.5 – 0.69	-2.27 x 10-6	-9.14 x 10-5	-3.90 x 10-5	-2.29 x 10-6	-9.18 x 10-5	-4.65 x 10-5
R-19	>= 0.7	-2.65 x 10-6	-1.39 x 10-4	-6.06 x 10-5	-4.16 x 10-6	-1.37 x 10-4	-6.18 x 10-5
R-30	0.15 - 0.29	N/A	N/A	N/A	-1.08 x 10-7	-3.76 x 10-6	-1.77 x 10-6
R-30	0.3 – 0.49	N/A	N/A	N/A	-1.19 x 10-6	-3.68 x 10-5	-1.74 x 10-5
R-30	0.5 – 0.69	-2.72 x 10-6	-7.35 x 10-5	-3.29 x 10-5	-2.34 x 10-6	-7.31 x 10-5	-3.62 x 10-5
R-30	>= 0.7	-3.34 x 10-6	-1.09 x 10-4	-4.88 x 10-5	-3.60 x 10-6	-1.09 x 10-4	-5.07 x 10-5
R-38	0.15 - 0.29	N/A	N/A	N/A	-1.87 x 10-7	-6.50 x 10-6	-3.06 x 10-6
R-38	0.3 – 0.49	N/A	N/A	N/A	-9.37 x 10-7	-3.12 x 10-5	-1.36 x 10-5
R-38	0.5 – 0.69	-3.05 x 10-6	-6.05 x 10-5	-2.85 x 10-5	-2.37 x 10-6	-5.95 x 10-5	-2.87 x 10-5
R-38	>= 0.7	-3.85 x 10-6	-8.74 x 10-5	-4.03 x 10-5	-3.19 x 10-6	-8.78 x 10-5	-4.27 x 10-5

Climate Zone 5: West Region

**Table 251. Cool Roofs—Climate Zone 5: West Region –
Deemed Winter Demand Savings for Residential Reflective Roof Installation (kW/sq. ft.)**

Roof deck insulation R-value	Installed roof material 3-year reflectance	Low slope			Steep slope		
		Gas heat	Electric resistance	Heat pump	Gas heat	Electric resistance	Heat pump
R-19	0.15 - 0.29	N/A	N/A	N/A	-	-	-
R-19	0.3 – 0.49	N/A	N/A	N/A	2.07 x 10-6	-5.87 x 10-5	-2.38 x 10-5
R-19	0.5 – 0.69	7.97 x 10-7	-1.30 x 10-4	-5.39 x 10-5	1.10 x 10-6	-1.31 x 10-4	-5.30 x 10-5
R-19	>= 0.7	-1.19 x 10-6	-2.13 x 10-4	-8.83 x 10-5	-8.95 x 10-7	-2.10 x 10-4	-8.53 x 10-5
R-30	0.15 - 0.29	N/A	N/A	N/A	-1.04 x 10-7	-4.45 x 10-6	-1.81 x 10-6
R-30	0.3 – 0.49	N/A	N/A	N/A	4.81 x 10-7	-4.81 x 10-5	-1.95 x 10-5
R-30	0.5 – 0.69	3.74 x 10-8	-1.01 x 10-4	-4.16 x 10-5	-7.12 x 10-7	-1.01 x 10-4	-4.15 x 10-5
R-30	>= 0.7	-1.64 x 10-6	-1.61 x 10-4	-6.73 x 10-5	-2.51 x 10-6	-1.60 x 10-4	-6.58 x 10-5
R-38	0.15 - 0.29	N/A	N/A	N/A	-1.79 x 10-7	-7.68 x 10-6	-3.13 x 10-6
R-38	0.3 – 0.49	N/A	N/A	N/A	-6.75 x 10-7	-4.04 x 10-5	-1.63 x 10-5
R-38	0.5 – 0.69	-5.15 x 10-7	-7.93 x 10-5	-3.26 x 10-5	-2.03 x 10-6	-7.94 x 10-5	-3.31 x 10-5
R-38	>= 0.7	-1.97 x 10-6	-1.24 x 10-4	-5.20 x 10-5	-3.68 x 10-6	-1.24 x 10-4	-5.16 x 10-5

