

Table 146. Attic Encapsulation—Climate Zone 5: El Paso, R-30 Summer Peak Demand Savings for Insulation Component (kW/sq. ft.)

Ceiling insulation base R-value	Refrigerated	Evaporative
< R-5	8.00E-04	2.23E-04
R-5 to R-8	4.72E-04	1.53E-04
R-9 to R-14	2.38E-04	6.25E-05
R-15 to R-22	1.03E-04	2.09E-05

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

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 summer peak demand savings per square foot of treated ceiling area.

Table 147. Attic Encapsulation—Summer Peak Demand Scale-down Factors for Insulating to Less than R-30 (kW/sq. ft./ΔR)

Climate zone	Refrigerated	Evaporative
Zone 1: Amarillo	6.41E-06	1.97E-06
Zone 2: Dallas	7.30E-06	–
Zone 3: Houston	7.91E-06	–
Zone 4: Corpus Christi	5.20E-06	–
Zone 5: El Paso	6.41E-06	1.97E-06

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

Table 148. Attic Encapsulation—Summer Peak Demand Scale-up Factors for Insulating to Greater than R-30 (kW/sq. ft./ΔR)

Climate zone	Refrigerated	Evaporative
Zone 1: Amarillo	4.22E-06	1.89E-06
Zone 2: Dallas	4.92E-06	–
Zone 3: Houston	5.92E-06	–
Zone 4: Corpus Christi	3.47E-06	–
Zone 5: El Paso	4.22E-06	1.89E-06

Deemed Winter Demand Savings Tables

Table 149 through Table 153 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 149 through Table 155 by a factor of 0.24.²³⁴

Table 149. 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 150. 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 151. 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

²³⁴ This factor was derived based on expected capacity reduction assuming 1200 sq. ft. (historical analysis of HTR participants) x 0.35 BTU/sq. ft. = 42,000 BTU for central electric furnaces and two 1,500-watt portable heaters per home rated at 5,100 BTU/heater. Taking the ratio of portable to furnace capacity yields 10,200 ÷ 42,000 = 0.24.

Table 152. 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 153. 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.

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

Equation 66

Where:

$R30\ Savings/ft^2$ = Sum of project-appropriate deemed Cooling and Heating Energy Savings per square feet taken from Table 142 through Table 146 or Table 149 through Table 153

$S_{D/U}$ = Project-appropriate scale-down or scale-up factor from either Table 147 and Table 148 (summer) or Table 154 and Table 155 (winter)

Note: the heating documentation adjustment should only be applied to winter peak savings calculations.

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 154. 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 155. 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 (kVWh) 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.²³⁵ 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).²³⁶ 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.²³⁷ 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 156. 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 21-14 ²³⁸

²³⁵ 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.

²³⁶ 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.

²³⁷ Air Conditioning Contractors of America. Manual J, 8th Edition Version 2.10. Nov. 2011, p. 188.

²³⁸ 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 157. 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	8754.5	3865.8
Zone 2: Dallas	209.2	600.3	3165.5
Zone 3: Houston	1621.9	47069.5	26059.6
Zone 4: Corpus Christi	18079.7	4121.9	2632.9
Zone 5: El Paso	64.3	5254.7	2276.5

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 158. 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 159. 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:

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

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

$$\{0.49 + [(4 \times 10^{-3} + 2.97 \times 10^{-4}) \times (38 - 30)]\} \times 900 = 4721.9 \text{ kWh}$$

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

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

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

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

Infiltration reduction component savings:

$$\text{Energy Savings, 18\% Infiltration Reduction} = 1624.9 \text{ kWh}$$

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

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

Measure savings:

$$\text{Energy Savings} = 4721.9 + 1621.9 = 6343.8 \text{ kWh}$$

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

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

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:

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

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

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

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),²³⁹ 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 or county
- 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
 - ~~If documentation is not provided, an adjustment factor of 0.75 will be applied to the heating energy and winter demand savings~~
- 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.

²³⁹ 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.

References and Efficiency Standards

Petitions and Rulings

- 10/2017

Relevant Standards and Reference Sources

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

Document Revision History

Table 160. 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.
v11.0	10/2023	TRM v11.0 update. Added electric resistance documentation adjustment factor.
<u>v12.0</u>	<u>10/2024</u>	<u>TRM v12.0 update. Clarified application of electric resistance documentation adjustment factor. Updated rounding for infiltration component energy savings.</u>

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.²⁴⁰ Space heating primarily refers to electric baseboard zonal heaters controlled by thermostats or to portable plug-load heaters.²⁴¹ 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 161.

Table 161. 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.

²⁴⁰ Electric Resistance Heating: <https://www.energy.gov/energysaver/home-heating-systems/electric-resistance-heating>.

²⁴¹ 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 162. 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 163 through Table 166 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 163 through Table 166 by a factor of 0.24.²⁴²

For residences reporting electric resistance heat, a documentation adjustment factor of 0.75 will be applied to deemed heating energy savings if no documentation is provided to validate the heating equipment. In all other cases, the documentation adjustment factor is set to 1.0.

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

2x4 Walls

Table 163 presents the deemed energy savings values for insulating 2x4 walls to R-13 for all five Texas climate zones.

Table 163. 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 164 presents the deemed energy savings values for insulating 2x4 walls to R-21 for all five Texas climate zones.

Table 164. 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 165 presents the deemed energy savings values for insulating 2x6 walls to R-17 for all five Texas climate zones.

Table 165. 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 166 presents the deemed energy savings values for insulating 2x6 walls to R-33 for all five Texas climate zones.

Table 166. 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 167 through Table 170 by a factor of 0.6.

2x4 Walls

Table 167 presents the deemed summer demand savings values for insulating 2x4 walls to R-13 for all five Texas climate zones.

**Table 167. 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 168 presents the deemed summer demand savings values for insulating 2x4 walls to R-13 for all five Texas climate zones.

**Table 168. 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 169 presents the deemed summer demand savings values for insulating 2x6 walls to R-17 for all five Texas climate zones.

Table 169. 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 170 presents the deemed summer demand savings values for insulating 2x6 walls to R-33 for all five Texas climate zones.

