Table 30. RES Solar PV—Climate Zone 1: Amarillo—Summer Demand kW Savings

Tilt (degrees)		Azimuth (degrees, center and range)				
		90	135	180	225	270
Center	Range	>67.5-112.5	>112.5-157.5	>157.5-202.5	>202.5-247.5	>247.5-292.5
0	0-7.5	48%	48%	48%	48%	48%
15	>7.5-22.5	35%	40%	49%	56%	58%
30	>22.5-37.5	20%	30%	47%	60%	64%
45	>37.5-52.5	10%	18%	42%	61%	66%
60	>52.5-67.5	7%	10%	34%	59%	65%

Table 31. RES Solar PV—Climate Zone 1: Amarillo—Winter Demand kW Savings

Tilt (degrees)		Azimuth (degrees, center and range)				
		90	135	180	225	270
Center	Range	>67.5-112.5	>112.5-157.5	>157.5-202.5	>202.5-247.5	>247.5-292.5
0	0-7.5	1%	1%	1%	1%	1%
15	>7.5-22.5	3%	3%	2%	1%	0%
30	>22.5-37.5	4%	5%	3%	1%	0%
45	>37.5-52.5	6%	6%	4%	1%	0%
60	>52.5-67.5	6%	7%	4%	0%	0%

Table 32. RES Solar PV—Climate Zone 2: Dallas—Summer Demand kW Savings

Tilt (degrees)		Azimuth (degrees, center and range)				
		90	135	180	225	270
Center	Range	>67.5-112.5	>112.5-157.5	>157.5-202.5	>202.5-247.5	>247.5-292.5
0	0-7.5	46%	46%	46%	46%	46%
15	>7.5-22.5	35%	39%	46%	52%	54%
30	>22.5-37.5	22%	29%	43%	55%	59%
45	>37.5-52.5	12%	19%	38%	56%	60%
60	>52.5-67.5	8%	12%	31%	53%	58%

Table 33. RES Solar PV—Climate Zone 2: Dallas—Winter Demand kW Savings

Tilt (degrees)		Azimuth (degrees, center and range)				
		90	135	180	225	270
Center	Range	>67.5-112.5	>112.5-157.5	>157.5-202.5	>202.5-247.5	>247.5-292.5
0	0-7.5	3%	3%	3%	3%	3%
15	>7.5-22.5	5%	6%	4%	2%	1%
30	>22.5-37.5	8%	8%	5%	2%	1%
45	>37.5-52.5	9%	10%	6%	1%	1%
60	>52.5-67.5	10%	11%	6%	1%	1%

Table 34. RES Solar PV—Climate Zone 3: Houston—Summer Demand kW Savings

Tilt (degrees)		Azimuth (degrees, center and range)				
		90	135	180	225	270
Center	Range	>67.5-112.5	>112.5-157.5	>157.5-202.5	>202.5-247.5	>247.5-292.5
0	0-7.5	36%	36%	36%	36%	36%
15	>7.5-22.5	26%	29%	36%	42%	44%
30	>22.5-37.5	16%	21%	34%	45%	49%
45	>37.5-52.5	9%	14%	29%	46%	51%
60	>52.5-67.5	8%	9%	23%	44%	51%

Table 35. RES Solar PV—Climate Zone 3: Houston—Winter Demand kW Savings

Tilt (degrees)		Azimuth (degrees, center and range)				
		90	135	180	225	270
Center	Range	>67.5-112.5	>112.5-157.5	>157.5-202.5	>202.5-247.5	>247.5-292.5
0	0-7.5	6%	6%	6%	6%	6%
15	>7.5-22.5	10%	11%	8%	5%	3%
30	>22.5-37.5	14%	15%	10%	4%	1%
45	>37.5-52.5	17%	18%	11%	3%	1%
60	>52.5-67.5	18%	19%	12%	2%	1%

Table 36. RES Solar PV—Climate Zone 4: Corpus Christi—Summer Demand kW Savings

Tilt (degrees)		Azimuth (degrees, center and range)				
		90	135	180	225	270
Center	Range	>67.5-112.5	>112.5-157.5	>157.5-202.5	>202.5-247.5	>247.5-292.5
0	0-7.5	41%	41%	41%	41%	41%
15	>7.5-22.5	30%	33%	41%	48%	51%
30	>22.5-37.5	16%	23%	39%	52%	57%
45	>37.5-52.5	8%	14%	34%	53%	60%
60	>52.5-67.5	8%	9%	27%	51%	59%