Example Deemed Savings Calculation

Example 1. A contractor installs 1500 square feet of white asphalt shingle roofing with a 3-year rated reflectance of 0.55 on a home in climate zone 3 with a roof slope of 4/12, refrigerated air, and a gas furnace, which has existing ceiling insulation estimated at R-12.

$$kWh\ savings = (0.26 - 0.01) \times 1500 = 375\ kWh$$

$$Summer\ kW\ savings = 2.03x10^{-4} \times 1500 = 0.30\ kW$$

$$Winter\ kW\ savings = -6.46x10^{-6} \times 1500 = -0.01\ kW$$

Example 2. A contractor applies a reflective coating to a 1200 square foot home with a heat pump and a low-slope roof in Climate Zone 2, with R-19 roof deck insulation. The coating has a 3-year rated reflectance of 0.75.

$$kWh\ savings = (0.32 - 0.11) \times 1200 = 252\ kWh$$

$$Summer\ kW\ savings = N/A$$

$$Winter\ kW\ savings = -5.96x10^{-5} \times 1200 = -0.07\ kW$$

Claimed Peak Demand Savings

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

Additional Calculators and Tools

Not applicable.

Measure Life and Lifetime Savings

The estimated useful life (EUL) is 15 years, as specified in the California Database of Energy Efficiency Resources (DEER) READI tool for EUL ID BS-LtRoof.[277] ~~for a cool roof measure is 15 years.~~

~~This value is consistent with the EUL reported in the 2014 California Database for Energy Efficiency Resources (DEER).~~[278]

Program Tracking Data and Evaluation Requirements

It is required that the following list of primary inputs and contextual data be specified and

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

[278] ~~2014 California Database for Energy Efficiency Resources. Accessed via the READI database v2.4.7 which can be downloaded from the California Public Utilities Commission Website at http://www.deeresources.com/.~~

tracked by the program database to inform the evaluation and apply the savings properly:

- Climate zone
- Insulation R-value (as is, post measure installation of ceiling/roof insulation)
- Cooling type (evaporative cooling, central refrigerated cooling, room air conditioner, none)
- Heating type (central gas, portable gas, central electric resistance, portable electric resistance, heat pump, none)
    - Additional documentation is required to validate electric resistance heat (e.g., nameplate photo, utility inspection, or other evaluator-approved approach); sampling is allowed for multifamily complexes
- Square footage of reflective roofing material installed
- Slope of the roof (low or high slope)
- Three-year solar reflectance as rated by Cool Roof Rating Certification of the reflective material installed
- Proof of purchase – with date of purchase and quantity
    - Alternative: photo of unit installed or another pre-approved method of installation verification.

References and Efficiency Standards

Petitions and Rulings

- Docket No. 47755-1. Petition of AEP Texas Inc., CenterPoint Energy Houston Electric, LLC, El Paso Electric Company, Entergy Texas, Inc., Oncor Electric Delivery Company LLC, Southwestern Electric Power Company, Southwestern Public Service Company, and Texas-New Mexico Power Company. Petition To Approve Revisions To Residential And Nonresidential Deemed Savings Incorporated In Texas Technical Reference Manual Version 5.0 Program Year 2018 And Deemed Savings Derived For A New Measure. Public Utility Commission of Texas.

Relevant Standards and Reference Sources

Not applicable.

Document Revision History

Table 252. Residential Cool Roofs Revision History

TRM version	Date	Description of change
v6.0	11/2018	TRM v6.0 origin.
v7.0	11/2019	TRM v7.0 update. Added savings for R-30 insulation.
v8.0	10/2020	TRM v8.0 update. Updated savings tables. Added space heat adjustment factor and electric resistance documentation requirement.
v9.0	10/2021	TRM v9.0 update. Updated EUL reference.