Table 170. 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 171 through Table 174 by a factor of 0.24.²⁴³

For residences reporting electric resistance heat, a documentation adjustment factor of 0.75 will be applied to deemed winter peak demand savings if no documentation is provided to validate the heating equipment. In all other cases, the documentation adjustment factor is set to 1.0.

²⁴³ This factor was derived based on expected capacity reduction assuming 1200 sq. ft. (historical analysis of HTR participants) x 0.35 BTU/sq. ft. = 42,000 BTU for central electric furnaces and two 1,500-watt portable heaters per home rated at 5,100 BTU/heater. Taking the ratio of portable to furnace capacity yields 10,200 ÷ 42,000 = 0.24.

2x4 Walls

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

**Table 171. 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 172 presents the deemed winter demand savings values for insulating 2x4 walls to R-21 for all five Texas climate zones.

**Table 172. Wall Insulation—Winter Peak Demand Savings (kW/sq. ft.),
Insulation of 2x4 Walls to R-21**

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

**Table 173. 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 174 presents the deemed winter demand savings values for insulating 2x6 walls to R-33 for all five Texas climate zones.

**Table 174. 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-21 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 or county
- 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
 - ~~If documentation is not provided, an adjustment factor of 0.75 will be applied to the heating energy and winter demand savings~~
- 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 175. 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.

TRM version	Date	Description of change
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.
v11.0	10/2023	TRM v11.0 update. Added electric resistance documentation adjustment factor.
<u>v12.0</u>	<u>10/2024</u>	<u>TRM v12.0 update. Clarified application of electric resistance documentation adjustment factor.</u>

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.²⁴⁴ Space heating primarily refers to electric baseboard zonal heaters controlled by thermostats or to portable plug-load heaters.²⁴⁵ 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.

²⁴⁴ Electric Resistance Heating: <https://www.energy.gov/energysaver/home-heating-systems/electric-resistance-heating>.

²⁴⁵ Portable Heaters: <https://www.energy.gov/energysaver/home-heating-systems/portable-heaters>.

Table 176. 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 177 through Table 181 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 177 through Table 181 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 177 through Table 181 by a factor of 0.24.²⁴⁶

For residences reporting electric resistance heat, a documentation adjustment factor of 0.75 will be multiplied applied to deemed heating energy savings if no documentation is provided to validate the heating equipment. In all other cases, the documentation adjustment factor is set to 1.0.

Table 177. 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

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

Table 178. 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

Table 179. 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 180. 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 181. 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 182 through Table 186 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 182 through Table 186 by a factor of 0.6.

Table 182. 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 183. 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 184. 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 185. 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 186. 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 187 through Table 191 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 187 through Table 191 by a factor of 0.24.²⁴⁷

For residences reporting electric resistance heat, a documentation adjustment factor of 0.75 will be applied to deemed winter peak demand savings if no documentation is provided to validate the heating equipment. In all other cases, the documentation adjustment factor is set to 1.0.

²⁴⁷ 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 187. 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 188. 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

Table 189. 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 190. 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 191. 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 or county
- 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
 - ~~If documentation is not provided, an adjustment factor of 0.75 will be applied to the heating energy and winter demand savings~~
- 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 192. 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.
v11.0	10/2023	TRM v11.0 update. Added electric resistance documentation adjustment factor.
<u>v12.0</u>	<u>10/2024</u>	<u>TRM v12.0 update. Clarified application of electric resistance documentation adjustment factor.</u>

2.3.6 Duct Insulation Measure Overview

TRM Measure ID: R-BE-DI

Market Sector: Residential

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

This measure consists of the installation of duct insulation with a minimum R value of 5.6 or 8.0 to uninsulated metal supply and return ductwork, located in unconditioned space that previously had no existing insulation. This measure applies to residential retrofit applications.

Eligibility Criteria

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. Homes heated with gas or electric resistance space heating are not eligible to claim heating savings.

Baseline Condition

The baseline for this measure is uninsulated sheet metal ducts or insulated metal ducts in which the insulation has failed. Failed insulation is insulation which has non-repairable tears to the vapor barrier or exhibits gaps with exposed metal between the insulation. Flex ducts and fiber board ducts are not eligible for this measure. The ducts must be located in unconditioned spaces, such as attics or crawl spaces. Old ductwork insulation must be removed prior to installation of new duct wrap insulation.

Unconditioned space is defined as a space which is neither directly nor indirectly conditioned and is isolated from conditioned space by partitions, such as walls and/or closeable doors and ceilings. The two specified locations available for claimed savings are attics and crawl spaces.

High-Efficiency Condition

The high-efficiency condition for this measure requires that ducts must be insulated with duct wrap to an R-value of 5.6 or 8.0.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

This measure references deemed savings from the Arkansas Technical Reference Manual (TRM) v9.1 where calibrated simulation modeling was used to develop these deemed savings.²⁴⁸ Specifically, these deemed savings estimates were developed using BEopt, running EnergyPlus as the underlying simulation engine. Since duct insulation 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.²⁴⁹

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 193.

Table 193. Duct Insulation—Cooling and Heating Adjustment Factors (AF)²⁵⁰

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 Savings Tables

Table 194 through Table 198 present the energy savings (kWh) in the five Texas climate zones per square foot of exposed metal duct area located in an unconditioned attic or crawl space. Annual energy savings are the sum of cooling and heating savings for the appropriate equipment types.

For residences reporting electric resistance heat, a documentation adjustment factor of 0.75 will be applied to deemed heating energy savings if no documentation is provided to validate the heating equipment. In all other cases, the documentation adjustment factor is set to 1.0.

²⁴⁸ [Arkansas Public Service Commission. Arkansas TRM v9.1](#)

²⁴⁹ NSRDB Viewer: <https://nsrdb.nrel.gov/>.

²⁵⁰ These adjustment factors were multiplied against respective cooling and heating savings from the Arkansas TRM v9.1 Duct Insulation 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 Texas climate zones were applied against savings for Arkansas Climate Zone 6 (El Dorado).

Table 194. Duct Insulation—Climate Zone 1: Amarillo, Energy Savings (kWh/sq. ft.)

