

Deemed Winter Demand Savings Tables

Table 162 through Table 166 present the winter demand savings associated with the Insulation Improvement component of the Attic Encapsulation Measure 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 162 through Table 168 by a factor of 0.24.²⁷⁰

Table 162. Attic Encapsulation—Climate Zone 1: Amarillo, R-30 Winter Peak Demand Savings for Insulation Component (kW/sq. ft.)

Ceiling insulation base R-value	Gas	Electric resistance	Heat pump
< R-5	4.25E-05	9.75E-04	8.00E-04
R-5 to R-8	2.51E-05	8.74E-04	4.53E-04
R-9 to R-14	1.37E-05	4.56E-04	2.38E-04
R-15 to R-22	4.72E-06	1.95E-04	1.01E-04

Table 163. Attic Encapsulation—Climate Zone 2: Dallas, R-30 Winter Peak Demand Savings for Insulation Component (kW/sq. ft.)

Ceiling insulation base R-value	Gas	Electric resistance	Heat pump
< R-5	3.50E-05	1.30E-03	8.25E-04
R-5 to R-8	2.79E-05	9.84E-04	6.60E-04
R-9 to R-14	1.45E-05	5.13E-04	3.51E-04
R-15 to R-22	6.42E-06	2.23E-04	1.52E-04

Table 164. Attic Encapsulation—Climate Zone 3: Houston, R-30 Winter Peak Demand Savings for Insulation Component (kW/sq. ft.)

Ceiling insulation base R-value	Gas	Electric resistance	Heat pump
< R-5	4.25E-05	1.15E-03	6.75E-04
R-5 to R-8	2.91E-05	7.71E-04	4.49E-04
R-9 to R-14	1.39E-05	4.01E-04	2.35E-04
R-15 to R-22	5.36E-06	1.74E-04	1.03E-04

²⁷⁰ 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 $10,200 \div 42,000 = 0.24$.

Table 165. Attic Encapsulation—Climate Zone 4: Corpus Christi, R-30 Winter Peak Demand Savings for Insulation Component (kW/sq. ft.)

Ceiling insulation base R-value	Gas	Electric resistance	Heat pump
< R-5	2.50E-05	8.25E-04	4.50E-04
R-5 to R-8	2.18E-05	6.31E-04	3.03E-04
R-9 to R-14	1.13E-05	3.28E-04	1.57E-04
R-15 to R-22	5.71E-06	1.44E-04	6.95E-05

Table 166. Attic Encapsulation—Zone 5: El Paso, R-30 Winter Peak Demand Savings for Insulation Component (kW/sq. ft.)

Ceiling insulation base R-value	Gas	Electric resistance	Heat pump
< R-5	2.25E-05	5.75E-04	2.25E-04
R-5 to R-8	1.14E-05	3.72E-04	1.57E-04
R-9 to R-14	5.38E-06	1.79E-04	7.54E-05
R-15 to R-22	2.26E-06	7.41E-05	3.11E-05

Scale-Down/Up Factors for Demand Reduction: Insulation to Below or Above R-30

The factors presented in this section are to be used when the average post-retrofit insulation depth is providing more or less than R-30 insulation. Scale-down factors are provided for the case when average post-retrofit insulation depth is not sufficient to achieve R-30; scale-up factors are provided for the case when insulating to a level greater than R-30. In either case, the following equation should be applied to scale down or scale up the summer peak demand savings.

$$Peak\ Demand\ Savings\ [\Delta kW] = \{R30\ Savings/ft^2 + [S_{D/U} \times (R_{Achieved} - 30)]\} \times A$$

Equation 67

Where:

$R30\ Savings/ft^2$ = Sum of project-appropriate deemed Cooling and Heating Energy Savings per square feet taken from Table 155 through Table 159 or Table 162 through Table 166

$S_{D/U}$ = Project-appropriate scale-down or scale-up factor from either Table 160 and Table 161 (summer) or Table 167 and Table 168 (winter)

If the roof deck and attic walls are insulated to a level less than R-30, the following factors shall be applied to scale down the achieved winter peak demand savings (per square foot of treated ceiling area).

Table 167. Attic Encapsulation—Winter Peak Demand Scale-down Factors for Insulating to Less than R-30 (kW/sq. ft./ΔR)

Climate zone	Gas	Electric resistance	Heat pump
Zone 1: Amarillo	4.29E-07	1.21E-05	6.30E-06
Zone 2: Dallas	3.97E-07	1.40E-05	9.55E-06
Zone 3: Houston	3.05E-07	1.10E-05	6.53E-06
Zone 4: Corpus Christi	3.19E-07	9.18E-06	4.32E-06
Zone 5: El Paso	4.29E-07	1.21E-05	6.30E-06

If the roof deck/attic walls are insulated to a level greater than R-30, the following factors shall be applied to scale up the achieved winter peak demand savings per square foot of treated ceiling area.

Table 168. Attic Encapsulation—Winter Peak Demand Scale-up Factors for Insulating to Greater than R-30 (kW/sq. ft./ ΔR)

Climate zone	Gas	Electric resistance	Heat pump
Zone 1: Amarillo	2.76E-07	7.85E-06	4.19E-06
Zone 2: Dallas	2.57E-07	8.33E-06	4.80E-06
Zone 3: Houston	2.19E-07	7.33E-06	4.46E-06
Zone 4: Corpus Christi	1.72E-07	5.79E-06	2.72E-06
Zone 5: El Paso	2.76E-07	7.85E-06	4.19E-06

Air Infiltration Reduction Component Savings

Energy and demand savings for the air infiltration reduction component of the attic encapsulation measure are calculated either using the results of pre- and post-retrofit blower door testing or an average percent infiltration reduction. Regardless of how air infiltration reduction component savings are calculated, they should be added to the insulation improvement component savings to arrive at the total energy and demand savings for implementing the Attic Encapsulation measure.

Homes without refrigerated cooling should not claim air infiltration reduction component savings for attic encapsulation.

With Blower Door Testing

Implementers choosing to perform pre- and post-measure blower door testing should claim the air infiltration reduction component deemed energy and demand savings for the Attic Encapsulation measure using the estimated CFM₅₀ reduction from the blower door tests with the equations and coefficients in the Residential Infiltration measure (Measure 2.3.1).

Without Blower Door Testing

Implementers electing not to perform blower door testing when performing this measure shall claim air infiltration reduction component deemed energy and demand savings for the Attic Encapsulation measure using this section, which presents the annual energy (kWh) and summer and winter demand savings (kW) associated with attic encapsulation for the five Texas climate zones, taking into account a mean leakage reduction of 18 percent.²⁷¹ Savings are presented per home.

Savings Algorithms and Input Variables (Infiltration Reduction Component)

Calibrated simulation modeling was used to develop air infiltration reduction deemed savings, which are expressed in Measure 2.3.1 as linear functions of the leakage reduction achieved (in CFM₅₀).²⁷² For details on the derivation of the air infiltration measure savings, refer to the Residential Air Infiltration measure (Measure 2.3.1).

ACCA Manual J provides an average leakage reduction attributable to attic encapsulation projects of 18 percent.²⁷³ Accordingly, deemed savings attributable to the air infiltration reduction component of an attic encapsulation project implemented without pre- and post-implementation blower door testing are estimated by applying an 18 percent leakage reduction to the infiltration rates embedded in the deemed savings prototype model homes used in the derivation of residential envelope measure deemed savings for the Texas TRM. This 18 percent leakage reduction provides the CFM₅₀ reduction input required to estimate air infiltration measure deemed savings with the equations in Measure 2.3.1.

Table 169. Attic Encapsulation—Prototypical Home Characteristics

Shell characteristic	CFM ₅₀ reduction	Source
Air infiltration reduction from attic encapsulation (without blower door testing)	18 percent reduction	Mean reduction achieved via attic encapsulation according to ACCA Manual J, 8 th Edition, Section 21-14 ²⁷⁴

²⁷¹ Section 21-14 of ACCA Manual J states that, "...a foam encapsulated attic eliminates ceiling leakage to the outdoors (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.

²⁷² Model testing indicates a straight-line relationship between demand and energy savings achieved and CFM₅₀ reductions is appropriate with beginning and ending leakage rates within the ranges permitted by the measure.

²⁷³ Air Conditioning Contractors of America. Manual J, 8th Edition Version 2.10. Nov. 2011, p. 188.

²⁷⁴ Section 21-14 of ACCA Manual J states that, "...a foam encapsulated attic eliminates ceiling leakage to the outdoors (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 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 170. Attic Encapsulation—Energy Savings for Infiltration Reduction Component, 18 Percent Air Infiltration Reduction (kWh/home)

Climate zone	Heating type		
	Gas/ no heat	Electric resistance	Heat pump
Zone 1: Amarillo	135.0	874.5	385.8
Zone 2: Dallas	209.2	600.3	315.5
Zone 3: Houston	161.9	469.5	259.6
Zone 4: Corpus Christi	179.7	411.9	262.9
Zone 5: El Paso	64.3	524.7	226.5

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 171. Attic Encapsulation—Summer Peak Demand Savings for Infiltration Reduction Component, 18 Percent Air Infiltration Reduction (kW/home)

Climate zone	Cooling type	
	Refrigerated	Evaporative
Zone 1: Amarillo	0.088	–
Zone 2: Dallas	0.117	–
Zone 3: Houston	0.117	–
Zone 4: Corpus Christi	0.098	–
Zone 5: El Paso	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 172. Attic Encapsulation—Winter Peak Demand Savings for the Infiltration Reduction Component, 18 Percent Air Infiltration Reduction (kW/home)

Climate zone	Heating type		
	Gas/ no heat	Electric resistance	Heat pump
Zone 1: Amarillo	–	0.404	0.235
Zone 2: Dallas	–	0.548	0.304
Zone 3: Houston	–	0.476	0.244
Zone 4: Corpus Christi	–	0.342	0.158
Zone 5: El Paso	–	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:

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

$$\text{Energy Savings, Insulation to } R - 38 =$$

$$\{0.49 + [(4 \times 10^{-3} + 2.97 \times 10^{-4}) \times (38 - 30)]\} \times 900 = 471.9 \text{ kWh}$$

$$\text{Summer Peak Demand Savings, Insulation to } R - 38 =$$

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

$$\text{Winter Peak Demand Savings, Insulation to } R - 38 =$$

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

Infiltration reduction component savings:

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

$$\text{Summer Peak Demand Savings, 18\% Infiltration Reduction} = 0.12 \text{ kW}$$

$$\text{Winter Peak Demand Savings, 18\% Infiltration Reduction} = 0$$

Measure savings:

$$\text{Energy Savings} = 471.9 + 161.9 = 633.8 \text{ kWh}$$

$$\text{Summer Peak Demand Savings} = 0.54 + 0.12 = 0.66 \text{ kW}$$

$$\text{Winter Peak Demand Savings} = 0.03 + 0 = 0.03 \text{ kW}$$

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 CFM₅₀ reduction in leakage rate.

Insulation component savings:

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

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

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

Infiltration reduction component savings:

$$\text{Energy Savings, 750 CFM}_{50} \text{ Infiltration Reduction} = 750 \times (0.39 \times 1 + 0.21) = 450 \text{ kWh}$$

$$\begin{aligned} \text{Summer Peak Demand Savings, 750 CFM}_{50} \text{ Infiltration Reduction} = \\ 750 \times (2.24 \times 10^{-4} \times 1) = 0.17 \text{ kW} \end{aligned}$$

$$\begin{aligned} \text{Winter Peak Demand Savings, 750 CFM}_{50} \text{ Infiltration Reduction} = \\ 750 \times (3.60 \times 10^{-4}) = 0.27 \text{ kW} \end{aligned}$$

Measure savings:

$$\text{Energy Savings} = 372 + 450 = 822 \text{ kWh}$$

$$\text{Summer Peak Demand Savings} = 0.21 + 0.17 = 0.38 \text{ kW}$$

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

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),²⁷⁵ 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

Primary inputs and contextual data that should 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

²⁷⁵ 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

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

Document Revision History

Table 173. 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.
v10.0	10/2022	TRM v10.0 update. No revision.

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 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.²⁷⁶ Space heating primarily refers to electric baseboard zonal heaters controlled by thermostats or to portable plug-load heaters.²⁷⁷ 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 ft² · °F · hr/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 174.

Table 174. 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 section found in the Air Infiltration section of this document. This requirement applies to retrofits implemented under the HTR and RSOP programs.

²⁷⁶ Electric Resistance Heating: <https://www.energy.gov/energysaver/home-heating-systems/electric-resistance-heating>.

²⁷⁷ 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 175. Wall Insulation—Prototypical Home Characteristics

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 176 through Table 179 by a factor of 0.6. 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 176 through Table 179 by a factor of 0.24.²⁷⁸

²⁷⁸ 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 $10,200 \div 42,000 = 0.24$.

2x4 Walls

Table 176 presents the deemed energy savings values for insulating 2x4 walls to R-13 for all five Texas climate zones.

Table 176. Wall Insulation—Energy Savings (kWh/sq. ft.), Insulation of 2x4 Walls to R- 13

Climate zone	Baseline R-value	Cooling savings		Heating savings		
		Refrigerated	Evaporative	Gas	Electric resistance	Heat pump
Zone 1: Amarillo	Uninsulated	0.50	0.17	0.18	3.96	1.67
Zone 2: Dallas		0.85	–	0.09	2.44	0.99
Zone 3: Houston		0.90	–	0.07	1.67	0.66
Zone 4: Corpus Christi		0.53	–	0.04	1.19	0.45
Zone 5: El Paso		0.76	0.29	0.09	2.40	0.98
Zone 1: Amarillo	R-4	0.18	0.06	0.07	1.52	0.64
Zone 2: Dallas		0.32	–	0.04	0.93	0.38
Zone 3: Houston		0.33	–	0.03	0.64	0.25
Zone 4: Corpus Christi		0.19	–	0.01	0.45	0.17
Zone 5: El Paso		0.28	0.11	0.03	0.92	0.37

Table 177 presents the deemed energy savings values for insulating 2x4 walls to R-21 for all five Texas climate zones.

Table 177. Wall Insulation—Energy Savings (kWh/sq. ft.), Insulation of 2x4 Walls to R-21

Climate zone	Baseline R-value	Cooling savings		Heating savings		
		Refrigerated	Evaporative	Gas	Electric resistance	Heat pump
Zone 1: Amarillo	Uninsulated	0.56	0.18	0.20	4.44	1.87
Zone 2: Dallas		0.95	–	0.10	2.73	1.11
Zone 3: Houston		1.01	–	0.08	1.88	0.74
Zone 4: Corpus Christi		0.59	–	0.04	1.33	0.50
Zone 5: El Paso		0.85	0.33	0.10	2.69	1.09
Zone 1: Amarillo	R-4	0.24	0.08	0.09	2.00	0.84
Zone 2: Dallas		0.42	–	0.05	1.23	0.50
Zone 3: Houston		0.43	–	0.03	0.84	0.33
Zone 4: Corpus Christi		0.26	–	0.02	0.59	0.22
Zone 5: El Paso		0.37	0.14	0.05	1.20	0.49

2x6 Walls

Table 178 presents the deemed energy savings values for insulating 2x6 walls to R-17 for all five Texas climate zones.