2.4 RESIDENTIAL: WATER HEATING

2.4.1 Faucet Aerators Measure Overview

TRM Measure ID: R-WH-FA

Market Sector: Residential

Measure Category: Water Heating

Applicable Building Types: Single-family, multifamily, manufactured

Fuels Affected: Electricity

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

Program Delivery Type(s): Prescriptive

Deemed Savings Type: Deemed savings calculation

Savings Methodology: Engineering algorithms and estimates

Measure Description

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

Eligibility Criteria

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

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

Baseline Condition

The 2.2 gallon per minute (GPM) baseline faucet flow rate is based on ~~on~~ the Department of Energy (DOE) maximum flow rate standard.[279] The deemed savings assume that the existing faucet aerators have a minimum flow rate of 2.2 GPM. The US EPA WaterSense specification for faucet aerators is 1.5 GPM.[280]

Table 253. Faucet Aerators—Baseline and Efficiency Standard

Baseline	Efficiency standard
2.2 GPM maximum	1.5 GPM maximum

[279] DOE maximum flow rate for faucet aerators. https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=40. ~~Accessed August 2020.~~

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

High-Efficiency Condition

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

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Energy Savings Algorithms

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

$$Energy\ Savings\ (per\ aerator) = \frac{\rho \times C_P \times (GPM_{Base} - GPM_{Low}) \times N \times t \times 365 \times \left(T_{FaucetAvg} - T_{SupplyAvg}\right)}{FPH \times RE \times Conversion\ Factor}$$

Equation 63

Where:

ρ	=	*Water density, 8.33 lbs/gallon*
C_P	=	*Specific heat of water, 1 Btu/lb°F*
GPM_{Base}	=	*Average baseline flow rate of aerator = 2.2 gallons per minute*
GPM_{Low}	=	*Post-installation flow rate of aerator, typically 1.5, 1.0, or 0.5 gallons per minute; if unknown, assume 1.5 gallons per minute*
N	=	*Average number of persons per household = 2.86 persons*[281]
t	=	*Average time in minutes of hot water usage per person per day; default = 2.34 min/person/day*[282]

Field Code Changed

[281] Occupants per home for Texas from US Census Bureau, "Persons per household,

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

$T_{SetPoint}$	=	*Average faucet temperature = 88°F*[283]
$T_{SupplyAverage}$	=	*Average supply water temperature (see Table 254)*
FPH	=	*Average number of faucets per household = 3.87 faucets*[284]
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.*[285]
ConversionFactor	=	*3,412 Btu/kWh*

Field Code Changed

Field Code Changed

Demand Savings Algorithms

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

$$Demand\ Savings\ (per\ aerator) = \frac{\rho \times C_P \times (GPM_{Base} - GPM_{Low}) \times N \times t \times \left(T_{FaucetAvg} - T_{SupplySeasonal}\right)}{FPH \times RE \times Conversion\ Factor} \times CF$$

Equation 64

Where:

$T_{SupplySeasonal}$	=	*Seasonal supply water temperature (Table 254)*
CF	=	*Peak coincidence factor (Table 255)*

[283] Cadmus and Opinion Dynamics Evaluation Team, "Memorandum: Showerhead and Faucet Aerator Meter Study". Prepared for Michigan Evaluation Working Group. Derived by taking weighted average of average temperature for kitchens (93 °F) and bathrooms (86 °F) assuming 1 kitchen aerator and 2.93 bathrooms.
Data collection discussed in Appendix D of the EM&V team's Annual Statewide Portfolio Report for Program Year 2014-Volume 1, Project Number 40891 (August 2015), also supports a default value of 120°F.

[284] Faucets per home assumed to be equal to one per kitchen and each half-bath plus 1.5 per each full bathrooms per home. Bathroom counts extracted from the 2015 Residential Energy Consumption Survey (RECS), Table HC2.8 Structural and geographic characteristics of homes in West South Central region.