Unconditioned duct location and added R-value	Refrigerated cooling savings	Heating savings		
		Gas	Electric resistance	Heat pump
Attic to R-8	0.093	–	0.354	0.347
Attic to R-5.6	0.048	–	0.182	0.177
Crawl space to R-8	0.064	–	0.352	0.338
Crawl space to R-5.6	0.032	–	0.180	0.173

Table 195. Duct Insulation—Climate Zone 2: Dallas, Energy Savings (kWh/sq. ft.)

Unconditioned duct location and added R-value	Refrigerated cooling savings	Heating savings		
		Gas	Electric resistance	Heat pump
Attic to R-8	0.132	–	0.224	0.198
Attic to R-5.6	0.068	–	0.114	0.102
Crawl space to R-8	0.086	–	0.252	0.209
Crawl space to R-5.6	0.043	–	0.129	0.108

Table 196. Duct Insulation—Climate Zone 3: Houston, Energy Savings (kWh/sq. ft.)

Unconditioned duct location and added R-value	Refrigerated cooling savings	Heating savings		
		Gas	Electric resistance	Heat pump
Attic to R-8	0.139	–	0.142	0.125
Attic to R-5.6	0.071	–	0.072	0.064
Crawl space to R-8	0.090	–	0.159	0.132
Crawl space to R-5.6	0.046	–	0.082	0.068

Table 197. Duct Insulation—Climate Zone 4: Corpus Christi, Energy (kWh/sq. ft.)

Unconditioned duct location and added R-value	Refrigerated cooling savings	Heating savings		
		Gas	Electric resistance	Heat pump
Attic to R-8	0.180	–	0.068	0.060
Attic to R-5.6	0.092	–	0.035	0.031
Crawl space to R-8	0.117	–	0.077	0.064
Crawl space to R-5.6	0.059	–	0.039	0.033

Table 198. Duct Insulation—Climate Zone 5: El Paso, Energy Savings (kWh/sq. ft.)

Unconditioned duct location and added R-value	Refrigerated cooling savings	Heating savings		
		Gas	Electric resistance	Heat pump
Attic to R-8	0.123	–	0.253	0.223
Attic to R-5.6	0.063	–	0.129	0.115
Crawl space to R-8	0.080	–	0.285	0.236
Crawl space to R-5.6	0.040	–	0.146	0.122

Deemed Summer Demand Savings Tables

Table 199 through Table 203 present the summer demand savings (kW) in the five Texas climate zones per square foot of exposed metal duct area located in an unconditioned attic or crawl space.

Table 199. Duct Insulation—Climate Zone 1: Amarillo, Summer Peak Demand Savings (kW/sq. ft.)

Unconditioned duct location and added R-value	Demand savings (kW/sq. ft.)
Attic to R-8	0.00016
Attic to R-5.6	0.00009
Crawl space to R-8	0.00004
Crawl space to R-5.6	0.00002

Table 200. Duct Insulation—Climate Zone 2: Dallas, Summer Peak Demand Savings (kW/sq. ft.)

Unconditioned duct location and added R-value	Demand savings (kW/sq. ft.)
Attic to R-8	0.00020
Attic to R-5.6	0.00011
Crawl space to R-8	0.00007
Crawl space to R-5.6	0.00003

Table 201. Duct Insulation—Climate Zone 3: Houston, Summer Peak Demand Savings (kW/sq. ft.)

Unconditioned duct location and added R-value	Demand savings (kW/sq. ft.)
Attic to R-8	0.00021
Attic to R-5.6	0.00011
Crawl space to R-8	0.00008
Crawl space to R-5.6	0.00003

Table 202. Duct Insulation—Climate Zone 4: Corpus Christi, Summer Peak Demand Savings (kW/sq. ft.)

Unconditioned duct location and added R-value	Demand savings (kW/sq. ft.)
Attic to R-8	0.00027
Attic to R-5.6	0.00014
Crawl space to R-8	0.00010
Crawl space to R-5.6	0.00004

Table 203. Duct Insulation—Climate Zone 5: El Paso, Summer Peak Demand Savings (kW/sq. ft.)

Unconditioned duct location and added R-value	Demand savings (kW/sq. ft.)
Attic to R-8	0.00019
Attic to R-5.6	0.00010
Crawl space to R-8	0.00007
Crawl space to R-5.6	0.00003

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

According to the GDS Associates Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures (2007),²⁵¹ the estimated useful life is 20 years for duct 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:

- Climate zone or county
- Uninsulated duct location
- R-value of installed insulation
- Square footage of treated duct area in unconditioned space
- 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
 - ~~If documentation is not provided, an adjustment factor of 0.75 will be applied to the heating energy and winter demand savings~~

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 204. Duct Insulation—Revision History

TRM version	Date	Description of change
v11.0	10/2023	TRM v11.0 origin.

²⁵¹ 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.

TRM version	Date	Description of change
<u>v12.0</u>	<u>10/2024</u>	<u>TRM v12.0 update. Clarified application of electric resistance documentation adjustment factor.</u>

2.3.7 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 7.4.²⁵² 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.²⁵³ Therefore, interior radiation control coatings are ineligible to use this measure.

²⁵² RIMA-I Handbook. <https://rimainternational.org/wp-content/uploads/2011/01/HandbookAll-2014-Final-1.pdf>.

²⁵³ "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.²⁵⁴

Table 205. Radiant Barriers—RIMA-I Product Testing Requirements²⁵⁵

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

²⁵⁴ RIMA International verified products. <https://rimainternational.org/verify/>.

²⁵⁵ 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.²⁵⁶ 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.²⁵⁷

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 206.

Table 206. Radiant Barriers—Cooling and Heating Adjustment Factors (AF)²⁵⁸

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 207 through Table 211 present the energy savings (kWh) in the five Texas climate zones. Annual energy savings are the sum of cooling and heating savings for the appropriate equipment types.

²⁵⁶ Arkansas Public Service Commission. AR TRM v9.0. <http://www.apscservices.info/EElInfo/TRMV9.0.pdf>.

²⁵⁷ NSRDB Viewer: <https://nsrdb.nrel.gov/>.