Table 178. Wall Insulation—Energy Savings (kWh/sq. ft.), Insulation of 2x6 Walls to R-17

Climate zone	Baseline R-value	Cooling savings		Heating Savings		
		Refrigerated	Evaporative	Gas	Electric resistance	Heat pump
Zone 1: Amarillo	Uninsulated	0.53	0.18	0.19	4.27	1.80
Zone 2: Dallas		0.91	–	0.10	2.63	1.07
Zone 3: Houston		0.97	–	0.08	1.81	0.71
Zone 4: Corpus Christi		0.56	–	0.04	1.27	0.48
Zone 5: El Paso		0.81	0.31	0.10	2.58	1.05
Zone 1: Amarillo	R-4	0.22	0.07	0.08	1.81	0.76
Zone 2: Dallas		0.38	–	0.04	1.11	0.45
Zone 3: Houston		0.39	–	0.03	0.76	0.30
Zone 4: Corpus Christi		0.23	–	0.02	0.53	0.20
Zone 5: El Paso		0.33	0.13	0.04	1.08	0.44

Table 179 presents the deemed energy savings values for insulating 2x6 walls to R-33 for all five Texas climate zones.

Table 179. Wall Insulation—Energy Savings (kWh/sq. ft.), Insulation of 2x6 Walls to R-33

Climate zone	Baseline R-value	Cooling savings		Heating savings		
		Refrigerated	Evaporative	Gas	Electric resistance	Heat pump
Zone 1: Amarillo	Uninsulated	0.59	0.20	0.22	4.79	2.01
Zone 2: Dallas		1.01	–	0.11	2.94	1.20
Zone 3: Houston		1.07	–	0.09	2.02	0.80
Zone 4: Corpus Christi		0.62	–	0.04	1.42	0.54
Zone 5: El Paso		0.90	0.35	0.11	2.88	1.17
Zone 1: Amarillo	R-4	0.28	0.09	0.11	2.33	0.98
Zone 2: Dallas		0.48	–	0.05	1.42	0.58
Zone 3: Houston		0.49	–	0.04	0.98	0.38
Zone 4: Corpus Christi		0.29	–	0.02	0.67	0.25
Zone 5: El Paso		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 180 through Table 183 by a factor of 0.6.

2x4 Walls

Table 180 presents the deemed summer demand savings values for insulating 2x4 walls to R-13 for all five Texas climate zones.

**Table 180. Wall Insulation—Summer Peak Demand Savings (kW/sq. ft.),
Insulation of 2x4 Walls to R-13**

Climate zone	Baseline R-value	Cooling type	
		Refrigerated	Evaporative
Zone 1: Amarillo	Uninsulated	6.41E-04	2.40E-04
Zone 2: Dallas		7.32E-04	–
Zone 3: Houston		8.50E-04	–
Zone 4: Corpus Christi		4.17E-04	–
Zone 5: El Paso		6.52E-04	2.00E-04
Zone 1: Amarillo	R-4	2.35E-04	9.16E-05
Zone 2: Dallas		2.70E-04	–
Zone 3: Houston		3.02E-04	–
Zone 4: Corpus Christi		1.55E-04	–
Zone 5: El Paso		2.43E-04	7.40E-05

Table 181 presents the deemed summer demand savings values for insulating 2x4 walls to R-13 for all five Texas climate zones.

**Table 181. Wall Insulation—Summer Peak Demand Savings,
Insulation of 2x4 Walls to R-21 (kW/sq. ft.)**

Climate zone	Baseline R-value	Cooling type	
		Refrigerated	Evaporative
Zone 1: Amarillo	Uninsulated	7.34E-04	2.66E-04
Zone 2: Dallas		8.16E-04	–
Zone 3: Houston		9.55E-04	–
Zone 4: Corpus Christi		4.69E-04	–
Zone 5: El Paso		7.32E-04	2.23E-04

Climate zone	Baseline R-value	Cooling type	
		Refrigerated	Evaporative
Zone 1: Amarillo	R-4	3.29E-04	1.18E-04
Zone 2: Dallas		3.55E-04	–
Zone 3: Houston		4.08E-04	–
Zone 4: Corpus Christi		2.07E-04	–
Zone 5: El Paso		3.24E-04	9.68E-05

2x6 Walls

Table 182 presents the deemed summer demand savings values for insulating 2x6 walls to R-17 for all five Texas climate zones.

Table 182. Wall Insulation—Summer Peak Demand Savings (kW/sq. ft.), Insulation of 2x6 Walls to R-17

Climate zone	Baseline R-value	Cooling type	
		Refrigerated	Evaporative
Zone 1: Amarillo	Uninsulated	8.00E-04	2.59E-04
Zone 2: Dallas		7.87E-04	–
Zone 3: Houston		9.20E-04	–
Zone 4: Corpus Christi		4.56E-04	–
Zone 5: El Paso		8.06E-04	2.14E-04
Zone 1: Amarillo	R-4	2.88E-04	1.06E-04
Zone 2: Dallas		3.19E-04	–
Zone 3: Houston		3.67E-04	–
Zone 4: Corpus Christi		1.88E-04	–
Zone 5: El Paso		2.91E-04	8.44E-05

Table 183 presents the deemed summer demand savings values for insulating 2x6 walls to R-33 for all five Texas climate zones.

Table 183. Wall Insulation—Summer Peak Demand Savings (kW/sq. ft.), Insulation of 2x6 Walls to R-33

Climate zone	Baseline R-value	Cooling type	
		Refrigerated	Evaporative
Zone 1: Amarillo	Uninsulated	7.76E-04	2.83E-04
Zone 2: Dallas		8.77E-04	–
Zone 3: Houston		1.02E-03	–
Zone 4: Corpus Christi		5.08E-04	–
Zone 5: El Paso		7.80E-04	2.38E-04
Zone 1: Amarillo	R-4	3.64E-04	1.30E-04
Zone 2: Dallas		4.09E-04	–
Zone 3: Houston		4.64E-04	–
Zone 4: Corpus Christi		2.40E-04	–
Zone 5: El Paso		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 184 through Table 187 by a factor of 0.24.²⁷⁹

²⁷⁹ 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 $10,200 \div 42,000 = 0.24$.

2x4 Walls

Table 184 presents the deemed winter demand savings values for insulating 2x4 walls to R-13 for all five Texas climate zones.

**Table 184. Wall Insulation—Winter Peak Demand Savings (kW/sq. ft.),
Insulation of 2x4 Walls to R-13**

Climate zone	Baseline R-value	Gas	Electric resistance	Heat pump
Zone 1: Amarillo	Uninsulated	6.93E-05	1.71E-03	8.78E-04
Zone 2: Dallas		6.66E-05	1.96E-03	1.30E-03
Zone 3: Houston		7.49E-05	1.48E-03	8.39E-04
Zone 4: Corpus Christi		4.28E-05	1.22E-03	5.78E-04
Zone 5: El Paso		2.06E-05	6.78E-04	2.84E-04
Zone 1: Amarillo	R-4	2.58E-05	6.20E-04	3.19E-04
Zone 2: Dallas		2.46E-05	7.32E-04	4.94E-04
Zone 3: Houston		2.61E-05	5.50E-04	3.20E-04
Zone 4: Corpus Christi		1.61E-05	4.51E-04	2.13E-04
Zone 5: El Paso		6.23E-06	2.23E-04	9.39E-05

Table 185 presents the deemed winter demand savings values for insulating 2x4 walls to R-21 for all five Texas climate zones.

**Table 185. Wall Insulation—Winter Peak Demand Savings (kW/sq. ft.),
Insulation of 2x4 Walls to R-17**

Climate zone	Baseline R-value	Gas	Electric resistance	Heat pump
Zone 1: Amarillo	Uninsulated	7.69E-05	1.89E-03	9.75E-04
Zone 2: Dallas		7.41E-05	2.18E-03	1.46E-03
Zone 3: Houston		8.19E-05	1.65E-03	9.40E-04
Zone 4: Corpus Christi		4.78E-05	1.36E-03	6.41E-04
Zone 5: El Paso		2.24E-05	7.37E-04	3.10E-04
Zone 1: Amarillo	R-4	3.34E-05	8.06E-04	4.16E-04
Zone 2: Dallas		3.20E-05	9.57E-04	6.50E-04
Zone 3: Houston		3.31E-05	7.19E-04	4.21E-04
Zone 4: Corpus Christi		2.11E-05	5.88E-04	2.77E-04
Zone 5: El Paso		8.01E-06	2.83E-04	1.20E-04

2x6 Walls

Table 186 presents the deemed winter demand savings values for insulating 2x6 walls to R-17 for all five Texas climate zones.

**Table 186. Wall Insulation—Winter Peak Demand Savings (kW/sq. ft.),
Insulation of 2x6 Walls to R-17**

Climate zone	Baseline R-value	Gas	Electric resistance	Heat pump
Zone 1: Amarillo	Uninsulated	6.99E-05	1.76E-03	9.09E-04
Zone 2: Dallas		7.01E-05	2.07E-03	1.40E-03
Zone 3: Houston		7.86E-05	1.57E-03	9.10E-04
Zone 4: Corpus Christi		4.58E-05	1.29E-03	6.08E-04
Zone 5: El Paso		1.84E-05	6.24E-04	2.64E-04
Zone 1: Amarillo	R-4	2.68E-05	6.93E-04	3.58E-04
Zone 2: Dallas		2.84E-05	8.49E-04	5.84E-04
Zone 3: Houston		2.96E-05	6.40E-04	3.82E-04
Zone 4: Corpus Christi		1.90E-05	5.19E-04	2.41E-04
Zone 5: El Paso		5.59E-06	2.06E-04	8.81E-05

Table 187 presents the deemed winter demand savings values for insulating 2x6 walls to R-33 for all five Texas climate zones.

**Table 187. Wall Insulation—Winter Peak Demand Savings (kW/sq. ft.),
Insulation of 2x6 Walls to R-33**

Climate zone	Baseline R-value	Gas	Electric resistance	Heat pump
Zone 1: Amarillo	Uninsulated	7.66E-05	1.95E-03	1.00E-03
Zone 2: Dallas		7.77E-05	2.31E-03	1.56E-03
Zone 3: Houston		8.62E-05	1.75E-03	1.02E-03
Zone 4: Corpus Christi		5.11E-05	1.43E-03	6.73E-04
Zone 5: El Paso		1.96E-05	6.66E-04	2.82E-04
Zone 1: Amarillo	R-4	3.35E-05	8.76E-04	4.53E-04
Zone 2: Dallas		3.60E-05	1.08E-03	7.44E-04
Zone 3: Houston		3.72E-05	8.17E-04	4.92E-04
Zone 4: Corpus Christi		2.43E-05	6.59E-04	3.06E-04
Zone 5: El Paso		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.

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

$$\text{Summer Peak Demand Savings} = 2.40 \times 10^{-4} \times 750 = 0.18 \text{ kW}$$

$$\text{Winter Peak Demand Savings} = 1.71 \times 10^{-3} \times 750 = 1.28 \text{ kW}$$

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.

$$\text{Energy Savings} = (0.56 + 0.04) \times 500 = 300.0 \text{ kWh}$$

$$\text{Summer Peak Demand Savings} = 4.56 \times 10^{-4} \times 500 = 0.23 \text{ kW}$$

$$\text{Winter Peak Demand Savings} = 4.58 \times 10^{-5} \times 500 = 0.02 \text{ kW}$$

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), 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

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

Document Revision History

Table 188. 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.
v10.0	10/2022	TRM v10.0 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 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.²⁸⁰ Space heating primarily refers to electric baseboard zonal heaters controlled by thermostats or to portable plug-load heaters.²⁸¹ 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.

²⁸⁰ Electric Resistance Heating: <https://www.energy.gov/energysaver/home-heating-systems/electric-resistance-heating>.

²⁸¹ Portable Heaters: <https://www.energy.gov/energysaver/home-heating-systems/portable-heaters>.

Table 189. 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 190 through Table 194 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 190 through Table 194 by a factor of 0.6. 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 190 through Table 194 by a factor of 0.24.²⁸²

Table 190. Floor Insulation—Climate Zone 1: Amarillo, Energy Savings (kWh/sq. ft.)

Home type	Cooling savings		Heating savings	
	Refrigerated	Evaporative	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

Table 191. Floor Insulation—Climate Zone 2: Dallas, Energy Savings (kWh/sq. ft.)

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

²⁸² 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 $10,200 \div 42,000 = 0.24$.

Table 192. Floor Insulation—Climate Zone 3: Houston, Energy Savings (kWh/sq. ft.)

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

Table 193. Floor Insulation—Climate Zone 4: Corpus Christi, Energy Savings (kWh/sq. ft.)

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

Table 194. Floor Insulation—Climate Zone 5: El Paso, Energy Savings (kWh/sq. ft.)

Home type	Cooling savings		Heating savings	
	Refrigerated	Evaporative	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 195 through Table 199 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 195 through Table 199 by a factor of 0.6.

Table 195. Floor Insulation—Climate Zone 1: Amarillo, Summer Peak Demand Savings (kW/sq. ft.)

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

Table 196. Floor Insulation—Climate Zone 2: Dallas, Summer Peak Demand Savings (kW/sq. ft.)

Home type	Refrigerated	Evaporative
Site-built home	3.10E-05	–
Manufactured home	2.75E-05	–

Table 197. Floor Insulation—Climate Zone 3: Houston, Summer Peak Demand Savings (kW/sq. ft.)

Home type	Refrigerated	Evaporative
Site-built home	3.36E-05	–
Manufactured home	2.77E-05	–

Table 198. Floor Insulation—Climate Zone 4: Corpus Christi, Summer Peak Demand Savings (kW/sq. ft.)

Home type	Refrigerated	Evaporative
Site-built home	3.58E-05	–
Manufactured home	3.07E-05	–

Table 199. Floor Insulation—Climate Zone 5: El Paso, Summer Peak Demand Savings (kW/sq. ft.)

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

Deemed Winter Demand Savings Tables

Table 200 through Table 204 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 200 through Table 204 by a factor of 0.24.²⁸³

Table 200. Floor Insulation—Climate Zone 1: Amarillo, Winter Peak 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

Table 201. Floor Insulation—Climate Zone 2: Dallas, Winter Peak 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

²⁸³ 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 $10,200 \div 42,000 = 0.24$.

Table 202. Floor Insulation—Climate Zone 3: Houston, Winter Peak 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 203. Floor Insulation—Climate Zone 4: Corpus Christi, Winter Peak 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 204. Floor Insulation—Climate Zone 5: El Paso, Winter Peak 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.

$$\text{Energy Savings} = (-0.06 + 0.97) \times 500 = 455.0 \text{ kWh}$$

$$\text{Summer Peak Demand Savings} = 1.85 \times 10^{-7} \times 500 = 0.00 \text{ kW}$$

$$\text{Winter Peak Demand Savings} = 3.19 \times 10^{-4} \times 500 = 0.16 \text{ kW}$$

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

$$\text{Energy Savings} = (-0.12 + 0.38) \times 825 = 214.5 \text{ kWh}$$

$$\text{Summer Peak Demand Savings} = 3.10 \times 10^{-5} \times 825 = 0.03 \text{ kW}$$

$$\text{Winter Peak Demand Savings} = 2.88 \times 10^{-4} \times 825 = 0.24 \text{ kW}$$

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), 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

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

Document Revision History

Table 205. 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.
v10.0	10/2022	TRM v10.0 update. No revision.

2.3.6 Radiant Barriers Measure Overview

TRM Measure ID: R-BE-RB

Market Sector: Residential, low-income, and hard-to-reach

Measure Category: Building envelope

Applicable Building Types: Single-family, multifamily, manufactured

Fuels Affected: Electricity

Decision/Action Type(s): Retrofit

Program Delivery Type(s): Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: Building simulation modeling

Measure Description

Radiant barriers are a highly reflective material designed to block radiant heat transfer between a roof and attic space insulation. They typically consist of a metallic foil material (usually aluminum) and are generally installed on the roof decking or beneath roof sheathing. Radiant barriers are most effective at reducing cooling consumption by reflecting heat away from a home.