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

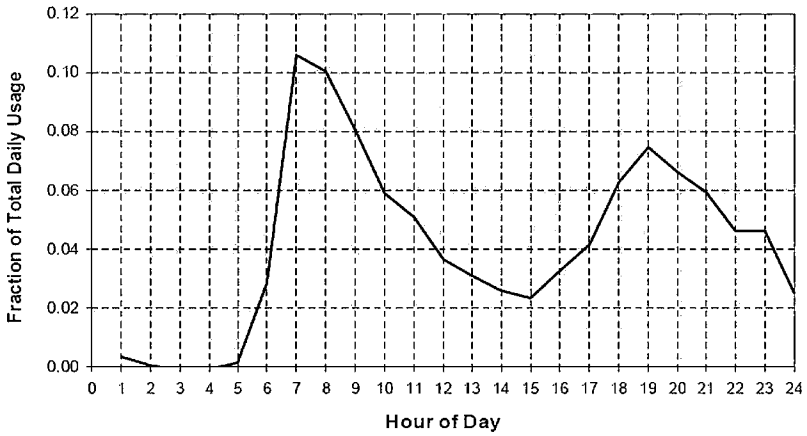
Table 254. Faucet Aerators—Water Mains Temperature

Climate zone	Water mains temperature °F[286]		
	$T_{SupplyAverage}$	$T_{SupplySeasonal}$	
		Summer	Winter
Climate zone 1: Panhandle	62.9	73.8	53.7
Climate zone 2: North	71.8	84.0	60.6
Climate zone 3: South	74.7	84.5	65.5
Climate zone 4: Valley	77.2	86.1	68.5
Climate zone 5: West	70.4	81.5	60.4

Table 255. Faucet Aerators—Peak Coincidence Factors

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

Figure 8. Shower, Bath, and Sink Hot Water Use Profile[287]



[286] Based on typical meteorological year (TMY) dataset for TMY3, available through the National Solar Radiation Database (NSRDB) Data Viewer, https://nsrdb.nrel.gov/data-sets/archives.html. Accessed August 2020.

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

Deemed Energy Savings Tables

There are no lookup tables available for this measure. See engineering algorithms in the previous section for calculating energy and demand savings.

Deemed Summer Demand Savings Tables

There are no lookup tables available for this measure. See engineering algorithms in the previous section for calculating energy and demand savings.

Deemed Winter Demand Savings Tables

There are no lookup tables available for this measure. See engineering algorithms in the previous section for calculating energy and demand savings.

Claimed Peak Demand Savings

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

Additional Calculators and Tools

Not applicable.

Measure Life and Lifetime Savings

The estimated useful life (EUL) is 10 years, as specified in the California Database of Energy Efficiency Resources (DEER) READI tool for EUL ID WtrHt-WH-Aertr.[288] ~~of a faucet aerator is established at 10 years.~~

~~This value is consistent with the EUL reported in the 2014 California Database for Energy Efficiency Resources (DEER).[289]~~

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

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

[289] ~~2014 California Database for Energy Efficiency Resources. http://www.deeresources.com/..~~

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

Not applicable.

Document Revision History

Table 256. Residential Faucet Aerators Revision History

TRM version	Date	Description of change
v1.0	11/25/2013	TRM v1.0 origin.
v2.0	4/18/2014	TRM v2.0 update. Minor edits to language.
v2.1	1/30/2015	TRM v2.1 update. No revision.
v3.0	4/10/2015	TRM v3.0 update. No revision.
v3.1	10/30/2015	TRM v3.1 update. Supplemented reference for water heater setpoint temperature.
v4.0	10/10/2016	TRM v4.0 update. Updated methodology to calculate energy and demand savings.
v5.0	10/2017	TRM v5.0 update. No revision.
v6.0	11/2018	TRM v6.0 update. No revision.
v7.0	11/2019	TRM v7.0 update. No revision.
v8.0	10/2020	TRM v8.0 update. Updated coincidence factors.
v9.0	10/2021	TRM v9.0 update. Updated EUL reference.

2.4.2 Low-Flow Showerheads Measure Overview

TRM Measure ID: R-WH-SH

Market Sector: Residential

Measure Category: Water Heating

Applicable Building Types: Single-family, multifamily, manufactured

Fuels Affected: Electricity

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

Program Delivery Type(s): Prescriptive

Deemed Savings Type: Deemed savings calculation

Savings Methodology: Engineering algorithms and estimates

Measure Description

This measure consists of removing existing showerheads and installing low-flow showerheads in residences.