²⁵⁸ 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 207 through Table 211 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 207 through Table 211 by a factor of 0.24.²⁵⁹

For residences reporting electric resistance heat, a documentation adjustment factor of 0.75 will be applied to deemed heating energy savings if no documentation is provided to validate the heating equipment. In all other cases, the documentation adjustment factor is set to 1.0.

Savings are specified per square foot of ceiling area over conditioned space directly below an unconditioned attic where the radiant barrier is installed. The square footage should not reflect the total area of installed radiant barrier.

Table 207. 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 208. 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 209. 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

²⁵⁹ 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 210. 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 211. 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 212 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 212 by a factor of 0.6.

Table 212. 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.²⁶⁰ 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)²⁶¹ and National Renewable Energy Laboratory (NREL).²⁶²

Program Tracking Data and Evaluation Requirements

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

- Climate zone or county
- 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
 - ◀ ~~If documentation is not provided, an adjustment factor of 0.75 will be applied to the heating energy and winter demand savings~~
- Baseline R-value of existing ceiling insulation (\leq R-19, $>$ R-19)
- Square footage of ceiling area over conditioned space directly below an unconditioned attic where the radiant barrier is installed
- Manufacturer and product name/model number

References and Efficiency Standards

Petitions and Rulings

Not applicable.

²⁶⁰ US Department of Energy (DOE) Insulation Fact Sheet.
<https://web.ornl.gov/sci/buildings/docs/factSheets/Insulation-FactSheet-2008.pdf>.

²⁶¹ "Radiant Barrier: Effect of Radiant Barriers on Heating and Cooling Bills", ORNL.
<https://web.ornl.gov/sci/buildings/tools/radiant/rb2/>.

²⁶² National Residential Efficiency Measures Database, NREL.
<https://remdb.nrel.gov/measures.php?gld=13&ctld=51>.

Relevant Standards and Reference Sources

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

Document Revision History

Table 213. Radiant Barriers—Revision History

TRM version	Date	Description of change
v10.0	10/2022	TRM v10.0 origin.
v11.0	10/2023	TRM v11.0 update. Clarified savings normalization by area. Added electric resistance documentation adjustment factor.
<u>v12.0</u>	<u>10/2024</u>	<u>TRM v12.0 update. Clarified application of electric resistance documentation adjustment factor.</u>

2.3.8 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.²⁶³ Space heating primarily refers to electric baseboard zonal heaters controlled by thermostats or to portable plug-load heaters.²⁶⁴ 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, 2022.²⁶⁵ Moving forward, installed roofing products will still be required to demonstrate compliance with the previous ENERGY STAR specification below.²⁶⁶

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)^{267,268} and be listed on the CRRC Rated Roof Products Directory.²⁶⁹ This is consistent with the former ENERGY STAR test criteria, which allows for products already participating in the CRRC Product Rating Program 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 214.

Table 214. Cool Roofs—ENERGY STAR Specification²⁷⁰

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

²⁶³ Electric Resistance Heating. <https://www.energy.gov/energysaver/home-heating-systems/electric-resistance-heating>.

²⁶⁴ Portable Heaters. <https://www.energy.gov/energysaver/home-heating-systems/portable-heaters>.

²⁶⁵ ENERGY STAR Roof Products Sunset Decision Memo. <https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Roof%20Products%20Sunset%20Decision%20Memo.pdf>.

²⁶⁶ ENERGY STAR Program Requirements for Roof Products v2.1. https://www.energystar.gov/ia/partners/product_specs/program_reqs/roofs_prog_req.pdf.

²⁶⁷ 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>.

²⁶⁸ CRRC Roof Rating Program. <https://coolroofs.org/programs/roof-rating-program>.

²⁶⁹ CRRC Rated Roof Products Directory. <https://coolroofs.org/directory/roof>.

²⁷⁰ 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 CRRC database, four reflectance levels were selected for modeling: 0.2, 0.4, 0.6, and 0.8, representing 20 to 80 percent reflectance.

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

These modifications are shown in Table 215.

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 215. 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 216 through Table 220 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 216 through Table 220 by a factor of 0.24.²⁷¹

Homes with Ceiling Insulation

Table 216 through Table 220 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 216. 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

²⁷¹ 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.

Ceiling insulation R-value	Installed roof material 3-year reflectance	Cooling savings		Heating savings		
		Refrigerated	Evaporative	Gas	Electric resistance	Heat pump
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
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 217. 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

Ceiling insulation R-value	Installed roof material 3-year reflectance	Cooling savings (refrigerated)	Heating savings		
			Gas	Electric resistance	Heat pump
< 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
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 218. 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
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

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	0.5 – 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 219. 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
R-15 to R-22	0.3 – 0.49	0.06	0.00	-0.03	-0.01
R-15 to R-22	0.5 – 0.69	0.12	0.00	-0.05	-0.02
R-15 to R-22	≥ 0.7	0.17	0.00	-0.08	-0.03
R-30	0.15 – 0.29	0.01	0.00	0.00	0.00
R-30	0.3 – 0.49	0.04	0.00	-0.02	-0.01
R-30	0.5 – 0.69	0.07	0.00	-0.03	-0.01
R-30	≥ 0.7	0.11	0.00	-0.05	-0.02

Ceiling insulation R-value	Installed roof material 3-year reflectance	Cooling savings (refrigerated)	Heating Savings		
			Gas	Electric resistance	Heat pump
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 220. 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
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

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	0.29	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 221 through Table 225 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 221. 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

Roof deck insulation R-value	Installed roof material 3-year reflectance	Cooling savings		Heating savings		
		Refrigerated	Evaporative	Gas	Electric resistance	Heat pump
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 222. 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
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

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	0.21	-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 223. 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
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 224. 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 225. 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

Roof deck insulation R-value	Installed roof material 3-year reflectance	Cooling savings		Heating savings		
		Refrigerated	Evaporative	Gas	Electric resistance	Heat pump
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 226 through Table 230 by a factor of 0.6.