Eligibility Criteria

This measure is only applicable to retrofit applications. All radiant barriers should be installed according to the Reflective Insulation Manufacturers Association International (RIMA-I) Handbook, Section 7.4.²⁸⁴ However, horizontal installation is not eligible due to the potential of moisture/dust accumulation and wear-and-tear damage to the radiant barrier that may negatively impact product performance.

A radiant barrier cannot be in contact with any other materials on its underside. Therefore, once a radiant barrier is installed on the roof decking, no additional roof deck insulation can be installed. However, additional insulation may still be added where it is not in contact (e.g., attic floor).

A study performed by RIMA-I found that none of the coating-type products currently on the market had an emittance of 0.10 or lower as required by the standards set by the American Society for Testing and Materials (ASTM) for a product to be considered a radiant barrier.²⁸⁵ Therefore, interior radiation control coatings are ineligible to use this measure.

²⁸⁴ RIMA-I Handbook. <https://rimainternational.org/wp-content/uploads/2011/01/HandbookAll-2014-Final-1.pdf>.

²⁸⁵ "Radiant Barrier and STS Interior Coatings," RIMA International. <https://rimainternational.org/technical/ircc/>.

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 heat pump to claim heating savings. Customers who participate in hard-to-reach (HTR) or low-income (LI) programs are eligible to claim reduced cooling savings for homes cooled by one or more room air conditioners by applying an adjustment to deemed savings that are specified for homes with central refrigerated air. Customers participating in HTR or LI programs are also eligible to claim reduced heating savings for homes heated with electric resistance space heaters by applying an adjustment to deemed savings that are specified for that heat type.

Baseline Condition

The baseline condition is defined as a residence with no existing radiant barrier installed on roof decking.

High-Efficiency Condition

The high efficiency condition is defined as a radiant barrier installed on roof decking. The radiant barrier must be compliant with the standards set by RIMA-I, including proper attic ventilation. A list of verified products is available on the RIMA-I website.²⁸⁶

Table 206. Radiant Barriers—RIMA-I Product Testing Requirements²⁸⁷

Physical property	Test method or standard	Requirement
Surface emittance	ASTM C 1371	0.1 or less
Water vapor transmission	ASTM E 96 Procedure A desiccant method	0.02 for vapor retarder; 0.5 or greater for perforated products
Surface burning		
Flame spread	ASTM E 84	25 or less
Smoke density	ASTM E 84	450 or less
Corrosivity	ASTM D 3310	Corrosion on less than two percent of the affected surface
Tear resistance	ASTM D 2261	N/A
Adhesive performance		
Bleeding	Section 10.1 of ASTM C 1313	Bleeding of delamination of less than two percent of the surface area
Pliability	Section 10.2 of ASTM C 1313	No cracking or delamination
Mold and mildew	ASTM C 1338	No growth when visually examined under 5x magnification
Tensile strength	ASTM D 2261	Report tearing strength in machine direction and cross direction

²⁸⁶ RIMA International verified products. <https://rimainternational.org/verify/>.

²⁸⁷ RIMA International Product Testing Requirements. <https://rimainternational.org/technical/testing/>.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

This measure references deemed savings from the Arkansas Technical Reference Manual (TRM) v9.0 where calibrated simulation modeling was used to develop these deemed savings.²⁸⁸ Specifically, these deemed savings estimates were developed using BEopt, running EnergyPlus as the underlying simulation engine. Since radiant barrier savings are sensitive to weather, savings were modeled using typical meteorological year (TMY) 3 weather data.

Arkansas savings were mapped to Texas climate zones by comparing cooling and heating degree days developed using TMY data. Since TMY3 data is no longer accessible through the National Solar Radiation Database (NSRDB) Viewer, degree days were compared using TMY 2020 weather data.²⁸⁹

Degree day ratios were derived by dividing Texas cooling and heating degree days by the closest degree day match among Arkansas climate zones. These ratios were multiplied against corresponding Arkansas TRM deemed savings yielding savings values adjusted for Texas climate. The resulting ratios are specified in Table 207.

Table 207. Radiant Barriers—Cooling and Heating Adjustment Factors (AF)²⁹⁰

Climate zone	Cooling AF	Heating AF
Zone 1: Amarillo	0.95	1.02
Zone 2: Dallas	1.06	0.88
Zone 3: Houston	1.12	0.56
Zone 4: Corpus Christi	1.44	0.27
Zone 5: El Paso	0.99	0.99

Deemed Energy Demand Savings Tables

Table 208 through Table 212 present the energy savings (kWh) in the five Texas climate zones per square foot of ceiling area over conditioned space directly below an unconditioned attic where the radiant barrier is installed. Annual energy savings are the sum of cooling and heating savings for the appropriate equipment types.

²⁸⁸ Arkansas Public Service Commission. AR TRM v9.0.
<http://www.apscservices.info/EEInfo/TRMV9.0.pdf>.

²⁸⁹ NSRDB Viewer: <https://nsrdb.nrel.gov/>.

²⁹⁰ These adjustment factors were multiplied against respective cooling and heating savings from the Arkansas TRM v9.0 Radiant Barriers measure. The cooling factor for Amarillo was applied against Arkansas Climate Zone 8 (Fort Smith), and the heating factor for Amarillo was applied against Arkansas Climate Zone 9 (Fayetteville). Factors for all remaining TX climate zones were applied against savings for Arkansas Climate Zone 6 (El Dorado).

For customers who participate in HTR or 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 208 through Table 212 by a factor of 0.6. 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 208 through Table 212 by a factor of 0.24.²⁹¹

Table 208. Radiant Barriers—Climate Zone 1: Amarillo, Energy Savings (kWh/sq. ft.)

Radiant barrier with existing ceiling insulation base R-value	Cooling savings	Heating savings		
	Refrigerated air	Gas	Electric resistance	Heat pump
≤ R-19	0.2234	0.0072	0.2099	0.1106
> R-19	0.1350	0.0031	0.0962	0.0573

Table 209. Radiant Barriers—Climate Zone 2: Dallas, Energy Savings (kWh/sq. ft.)

Radiant barrier with existing ceiling insulation base R-value	Cooling savings	Heating savings		
	Refrigerated air	Gas	Electric resistance	Heat pump
≤ R-19	0.2887	0.0044	0.1449	0.0334
> R-19	0.1777	0.0026	0.0676	0.0132

Table 210. Radiant Barriers—Climate Zone 3: Houston, Energy Savings (kWh/sq. ft.)

Radiant barrier with existing ceiling insulation base R-value	Cooling savings	Heating savings		
	Refrigerated air	Gas	Electric resistance	Heat pump
≤ R-19	0.3046	0.0028	0.0916	0.0211
> R-19	0.1874	0.0017	0.0427	0.0083

²⁹¹ This factor was derived based on expected capacity reduction assuming 1,200 sq. ft. (historical analysis of HTR participants) x 0.35 BTU/sq. ft. = 42,000 BTU for central electric furnaces and two 1,500 W 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. Radiant Barriers—Climate Zone 4: Corpus Christi, Energy Savings (kWh/sq. ft.)

Radiant barrier with existing ceiling insulation base R-value	Cooling savings	Heating savings		
	Refrigerated air	Gas	Electric resistance	Heat pump
≤ R-19	0.3937	0.0013	0.0443	0.0102
> R-19	0.2423	0.0008	0.0207	0.0040

Table 212. Radiant Barriers—Climate Zone 5: El Paso, Energy Savings (kWh/sq. ft.)

Radiant barrier with existing ceiling insulation base R-value	Cooling savings	Heating savings		
	Refrigerated	Gas	Electric resistance	Heat pump
≤ R-19	0.2691	0.0050	0.1636	0.0377
> R-19	0.1656	0.0030	0.0764	0.0149

Deemed Summer Demand Savings Tables

Table 213 presents the summer demand savings (kW) in the five Texas climate zones per square foot of ceiling area over conditioned space directly below an unconditioned attic where the radiant barrier is installed.

For customers who participate in HTR or 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 213 by a factor of 0.6.

Table 213. Radiant Barriers—Summer Peak Demand Savings for Residences with Refrigerated Air (kWh/sq. ft.)

Radiant barrier with existing ceiling insulation base R-value	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
≤ R-19	0.00014	0.00015	0.00016	0.00020	0.00014
> R-19	0.00008	0.00010	0.00010	0.00013	0.00009

Deemed Winter Demand Savings Tables

Winter demand savings are not specified for this measure at this time. They will be added when savings are updated to reflect Texas consumption data.

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

Radiant barriers and other reflective insulation systems have similar lifetime expectations to other attic insulation measures.²⁹² The estimated useful life (EUL) of radiant barriers is 25 years for radiant barriers based on the GDS Associates Measure Life Report value for ceiling insulation.

This value matches lifetime assumptions for radiant barriers from both Oak Ridge National Laboratory (ORNL)²⁹³ and National Renewable Energy Laboratory (NREL).²⁹⁴

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 (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
- Baseline R-value of existing ceiling insulation (\leq R-19, $>$ R-19)
- Square footage of treated attic area above conditioned space
- Manufacturer and product name/model number

References and Efficiency Standards

Petitions and Rulings

Not applicable.

Relevant Standards and Reference Sources

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

²⁹² US Department of Energy (DOE) Insulation Fact Sheet.

<https://web.ornl.gov/sci/buildings/docs/factSheets/Insulation-FactSheet-2008.pdf>.

²⁹³ “Radiant Barrier: Effect of Radiant Barriers on Heating and Cooling Bills”, ORNL.

<https://web.ornl.gov/sci/buildings/tools/radiant/rb2/>.

²⁹⁴ National Residential Efficiency Measures Database, NREL.

<https://remdb.nrel.gov/measures.php?gId=13&ctId=51>.

Document Revision History

Table 214. Radiant Barriers—Revision History

TRM version	Date	Description of change
v10.0	10/2022	TRM v10.0 origin.

2.3.7 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.²⁹⁵ Space heating primarily refers to electric baseboard zonal heaters controlled by thermostats or to portable plug-load heaters.²⁹⁶ 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 ENERGY STAR roofing products certification program was discontinued effective June 1, 2022.²⁹⁷ Moving forward, installed roofing products will still be required to demonstrate compliance with the previous ENERGY STAR specification below.²⁹⁸

In lieu of the former ENERGY STAR list of qualified products, roofing products must now have a performance rating that is validated by the Cool Roof Rating Council (CRRC)^{299,300} and be listed on the CRRC Rated Roof Products Directory.³⁰¹ This is consistent with the former ENERGY STAR test criteria, which allows for products already participating in the CRRC Product Rating Program³⁰² 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 215.

Table 215. Cool Roofs—ENERGY STAR Specification³⁰³

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

²⁹⁵ Electric Resistance Heating. <https://www.energy.gov/energysaver/home-heating-systems/electric-resistance-heating>.

²⁹⁶ Portable Heaters. <https://www.energy.gov/energysaver/home-heating-systems/portable-heaters>.

²⁹⁷ ENERGY STAR® Roof Products Sunset Decision Memo. <https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Roof%20Products%20Sunset%20Decision%20Memo.pdf>.

²⁹⁸ ENERGY STAR® Program Requirements for Roof Products v2.1. https://www.energystar.gov/ia/partners/product_specs/program_reqs/roofs_prog_req.pdf.

²⁹⁹ CRRC guidance for roof rating alternative to discontinued ENERGY STAR® program. <https://coolroofs.org/documents/CRRC-ENERGY-STAR-Sunset-Info-Sheet-2022-03-07.pdf>.

³⁰⁰ CRRC Roof Rating Program. <https://coolroofs.org/programs/roof-rating-program>.

³⁰¹ CRRC Rated Roof Products Directory. <https://coolroofs.org/directory/roof>.

³⁰² CRRC Rated Roof Products Directory: <https://coolroofs.org/directory/roof>.

³⁰³ ENERGY STAR® Roof Products Specification. https://www.energystar.gov/products/building_products/roof_products/key_product_criteria.

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.

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 $\leq 2/12$), 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 CRRRC 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 216.

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 216. 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: $0.15 \leq R < 0.3$ Reflectance $0.3 \leq R < 0.5$ Reflectance $0.5 \leq R < 0.7$ 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

Shell characteristic	Value	Source
Ceiling (attic floor) insulation levels	< R-5 R-5 to R-8 R-9 to R-14 R-15 to R-22 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 217 through Table 221 by a factor of 0.6.

Homes with Ceiling Insulation

Table 217 through Table 221 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.

**Table 217. Cool Roofs—Climate Zone 1: Amarillo,
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	Evaporative	Gas	Electric resistance	Heat pump
Steep slope						
< R-5	0.15 – 0.29	0.03	0.01	0.00	-0.05	-0.02
< R-5	0.3 – 0.49	0.15	0.06	-0.02	-0.26	-0.09
< R-5	0.5 – 0.69	0.27	0.10	-0.03	-0.47	-0.18
< R-5	≥ 0.7	0.40	0.15	-0.06	-0.71	-0.26
R-5 to R-8	0.15 – 0.29	0.02	0.01	0.00	-0.04	-0.01
R-5 to R-8	0.3 – 0.49	0.12	0.04	-0.02	-0.20	-0.07
R-5 to R-8	0.5 – 0.69	0.21	0.08	-0.03	-0.36	-0.14
R-5 to 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
Low slope						
< R-5	0.5 – 0.69	0.30	0.11	-0.04	-0.52	-0.20
< R-5	≥ 0.7	0.43	0.16	-0.06	-0.77	-0.29
R-5 to R-8	0.5 – 0.69	0.23	0.09	-0.03	-0.40	-0.15
R-5 to 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

Ceiling insulation R-value	Installed roof material 3-year reflectance	Cooling savings		Heating savings		
		Refrigerated	Evaporative	Gas	Electric resistance	Heat pump
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

Table 218. Cool Roofs—Climate Zone 2: Dallas, Energy Savings for Residential Reflective Roof Installation (kWh/sq. ft.)

Ceiling insulation R-value	Installed roof material 3-year reflectance	Cooling savings (refrigerated)	Heating savings		
			Gas	Electric resistance	Heat pump
Steep slope					
< R-5	0.15 – 0.29	0.05	0.00	-0.04	-0.01
< R-5	0.3 – 0.49	0.23	-0.01	-0.17	-0.07
< R-5	0.5 – 0.69	0.43	-0.01	-0.32	-0.12
< R-5	≥ 0.7	0.64	-0.02	-0.48	-0.18
R-5 to R-8	0.15 – 0.29	0.04	0.00	-0.03	-0.01
R-5 to R-8	0.3 – 0.49	0.18	-0.01	-0.13	-0.05
R-5 to R-8	0.5 – 0.69	0.34	-0.01	-0.24	-0.09
R-5 to 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
Low slope					
< R-5	0.5 – 0.69	0.47	-0.01	-0.35	-0.13
< R-5	≥ 0.7	0.70	-0.02	-0.53	-0.20
R-5 to R-8	0.5 – 0.69	0.37	-0.01	-0.27	-0.10

Ceiling insulation R-value	Installed roof material 3-year reflectance	Cooling savings (refrigerated)	Heating savings		
			Gas	Electric resistance	Heat pump
R-5 to 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

Table 219. Cool Roofs—Climate Zone 3: Houston, Energy Savings for Residential Reflective Roof Installation (kWh/sq. ft.)