Eligibility Criteria

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

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

Baseline Condition

Federal standards set a maximum flow rate of 2.5 GPM,[290] while the US Environmental Protection Agency (EPA) WaterSense Program has implemented efficiency standards for showerheads requiring a maximum flow rate of 2.0 GPM.[291]

Table 257. Low-Flow Showerheads—Baseline and Efficiency Standards

Existing showerhead baseline flow rate	New showerhead flow rate[292]
2.5 GPM maximum	2.0 GPM maximum

[290] http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/37. ~~Accessed August 2020~~

[291] http://www.epa.gov/watersense/products/showerheads.html. ~~Accessed August 2020~~

[292] All flow rate requirements listed here are the rated flow of the showerhead measured at 80 pounds per square inch of pressure (psi).

High-Efficiency Condition

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

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Energy Savings Algorithms

Energy savings for this measure are calculated as follows:

$$Energy\ Savings\ (per\ showerhead) = \frac{\rho \times C_P \times (GPM_{Base} - GPM_{Low}) \times N \times t \times 365 \times (T_{ShowerAvg} - T_{SupplyAvg})}{SPH \times RE \times Conversion\ Factor}$$

Equation 65

Where:

ρ	=	*Water density, 8.33 lbs/gallon*
C_P	=	*Specific heat of water, 1 Btu/lb°F*
GPM_{Base}	=	*Average baseline flow rate of aerator = 2.5 gallons per minute*
GPM_{Low}	=	*Post-installation flow rate of aerator; if unknown, assume 2.0 gallons per minute*
N	=	*Average number of persons per household = 2.86 persons*[293]
t	=	*Average time in minutes of hot water usage per person per day; default = 7.8 min/person/day*[294]
$T_{SetPoint}$	=	*Average shower temperature = 101°F* [295]
T_{Supply}	=	*Average supply water temperature (see Table 258)*
SPH	=	*Average number of showerheads per household = 1.74 showerheads*[296]

[293] Occupants per home for Texas from US Census Bureau, "Persons per household, 2009-2013". August 2020.https://www.census.gov/quickfacts/TX.

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

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

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

RE = *Recovery Efficiency (or in the case of heat pump water heaters, COP). If unknown, use 0.98 as a default for electric resistance water heaters or 2.2 for heat pump water* heaters.[297]

ConversionFactor = *3,412 Btu/kWh*

Demand Savings Algorithms

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

$$Demand\ Savings\ (per\ showerhead) = \frac{\rho \times C_P \times (GPM_{Base} - GPM_{Low}) \times N \times t \times (T_{ShowerAvg} - T_{SupplySeasonal})}{SPH \times RE \times Conversion\ Factor} \times CF$$

Equation 66

Where:

$T_{SupplySeasonal}$ = *Seasonal supply water temperature (see Table 258)*

CF = *Peak coincidence factor_savings (see Table 259)*

Table 258. Low-Flow Showerheads—Water Mains Temperatures

Climate zone	Water mains temperature (°F)[298]		
	$T_{SupplyAverage}$	$T_{SupplySeasonal}$	
		Summer	Winter
Climate zone 1: Panhandle	62.9	73.8	53.7
Climate zone 2: North	71.8	84.0	60.6
Climate zone 3: South	74.7	84.5	65.5
Climate zone 4: Valley	77.2	86.1	68.5
Climate zone 5: West	70.4	81.5	60.4

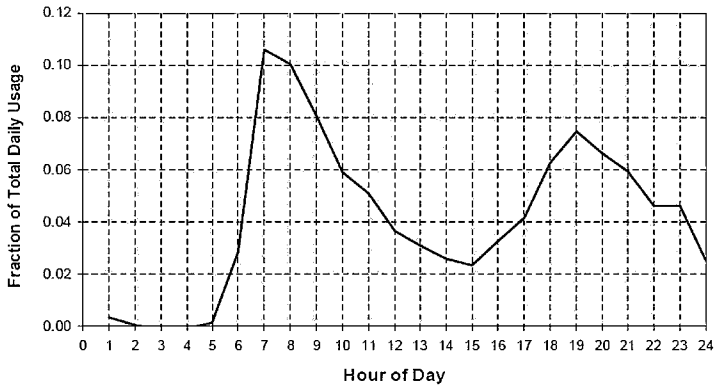
[297] Default values based on median recovery efficiency of residential water heaters by fuel type in the AHRI database, at http://cafs.ahrinet.org/gama_cafs/sdpsearch/search.jsp?table=CWH.