Table 37. RES Solar PV—Climate Zone 4: Corpus Christi—Winter Demand kW Savings

Tilt (degrees)		Azimuth (degrees, center and range)				
		90	135	180	225	270
Center	Range	>67.5-112.5	>112.5-157.5	>157.5-202.5	>202.5-247.5	>247.5-292.5
0	0-7.5	5%	5%	5%	5%	5%
15	>7.5-22.5	8%	9%	7%	4%	2%
30	>22.5-37.5	11%	12%	8%	3%	1%
45	>37.5-52.5	13%	14%	9%	2%	1%
60	>52.5-67.5	13%	15%	9%	2%	1%

Table 38. RES Solar PV—Climate Zone 5: El Paso—Summer Demand kW Savings

Tilt (degrees)		Azimuth (degrees, center and range)				
		90	135	180	225	270
Center	Range	>67.5-112.5	>112.5-157.5	>157.5-202.5	>202.5-247.5	>247.5-292.5
0	0-7.5	49%	49%	49%	49%	49%
15	>7.5-22.5	40%	44%	49%	54%	55%
30	>22.5-37.5	29%	35%	47%	56%	58%
45	>37.5-52.5	16%	25%	42%	55%	58%
60	>52.5-67.5	10%	15%	34%	51%	55%

Table 39. RES Solar PV—Climate Zone 5: El Paso—Winter Demand kW Savings

Tilt (degrees)		Azimuth (degrees, center and range)				
		90	135	180	225	270
Center	Range	>67.5-112.5	>112.5-157.5	>157.5-202.5	>202.5-247.5	>247.5-292.5
0	0-7.5	0%	0%	0%	0%	0%
15	>7.5-22.5	0%	0%	0%	0%	0%
30	>22.5-37.5	0%	0%	0%	0%	0%
45	>37.5-52.5	0%	0%	0%	0%	0%
60	>52.5-67.5	0%	0%	0%	0%	0%

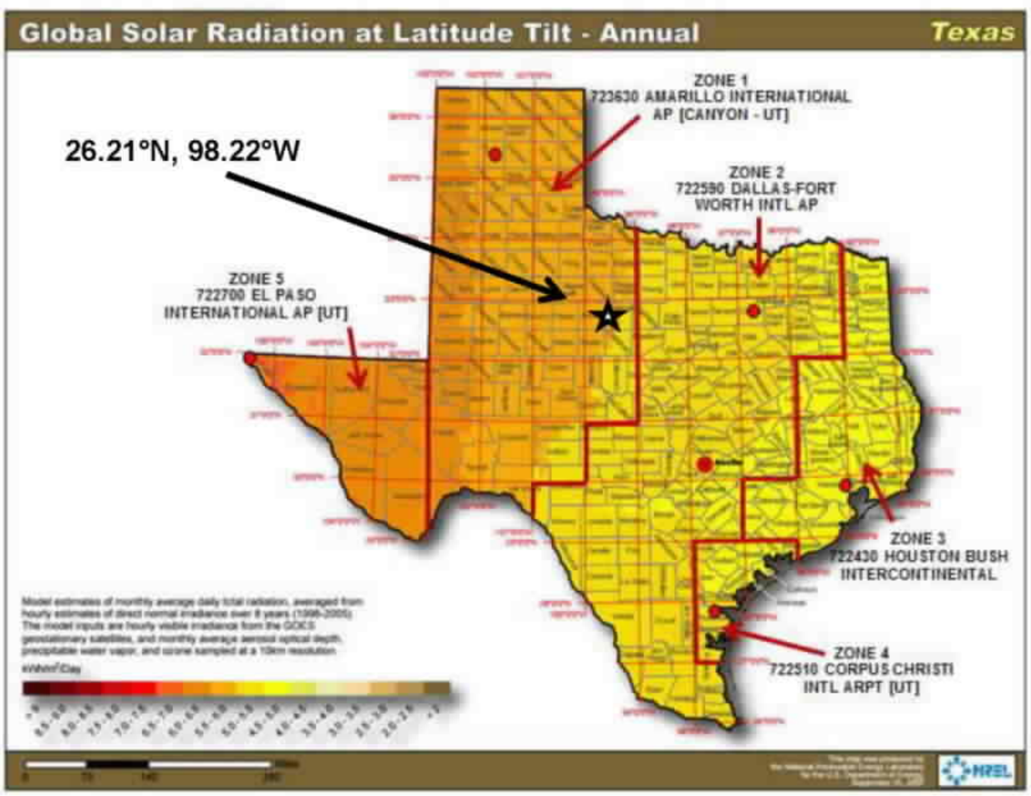
Deemed Summer and Winter Demand Savings—Example