Ceiling insulation R-value	Installed roof material 3-year reflectance	Cooling savings (refrigerated)	Heating savings		
			Gas	Electric resistance	Heat pump
Steep slope					
< R-5	0.15 – 0.29	0.05	0.00	-0.02	-0.01
< R-5	0.3 – 0.49	0.26	0.00	-0.13	-0.05
< R-5	0.5 – 0.69	0.48	-0.01	-0.24	-0.09
< R-5	≥ 0.7	0.71	-0.01	-0.37	-0.13
R-5 to R-8	0.15 – 0.29	0.04	0.00	-0.02	-0.01
R-5 to R-8	0.3 – 0.49	0.20	0.00	-0.10	-0.04
R-5 to R-8	0.5 – 0.69	0.37	-0.01	-0.18	-0.07
R-5 to 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

Ceiling insulation R-value	Installed roof material 3-year reflectance	Cooling savings (refrigerated)	Heating savings		
			Gas	Electric resistance	Heat pump
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
Low slope					
< R-5	0.5 – 0.69	0.54	-0.01	-0.27	-0.10
< R-5	≥ 0.7	0.79	-0.01	-0.41	-0.15
R-5 to R-8	0.5 – 0.69	0.42	-0.01	-0.21	-0.08
R-5 to 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

Table 220. Cool Roofs—Climate Zone 4: Corpus Christi, Energy Savings for Residential Reflective Roof Installation (kWh/sq. ft.)

Ceiling insulation R-value	Installed roof material 3-year reflectance	Cooling savings (refrigerated)	Heating Savings		
			Gas	Electric resistance	Heat pump
Steep slope					
< R-5	0.15 – 0.29	0.04	0.00	-0.01	0.00
< R-5	0.3 – 0.49	0.19	0.00	-0.08	-0.03
< R-5	0.5 – 0.69	0.34	0.00	-0.15	-0.06
< R-5	≥ 0.7	0.50	-0.01	-0.23	-0.08
R-5 to R-8	0.15 – 0.29	0.03	0.00	-0.01	0.00
R-5 to R-8	0.3 – 0.49	0.14	0.00	-0.06	-0.02
R-5 to R-8	0.5 – 0.69	0.26	0.00	-0.11	-0.04
R-5 to 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

Ceiling insulation R-value	Installed roof material 3-year reflectance	Cooling savings (refrigerated)	Heating Savings		
			Gas	Electric resistance	Heat pump
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
Low slope					
< R-5	0.5 – 0.69	0.37	0.00	-0.17	-0.07
< R-5	≥ 0.7	0.54	-0.01	-0.25	-0.09
R-5 to R-8	0.5 – 0.69	0.28	0.00	-0.13	-0.05
R-5 to 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

Table 221. Cool Roofs—Climate Zone 5: El Paso, 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	Evaporative	Gas	Electric resistance	Heat pump
Steep slope						
< R-5	0.15 – 0.29	0.05	0.02	0.00	-0.05	-0.02
< R-5	0.3 – 0.49	0.27	0.10	-0.01	-0.26	-0.09
< R-5	0.5 – 0.69	0.50	0.19	-0.02	-0.49	-0.19
< R-5	≥ 0.7	0.74	0.29	-0.04	-0.77	-0.29
R-5 to R-8	0.15 – 0.29	0.04	0.02	0.00	-0.04	-0.01
R-5 to R-8	0.3 – 0.49	0.21	0.08	-0.01	-0.20	-0.07
R-5 to R-8	0.5 – 0.69	0.39	0.15	-0.02	-0.38	-0.14
R-5 to R-8	≥ 0.7	0.58	0.23	-0.03	-0.59	-0.22

Ceiling insulation R-value	Installed roof material 3-year reflectance	Cooling savings		Heating savings		
		Refrigerated	Evaporative	Gas	Electric resistance	Heat pump
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
Low slope						
< R-5	0.5 – 0.69	0.57	0.22	-0.02	-0.56	-0.21
< R-5	≥ 0.7	0.84	0.32	-0.04	-0.88	-0.33
R-5 to R-8	0.5 – 0.69	0.45	0.18	-0.02	-0.44	-0.16
R-5 to 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 222 through Table 226 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.

**Table 222. Cool Roofs—Climate Zone 1: Amarillo,
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	Evaporative	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
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

**Table 223. Cool Roofs—Climate Zone 2: Dallas,
Energy Savings for Residential Reflective Roof Installation (kWh/sq. ft.)**

Roof deck insulation R-value	Installed roof material 3-year reflectance	Cooling savings (refrigerated)	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

Roof deck insulation R-value	Installed roof material 3-year reflectance	Cooling savings (refrigerated)	Heating savings		
			Gas	Electric resistance	Heat pump
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

Table 224. Cool Roofs—Climate Zone 3: Houston, Energy Savings for Residential Reflective Roof Installation (kWh/sq. ft.)

Roof deck insulation R-value	Installed roof material 3-year reflectance	Cooling savings (refrigerated)	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	0.11	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

Roof deck insulation R-value	Installed roof material 3-year reflectance	Cooling savings (refrigerated)	Heating savings		
			Gas	Electric resistance	Heat pump
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

**Table 225. Cool Roofs—Climate Zone 4: Corpus Christi,
Energy Savings for Residential Reflective Roof Installation (kWh/sq. ft.)**

Roof deck insulation R-value	Installed roof material 3-year reflectance	Cooling savings (refrigerated)	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
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

**Table 226. Cool Roofs—Climate Zone 5: El Paso,
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	Evaporative	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 227 through Table 231 by a factor of 0.6.

Homes with Ceiling Insulation

Table 227 through Table 231 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.

**Table 227. Cool Roofs—Climate Zone 1: Amarillo,
Summer Peak 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	Evaporative	Refrigerated	Evaporative
< R-5	0.15 – 0.29	–	–	2.34 x 10 ⁻⁵	1.06 x 10 ⁻⁵
< R-5	0.3 – 0.49	–	–	1.21 x 10 ⁻⁴	6.05 x 10 ⁻⁵
< R-5	0.5 – 0.69	2.50 x 10 ⁻⁴	1.18 x 10 ⁻⁴	2.35 x 10 ⁻⁴	1.06 x 10 ⁻⁴
< R-5	≥ 0.7	3.97 x 10 ⁻⁴	1.94 x 10 ⁻⁴	3.94 x 10 ⁻⁴	1.85 x 10 ⁻⁴
R-5 to R-8	0.15 – 0.29	–	–	1.48 x 10 ⁻⁵	6.69 x 10 ⁻⁶
R-5 to R-8	0.3 – 0.49	–	–	8.09 x 10 ⁻⁵	4.47 x 10 ⁻⁵
R-5 to 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-5 to 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	–	–	6.05 x 10 ⁻⁶	7.93 x 10 ⁻⁶
R-9 to R-14	0.3 – 0.49	–	–	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	–	–	2.30 x 10 ⁻⁶	-8.73 x 10 ⁻⁷
R-15 to R-22	0.3 – 0.49	–	–	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	–	–	-8.06 x 10 ⁻⁷	3.42 x 10 ⁻⁶
R-30	0.3 – 0.49	–	–	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

**Table 228. Cool Roofs—Climate Zone 2: Dallas,
Summer Peak 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-5	0.15 – 0.29	–	3.46 x 10 ⁻⁵
< R-5	0.3 – 0.49	–	1.79 x 10 ⁻⁴
< R-5	0.5 – 0.69	3.63 x 10 ⁻⁴	3.41 x 10 ⁻⁴
< R-5	≥ 0.7	5.36 x 10 ⁻⁴	5.15 x 10 ⁻⁴
R-5 to R-8	0.15 – 0.29	–	2.63 x 10 ⁻⁵
R-5 to R-8	0.3 – 0.49	–	1.36 x 10 ⁻⁴
R-5 to R-8	0.5 – 0.69	2.83 x 10 ⁻⁴	2.64 x 10 ⁻⁴
R-5 to R-8	≥ 0.7	4.10 x 10 ⁻⁴	4.06 x 10 ⁻⁴

Ceiling insulation R-value	Installed roof material 3-year reflectance	Low slope	Steep slope
R-9 to R-14	0.15 – 0.29	–	1.78 x 10 ⁻⁵
R-9 to R-14	0.3 – 0.49	–	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	–	9.26 x 10 ⁻⁶
R-15 to R-22	0.3 – 0.49	–	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	–	1.34 x 10 ⁻⁵
R-30	0.3 – 0.49	–	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

Table 229. Cool Roofs—Climate Zone 3: Houston, Summer Peak 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-5	0.15 – 0.29	–	3.27 x 10 ⁻⁵
< R-5	0.3 – 0.49	–	1.74 x 10 ⁻⁴
< R-5	0.5 – 0.69	3.62 x 10 ⁻⁴	3.56 x 10 ⁻⁴
< R-5	≥ 0.7	5.86 x 10 ⁻⁴	5.48 x 10 ⁻⁴
R-5 to R-8	0.15 – 0.29	–	2.38 x 10 ⁻⁵
R-5 to R-8	0.3 – 0.49	–	1.33 x 10 ⁻⁴
R-5 to R-8	0.5 – 0.69	2.76 x 10 ⁻⁴	2.72 x 10 ⁻⁴
R-5 to R-8	≥ 0.7	4.64 x 10 ⁻⁴	4.28 x 10 ⁻⁴
R-9 to R-14	0.15 – 0.29	–	1.55 x 10 ⁻⁵
R-9 to R-14	0.3 – 0.49	–	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	–	1.75 x 10 ⁻⁵
R-15 to R-22	0.3 – 0.49	–	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	–	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	–	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

Table 230. Cool Roofs—Climate Zone 4: Corpus Christi, Summer Peak 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-5	0.15 – 0.29	–	1.82 x 10 ⁻⁵
< R-5	0.3 – 0.49	–	9.19 x 10 ⁻⁵
< R-5	0.5 – 0.69	1.67 x 10 ⁻⁴	1.66 x 10 ⁻⁴
< R-5	≥ 0.7	2.75 x 10 ⁻⁴	2.69 x 10 ⁻⁴
R-5 to R-8	0.15 – 0.29	–	1.46 x 10 ⁻⁵
R-5 to R-8	0.3 – 0.49	–	6.97 x 10 ⁻⁵
R-5 to R-8	0.5 – 0.69	1.22 x 10 ⁻⁴	1.23 x 10 ⁻⁴
R-5 to R-8	≥ 0.7	2.02 x 10 ⁻⁴	2.01 x 10 ⁻⁴
R-9 to R-14	0.15 – 0.29	–	6.80 x 10 ⁻⁶
R-9 to R-14	0.3 – 0.49	–	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	–	4.71 x 10 ⁻⁶
R-15 to R-22	0.3 – 0.49	–	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	–	2.50 x 10 ⁻⁶
R-30	0.3 – 0.49	–	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

Table 231. Cool Roofs—Climate Zone 5: El Paso, Summer Peak 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	Evaporative	Refrigerated	Evaporative
< R-5	0.15 – 0.29	–	–	3.58 x 10 ⁻⁵	1.28 x 10 ⁻⁵
< R-5	0.3 – 0.49	–	–	1.72 x 10 ⁻⁴	7.49 x 10 ⁻⁵

Ceiling insulation R-value	Installed roof material 3-year reflectance	Low slope		Steep slope	
		Refrigerated	Evaporative	Refrigerated	Evaporative
< R-5	0.5 – 0.69	3.95 × 10 ⁻⁴	1.54 × 10 ⁻⁴	3.44 × 10 ⁻⁴	1.65 × 10 ⁻⁴
< R-5	≥ 0.7	6.15 × 10 ⁻⁴	2.42 × 10 ⁻⁴	5.19 × 10 ⁻⁴	2.20 × 10 ⁻⁴
R-5 to R-8	0.15 – 0.29	–	–	2.72 × 10 ⁻⁵	8.96 × 10 ⁻⁶
R-5 to R-8	0.3 – 0.49	–	–	1.27 × 10 ⁻⁴	6.00 × 10 ⁻⁵
R-5 to R-8	0.5 – 0.69	3.06 × 10 ⁻⁴	1.34 × 10 ⁻⁴	2.59 × 10 ⁻⁴	1.38 × 10 ⁻⁴
R-5 to R-8	≥ 0.7	4.77 × 10 ⁻⁴	2.05 × 10 ⁻⁴	3.97 × 10 ⁻⁴	1.78 × 10 ⁻⁴
R-9 to R-14	0.15 – 0.29	–	–	1.25 × 10 ⁻⁵	9.26 × 10 ⁻⁶
R-9 to R-14	0.3 – 0.49	–	–	8.24 × 10 ⁻⁵	5.30 × 10 ⁻⁵
R-9 to R-14	0.5 – 0.69	2.07 × 10 ⁻⁴	1.00 × 10 ⁻⁴	1.73 × 10 ⁻⁴	8.86 × 10 ⁻⁵
R-9 to R-14	≥ 0.7	3.27 × 10 ⁻⁴	1.44 × 10 ⁻⁴	2.60 × 10 ⁻⁴	1.22 × 10 ⁻⁴
R-15 to R-22	0.15 – 0.29	–	–	6.16 × 10 ⁻⁶	3.73 × 10 ⁻⁶
R-15 to R-22	0.3 – 0.49	–	–	6.18 × 10 ⁻⁵	4.40 × 10 ⁻⁵
R-15 to R-22	0.5 – 0.69	1.50 × 10 ⁻⁴	7.63 × 10 ⁻⁵	1.24 × 10 ⁻⁴	6.49 × 10 ⁻⁵
R-15 to R-22	≥ 0.7	2.42 × 10 ⁻⁴	1.11 × 10 ⁻⁴	1.88 × 10 ⁻⁴	8.86 × 10 ⁻⁵
R-30	0.15 – 0.29	–	–	6.64 × 10 ⁻⁶	5.65 × 10 ⁻⁷
R-30	0.3 – 0.49	–	–	4.77 × 10 ⁻⁵	2.87 × 10 ⁻⁵
R-30	0.5 – 0.69	1.01 × 10 ⁻⁴	5.91 × 10 ⁻⁵	8.81 × 10 ⁻⁵	5.07 × 10 ⁻⁵
R-30	≥ 0.7	1.80 × 10 ⁻⁴	8.50 × 10 ⁻⁵	1.32 × 10 ⁻⁴	6.75 × 10 ⁻⁵

Homes with Roof Deck Insulation

Table 232 through Table 236 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.