[298] Based on typical meteorological year (TMY) dataset for TMY3, available through the National Solar Radiation Database (NSRDB) Data Viewer. https://nsrdb.nrel.gov/data-sets/archives.html. ~~Accessed August 2020.~~

Table 259. Low-Flow Showerheads—Peak Coincidence Factors

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

Figure 9. Shower, Bath, and Sink Hot Water Use Profile[299]



Source: Building America Performance Analysis Procedures for Existing Homes.

Deemed Energy Savings Tables

There are no lookup tables available for this measure. See engineering algorithms in the previous section for calculating energy and demand savings.

Deemed Summer Demand Savings Tables

There are no lookup tables available for this measure. See engineering algorithms in the previous section for calculating energy and demand savings.

Deemed Winter Demand Savings Tables

There are no lookup tables available for this measure. See engineering algorithms in the previous section for calculating energy and demand savings.

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

Claimed Peak Demand Savings

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

Additional Calculators and Tools

Not applicable.

Measure Life and Lifetime Savings

The estimated useful life (EUL) is 10 years, as specified in the California Database of Energy Efficiency Resources (DEER) READI tool for EUL ID WtrHt-WH-Shrhd.[300] ~~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).[301]~~

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
- 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.

[300] DEER READI (Remote Ex-Ante Database Interface). http://www.deeresources.com/index.php/readi.
[301] ~~2014 California Database for Energy Efficiency Resources. http://www.deeresources.com/.~~

Relevant Standards and Reference Sources

Not applicable.

Document Revision History

Table 260. Residential Low-Flow Showerheads Revision History

TRM version	Date	Description of change
v1.0	11/25/2013	TRM v1.0 origin.
v2.0	4/18/2014	TRM v2.0 update. Minor edits to language.
v2.1	1/30/2015	TRM v2.1 update. No revision.
v3.0	4/10/2015	TRM v3.0 update. No revision.
v3.1	11/05/2015	TRM v3.1 update. Provided clarification that savings are to be awarded per showerhead. Supplemented reference for water heater setpoint temperature.
v4.0	10/10/2016	TRM v4.0 update. Updated methodology to calculate energy and demand savings.
v5.0	10/2017	TRM v5.0 update. No revision.
v6.0	11/2018	TRM v6.0 update. No revision.
v7.0	11/2019	TRM v7.0 update. No revision.
v8.0	10/2020	TRM v8.0 update. Added new savings category and updated coincidence factors.
v9.0	10/2021	TRM v9.0 update. Updated EUL reference.

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, multifamily, manufactured

Fuels Affected: Electricity

Decision/Action Type(s): Retrofit

Program Delivery Type(s): Prescriptive

Deemed Savings Type: Deemed savings calculation

Savings Methodology: Engineering algorithms and estimates

Measure Description

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

Eligibility Criteria

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

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

Baseline Condition

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

Table 261. 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) 2018 section N1103.4: Mechanical system piping insulation requires R-3 insulation.

Table 262. 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:

$$\text{kWh}_{Savings} = \left(U_{pre} - U_{post}\right) \times A \times \left(T_{pipe} - T_{ambient\ annual}\right) \times \left(\frac{1}{RE}\right) \times \frac{Hours_{Total}}{\sout{conversion\ factor}3{,}412}$$

Equation 67

Where:

U_{pre}[302] = $\frac{1}{2.03} = 0.49\ {}^{Btu}/_{hr \cdot sq.ft.\cdot °\text{F}}$

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

$\text{R}_{\text{Insulation}}$ = *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:*

[302] 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 263. Estimated Pipe Surface Area

Pipe diameter (inches)	Pipe surface area (square feet)[303]
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*[304]

$T_{ambientannual}$ *(°F)* = *Ambient annual temperature (see Table 264)*

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.*[305]

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

~~*Conversion factor = 3,412 Btu per kWh*~~

Demand Savings Algorithms

$$kW = (U_{pre} - U_{post}) \times A \times (T_{Pipe} - T_{ambient\ seasonal}) \times \left(\frac{1}{RE}\right) \times \frac{CF}{3{,}412 \sim\!\sim conversion\ factor \sim\!\sim}$$

Equation 68

Where:

$T_{ambientseasonal}$*(°F)* = *Ambient seasonal temperature (see Table 264)*

CF= *Coincident peak demand factor, 1*[306]

[303] 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

[304] 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.