Example: A residential customer at 555 Walnut Street, Abilene, TX 79601 installs a 5 kW_{dc} fixed array of standard crystalline silicon modules on their roof with a tilt of 20 degrees and an azimuth of 200 degrees.

- **Step 1.** Determine the appropriate weather zone. Geographic coordinates for this system (26.21°N, 98.22°W from Figure 8) were derived when determining the annual energy savings (kWh).

  From the weather zone map, this location is in zone 1. See Figure 8.

Figure 8. RES Solar PV—Application of the Weather Zone Map



- **Step 2.** Calculate summer and winter demand savings. From the zone 1 lookup table, 20-degree tilt falls within the 7.5- to 22.5-degree tilt range, and 200-degree azimuth falls within the 157.5–202.5 azimuth range. The summer lookup value is 49 percent, and the winter lookup value is 2 percent.

  Applying Equation 54,

  $$\textit{Deemed summer demand} = \textit{DC system size (kW)} * \textit{lookup value}$$

  $$\textit{Deemed summer demand} = 5.000\ kW * 49\%$$

  $$\textit{Deemed summer demand} = 5.000\ kW * 0.49$$

  $$\textit{Deemed summer demand} = 2.450\ kW$$

  Applying Equation 55,

  $$\textit{Deemed winter demand} = \textit{DC system size (kW)} * \textit{lookup value}$$

  $$\textit{Deemed summer demand} = 5.000\ kW * 2\%$$

  $$\textit{Deemed summer demand} = 5.000\ kW * 0.02$$

  $$\textit{Deemed summer demand} = 0.100\ kW$$

Claimed Peak Demand Savings

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

Measure Life and Lifetime Savings

The estimated useful life (EUL) of photovoltaic systems is established at 30 years. This value is consistent with engineering estimates based on manufacturers' warranties and historical data.

Program Tracking Data and Evaluation Requirements

The following information will be required to be collected.

- Project location (full address, including city, state, and zip code)
- Module type: Standard, premium, or thin film
- Array type: Fixed (open rack), fixed (roof mount), one-axis tracking, one-axis backtracking, two-axis tracking, etc.
- Tilt, azimuth, and DC system size rating for each array
- Shading study, if not using PVWatts default values

- The calculation of electricity production through PVWatts can be completed by accessing the online calculator or utilizing an application programming interface (API). The required documentation varies between the two methods.
    - Online calculator: Date of PVWatts run and PVWatts printed results report (as a file retained with project documentation)
- API: Date of API access and response, documentation of API programming (including the access endpoint and request parameters), and the response results.
- Selected climate zone and demand method used
- For projects using the alternative method, retention of the TRM 4.0 PV tool workbook for each array evaluated

References and Efficiency Standards

Petitions and Rulings

- PUCT Docket 36779—Provides estimate for EUL.

Relevant Standards and Reference Sources

- National Electric Code (NEC) 690, "Solar Photovoltaic Systems" or local building codes.
- P. Dobos. PVWatts Version 5 Manual. National Renewable Energy Laboratory. NREL/TP-6A20-62641. September 2014. http://www.nrel.gov/docs/fy14osti/62641.pdf. PVWatts calculator available at: https://pvwatts.nrel.gov/index.php.

Document Revision History

Table 40. RES Solar PV—Revision History

TRM version	Date	Description of change
v1.0	11/25/2013	TRM v1.0 origin.
v2.0	04/18/2014	Minor edits to language and structure.
v2.1	01/30/2015	No revision.
v3.0	04/10/2015	No revision.
v4.0	10/10/2016	Removed deemed savings option for energy. Provided new method for calculating summer and winter demand savings and provided deemed summer and winter demand savings lookup tables.
v5.0	10/10/2017	Corrected equation, figure, and table references.
v6.0	10/2018	No revision.
v7.0	10/2019	No revision.
v8.0	10/2020	Updated instructions for new version of PVWatts and references to NREL National Solar Radiation Database (NSRD) (previously TMY3).