Table 232. Cool Roofs—Climate Zone 1: Amarillo, Summer Peak 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	Evaporative	Refrigerated	Evaporative
R-19	0.15 – 0.29	–	–	–	–
R-19	0.3 – 0.49	–	–	2.67 × 10 ⁻⁵	7.62 × 10 ⁻⁶
R-19	0.5 – 0.69	5.56 × 10 ⁻⁵	1.84 × 10 ⁻⁵	5.35 × 10 ⁻⁵	1.55 × 10 ⁻⁵
R-19	≥ 0.7	9.88 × 10 ⁻⁵	7.61 × 10 ⁻⁶	8.81 × 10 ⁻⁵	1.52 × 10 ⁻⁵
R-30	0.15 – 0.29	–	–	3.37 × 10 ⁻⁶	3.42 × 10 ⁻⁶
R-30	0.3 – 0.49	–	–	1.97 × 10 ⁻⁵	7.38 × 10 ⁻⁶

Roof deck insulation R-value	Installed roof material 3-year reflectance	Low slope		Steep slope	
		Refrigerated	Evaporative	Refrigerated	Evaporative
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	–	–	5.82 x 10 ⁻⁶	5.90 x 10 ⁻⁶
R-38	0.3 – 0.49	–	–	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

Table 233. Cool Roofs—Climate Zone 2: Dallas, Summer Peak 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	Refrigerated
R-19	0.15 – 0.29	–	5.45 x 10 ⁻⁵
R-19	0.3 – 0.49	–	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	–	2.22 x 10 ⁻⁵
R-30	0.3 – 0.49	–	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	–	-1.31 x 10 ⁻⁶
R-38	0.3 – 0.49	–	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	4.36 x 10 ⁻⁵	5.45 x 10 ⁻⁵

Table 234. Cool Roofs—Climate Zone 3: Houston, Summer Peak 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	Refrigerated
R-19	0.15 – 0.29	–	–
R-19	0.3 – 0.49	–	–
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	–	-1.46 x 10 ⁻⁶
R-30	0.3 – 0.49	–	2.60 x 10 ⁻⁵

Roof deck insulation R-value	Installed roof material 3-year reflectance	Low slope	Steep slope
		Refrigerated	Refrigerated
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	–	-2.53 x 10 ⁻⁶
R-38	0.3 – 0.49	–	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

Table 235. Cool Roofs—Climate Zone 4: Corpus Christi, Summer Peak 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	Refrigerated
R-19	0.15 – 0.29	–	–
R-19	0.3 – 0.49	–	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	–	3.36 x 10 ⁻⁶
R-30	0.3 – 0.49	–	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	–	5.81 x 10 ⁻⁶
R-38	0.3 – 0.49	–	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

Table 236. Cool Roofs—Climate Zone 5: El Paso, Summer Peak 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	Evaporative	Refrigerated	Evaporative
R-19	0.15 – 0.29	–	–	–	–
R-19	0.3 – 0.49	–	–	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
R-30	0.15 – 0.29	–	–	6.66 x 10 ⁻⁶	1.11 x 10 ⁻⁶
R-30	0.3 – 0.49	–	–	3.01 x 10 ⁻⁵	5.29 x 10 ⁻⁶

Roof deck insulation R-value	Installed roof material 3-year reflectance	Low slope		Steep slope	
		Refrigerated	Evaporative	Refrigerated	Evaporative
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	–	–	1.15 x 10 ⁻⁵	1.91 x 10 ⁻⁶
R-38	0.3 – 0.49	–	–	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 237 through Table 241 by a factor of 0.24.³⁰⁴

Homes with Ceiling Insulation

Table 237 through Table 241 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.

**Table 237. Cool Roofs—Climate Zone 1: Amarillo,
Winter Peak 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	Electric resistance	Heat pump	Gas	Electric resistance	Heat pump
< R-5	0.15 – 0.29	–	–	–	-5.60 x 10 ⁻⁷	-1.18 x 10 ⁻⁵	-5.68 x 10 ⁻⁶
< R-5	0.3 – 0.49	–	–	–	-3.08 x 10 ⁻⁶	-5.83 x 10 ⁻⁵	-2.67 x 10 ⁻⁵
< R-5	0.5 – 0.69	-3.03 x 10 ⁻⁶	-1.14 x 10 ⁻⁴	-5.47 x 10 ⁻⁵	-6.38 x 10 ⁻⁶	-1.06 x 10 ⁻⁴	-4.91 x 10 ⁻⁵
< R-5	≥ 0.7	-1.46 x 10 ⁻⁵	-1.66 x 10 ⁻⁴	-8.19 x 10 ⁻⁵	-2.21 x 10 ⁻⁵	-1.54 x 10 ⁻⁴	-7.28 x 10 ⁻⁵
R-5 to R-8	0.15 – 0.29	–	–	–	-1.01 x 10 ⁻⁶	-9.53 x 10 ⁻⁶	-4.74 x 10 ⁻⁶
R-5 to R-8	0.3 – 0.49	–	–	–	-4.25 x 10 ⁻⁶	-4.66 x 10 ⁻⁵	-2.12 x 10 ⁻⁵
R-5 to 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-5 to 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

³⁰⁴ 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	Electric resistance	Heat pump	Gas	Electric resistance	Heat pump
R-9 to R-14	0.15 – 0.29	–	–	–	-8.59×10^{-7}	-7.63×10^{-6}	-3.69×10^{-6}
R-9 to R-14	0.3 – 0.49	–	–	–	-3.68×10^{-6}	-3.63×10^{-5}	-1.55×10^{-5}
R-9 to R-14	0.5 – 0.69	-1.04×10^{-7}	-7.28×10^{-5}	-3.43×10^{-5}	-1.49×10^{-5}	-6.73×10^{-5}	-3.07×10^{-5}
R-9 to R-14	≥ 0.7	-6.86×10^{-6}	-1.05×10^{-4}	-4.98×10^{-5}	-2.11×10^{-5}	-9.83×10^{-5}	-4.57×10^{-5}
R-15 to R-22	0.15 – 0.29	–	–	–	-8.96×10^{-7}	-5.40×10^{-6}	-2.51×10^{-6}
R-15 to R-22	0.3 – 0.49	–	–	–	-3.85×10^{-6}	-2.60×10^{-5}	-1.08×10^{-5}
R-15 to R-22	0.5 – 0.69	-1.72×10^{-6}	-5.26×10^{-5}	-2.47×10^{-5}	-1.19×10^{-5}	-4.80×10^{-5}	-2.15×10^{-5}
R-15 to R-22	≥ 0.7	-9.72×10^{-7}	-7.65×10^{-5}	-3.64×10^{-5}	-1.44×10^{-5}	-7.05×10^{-5}	-3.23×10^{-5}
R-30	0.15 – 0.29	–	–	–	-8.09×10^{-7}	-3.58×10^{-6}	-1.64×10^{-6}
R-30	0.3 – 0.49	–	–	–	-1.08×10^{-5}	-1.73×10^{-5}	-7.31×10^{-6}
R-30	0.5 – 0.69	-5.10×10^{-6}	-3.52×10^{-5}	-1.58×10^{-5}	-1.54×10^{-5}	-3.12×10^{-5}	-1.36×10^{-5}
R-30	≥ 0.7	-3.71×10^{-6}	-5.35×10^{-5}	-2.58×10^{-5}	-2.10×10^{-5}	-4.64×10^{-5}	-2.11×10^{-5}

Table 238. Cool Roofs—Climate Zone 2: Dallas, Winter Peak 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	Electric resistance	Heat pump	Gas	Electric resistance	Heat pump
< R-5	0.15 – 0.29	–	–	–	2.40×10^{-6}	-1.29×10^{-5}	-6.63×10^{-6}
< R-5	0.3 – 0.49	–	–	–	-2.62×10^{-8}	-6.19×10^{-5}	-3.24×10^{-5}
< R-5	0.5 – 0.69	-2.83×10^{-6}	-1.48×10^{-4}	-7.24×10^{-5}	-1.44×10^{-6}	-1.19×10^{-4}	-6.06×10^{-5}
< R-5	≥ 0.7	-6.02×10^{-6}	-2.17×10^{-4}	-1.07×10^{-4}	-4.75×10^{-6}	-1.81×10^{-4}	-9.06×10^{-5}
R-5 to R-8	0.15 – 0.29	–	–	–	4.57×10^{-6}	-1.03×10^{-5}	-5.30×10^{-6}
R-5 to R-8	0.3 – 0.49	–	–	–	1.59×10^{-6}	-4.70×10^{-5}	-2.68×10^{-5}
R-5 to R-8	0.5 – 0.69	-3.36×10^{-6}	-1.19×10^{-4}	-5.69×10^{-5}	1.19×10^{-6}	-9.33×10^{-5}	-4.88×10^{-5}
R-5 to R-8	≥ 0.7	-3.79×10^{-6}	-1.74×10^{-4}	-8.66×10^{-5}	-4.46×10^{-6}	-1.43×10^{-4}	-7.18×10^{-5}
R-9 to R-14	0.15 – 0.29	–	–	–	-7.26×10^{-7}	-8.09×10^{-6}	-3.86×10^{-6}
R-9 to R-14	0.3 – 0.49	–	–	–	-2.92×10^{-6}	-4.23×10^{-5}	-2.03×10^{-5}
R-9 to R-14	0.5 – 0.69	-1.29×10^{-5}	-9.30×10^{-5}	-4.31×10^{-5}	-3.26×10^{-6}	-7.90×10^{-5}	-3.76×10^{-5}
R-9 to R-14	≥ 0.7	-1.27×10^{-5}	-1.41×10^{-4}	-6.53×10^{-5}	-7.53×10^{-6}	-1.19×10^{-4}	-5.52×10^{-5}
R-15 to R-22	0.15 – 0.29	–	–	–	3.23×10^{-7}	-5.84×10^{-6}	-2.76×10^{-6}
R-15 to R-22	0.3 – 0.49	–	–	–	-1.95×10^{-6}	-3.04×10^{-5}	-1.43×10^{-5}
R-15 to R-22	0.5 – 0.69	-1.48×10^{-5}	-6.81×10^{-5}	-3.23×10^{-5}	-2.74×10^{-6}	-5.69×10^{-5}	-2.66×10^{-5}

Ceiling insulation R-value	Installed roof material 3-year reflectance	Low slope			Steep slope		
		Gas	Electric resistance	Heat pump	Gas	Electric resistance	Heat pump
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
R-30	0.15 – 0.29	–	–	–	-3.74 x 10 ⁻⁷	2.81 x 10 ⁻⁶	8.71 x 10 ⁻⁶
R-30	0.3 – 0.49	–	–	–	-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

Table 239. Cool Roofs—Climate Zone 3: Houston, Winter Peak 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	Electric resistance	Heat pump	Gas	Electric resistance	Heat pump
< R-5	0.15 - 0.29	–	–	–	-7.91 x 10 ⁻⁷	-1.54 x 10 ⁻⁵	-7.77 x 10 ⁻⁶
< R-5	0.3 – 0.49	–	–	–	-3.12 x 10 ⁻⁶	-7.71 x 10 ⁻⁵	-3.90 x 10 ⁻⁵
< R-5	0.5 – 0.69	-3.28 x 10 ⁻⁶	-1.56 x 10 ⁻⁴	-7.95 x 10 ⁻⁵	-6.08 x 10 ⁻⁶	-1.40 x 10 ⁻⁴	-7.09 x 10 ⁻⁵
< R-5	≥ 0.7	-4.78 x 10 ⁻⁶	-2.23 x 10 ⁻⁴	-1.11 x 10 ⁻⁴	-7.97 x 10 ⁻⁶	-2.04 x 10 ⁻⁴	-1.05 x 10 ⁻⁴
R-5 to R-8	0.15 - 0.29	–	–	–	-7.39 x 10 ⁻⁷	-1.25 x 10 ⁻⁵	-6.46 x 10 ⁻⁶
R-5 to R-8	0.3 – 0.49	–	–	–	-2.67 x 10 ⁻⁶	-6.28 x 10 ⁻⁵	-3.05 x 10 ⁻⁵
R-5 to 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-5 to 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	–	–	–	-6.93 x 10 ⁻⁷	-9.35 x 10 ⁻⁶	-4.68 x 10 ⁻⁶
R-9 to R-14	0.3 – 0.49	–	–	–	-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	–	–	–	-7.06 x 10 ⁻⁷	-6.48 x 10 ⁻⁶	-3.22 x 10 ⁻⁶
R-15 to R-22	0.3 – 0.49	–	–	–	-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	–	–	–	-6.32 x 10 ⁻⁷	-4.54 x 10 ⁻⁶	-2.25 x 10 ⁻⁶
R-30	0.3 – 0.49	–	–	–	-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

**Table 240. Cool Roofs—Climate Zone 4: Corpus Christi,
Winter Peak 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	Electric resistance	Heat pump	Gas	Electric resistance	Heat pump
< R-5	0.15 - 0.29	–	–	–	-4.72 x 10 ⁻⁷	-1.47 x 10 ⁻⁵	-6.94 x 10 ⁻⁶
< R-5	0.3 – 0.49	–	–	–	-2.45 x 10 ⁻⁶	-7.36 x 10 ⁻⁵	-3.49 x 10 ⁻⁵
< R-5	0.5 – 0.69	-5.41 x 10 ⁻⁶	-1.51 x 10 ⁻⁴	-7.33 x 10 ⁻⁵	-4.77 x 10 ⁻⁶	-1.34 x 10 ⁻⁴	-6.20 x 10 ⁻⁵
< R-5	≥ 0.7	-7.53 x 10 ⁻⁶	-2.19 x 10 ⁻⁴	-1.02 x 10 ⁻⁴	-7.11 x 10 ⁻⁶	-1.99 x 10 ⁻⁴	-9.32 x 10 ⁻⁵
R-5 to R-8	0.15 - 0.29	–	–	–	-4.02 x 10 ⁻⁷	-1.19 x 10 ⁻⁵	-5.71 x 10 ⁻⁶
R-5 to R-8	0.3 – 0.49	–	–	–	-2.13 x 10 ⁻⁶	-5.99 x 10 ⁻⁵	-2.89 x 10 ⁻⁵
R-5 to 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-5 to 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	–	–	–	-6.35 x 10 ⁻⁷	-8.94 x 10 ⁻⁶	-4.36 x 10 ⁻⁶
R-9 to R-14	0.3 – 0.49	–	–	–	-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	–	–	–	-1.73 x 10 ⁻⁶	-6.16 x 10 ⁻⁶	-2.94 x 10 ⁻⁶
R-15 to R-22	0.3 – 0.49	–	–	–	-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	–	–	–	-1.34 x 10 ⁻⁷	-4.03 x 10 ⁻⁶	-1.87 x 10 ⁻⁶
R-30	0.3 – 0.49	–	–	–	-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

**Table 241. Cool Roofs—Climate Zone 5: El Paso,
Winter Peak 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	Electric resistance	Heat pump	Gas	Electric resistance	Heat pump
< R-5	0.15 - 0.29	–	–	–	-6.68 x 10 ⁻⁷	-2.51 x 10 ⁻⁵	-1.01 x 10 ⁻⁵
< R-5	0.3 – 0.49	–	–	–	-7.29 x 10 ⁻⁶	-1.33 x 10 ⁻⁴	-5.50 x 10 ⁻⁵
< R-5	0.5 – 0.69	-1.53 x 10 ⁻⁵	-2.93 x 10 ⁻⁴	-1.17 x 10 ⁻⁴	-1.34 x 10 ⁻⁵	-2.50 x 10 ⁻⁴	-1.02 x 10 ⁻⁴
< R-5	≥ 0.7	-1.73 x 10 ⁻⁵	-4.44 x 10 ⁻⁴	-1.79 x 10 ⁻⁴	-1.93 x 10 ⁻⁵	-3.82 x 10 ⁻⁴	-1.57 x 10 ⁻⁴
R-5 to R-8	0.15 - 0.29	–	–	–	-2.41 x 10 ⁻⁷	-1.98 x 10 ⁻⁵	-7.98 x 10 ⁻⁶

Ceiling insulation R-value	Installed roof material 3-year reflectance	Low slope			Steep slope		
		Gas	Electric resistance	Heat pump	Gas	Electric resistance	Heat pump
R-5 to R-8	0.3 – 0.49	–	–	–	-4.83 x 10 ⁻⁶	-1.03 x 10 ⁻⁴	-4.14 x 10 ⁻⁵
R-5 to 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-5 to 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	–	–	–	-5.77 x 10 ⁻⁷	-1.35 x 10 ⁻⁵	-5.48 x 10 ⁻⁶
R-9 to R-14	0.3 – 0.49	–	–	–	-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
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	–	–	–	-4.29 x 10 ⁻⁷	-9.41 x 10 ⁻⁶	-4.20 x 10 ⁻⁶
R-15 to R-22	0.3 – 0.49	–	–	–	-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	–	–	–	-2.85 x 10 ⁻⁷	-6.26 x 10 ⁻⁶	-2.54 x 10 ⁻⁶
R-30	0.3 – 0.49	–	–	–	-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 242 through Table 246 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.