Homes with Ceiling Insulation

Table 226 through Table 230 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 226. 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

Ceiling insulation R-value	Installed roof material 3-year reflectance	Low slope		Steep slope	
		Refrigerated	Evaporative	Refrigerated	Evaporative
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 227. 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
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

Ceiling insulation R-value	Installed roof material 3-year reflectance	Low slope	Steep slope
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 228. 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
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 229. 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 230. 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
< R-5	0.5 – 0.69	3.95 x 10 ⁻⁴	1.54 x 10 ⁻⁴	3.44 x 10 ⁻⁴	1.65 x 10 ⁻⁴
< R-5	≥ 0.7	6.15 x 10 ⁻⁴	2.42 x 10 ⁻⁴	5.19 x 10 ⁻⁴	2.20 x 10 ⁻⁴
R-5 to R-8	0.15 – 0.29	–	–	2.72 x 10 ⁻⁵	8.96 x 10 ⁻⁶
R-5 to R-8	0.3 – 0.49	–	–	1.27 x 10 ⁻⁴	6.00 x 10 ⁻⁵
R-5 to R-8	0.5 – 0.69	3.06 x 10 ⁻⁴	1.34 x 10 ⁻⁴	2.59 x 10 ⁻⁴	1.38 x 10 ⁻⁴

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

Homes with Roof Deck Insulation

Table 231 through Table 235 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 231. 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 x 10 ⁻⁵	7.62 x 10 ⁻⁶
R-19	0.5 – 0.69	5.56 x 10 ⁻⁵	1.84 x 10 ⁻⁵	5.35 x 10 ⁻⁵	1.55 x 10 ⁻⁵
R-19	≥ 0.7	9.88 x 10 ⁻⁵	7.61 x 10 ⁻⁶	8.81 x 10 ⁻⁵	1.52 x 10 ⁻⁵
R-30	0.15 – 0.29	–	–	3.37 x 10 ⁻⁶	3.42 x 10 ⁻⁶
R-30	0.3 – 0.49	–	–	1.97 x 10 ⁻⁵	7.38 x 10 ⁻⁶
R-30	0.5 – 0.69	3.21 x 10 ⁻⁵	9.13 x 10 ⁻⁶	3.06 x 10 ⁻⁵	1.25 x 10 ⁻⁵
R-30	≥ 0.7	6.91 x 10 ⁻⁵	8.48 x 10 ⁻⁶	5.94 x 10 ⁻⁵	1.60 x 10 ⁻⁵
R-38	0.15 – 0.29	–	–	5.82 x 10 ⁻⁶	5.90 x 10 ⁻⁶

Roof deck insulation R-value	Installed roof material 3-year reflectance	Low slope		Steep slope	
		Refrigerated	Evaporative	Refrigerated	Evaporative
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 232. 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 233. 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
R-30	0.5 – 0.69	7.13 x 10 ⁻⁵	6.50 x 10 ⁻⁵

Roof deck insulation R-value	Installed roof material 3-year reflectance	Low slope	Steep slope
		Refrigerated	Refrigerated
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 234. 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 235. 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
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

Roof deck insulation R-value	Installed roof material 3-year reflectance	Low slope		Steep slope	
		Refrigerated	Evaporative	Refrigerated	Evaporative
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 236 through Table 240 by a factor of 0.24.²⁷²

Homes with Ceiling Insulation

Table 236 through Table 240 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 236. 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
R-9 to R-14	0.15 – 0.29	–	–	–	-8.59 x 10 ⁻⁷	-7.63 x 10 ⁻⁶	-3.69 x 10 ⁻⁶

²⁷² 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	0.3 – 0.49	–	–	–	-3.68 x 10 ⁻⁶	-3.63 x 10 ⁻⁵	-1.55 x 10 ⁻⁵
R-9 to R-14	0.5 – 0.69	-1.04 x 10 ⁻⁷	-7.28 x 10 ⁻⁵	-3.43 x 10 ⁻⁵	-1.49 x 10 ⁻⁵	-6.73 x 10 ⁻⁵	-3.07 x 10 ⁻⁵
R-9 to R-14	≥ 0.7	-6.86 x 10 ⁻⁶	-1.05 x 10 ⁻⁴	-4.98 x 10 ⁻⁵	-2.11 x 10 ⁻⁵	-9.83 x 10 ⁻⁵	-4.57 x 10 ⁻⁵
R-15 to R-22	0.15 – 0.29	–	–	–	-8.96 x 10 ⁻⁷	-5.40 x 10 ⁻⁶	-2.51 x 10 ⁻⁶
R-15 to R-22	0.3 – 0.49	–	–	–	-3.85 x 10 ⁻⁶	-2.60 x 10 ⁻⁵	-1.08 x 10 ⁻⁵
R-15 to R-22	0.5 – 0.69	-1.72 x 10 ⁻⁶	-5.26 x 10 ⁻⁵	-2.47 x 10 ⁻⁵	-1.19 x 10 ⁻⁵	-4.80 x 10 ⁻⁵	-2.15 x 10 ⁻⁵
R-15 to R-22	≥ 0.7	-9.72 x 10 ⁻⁷	-7.65 x 10 ⁻⁵	-3.64 x 10 ⁻⁵	-1.44 x 10 ⁻⁵	-7.05 x 10 ⁻⁵	-3.23 x 10 ⁻⁵
R-30	0.15 – 0.29	-	-	-	-8.09 x 10 ⁻⁷	-3.58 x 10 ⁻⁶	-1.64 x 10 ⁻⁶
R-30	0.3 – 0.49	-	-	-	-1.08 x 10 ⁻⁵	-1.73 x 10 ⁻⁵	-7.31 x 10 ⁻⁶
R-30	0.5 – 0.69	-5.10 x 10 ⁻⁶	-3.52 x 10 ⁻⁵	-1.58 x 10 ⁻⁵	-1.54 x 10 ⁻⁵	-3.12 x 10 ⁻⁵	-1.36 x 10 ⁻⁵
R-30	≥ 0.7	-3.71 x 10 ⁻⁶	-5.35 x 10 ⁻⁵	-2.58 x 10 ⁻⁵	-2.10 x 10 ⁻⁵	-4.64 x 10 ⁻⁵	-2.11 x 10 ⁻⁵