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

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

Table 264. Ambient Temperatures per Climate Zone

Climate zone		Ambient temperature (°F)					
		Water heater location: unconditioned space[307]			Water heater location: Conditioned Space[308]		
		Annual	Peak seasonal		Annual	Peak seasonal	
			Summer	Winter		Summer	Winter
1	Panhandle	65.5	106	32	71.8	73.9	69.6
2	North	73.1	108.1	42			
3	South	76.3	108.2	46			
4	Valley	78.4	103	55			
5	West	71.8	108	41.1			

Deemed Energy Savings Tables

There are no lookup tables available for this measure. See engineering algorithms in the previous section for calculating energy and demand savings.

Deemed Summer Demand Savings Tables

There are no lookup tables available for this measure. See engineering algorithms in the previous section for calculating energy and demand savings.

Deemed Winter Demand Savings Tables

There are no lookup tables available for this measure. See engineering algorithms in the previous section for calculating energy and demand savings.

Claimed Peak Demand Savings

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

Additional Calculators and Tools

Not applicable.

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

[308] Average ambient temperatures for conditioned space were taken from the U.S. Energy Information Administration Residential Energy Consumption Survey (RECS), tables hc7.9 and hc6.8. Summer and winter indoor temperature averages are weighted by the number of homes. Annual temperature is the average of summer and winter weighted by number of days.

Measure Life and Lifetime Savings

The estimated useful life (EUL) is 13 years, as specified in the California Database of Energy Efficiency Resources (DEER) READI tool for EUL ID WtrHt-WH-PipeIns-Elec.[309] ~~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).[310]~~

Program Tracking Data and Evaluation Requirements

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

- Climate zone
- The 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

Not applicable.

[309] DEER READI (Remote Ex-Ante Database Interface). http://www.deeresources.com/index.php/readi.
[310] ~~2014 California Database for Energy Efficiency Resources. http://www.deeresources.com.~~

Document Revision History

Table 265. Residential 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 setpoint temperature.
v4.0	10/10/2016	TRM v4.0 update. No revision.
v5.0	10/2017	TRM v5.0 update. No revision.
v6.0	11/2018	TRM v6.0 update. No revision.
v7.0	11/2019	TRM v7.0 update. No revision.
v8.0	10/2020	TRM v8.0 update. Updated ambient temperatures.
v9.0	10/2021	TRM v9.0 update. Updated EUL reference.

2.4.4 Water Heater Tank Insulation Measure Overview

TRM Measure ID: R-WH-TI

Market Sector: Residential

Measure Category: Water Heating

Applicable Building Types: Single-family, multifamily, manufactured

Fuels Affected: Electricity

Decision/Action Type(s): Retrofit

Program Delivery Type(s): Prescriptive

Deemed Savings Type: Deemed savings calculation

Savings Methodology: Engineering algorithms and estimates

Measure Description

This measure requires the installation of tank insulation on uninsulated 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. To be awarded these deemed savings, the fuel type of the water heater must be electricity.

Baseline Condition

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

High-Efficiency Condition

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

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Energy Savings Algorithms

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

$$kWh_{Saving} = (U_{pre} - U_{post}) \times A \times (T_{tank} - T_{ambient\ annual}) \times \left(\frac{1}{RE}\right) \times \frac{Hours_{Total}}{\sout{conversion\ factor}3{,}412}$$

Equation 69

Where:

U_{pre} = *1/ (5) Btu/hr sq.ft. °F*[311]

U_{post} = *1/ (5+*$R_{Insulation}$*) Btu/hr sq.ft. °F*

$R_{Insulation}$ = *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 266.*

Table 266. Estimated Tank Area[312]

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

T_{tank}*(°F)* = *Average temperature of the tank, default use 120°F* [313]

$T_{ambientannual}$ *(°F)* = *Ambient annual temperature (see Table 267)*

[311] Baseline storage tank assembly is assumed to have thermal performance of R5.