Table 242. Cool Roofs—Climate Zone 1: Amarillo, Winter Peak 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	Electric resistance	Heat pump	Gas	Electric resistance	Heat pump
R-19	0.15 - 0.29	–	–	–	–	–	–
R-19	0.3 – 0.49	–	–	–	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	–	–	–	-1.08 x 10 ⁻⁷	-3.00 x 10 ⁻⁶	-1.52 x 10 ⁻⁶
R-30	0.3 – 0.49	–	–	–	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

Roof deck insulation R-value	Installed roof material 3-year reflectance	Low slope			Steep slope		
		Gas	Electric resistance	Heat pump	Gas	Electric resistance	Heat pump
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	–	–	–	-1.87 x 10 ⁻⁷	-5.19 x 10 ⁻⁶	-2.62 x 10 ⁻⁶
R-38	0.3 – 0.49	–	–	–	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

Table 243. Cool Roofs—Climate Zone 2: Dallas, Winter Peak 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	Electric resistance	Heat pump	Gas	Electric resistance	Heat pump
R-19	0.15 - 0.29	–	–	–	–	–	–
R-19	0.3 – 0.49	–	–	–	-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	–	–	–	-7.35 x 10 ⁻⁸	-3.36 x 10 ⁻⁶	-1.70 x 10 ⁻⁶
R-30	0.3 – 0.49	–	–	–	-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	–	–	–	-1.27 x 10 ⁻⁷	-5.81 x 10 ⁻⁶	-2.93 x 10 ⁻⁶
R-38	0.3 – 0.49	–	–	–	-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

Table 244. Cool Roofs—Climate Zone 3: Houston, Winter Peak 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	Electric resistance	Heat pump	Gas	Electric resistance	Heat pump
R-19	0.15 - 0.29	–	–	–	–	–	–
R-19	0.3 – 0.49	–	–	–	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	–	–	–	2.41 x 10 ⁻⁸	-3.94 x 10 ⁻⁶	-2.10 x 10 ⁻⁶

Roof deck insulation R-value	Installed roof material 3-year reflectance	Low slope			Steep slope		
		Gas	Electric resistance	Heat pump	Gas	Electric resistance	Heat pump
R-30	0.3 – 0.49	–	–	–	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	–	–	–	4.96 x 10 ⁻⁸	-6.80 x 10 ⁻⁶	-3.63 x 10 ⁻⁶
R-38	0.3 – 0.49	–	–	–	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

Table 245. Cool Roofs—Climate Zone 4: Corpus Christi, Winter Peak 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	Electric resistance	Heat pump	Gas	Electric resistance	Heat pump
R-19	0.15 - 0.29	–	–	–	–	–	–
R-19	0.3 – 0.49	–	–	–	-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	–	–	–	-1.08 x 10 ⁻⁷	-3.76 x 10 ⁻⁶	-1.77 x 10 ⁻⁶
R-30	0.3 – 0.49	–	–	–	-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	–	–	–	-1.87 x 10 ⁻⁷	-6.50 x 10 ⁻⁶	-3.06 x 10 ⁻⁶
R-38	0.3 – 0.49	–	–	–	-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

Table 246. Cool Roofs—Climate Zone 5: El Paso, Winter Peak 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	Electric resistance	Heat pump	Gas	Electric resistance	Heat pump
R-19	0.15 - 0.29	–	–	–	–	–	–
R-19	0.3 – 0.49	–	–	–	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

Roof deck insulation R-value	Installed roof material 3-year reflectance	Low slope			Steep slope		
		Gas	Electric resistance	Heat pump	Gas	Electric resistance	Heat pump
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	–	–	–	-1.04 x 10 ⁻⁷	-4.45 x 10 ⁻⁶	-1.81 x 10 ⁻⁶
R-30	0.3 – 0.49	–	–	–	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	–	–	–	-1.79 x 10 ⁻⁷	-7.68 x 10 ⁻⁶	-3.13 x 10 ⁻⁶
R-38	0.3 – 0.49	–	–	–	-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.

$$\text{Energy Savings} = (0.26 - 0.01) \times 1500 = 375 \text{ kWh}$$

$$\text{Summer Peak Demand Savings} = 2.03 \times 10^{-4} \times 1500 = 0.30 \text{ kW}$$

$$\text{Winter Peak Demand Savings} = -6.46 \times 10^{-6} \times 1500 = -0.01 \text{ kW}$$

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.

$$\text{Energy Savings} = (0.32 - 0.11) \times 1200 = 252 \text{ kWh}$$

$$\text{Summer Peak Demand Savings} = N/A$$

$$\text{Winter Peak Demand Savings} = -5.96 \times 10^{-5} \times 1200 = -0.07 \text{ kW}$$

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

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.³⁰⁵

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:

- Climate zone
- Insulation R-value (as is, post measure installation of ceiling/roof insulation)
- 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.
- 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

³⁰⁵ DEER READI (Remote Ex-Ante Database Interface). <http://www.deeresources.com/index.php/readi>.

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

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

Document Revision History

Table 247. 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 savings tables for < R-5 baseline category. Updated EUL reference.
v10.0	10/2022	TRM v10.0 update. Addressed sunseting of ENERGY STAR Roof program.

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.³⁰⁶ Space heating primarily refers to electric baseboard zonal heaters controlled by thermostats or to portable plug-load heaters.³⁰⁷ 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-sq. ft.-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.³⁰⁸

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.

³⁰⁶ Electric Resistance Heating: <https://www.energy.gov/energysaver/home-heating-systems/electric-resistance-heating>.

³⁰⁷ Portable Heaters: <https://www.energy.gov/energysaver/home-heating-systems/portable-heaters>.

³⁰⁸ 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, 1/4" 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 percent³⁰⁹ 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.

$$\text{Energy Savings} = (6.09 + (-3.21)) \times 75 = 216 \text{ kWh}$$

$$\text{Summer Peak Demand Savings} = 3.17 \times 10^{-3} \times 75 = 0.24 \text{ kW}$$

$$\text{Winter Peak Demand Savings} = -2.32 \times 10^{-3} \times 75 = -0.17 \text{ kW}$$

Deemed Energy Savings Tables

Table 248 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 248 by a factor of 0.6. 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 248 by a factor of 0.24.³¹⁰

³⁰⁹ Residential Windows – A Guide to New Technologies and Energy Performance, 2000.

³¹⁰ 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 $10,200 \div 42,000 = 0.24$.

Table 248. Solar Screens—Energy Savings (kWh) per Square Foot of Solar Screen

Climate zone	Cooling savings (kWh/sq. ft.)		Heating savings (kWh/sq. ft.)		
	Refrigerated	Evaporative	Gas	Electric resistance	Heat pump
Zone 1: Amarillo	3.67	1.34	-0.62	-12.81	-4.54
Zone 2: Dallas	5.38	-	-0.29	-7.14	-2.56
Zone 3: Houston	5.33	-	-0.16	-4.69	-1.69
Zone 4: Corpus Christi	6.09	-	-0.09	-3.21	-1.16
Zone 5: El Paso	5.62	1.99	-0.44	-10.48	-3.81

Deemed Summer Demand Savings Tables

Table 249 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 249 by a factor of 0.6.

Table 249. Solar Screens—Summer Peak Demand Savings (kW) per Square Foot of Solar Screen

Climate zone	Refrigerated	Evaporative
Zone 1: Amarillo	2.89E-03	1.35E-03
Zone 2: Dallas	3.42E-03	-
Zone 3: Houston	3.29E-03	-
Zone 4: Corpus Christi	3.17E-03	-
Zone 5: El Paso	3.12E-03	1.07E-03

Deemed Winter Demand Savings Tables

Table 250 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 250 by a factor of 0.24.³¹¹

³¹¹ 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 $10,200 \div 42,000 = 0.24$.

Table 250. Solar Screens—Winter Peak Demand Savings (kW) per Square Foot of Solar Screen

Climate zone	Gas	Electric resistance	Heat pump
Zone 1: Amarillo	-1.16E-04	-1.73E-03	-9.45E-04
Zone 2: Dallas	-5.20E-05	-1.32E-03	-7.96E-04
Zone 3: Houston	-1.07E-04	-2.65E-03	-1.71E-03
Zone 4: Corpus Christi	-7.68E-05	-2.32E-03	-1.08E-03
Zone 5: El Paso	-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) is 10 years as specified in the California Database of Energy Efficiency Resources (DEER) READI tool for EUL ID BS-WinFilm.³¹²

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 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

³¹² DEER READI (Remote Ex-Ante Database Interface). <http://www.deeresources.com/index.php/readi>.

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

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

Document Revision History

Table 251. 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.
v9.0	10/2021	TRM v9.0 update. Updated EUL reference.
v10.0	10/2022	TRM v10.0 update. No revision.

2.3.9 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

Replacing existing single- or double-pane windows with ENERGY STAR-compliant windows can help reduce heat transfer through window glazing, minimize air infiltration around window frames, reduce sun ultraviolet damage to household furniture, and lower household energy bills by an average of 12 percent nationwide.³¹³

Window 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 252. A weighted single- and double-pane baseline is also provided, assuming a standard distribution

³¹³ ENERGY STAR Windows, Doors, & Skylights.

https://www.energystar.gov/products/res_windows_doors_skylights.

of 46 percent single-pane and 54 percent double-pane based on 2020 RECS survey data.³¹⁴ This baseline may be used exclusively if applied consistently for all projects.

Electric resistance heating baselines may refer to residences heated by a centralized forced-air furnace or by individual space heaters.³¹⁵ Space heating primarily refers to electric baseboard zonal heaters controlled by thermostats or to portable plug-load heaters.³¹⁶ 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.

Table 252. Windows—Baseline Window Specification

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

High-Efficiency Condition

Performance criteria are based on ratings certified by the National Fenestration Rating Council (NFRC) and vary by location.

The table below displays the ENERGY STAR Final Version 6.0 Requirements for eligible windows, doors, and skylights effective January 1, 2015.³¹⁷ Energy efficiency service providers are expected to comply with the latest ENERGY STAR requirements.

Table 253. Windows—High-Efficiency Requirements effective January 2015

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

³¹⁴ 2020 Residential Energy Consumption Survey (RECS). Structural and geographic characteristics in the South and West regions (HC2.8). Analysis based on West South-Central census region. <https://www.eia.gov/consumption/residential/data/2020/>.

³¹⁵ Electric Resistance Heating. <https://www.energy.gov/energysaver/home-heating-systems/electric-resistance-heating>.

³¹⁶ Portable Heaters. <https://www.energy.gov/energysaver/home-heating-systems/portable-heaters>.

³¹⁷ ENERGY STAR® Residential Windows, Doors, and Skylights Final Version 6.0 Program Requirements. https://www.energystar.gov/sites/default/files/Windows_Doors_and_Skylights_Program_Requirements%20v6.pdf.

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. Efficiency 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 254.

Table 254. Windows—TRM and ENERGY STAR Climate Zones

Climate zone	US region, ENERGY STAR
Zone 1: Amarillo	North-Central
Zone 2: Dallas	South-Central
Zone 3: Houston	Southern
Zone 4: Corpus Christi	Southern
Zone 5: El Paso	South-Central

Deemed Energy Savings Tables

Table 255 through Table 257 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 255 and Table 257 by a factor of 0.6. 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 deemed heating values by a factor of 0.24.³¹⁸

³¹⁸ 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 $10,200 \div 42,000 = 0.24$.

Table 255. Windows—Energy Savings (kWh/sq. ft.), Single-Pane Baseline

Climate zone	Cooling savings		Heating savings		
	Refrigerated	Evaporative	Gas	Electric resistance	Heat pump
Zone 1: Amarillo	2.83	0.98	0.29	6.70	3.16
Zone 2: Dallas	5.42	–	0.10	3.09	1.45
Zone 3: Houston	5.32	–	0.02	0.77	0.41
Zone 4: Corpus Christi	5.97	–	0.02	0.82	0.34
Zone 5: El Paso	5.67	1.90	0.00	0.99	0.69

Table 256. Windows—Energy Savings (kWh/sq. ft.), Double-Pane Baseline

Climate zone	Cooling savings		Heating savings		
	Refrigerated	Evaporative	Gas	Electric resistance	Heat pump
Zone 1: Amarillo	2.03	0.72	0.18	4.15	2.00
Zone 2: Dallas	4.11	–	0.04	1.47	0.76
Zone 3: Houston	3.96	–	-0.01	-0.21	0.01
Zone 4: Corpus Christi	4.45	–	0.00	-0.01	0.02
Zone 5: El Paso	4.24	1.46	-0.03	-0.18	0.16

Table 257. Windows—Energy Savings (kWh/sq. ft.), Weighted-Pane Baseline

Climate zone	Cooling savings		Heating savings		
	Refrigerated	Evaporative	Gas	Electric resistance	Heat pump
Zone 1: Amarillo	2.40	0.84	0.23	5.33	2.54
Zone 2: Dallas	4.71	–	0.07	2.22	1.08
Zone 3: Houston	4.59	–	–	0.24	0.19
Zone 4: Corpus Christi	5.15	–	0.01	0.37	0.17
Zone 5: El Paso	4.90	1.66	-0.02	0.36	0.40

Deemed Summer Demand Savings Tables

Table 258 through Table 260 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 deemed cooling values by a factor of 0.6.

Table 258. Windows—Summer Peak Demand Savings (kW/sq. ft.), Single-Pane Baseline

Climate zone ^a	Refrigerated	Evaporative
Zone 1: Amarillo	3.09E-03	1.16E-03
Zone 2: Dallas	3.89E-03	–
Zone 3: Houston	3.51E-03	–
Zone 4: Corpus Christi	2.99E-03	–
Zone 5: El Paso	3.86E-03	1.05E-03

Table 259. Windows—Summer Peak Demand Savings (kW/sq. ft.), Double-Pane Baseline

Climate zone	Refrigerated	Evaporative
Zone 1: Amarillo	2.08E-03	8.36E-04
Zone 2: Dallas	2.80E-03	–
Zone 3: Houston	2.40E-03	–
Zone 4: Corpus Christi	2.15E-03	–
Zone 5: El Paso	2.76E-03	8.09E-04

Table 260. Windows—Summer Peak Demand Savings (kW/sq. ft.), Weighted-Pane Baseline

Climate zone:	Refrigerated	Evaporative
Zone 1: Amarillo	2.55E-03	9.86E-04
Zone 2: Dallas	3.30E-03	–
Zone 3: Houston	2.91E-03	–
Zone 4: Corpus Christi	2.54E-03	–
Zone 5: El Paso	3.27E-03	9.20E-04

Deemed Winter Demand Savings Table 261 through Table 263 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 deemed heating values by a factor of 0.24.³¹⁹

³¹⁹ 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 $10,200 \div 42,000 = 0.24$.