Table 237. 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 x 10 ⁻⁶	-1.29 x 10 ⁻⁵	-6.63 x 10 ⁻⁶
< R-5	0.3 – 0.49	–	–	–	-2.62 x 10 ⁻⁸	-6.19 x 10 ⁻⁵	-3.24 x 10 ⁻⁵
< R-5	0.5 – 0.69	-2.83 x 10 ⁻⁶	-1.48 x 10 ⁻⁴	-7.24 x 10 ⁻⁵	-1.44 x 10 ⁻⁶	-1.19 x 10 ⁻⁴	-6.06 x 10 ⁻⁵
< R-5	≥ 0.7	-6.02 x 10 ⁻⁶	-2.17 x 10 ⁻⁴	-1.07 x 10 ⁻⁴	-4.75 x 10 ⁻⁶	-1.81 x 10 ⁻⁴	-9.06 x 10 ⁻⁵
R-5 to R-8	0.15 – 0.29	–	–	–	4.57 x 10 ⁻⁶	-1.03 x 10 ⁻⁵	-5.30 x 10 ⁻⁶
R-5 to R-8	0.3 – 0.49	–	–	–	1.59 x 10 ⁻⁶	-4.70 x 10 ⁻⁵	-2.68 x 10 ⁻⁵
R-5 to R-8	0.5 – 0.69	-3.36 x 10 ⁻⁶	-1.19 x 10 ⁻⁴	-5.69 x 10 ⁻⁵	1.19 x 10 ⁻⁶	-9.33 x 10 ⁻⁵	-4.88 x 10 ⁻⁵
R-5 to R-8	≥ 0.7	-3.79 x 10 ⁻⁶	-1.74 x 10 ⁻⁴	-8.66 x 10 ⁻⁵	-4.46 x 10 ⁻⁶	-1.43 x 10 ⁻⁴	-7.18 x 10 ⁻⁵
R-9 to R-14	0.15 – 0.29	–	–	–	-7.26 x 10 ⁻⁷	-8.09 x 10 ⁻⁶	-3.86 x 10 ⁻⁶
R-9 to R-14	0.3 – 0.49	–	–	–	-2.92 x 10 ⁻⁶	-4.23 x 10 ⁻⁵	-2.03 x 10 ⁻⁵
R-9 to R-14	0.5 – 0.69	-1.29 x 10 ⁻⁵	-9.30 x 10 ⁻⁵	-4.31 x 10 ⁻⁵	-3.26 x 10 ⁻⁶	-7.90 x 10 ⁻⁵	-3.76 x 10 ⁻⁵
R-9 to R-14	≥ 0.7	-1.27 x 10 ⁻⁵	-1.41 x 10 ⁻⁴	-6.53 x 10 ⁻⁵	-7.53 x 10 ⁻⁶	-1.19 x 10 ⁻⁴	-5.52 x 10 ⁻⁵
R-15 to R-22	0.15 – 0.29	–	–	–	3.23 x 10 ⁻⁷	-5.84 x 10 ⁻⁶	-2.76 x 10 ⁻⁶
R-15 to R-22	0.3 – 0.49	–	–	–	-1.95 x 10 ⁻⁶	-3.04 x 10 ⁻⁵	-1.43 x 10 ⁻⁵
R-15 to R-22	0.5 – 0.69	-1.48 x 10 ⁻⁵	-6.81 x 10 ⁻⁵	-3.23 x 10 ⁻⁵	-2.74 x 10 ⁻⁶	-5.69 x 10 ⁻⁵	-2.66 x 10 ⁻⁵
R-15 to R-22	≥ 0.7	-1.61 x 10 ⁻⁵	-1.02 x 10 ⁻⁴	-4.67 x 10 ⁻⁵	-3.88 x 10 ⁻⁷	-8.65 x 10 ⁻⁵	-4.05 x 10 ⁻⁵

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

Table 238. 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	–	–	–	-7.91×10^{-7}	-1.54×10^{-5}	-7.77×10^{-6}
< R-5	0.3 – 0.49	–	–	–	-3.12×10^{-6}	-7.71×10^{-5}	-3.90×10^{-5}
< R-5	0.5 – 0.69	-3.28×10^{-6}	-1.56×10^{-4}	-7.95×10^{-5}	-6.08×10^{-6}	-1.40×10^{-4}	-7.09×10^{-5}
< R-5	≥ 0.7	-4.78×10^{-6}	-2.23×10^{-4}	-1.11×10^{-4}	-7.97×10^{-6}	-2.04×10^{-4}	-1.05×10^{-4}
R-5 to R-8	0.15 - 0.29	–	–	–	-7.39×10^{-7}	-1.25×10^{-5}	-6.46×10^{-6}
R-5 to R-8	0.3 – 0.49	–	–	–	-2.67×10^{-6}	-6.28×10^{-5}	-3.05×10^{-5}
R-5 to R-8	0.5 – 0.69	-4.26×10^{-6}	-1.28×10^{-4}	-6.54×10^{-5}	-5.79×10^{-6}	-1.14×10^{-4}	-5.59×10^{-5}
R-5 to R-8	≥ 0.7	-4.68×10^{-6}	-1.84×10^{-4}	-9.11×10^{-5}	-9.38×10^{-6}	-1.68×10^{-4}	-8.50×10^{-5}
R-9 to R-14	0.15 - 0.29	–	–	–	-6.93×10^{-7}	-9.35×10^{-6}	-4.68×10^{-6}
R-9 to R-14	0.3 – 0.49	–	–	–	-3.38×10^{-6}	-4.69×10^{-5}	-2.31×10^{-5}
R-9 to R-14	0.5 – 0.69	-5.14×10^{-6}	-9.71×10^{-5}	-4.78×10^{-5}	-6.46×10^{-6}	-8.68×10^{-5}	-4.28×10^{-5}
R-9 to R-14	≥ 0.7	-4.83×10^{-6}	-1.41×10^{-4}	-6.90×10^{-5}	-1.00×10^{-5}	-1.27×10^{-4}	-6.19×10^{-5}
R-15 to R-22	0.15 - 0.29	–	–	–	-7.06×10^{-7}	-6.48×10^{-6}	-3.22×10^{-6}
R-15 to R-22	0.3 – 0.49	–	–	–	-3.70×10^{-6}	-3.32×10^{-5}	-1.62×10^{-5}
R-15 to R-22	0.5 – 0.69	-5.52×10^{-6}	-6.85×10^{-5}	-3.34×10^{-5}	-6.80×10^{-6}	-6.15×10^{-5}	-3.00×10^{-5}
R-15 to R-22	≥ 0.7	-8.06×10^{-6}	-1.00×10^{-4}	-4.89×10^{-5}	-9.55×10^{-6}	-9.10×10^{-5}	-4.44×10^{-5}
R-30	0.15 - 0.29	–	–	–	-6.32×10^{-7}	-4.54×10^{-6}	-2.25×10^{-6}
R-30	0.3 – 0.49	–	–	–	-3.32×10^{-6}	-2.23×10^{-5}	-1.07×10^{-5}
R-30	0.5 – 0.69	-5.55×10^{-6}	-4.83×10^{-5}	-2.35×10^{-5}	-6.05×10^{-6}	-4.13×10^{-5}	-2.00×10^{-5}
R-30	≥ 0.7	-6.77×10^{-6}	-7.30×10^{-5}	-3.95×10^{-5}	-8.39×10^{-6}	-6.06×10^{-5}	-2.93×10^{-5}