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

[313] 120°F represents the assumed water heater setpoint. New York Department of Public Service recommends using water heater setpoint as a default value, see "New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs" October 2010, page 99.
Data collection discussed in Appendix D of the EM&V team's Annual Statewide Portfolio Report for Program Year 2014-Volume 1, Project Number 40891 (August 2015), supports a default value of 120°F.

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.*[314]

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

~~*Conversion factor = 3,412 Btu per kWh*~~

Demand Savings Algorithms

$$Tank\ Insulation\ Demand\ Savings\ (kW) = (U_{pre} - U_{post}) \times A \times (T_{Tank} - T_{ambient\ seasonal}) \times \frac{1}{RE} \times \frac{CF}{3{,}412 \sim\sim conversion\ factor \sim\sim}$$

Equation 70

Where:

$T_{ambientseasonal}$(°F) = *Ambient seasonal temperature (see Table 267)*

CF = *Peak coincidence factor*[315] *= 1*

Table 267. Ambient Temperatures per Climate Zone

		Ambient temperature (°F)					
		Water heater location: unconditioned space[316]			Water heater location: conditioned space[317]		
			Peak seasonal			Peak seasonal	
	Climate zone	Annual	Summer	Winter	Annual	Summer	Winter
1	Panhandle	65.5	106	32	71.8	73.9	69.6
2	North	73.1	108.1	42			
3	South	76.3	108.2	46			
4	Valley	78.4	103	55			
5	West	71.8	108	41.1			

Deemed Energy Savings Tables

There are no lookup tables available for this measure. See engineering algorithms in the previous section for calculating energy and demand savings.

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

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

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

[317] Average ambient temperatures for conditioned space were taken from the U.S. Energy Information Administration Residential Energy Consumption Survey (RECS), tables hc7.9 and hc6.8. Summer and winter indoor temperature averages are weighted by the number of homes. Annual temperature is the average of summer and winter weighted by number of days.

Deemed Summer Demand Savings Tables

There are no lookup tables available for this measure. See engineering algorithms in the previous section for calculating energy and demand savings.

Deemed Winter Demand Savings Tables

There are no lookup tables available for this measure. See engineering algorithms in the previous section for calculating energy and demand savings.

Claimed Peak Demand Savings

Refer to Volume 1, Section 4

Additional Calculators and Tools

Not applicable.

Measure Life and Lifetime Savings

The estimated useful life (EUL) is 7 years, as specified in the California Database of Energy Efficiency Resources (DEER) READI tool for EUL ID WtrHt-TankIns-Elec.[318] ~~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).[319]~~

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
- 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
- Water heater manufacture date

[318] DEER READI (Remote Ex-Ante Database Interface). http://www.deeresources.com/index.php/readi.
[319] ~~2014 California Database for Energy Efficiency Resources. http://www.deeresources.com.~~

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

Not applicable.

Document Revision History

Table 268. Residential 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 setpoint temperature.
v4.0	10/10/2016	TRM v4.0 update. No revision.
v5.0	10/2017	TRM v5.0 update. No revision.
v6.0	11/2018	TRM v6.0 update. No revision.
v7.0	11/2019	TRM v7.0 update. No revision.
v8.0	10/2020	TRM v8.0 update. Updated ambient temperatures.
v9.0	10/2021	TRM v9.0 update. Updated EUL reference.

2.4.5 Water Heater Installations—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, multifamily manufactured

Fuels Affected: Electricity and gas

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

Program Delivery Type(s): Prescriptive

Deemed Savings Type: Deemed savings calculation

Savings Methodology: Engineering algorithms and estimates

Measure Description

This measure involves installing a new electric tankless or gas-fueled water heater (storage or tankless) in place of an electric storage water heater.[320]

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

[320] 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.