Table 261. Windows—Winter Peak Demand Savings (kW/sq. ft.), Single-Pane Baseline

Climate zone	Gas	Electric resistance	Heat pump
Zone 1: Amarillo	2.01E-04	4.98E-03	2.43E-03
Zone 2: Dallas	1.77E-04	4.73E-03	2.74E-03
Zone 3: Houston	6.89E-05	1.78E-03	3.11E-04
Zone 4: Corpus Christi	4.78E-05	1.65E-03	6.68E-04
Zone 5: El Paso	2.83E-05	1.10E-03	5.00E-04

Table 262. Windows—Winter Peak Demand Savings (kW/sq. ft.), Double-Pane Baseline

Climate zone	Gas	Electric resistance	Heat pump
Zone 1: Amarillo	1.32E-04	3.30E-03	1.64E-03
Zone 2: Dallas	1.12E-04	3.16E-03	1.89E-03
Zone 3: Houston	2.33E-05	6.68E-04	3.58E-06
Zone 4: Corpus Christi	1.53E-05	5.62E-04	2.34E-04
Zone 5: El Paso	1.31E-05	5.84E-04	2.76E-04

Table 263. Windows—Winter Peak Demand Savings (kW/sq. ft.), Weighted-Pane Baseline

Climate zone	Gas	Electric resistance	Heat pump
Zone 1: Amarillo	1.64E-04	4.08E-03	2.00E-03
Zone 2: Dallas	4.42E-04	3.88E-03	2.28E-03
Zone 3: Houston	4.44E-05	1.18E-03	1.46E-04
Zone 4: Corpus Christi	3.03E-05	1.06E-03	4.34E-04
Zone 5: El Paso	2.01E-05	8.22E-04	3.79E-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.

$$\text{Energy Savings} = (0.98 + 6.70) \times 125 = 960 \text{ kWh}$$

$$\text{Summer Peak Demand Savings} = 1.16 \times 10^{-3} \times 125 = 0.15 \text{ kW}$$

$$\text{Winter Peak Demand Savings} = 4.98 \times 10^{-3} \times 125 = 0.62 \text{ kW}$$

Example 2. A home in Climate Zone 5 with a central air conditioning unit and a gas furnace replaces 250 square feet of windows with unknown number of panes with ENERGY STAR windows.

$$\text{Energy Demand Savings} = (4.90 + (-0.02)) \times 250 = 1,220 \text{ kWh}$$

$$\text{Summer Peak Demand Savings} = 3.27 \times 10^{-3} \times 250 = 0.82 \text{ kW}$$

$$\text{Winter Peak Demand Savings} = 2.01 \times 10^{-5} \times 250 = 0.01 \text{ kW}$$

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), the Estimated Useful Life is 25 years for ENERGY STAR windows³²⁰.

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:

- 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
- Baseline window number of panes (single, double, weighted)
 - The weighted baseline may be used if applied universally for all projects in a given program during the entire program year.
- 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

³²⁰ “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.

Set of Deemed Savings Estimates. Public Utility Commission of Texas.

- Docket No. 27903. Order Adopting New §25.184 as Approved at the August 21, 2003, Open Meeting and Submitted to the Secretary of State. Public Utility Commission of Texas.

Relevant Standards and Reference Sources

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

Document Revision History

Table 264. 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.
v10.0	10/2022	TRM v10.0 update. Added option for a weighted single-pane and double-pane baseline.

2.3.10 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 low-e 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. A weighted single- and double-pane baseline is also provided, assuming a standard distribution of 46 percent single-pane and 54 percent double-pane based on 2020 RECS survey data.³²¹ This baseline may be used exclusively if applied consistently for all projects.

Electric resistance heating baselines may refer to residences heated by a centralized forced-air furnace or by individual space heaters.³²² Space heating primarily refers to electric baseboard zonal heaters controlled by thermostats or to portable plug-load heaters.³²³ 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

Performance criteria are based on ratings certified by the National Fenestration Rating Council (NFRC) and vary by location.

The table below displays the ENERGY STAR Final Version 1.0 Requirements for eligible exterior and interior storm windows effective September 5, 2018.³²⁴ Energy efficiency service providers are expected to comply with the latest ENERGY STAR requirements.

³²¹ 2020 Residential Energy Consumption Survey (RECS). Structural and geographic characteristics in the South and West regions (HC2.8). Analysis based on West South-Central census region. <https://www.eia.gov/consumption/residential/data/2020/>.

³²² Electric Resistance Heating. <https://www.energy.gov/energysaver/home-heating-systems/electric-resistance-heating>.

³²³ Portable Heaters. <https://www.energy.gov/energysaver/home-heating-systems/portable-heaters>.

³²⁴ ENERGY STAR® Program Requirements Product Specification for Exterior and Interior Storm Windows, v1.0. https://www.energystar.gov/sites/default/files/Storm%20Window%20Product%20Specification_Final_0.pdf.

Table 265. Low-E Storm Windows—ENERGY STAR Requirements

US region, ENERGY STAR®	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.³²⁵ The properties of low-e storm windows used in the RESFEN building models are presented in Table 266. This measure assumes equal weighting between the three low-e storm window glass options.

Table 266. Low-E Storm Windows—Window Assembly Properties³²⁶

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-foot single-story and 2,800 square-foot two-story residence. The modeled residence has a 15 percent window-to-floor-area ratio. Assumed building characteristics are presented in Table 267.

Table 267. 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 ^{327,328}	Single pane: 0.88 U-factor, 0.61 SHGC, 2 cfm/sq. ft. air infiltration Double pane: 0.51 U-factor, 0.57 SHGC, 2 cfm/sq. ft. air infiltration
Existing window area	15 percent of floor area
Existing window frame	Wood double-hung

³²⁵ RESFEN window tool. LBNL. <https://windows.lbl.gov/software/resfen>.

³²⁶ Averaged values from the selected products in Attachments Energy Rating Council (AERC). <https://aercenergyrating.org/product-search/residential-product-search/>.

³²⁷ Culp, TD and KA Cort. “Database of Low-e Storm Window Energy Performance across US Climate Zones.” US DOE, September 2014. https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-22864rev2.pdf.

³²⁸ Air infiltration assumption from: “AERC 1.2: Physical Test Methods for Measuring Energy Performance Properties of Fenestration Attachments.” AERC, 2018. www.aercnet.org.

Characteristic	Model assumption
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 268 through Table 270 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 HTR or LI programs, cooling savings may be claimed for homes cooled by one or more room air conditioners by multiplying appropriate cooling values in Table 268 and Table 270 by a factor of 0.6. 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 deemed heating values by a factor of 0.24.³²⁹

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

Table 268. Low-E Storm Windows—Energy Savings (kWh/sq. ft.), Single-Pane Baseline

Climate zone	Cooling savings	Heating savings		
	Refrigerated	Gas	Electric resistance	Heat pump
Zone 1: Amarillo	1.49	–	15.66	5.34
Zone 2: Dallas	2.52	–	6.65	2.09
Zone 3: Houston	2.49	–	4.55	1.48
Zone 4: Corpus Christi	3.22	–	2.82	0.80
Zone 5: El Paso	2.35	–	6.00	2.06

Table 269. Low-E Storm Windows—Energy Savings (kWh/sq. ft.), Double-Pane Baseline

Climate zone	Cooling savings	Heating savings		
	Refrigerated	Gas	Electric resistance	Heat pump
Zone 1: Amarillo	1.56	–	6.23	2.35
Zone 2: Dallas	2.50	–	2.46	0.88
Zone 3: Houston	2.62	–	1.84	0.67

³²⁹ This factor was derived based on expected capacity reduction assuming 1,200 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 $10,200 \div 42,000 = 0.24$.

Climate zone	Cooling savings	Heating savings		
	Refrigerated	Gas	Electric resistance	Heat pump
Zone 4: Corpus Christi	3.21	–	1.05	0.32
Zone 5: El Paso	2.37	–	1.90	0.79

Table 270. Low-E Storm Windows—Energy Savings (kWh/sq. ft.), Weighted-Pane Baseline

Climate zone	Cooling savings	Heating savings		
	Refrigerated	Gas	Electric resistance	Heat pump
Zone 1: Amarillo	1.53	–	10.58	3.73
Zone 2: Dallas	2.51	–	4.39	1.44
Zone 3: Houston	2.56	–	3.09	1.04
Zone 4: Corpus Christi	3.21	–	1.87	0.54
Zone 5: El Paso	2.36	–	3.79	1.38

Deemed Summer Demand Savings Tables

Table 271 through Table 273 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 deemed cooling values by a factor of 0.6.

Table 271. Low-E Storm Windows—Summer Peak Demand Savings (kW/sq. ft.), Single-Pane Baseline

Climate zone	Refrigerated air
Zone 1: Amarillo	0.0016
Zone 2: Dallas	0.0018
Zone 3: Houston	0.0016
Zone 4: Corpus Christi	0.0016
Zone 5: El Paso	0.0016

Table 272. Low-E Storm Windows—Summer Peak Demand Savings (kW/sq. ft.), Double-Pane Baseline

Climate zone	Refrigerated air
Zone 1: Amarillo	0.0016
Zone 2: Dallas	0.0017
Zone 3: Houston	0.0016
Zone 4: Corpus Christi	0.0016
Zone 5: El Paso	0.0015

Table 273. Low-E Storm Window—Summer Peak Demand Savings (kW/sq. ft.), Weighted-Pane Baseline

Climate zone	Refrigerated air
Zone 1: Amarillo	0.0016
Zone 2: Dallas	0.0017
Zone 3: Houston	0.0016
Zone 4: Corpus Christi	0.0016
Zone 5: El Paso	0.0015

Deemed Winter Demand Savings Tables

Table 274 through Table 276 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 deemed heating values by a factor of 0.24.³³⁰

Table 274. Low-E Storm Windows—Winter Peak Demand Savings (kW/sq. ft.), Single-Pane Baseline

Climate zone	Gas	Electric resistance	Heat pump
Zone 1: Amarillo	–	0.0116	0.0041
Zone 2: Dallas	–	0.0102	0.0039
Zone 3: Houston	–	0.0105	0.0011
Zone 4: Corpus Christi	–	0.0057	0.0016
Zone 5: El Paso	–	0.0067	0.0015

³³⁰ This factor was derived based on expected capacity reduction assuming 1,200 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 $10,200 \div 42,000 = 0.24$.

**Table 275. Low-E Storm Windows—Peak Demand Savings (kW/sq. ft.),
Double-Pane Baseline**

Climate zone	Gas	Electric resistance	Heat pump
Zone 1: Amarillo	–	0.0050	0.0019
Zone 2: Dallas	–	0.0053	0.0022
Zone 3: Houston	–	0.0039	0.0002
Zone 4: Corpus Christi	–	0.0019	0.0037
Zone 5: El Paso	–	0.0035	0.0014

**Table 276. Low-E Storm Windows—Winter Peak Demand Savings (kW/sq. ft.),
Weighted-Pane Baseline**

Climate zone	Gas	Electric resistance	Heat pump
Zone 1: Amarillo	–	0.0080	0.0029
Zone 2: Dallas	–	0.0076	0.0030
Zone 3: Houston	–	0.0069	0.0006
Zone 4: Corpus Christi	–	0.0037	0.0027
Zone 5: El Paso	–	0.0050	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 US Department of Energy.³³¹

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:

- Climate zone

³³¹ Culp, TD and KA Cort. “Database of Low-e Storm Window Energy Performance across US Climate Zones.” US DOE, September 2014.

https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-22864rev2.pdf.

- 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
- Baseline window number of panes (single, double, weighted)
 - The weighted baseline may be used if applied universally for all projects in a given program during the entire program year.
- 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

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

Document Revision History

Table 277. Low-E Storm Windows—Revision History

TRM version	Date	Description of change
v9.0	10/2021	TRM v9.0 origin.
v10.0	10/2022	TRM v10.0 update. Added option for a weighted single-pane and double-pane baseline.

2.4 RESIDENTIAL: WATER HEATING

2.4.1 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.³³²

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.

³³² 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.

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.

Baseline Condition

This baseline applies to replace-on-burnout, early retirement, and new construction.

For most installations, the baseline condition is an electric storage water heater with baseline efficiency determined by tank size according to the amended federal energy efficiency standards for residential water heaters with tank sizes from 20 to 120 gallons, which took effect April 16, 2015, as published in 10 CFR Part 430.32 of the Federal Register (see Table 278).³³³

Table 278. DHW Replacements—Federal Standard for Residential Electric Storage Water Heaters

Rated storage volume	Draw pattern	First hour rating (FHR) ^{334,335}	Uniform energy factor (UEF) ³³⁶
≥ 20 gal and ≤ 55 gal	Very small usage	$0 \leq \text{FHR} < 18$	$0.8808 - (0.0008 \times V_r)$
	Low usage	$18 \leq \text{FHR} < 51$	$0.9254 - (0.0003 \times V_r)$
	Medium usage	$51 \leq \text{FHR} < 75$	$0.9307 - (0.0002 \times V_r)$
	High usage	$75 \leq \text{FHR}$	$0.9349 - (0.0001 \times V_r)$
> 55 gal and ≤ 120 gal	Very small usage	$0 \leq \text{FHR} < 18$	$1.9236 - (0.0011 \times V_r)$
	Low usage	$18 \leq \text{FHR} < 51$	$2.0440 - (0.0011 \times V_r)$
	Medium usage	$51 \leq \text{FHR} < 75$	$2.1171 - (0.0011 \times V_r)$
	High usage	$75 \leq \text{FHR}$	$2.2418 - (0.0011 \times V_r)$

The new DOE efficiency standard effectively requires HPWHs (assuming electric water heating) for electric storage water heaters with tank size greater than 55 gallons. As such, electric water heaters with tanks greater than 55 gallons are not eligible for this measure. Instead, see the *heat pump water heater* measure. Furthermore, gas water heaters greater than 55 gallons must use HPWH baseline consumption to calculate savings.

For smaller systems, the baseline technology remains an electric storage water heater with electric resistance as the primary heat source.

³³³ 10 CFR Part 430.32 Energy and water conservation standards and their effective dates. Available online: https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=32.

³³⁴ “The Revised Method of Test for Residential Water Heating and Its Impact on Incentive Programs” presentation, Glanville, Paul. ACEEE Hot Water Forum. February 24, 2015. <https://aceee.org/sites/default/files/pdf/conferences/hwf/2015/6B-Glanville.pdf>.

³³⁵ Assume FHR equal to that of installed water heater.

³³⁶ V_r is the rated storage volume (in gallons), as determined pursuant to 10 CFR 429.17.

High-Efficiency Condition

For water heater replacement and fuel substitution, the new unit must meet the following federal minimum energy factor shown in Table 279. Water heaters must be installed in accordance with local code requirements.

Table 279. DHW Replacements—Efficiency Standards³³⁷

DHW type	Rated storage volume	Draw pattern	FHR	UEF ³³⁸
Electric tankless ³³⁹	< 2 gal	Very small usage	$0 \leq \text{FHR} < 18$	0.91
		Low usage	$18 \leq \text{FHR} < 51$	0.91
		Medium usage	$51 \leq \text{FHR} < 75$	0.91
		High usage	$75 \leq \text{FHR}$	0.92
Gas tankless	< 2 gal and > 50,000 Btuh	Very small usage	$0 \leq \text{FHR} < 18$	0.80
		Low usage	$18 \leq \text{FHR} < 51$	0.81
		Medium usage	$51 \leq \text{FHR} < 75$	0.81
		High usage	$75 \leq \text{FHR}$	0.81
Gas storage	≥ 20 gal and ≤ 55 gal	Very small usage	$0 \leq \text{FHR} < 18$	$0.3456 - (0.0020 \times V_r)$
		Low usage	$18 \leq \text{FHR} < 51$	$0.5982 - (0.0019 \times V_r)$
		Medium usage	$51 \leq \text{FHR} < 75$	$0.6483 - (0.0017 \times V_r)$
		High usage	$75 \leq \text{FHR}$	$0.6920 - (0.0013 \times V_r)$
	> 55 gal and ≤ 100 gal	Very small usage	$0 \leq \text{FHR} < 18$	$0.6470 - (0.0006 \times V_r)$
		Low usage	$18 \leq \text{FHR} < 51$	$0.7689 - (0.0005 \times V_r)$
		Medium usage	$51 \leq \text{FHR} < 75$	$0.7897 - (0.0004 \times V_r)$
		High usage	$75 \leq \text{FHR}$	$0.8072 - (0.0003 \times V_r)$

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

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

³³⁷ 10 CFR Part 430.32 Energy and water conservation standards. Available online:

https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=32.

³³⁸ V_r is the rated storage volume (in gallons), as determined pursuant to 10 CFR 429.17.

³³⁹ There is no ENERGY STAR tankless water heater category because all products perform at or near the federal standard. These units are still eligible to claim savings against the *electric storage water heater* baseline if FHR and UEF can be verified using manufacturer specification sheets or other documentation.