**Table 239. 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 240. 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 241 through Table 245 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 241. 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 242. 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 243. 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 244. 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 245. 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.²⁷³

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 or county
- 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
 - Because heating savings are negative, no adjustment factor will be applied to projects with missing documentation
- 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.

²⁷³ DEER READI (Remote Ex-Ante Database Interface). <http://www.deeresources.com/index.php/readi>.

References and Efficiency Standards

Petitions and Rulings

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

Relevant Standards and Reference Sources

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

Document Revision History

Table 246. 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.
v11.0	10/2023	TRM v11.0 update. No revision.
<u>v12.0</u>	<u>10/2024</u>	<u>TRM v12.0 update. No revision.</u>

2.3.9 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.²⁷⁴ Space heating primarily refers to electric baseboard zonal heaters controlled by thermostats or to portable plug-load heaters.²⁷⁵ 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.²⁷⁶

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.

²⁷⁴ Electric Resistance Heating: <https://www.energy.gov/energysaver/home-heating-systems/electric-resistance-heating>.

²⁷⁵ Portable Heaters: <https://www.energy.gov/energysaver/home-heating-systems/portable-heaters>.

²⁷⁶ 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 percent²⁷⁷ 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 247 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 247 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 247 by a factor of 0.24.²⁷⁸

²⁷⁷ Residential Windows – A Guide to New Technologies and Energy Performance, 2000.

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 ÷ 42,000 = 0.24.

Table 247. 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 248 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 248 by a factor of 0.6.

Table 248. 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 249 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 249 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 ÷ 42,000 = 0.24.

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

Climate zone ^a	Gas	Electric resistance	Heat pump ^b
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.²⁸⁰

Program Tracking Data and Evaluation Requirements

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

- Climate zone or county
- 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
 - Because heating savings are negative, no adjustment factor will be applied to projects with missing documentation
- 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

²⁸⁰ 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 250. 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.
v11.0	10/2023	TRM v11.0 update. No revision.
<u>v12.0</u>	<u>10/2024</u>	<u>TRM v12.0 update. No revision.</u>

2.3.10 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.²⁸¹

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 Condition

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

²⁸¹ 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.²⁸² 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.²⁸³ Space heating primarily refers to electric baseboard zonal heaters controlled by thermostats or to portable plug-load heaters.²⁸⁴ 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 251. 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 7.0 Requirements for eligible windows, doors, and skylights effective October 23, 2023.²⁸⁵ Energy efficiency service providers are expected to comply with the latest ENERGY STAR requirements.

Table 252. Windows—ENERGY STAR Requirements²⁸⁶

US region, ENERGY STAR	U-factor Btu/(h·sq. ft.·°F)	Solar heat gain coefficient (SHGC)
North-Central	≤ 0.25	≤ 0.40
South-Central	≤ 0.28	≤ 0.23
Southern	≤ 0.32	≤ 0.23

²⁸² 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/>.

²⁸³ Electric Resistance Heating. <https://www.energy.gov/energysaver/home-heating-systems/electric-resistance-heating>.

²⁸⁴ Portable Heaters. <https://www.energy.gov/energysaver/home-heating-systems/portable-heaters>.

²⁸⁵ ENERGY STAR Residential Windows, Doors, and Skylights Final Version 6.0 Program Requirements. https://www.energystar.gov/sites/default/files/ES_Residential_WDS_V7_Final%20Specification%202022.pdf.

²⁸⁶ ENERGY STAR Windows, Doors, and Skylights Climate Zone Finder. Note that these zones differ from the TRM climate zones. https://www.energystar.gov/products/building_products/residential_windows_doors_and_skylights/climate_zone/search.

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 253.

Table 253. 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 254 through Table 256 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 254 and Table 256 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 0.24.²⁸⁷

For residences reporting electric resistance heat, a documentation adjustment factor of 0.75 will be applied to deemed heating energy savings if no documentation is provided to validate the heating equipment. In all other cases, the documentation adjustment factor is set to 1.0.

²⁸⁷ 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 254. 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 255. 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 256. 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 257 through Table 259 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 257. Windows—Summer Peak Demand Savings (kW/sq. ft.), Single-Pane Baseline

Climate zone	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 258. 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 259. 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 260 through Table 262 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 0.24.²⁸⁸

For residences reporting electric resistance heat, a documentation adjustment factor of 0.75 will be applied to deemed winter peak demand savings if no documentation is provided to validate the heating equipment. In all other cases, the documentation adjustment factor is set to 1.0.

²⁸⁸ This factor was derived based on expected capacity reduction assuming 1200 sq. ft. (historical analysis of HTR participants) x 0.35 BTU/sq. ft. = 42,000 BTU for central electric furnaces and two 1,500-watt portable heaters per home rated at 5,100 BTU/heater. Taking the ratio of portable to furnace capacity yields 10,200 ÷ 42,000 = 0.24.

Table 260. 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 261. 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 262. 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 windows²⁸⁹.

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 or county
- 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
 - ~~If documentation is not provided, an adjustment factor of 0.75 will be applied to the heating energy and winter demand savings~~
- 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.
- U-factor and SHGC of each new window
- Area of new ENERGY STAR windows
- Proof of purchase – with date of purchase and quantity
 - Alternative: photo of unit installed or another pre-approved method of installation verification.

²⁸⁹ "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.

References and Efficiency Standards

Petitions and Rulings

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

Relevant Standards and Reference Sources

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

Document Revision History

Table 263. 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.
v11.0	10/2023	TRM v11.0 update. Updated ENERGY STAR specification. Added electric resistance documentation adjustment factor.
<u>v12.0</u>	<u>10/2024</u>	<u>TRM v12.0 update. Clarified application of electric resistance documentation adjustment factor.</u>

2.3.11 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 Condition

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.²⁹⁰ 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.²⁹¹ Space heating primarily refers to electric baseboard zonal heaters controlled by thermostats or to portable plug-load heaters.²⁹² 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, 2018.²⁹³ Energy efficiency service providers are expected to comply with the latest ENERGY STAR requirements.

²⁹⁰ 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/>.

²⁹¹ Electric Resistance Heating. <https://www.energy.gov/energysaver/home-heating-systems/electric-resistance-heating>.

²⁹² Portable Heaters. <https://www.energy.gov/energysaver/home-heating-systems/portable-heaters>.

²⁹³ 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 264. 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.²⁹⁴ The properties of low-e storm windows used in the RESFEN building models are presented in Table 265. This measure assumes equal weighting between the three low-e storm window glass options.

Table 265. Low-E Storm Windows—Window Assembly Properties²⁹⁵

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 266.

Table 266. 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 ^{296,297}	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

²⁹⁴ RESFEN window tool. LBNL. <https://windows.lbl.gov/software/resfen>.

²⁹⁵ Averaged values from the selected products in Attachments Energy Rating Council (AERC). <https://aercenergyrating.org/product-search/residential-product-search/>.

²⁹⁶ 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.

²⁹⁷ 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
Existing window frame	Wood double-hung
Foundation	Slab on-grade
Insulation	Newer construction: IECC 2006 based on climate zone Older construction: See RESFEN 6 documentation
HVAC efficiency	Newer construction: 13 SEER, 7.7 HSPF, 0.8 AFUE for IECC Climate Zones 1-3 and 0.9 AFUE for IECC Climate Zones 4-8 Older construction: 10 SEER, 6.8 HSPF, 0.78 AFUE

Deemed Energy Savings Tables

Table 267 through Table 269 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 267 and Table 269 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 0.24.²⁹⁸

For residences reporting electric resistance heat, a documentation adjustment factor of 0.75 will be applied to deemed heating energy savings if no documentation is provided to validate the heating equipment. In all other cases, the documentation adjustment factor is set to 1.0.

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

Table 267. 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

²⁹⁸ 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 ÷ 42,000 = 0.24.

Table 268. 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
Zone 4: Corpus Christi	3.21	–	1.05	0.32
Zone 5: El Paso	2.37	–	1.90	0.79

Table 269. 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 270 through Table 272 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 270. 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 271. 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 272. 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 273 through Table 275 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 0.24.²⁹⁹

For residences reporting electric resistance heat, a documentation adjustment factor of 0.75 will be applied to deemed winter peak demand savings if no documentation is provided to validate the heating equipment. In all other cases, the documentation adjustment factor is set to 1.0.

²⁹⁹ 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 273. 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

Table 274. 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 275. 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.³⁰⁰

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 or county
- 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
 - ~~If documentation is not provided, an adjustment factor of 0.75 will be applied to the heating energy and winter demand savings~~
- 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.
- Emissivity and solar transmission of each new window
- Area of new ENERGY STAR storm windows
- 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

³⁰⁰ 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.

Document Revision History

Table 276. 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.
v11.0	10/2023	TRM v11.0 update. Added electric resistance documentation adjustment factor.
v12.0	10/2024	TRM v12.0 update. Clarified application of electric resistance documentation adjustment factor.

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 tankless³⁰¹ or gas-fueled water heater (storage or tankless) in place of an electric storage water heater.

Eligibility Criteria

This measure involves installing a gas storage, gas (instantaneous tankless), or electric tankless water heater in place of an electric storage water heater that meets all the additional requirements described below. 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.

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.

³⁰¹ Currently, most electric tankless water heaters are rated at or near the federal standard and may yield negative or no energy savings using the current baseline. However, this measure maintains eligibility for any electric tankless water heaters that may be rated above current minimum efficiency requirements.

Baseline Condition

The baseline condition is an electric storage water heater with baseline efficiency Uniform Energy Factor (UEF) determined by tank size and first hour rating (FHR), a proxy for draw pattern. This baseline is specified according to the current federal energy efficiency standards for residential water heaters with tank sizes from 20 to 120 gallons, effective April 16, 2015, as published in 10 CFR Part 430.32 of the Federal Register (see Table 277).³⁰²

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

Table 277. DHW Replacements—Federal Standard for Residential Electric Storage Water Heaters

Rated storage volume	Draw pattern	First hour rating (FHR) ^{303,304}	Uniform energy factor (UEF) ³⁰⁵
≥ 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	$75 \leq \text{FHR}$	$2.2418 - (0.0011 \times V_r)$

High-Efficiency Condition

Eligible equipment must be compliant with the current ENERGY STAR v5.0 specification effective April 18, 2023, with qualified products meeting the minimum requirements from

Table 278³⁰⁶. However, the ENERGY STAR v5.0 specification does not cover electric tankless water heaters or gas storage products with an FHR less than 51. In these cases, the high efficiency condition corresponds to the respective federal standards for residential water heaters.³⁰⁷

³⁰² 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.

³⁰³ "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>.

³⁰⁴ Assume FHR equal to that of installed water heater.

³⁰⁵ V_r is the rated storage volume (in gallons), as determined pursuant to 10 CFR 429.17.

³⁰⁶ https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Residential%20Water%20Heater%20Version%205.0%20Specification%20and%20Partner%20Commitments_0.pdf.

³⁰⁷ 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.