Electric Tankless Water Heater

Energy Savings Algorithm

$$\text{Energy Savings } [\Delta kWh] = \frac{\rho \times C_p \times GPY \times (T_{\text{setpoint}} - T_{\text{supply,avg}}) \times \left(\frac{1}{UEF_{\text{pre}}} - \frac{1}{UEF_{\text{post}}} \right)}{3,412}$$

Equation 68

Where:

- ρ = Water density [lbs/gal] = 8.33
- C_p = Specific heat of water [Btu/lb·°F] = 1
- GPY = Estimated annual hot water use in gallons/year, specified by number of bedrooms in the home (see Table 280)

Table 280. DHW Replacements—Water Heater Consumption (Gal/Year)³⁴⁰

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

- T_{setpoint} = Water heater setpoint temperature [°F]³⁴¹ = 120
- $T_{\text{supply,avg}}$ = Average annual supply water temperature [°F] (see Table 281)
- UEF_{pre} = Baseline uniform energy factor (see Table 279)³⁴²
- UEF_{post} = Uniform energy factor of new water heater (see Table 279)
- 3,412 = Constant to convert from Btu to kWh

³⁴⁰ Building America Research Benchmark Definition. December 2009, p 13. Available online: <http://www.nrel.gov/docs/fy10osti/47246.pdf>.

³⁴¹ 120°F represents the assumed water heater setpoint. The New York Department of Public Service recommends using the water heater setpoint as a default value, see “New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs.” Page 99. October 2010. The data collection discussed in Appendix D of the EM&V team’s Annual Statewide Portfolio Report for Program Year 2014-Volume 1, Project Number 40891 (August 2015) also supports a default value of 120°F.

³⁴² Note that for efficient water heater installations in newly-constructed homes, the baseline energy factor is the efficiency of the electric storage water heater that would otherwise have been installed, according to appropriate design documentation.

Table 281. DHW Replacements—Water Mains Temperature (°F)³⁴³

Climate zone	T _{supply,avg}	T _{supply,seasonal}	
		Summer	Winter
Zone 1: Amarillo	62.9	73.8	53.7
Zone 2: Dallas	71.8	84.0	60.6
Zone 3: Houston	74.7	84.5	65.5
Zone 4: Corpus Christi	77.2	86.1	68.5
Zone 5: El Paso	70.4	81.5	60.4

Demand Savings Algorithm

Peak Demand Savings [ΔkW]

$$= \frac{\rho \times C_p \times GPY \times (T_{setpoint} - T_{supply,w}) \times \left(\frac{1}{UEF_{pre}} - \frac{1}{UEF_{post}} \right)}{365 \times 3,412} \times CF_{S/W}$$

Equation 69

Where:

$CF_{S/W}$ = Summer/winter peak coincidence factor (see Table 282)

$T_{supply,seasonal}$ = Seasonal supply water temperature [°F] (see Table 281)

Table 282. DHW Replacements—Coincidence Factors³⁴⁴

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

³⁴³ Based on typical meteorological year (TMY) 3 dataset for TMY3, available through the National Solar Radiation Database (NSRDB) Data Viewer. <https://nsrdb.nrel.gov/data-viewer>. Data for Texas climate zones can also be accessed directly here: <https://texasefficiency.com/index.php/regulatory-filings/deemed-savings>.

³⁴⁴ Probability weighted peak load factors are calculated according to the method in Section 4 of the Texas TRM Vol 1 using data from Building America Performance Analysis Procedures for Existing Homes, page 18, Figure 4: Combined Domestic Hot Water Use Profile. <https://www.nrel.gov/docs/fy06osti/38238.pdf>.

Gas Storage or Tankless Water Heater (Fuel Substitution)

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

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

Energy Savings Algorithm for Units Less than 55 Gallons

$$\text{Energy Savings } [\Delta kWh] = \frac{\rho \times C_p \times GPY \times (T_{\text{setpoint}} - T_{\text{supply,annual}}) \times \left(\frac{1}{UEF_{\text{pre}}}\right)}{3,412}$$

Equation 70

Demand Savings Algorithm for Units Less than 55 Gallons

$$\begin{aligned} \text{Summer Peak Demand Savings } [\Delta kW] \\ = CF_S \times \frac{\rho \times C_p \times GPY \times (T_{\text{setpoint}} - T_{\text{supply,summer}}) \times \left(\frac{1}{UEF_{\text{pre}}}\right)}{365 \times 3,412} \end{aligned}$$

Equation 71

$$\begin{aligned} \text{Winter Peak Demand Savings } [\Delta kW] \\ = CF_W \times \frac{\rho \times C_p \times GPY \times (T_{\text{setpoint}} - T_{\text{supply,winter}}) \times \left(\frac{1}{UEF_{\text{pre}}}\right)}{365 \times 3,412} \end{aligned}$$

Equation 72

Example Deemed Savings Calculation

Example 1. An old 40-gallon electric water heater in a two-bedroom home in Dallas is replaced with a new, tankless electric water heater with a first-hour rating of 60 gal/hr and a uniform energy factor of 0.99.

$$\Delta kWh = \frac{[8.33 \times 1 \times 19,244 \times (120 - 71.8) \times \left(\frac{1}{0.9227} - \frac{1}{0.99}\right)]}{3,412} = 167 kWh$$

$$\Delta kW_S = 0.042 \times \frac{[8.33 \times 1 \times 19,244 \times (120 - 84) \times \left(\frac{1}{0.9227} - \frac{1}{0.99}\right)]}{365 \times 3,412} = 0.01 kW$$

$$\Delta kW_W = 0.068 \times \frac{[8.33 \times 1 \times 19,244 \times (120 - 60.6) \times \left(\frac{1}{0.9227} - \frac{1}{0.99}\right)]}{365 \times 3,412} = 0.04 kW$$

Example 2. An old 30-gallon electric water heater in a one-bedroom house in El Paso is replaced with a new gas storage water heater with a first-hour rating of 51 gal/hr and a uniform energy factor of 0.81.

$$\Delta kWh = \frac{[8.33 \times 1 \times 14,905 \times (120 - 70.4) \times (\frac{1}{0.9247})]}{3,412} = 1,952 kWh$$

$$\Delta kW_s = 0.036 \times \frac{[8.33 \times 1 \times 14,905 \times (120 - 81.5) \times (\frac{1}{0.9247})]}{365 \times 3,412} = 0.15 kW$$

$$\Delta kW_w = 0.067 \times \frac{[8.33 \times 1 \times 14,905 \times (120 - 60.4) \times (\frac{1}{0.9247})]}{365 \times 3,412} = 0.43 kW$$

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 20 years for a tankless water heater (gas or electric), as specified in the California Database of Energy Efficiency Resources (DEER) READI tool for EUL ID WtrHt-Instant-Res.³⁴⁵

The EUL is 11 years for a high-efficiency gas water heater, as specified for EUL ID WtrHt-Res-Gas.

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

³⁴⁵ DEER READI (Remote Ex-Ante Database Interface). <http://www.deeresources.com/index.php/readi>.

- Volume of the newly installed water heater (gallons, zero if tankless)
- Volume of the baseline water heater (gallons)
- First hour rating of newly installed water heater (gal/hr)
- Uniform energy factor of the newly installed water heater
- Number of bedrooms
- Manufacturer and model number of newly installed unit
- Proof of purchase – with date of purchase and quantity
 - Alternative: photo of unit installed or another pre-approved method of installation verification.

References and Efficiency Standards

Petitions and Rulings

Not applicable.

Relevant Standards and Reference Sources

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

Document Revision History

Table 283. DHW Replacements—Revision History

TRM version	Date	Description of change
v1.0	11/25/2013	TRM v1.0 origin.
v2.0	04/18/2014	TRM v2.0 update. Updated measure to require electric tankless rather than electric storage water heater installation for non-fuel-switching option. Updated by Frontier Energy, March 2014, based on new federal standards.
v2.1	01/30/2015	TRM v2.1 update. Updated to reflect that new construction permitted to claim savings subject to documentation requirements and that gas-fueled tankless water heaters are eligible for installation.
v3.0	04/10/2015	TRM v3.0 update. Amended fuel substitution savings to reflect the full consumption of the electric unit being replaced. Revised demand savings for installing an electric tankless unit to reflect daily usage patterns.
v3.1	11/05/2015	TRM v3.1 update. Clarified the baseline for water heaters greater than 55 gallons.
v4.0	10/10/2016	TRM v4.0 update. Updated HPWH baseline usage for gas storage water heaters larger than 55 gallons.
v5.0	10/2017	TRM v5.0 update. No revision.
v6.0	11/2018	TRM v6.0 update. No revision.

TRM version	Date	Description of change
v7.0	11/2019	TRM v7.0 update. Implemented new baseline and high-efficiency standards.
v8.0	10/2020	TRM v8.0 update. Clarified HPWH baseline for tanks sizes over 55 gal. Updated algorithms to refer to UEF.
v9.0	10/2021	TRM v9.0 update. Updated EUL reference.
v10.0	10/2022	TRM v10.0 update. Verified compliance with ENERGY STAR Version 4.0 Requirements. Updated documentation requirements.

2.4.2 Heat Pump Water Heaters Measure Overview

TRM Measure ID: R-WH-HW

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: Look-up tables

Savings Methodology: Engineering algorithms and estimates

Measure Description

This measure involves the installation of an ENERGY STAR®-compliant heat pump water heater (HPWH). Note that this measure does not account for the interactive air conditioning energy savings and heating penalty associated with the HPWH when installed inside conditioned space considering interaction with space heating equipment only affects deemed savings for units below 55 gallons.³⁴⁶

Eligibility Criteria

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

Baseline Condition

The baseline condition is an electric storage water heater (EWH) with baseline efficiency (UEF) determined by tank size and draw pattern—a proxy for first-hour rating—according to the amended federal energy efficiency standards for residential water heaters with tank sizes 20 to 120 gallons, as published in 10 CFR Part 430.32 of the Federal Register.³⁴⁷

³⁴⁶ This is because the measure assumes replace on burnout and because the latest manufacturer standards effectively require heat pump water heaters (assuming electric water heating) for residential units with storage tank size greater than 55 gallons. For these units any interaction with the space conditioning systems is essentially the same for base and change case systems, so they cancel each other out.

³⁴⁷ 10 CFR Part 430.32 Energy and water conservation standards and their effective dates.

www.ecfr.gov/cgi-bin/text-idx?SID=80dfa785ea350ebee184bb0ae03e7f0&mc=true&node=se10.3.430_132&rgn=div8..

This baseline applies to replace-on-burnout and new construction applications. No additional savings are awarded for early retirement at this time. Early retirement projects should calculate savings using an assumed replace-on-burnout baseline.

Table 284. HPWHs—Federal Standard for Residential Water Heaters

Rated storage volume	Draw pattern	First hour rating (FHR) ^{348 349}	Uniform energy factor ³⁵⁰
≥ 20 gal and ≤ 55 gal	Very Small Usage	0 ≤ FHR < 18	0.8808 – (0.0008 × V _r)
	Low Usage	18 ≤ FHR < 51	0.9254 – (0.0003 × V _r)
	Medium Usage	51 ≤ FHR < 75	0.9307 – (0.0002 × V _r)
	High Usage	75 ≤ FHR	0.9349 – (0.0001 × V _r)
> 55 gal and ≤ 120 gal	Very Small Usage	0 ≤ FHR < 18	1.9236 – (0.0011 × V _r)
	Low Usage	18 ≤ FHR < 51	2.0440 – (0.0011 × V _r)
	Medium Usage	51 ≤ FHR < 75	2.1171 – (0.0011 × V _r)
	High Usage	75 ≤ FHR	2.2418 – (0.0011 × V _r)

There are no certified ENERGY STAR water heaters in the *very small usage* category, and 98 percent of certified units are in the *medium* and *high usage* categories.

The Department of Energy (DOE) efficiency standard effectively requires heat pump water heaters (assuming electric water heating) for storage water heaters with tank sizes greater than 55 gallons. As such, the baseline technology for water heaters with tanks greater than 55 gallons is a heat pump water heater.

High-Efficiency Condition

The efficient condition is an HPWH certified by ENERGY STAR that adheres to the criteria outlined in Table 285.³⁵¹

³⁴⁸ “The Revised Method of Test for Residential Water Heating and Its Impact on Incentive Programs” presentation, Glanville, Paul. ACEEE Hot Water Forum. February 24, 2015.

<https://aceee.org/sites/default/files/pdf/conferences/hwf/2015/6B-Glanville.pdf>.

³⁴⁹ Assume FHR equal to that of installed water heater.

³⁵⁰ V_r is the rated storage volume (in gallons), as determined pursuant to 10 CFR 429.17.

³⁵¹ ENERGY STAR® Requirements (as of March 2022). HPWH must have a maximum current rating of 24 amperes, voltage no greater than 250 volts, and a transfer of thermal energy from one temperature to a higher temperature level for the purpose of heating water.

https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Version%204.0%20Water%20Heaters%20Final%20Specification%20and%20Partner%20Commitments-March2022_5.pdf

Table 285. HPWHs—Federal Standard for Residential Water Heaters

Criteria		ENERGY STAR Requirements
Uniform energy factor	Integrated HPWH	UEF ≥ 3.30
	Integrated HPWH, 120 volt/15 amp circuit	UEF ≥ 2.20
	Split-system HPWHT	UEF ≥ 2.20
First-hour rating		FHR ≥ 45 gallons per hour
Warranty		Warranty ≥ 6 years on sealed system
Safety		UL 174 and UL 1995 or UL 60335-2-40
Lower compressor cut-off temperature (reporting requirement only)		Report ambient temperature below which the compressor cuts off and electric-resistance-only operation begins

A complete list of certified ENERGY STAR heat pump water heaters can be accessed via the ENERGY STAR program website.³⁵²

Heat pump water heaters depend on adequate ventilation to properly function, including adequate space for both inlet and outlet airflow, and should be installed in spaces in where temperature does not drop below a certain level. The Department of Energy recommends installation in locations that remain above 40°F year-round and provide a minimum of 1,000 cubic feet of air space around the water heater.³⁵³

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

HPWH savings are calculated on a per-unit basis. Deemed savings are calculated utilizing the standard algorithms outlined below for water heating. Consumption in gallons per year is estimated using data from Building America Performance Analysis Procedures for Existing Homes.³⁵⁴ Temperature data are based on TMY3 dataset.³⁵⁵

³⁵² ENERGY STAR®-certified water heaters qualified product listing. https://www.energystar.gov/productfinder/product/certified-water-heaters/?formId=96913462-da32-4dc2-ad53-f31203352209&scrollTo=546&search_text=&type_filter=Hybrid%2FElectric+Heat+Pump&fuel_filter=Electric&brand_name_isopen=0&input_rate_thousand_btu_per_hour_isopen=0&markets_filter=United+States&zip_code_filter=&product_types=Select+a+Product+Category&sort_by=brand_name&sort_direction=asc&page_number=0&lastpage=0.

³⁵³ Heat Pump Water Heaters. Department of Energy, May 2012. <http://energy.gov/energysaver/articles/heat-pump-water-heaters>

³⁵⁴ Building America Performance Analysis Procedures for Existing Homes, page 18, figure 4: combined domestic hot water use profile. <https://www.nrel.gov/docs/fy06osti/38238.pdf>.

³⁵⁵ TMY data is available through the National Solar Radiation Database (NSRDB) Data Viewer, <https://maps.nrel.gov/nsrdb-viewer/>. Data for Texas climate zones can also be accessed directly here: <https://texasefficiency.com/index.php/regulatory-filings/deemed-savings>.