TRM version	Date	Description of change
v9.0	10/2021	Clarified PVWatts kWh modeling instructions and documentation requirements. Provided guidance for slightly tilted arrays that fall outside lookup table azimuth ranges.
v10.0	10/2022	No revision.
v11.0	10/2023	Eliminated alternate savings method and adjusted premium module type requirements to match PVWatts. Clarified assumptions to use in PVWatts analysis.
v12.0	10/2024	No revision.

2.4.2 Nonresidential Solar Photovoltaics (PV) Measure Overview

TRM Measure ID: NR-RN-PV

Market Sector: Commercial

Measure Category: Renewables

Applicable Building Types: All

Fuels Affected: Electricity

Decision/Action Type: Retrofit (RET), new construction (NC)

Program Delivery Type: Prescriptive

Deemed Savings Type: Simulation software (kWh), deemed values (kW)

Savings Methodology: Model-calculator (PVWatts®)

Measure Description

This section summarizes savings calculations for solar photovoltaic (PV) standard offer, market transformation, and pilot programs. These programs are offered by Texas utilities, with the primary objective to achieve cost-effective energy and peak demand savings. Participation in the PV program involves the installation of a solar photovoltaic system. The method uses a simulation tool, the National Renewable Energy Laboratory's (NREL) PVWatts Calculator,[69] to calculate energy savings. Lookup tables are used to determine deemed summer and winter peak demand savings.

Eligibility Criteria

Only photovoltaic systems that result in reductions of the customer's purchased energy or peak demand qualify for savings. Off-grid systems are not eligible. Each utility may have additional incentive program eligibility and interconnection requirements, which are not listed here.

Baseline Condition

PV system not currently installed (typical) or an existing system is present, but additional capacity (including both panels and inverters) may be added.

High-Efficiency Condition

Not applicable.

[69] PVWatts Calculator: http://pvwatts.nrel.gov/.

Energy and Demand Savings Methodology

Solar PV systems shall be modeled using the current version of the National Renewable Energy Laboratory's (NREL) PVWatts calculator. Energy savings are estimated using the default weather data source offered by PVWatts.[70] Demand savings use lookup tables derived from PVWatts, based on NREL National Solar Radiation Database (NSRDB) weather data sources defined by location of the project.

Savings Algorithms and Input Variables

All Installations

PVWatts input variables (for each array, where an array is defined as a set of PV modules with less than 5 degrees difference in tilt or azimuth):

- Installation address: Use complete site address, including five-digit ZIP code.
- Weather data file: Default NSRDB data is a detailed grid of solar radiation throughout Texas (and North America), identified as a blue square in the map (see Figure 10).
- DC system size (kilo-watt): Input the sum of the DC (direct current) power rating of all photovoltaic modules in the array at standard test conditions (STC), in kilowatts DC.
  - For AC modules, refer to the module specification sheet to obtain the DC (STC) power rating.
- Module type: Standard, premium, or thin film. Use the nominal module efficiency, cell material, and temperature coefficient from the module datasheet to choose the module type, or accept the default provided by PVWatts.

Table 41. Non-RES Solar PV—Module Type Options

Type	Approximate efficiency	Module cover	Temperature coefficient of power
Standard (crystalline silicon)	19 percent	Anti-reflective	-0.37 %/°C
Premium (crystalline silicon)	21 percent	Anti-reflective	-0.35 %/°C
Thin film	18 percent	Anti-reflective	-0.32 %/°C

- Array Type: Fixed (open rack), fixed (roof mount), one-axis tracking, two-axis backtracking, two-axis tracking.
- Tilt (deg): Enter the angle from horizontal of the photovoltaic modules in the array.
- Azimuth (deg): Enter the angle clockwise from true north, describing the direction that the array faces.
- Shading: Accept the PVWatts default values as the minimum shading[71] or adjust the shading percentage only if the actual conditions exceed this value.

[70] PVWatts Calculator: https://pvwatts.nrel.gov/.
[71] Three percent default shading, PVWatts Calculator accessed on August 8, 2023.

- DC to AC size ratio: Adjust to match the equipment or use the default.
- Bifacial: Adjust to match installed equipment.
- All other input variables: accept the PVWatts default values.

Annual Energy Savings (kWh)

Given the inputs above, PVWatts calculates the estimated annual energy savings for each array.

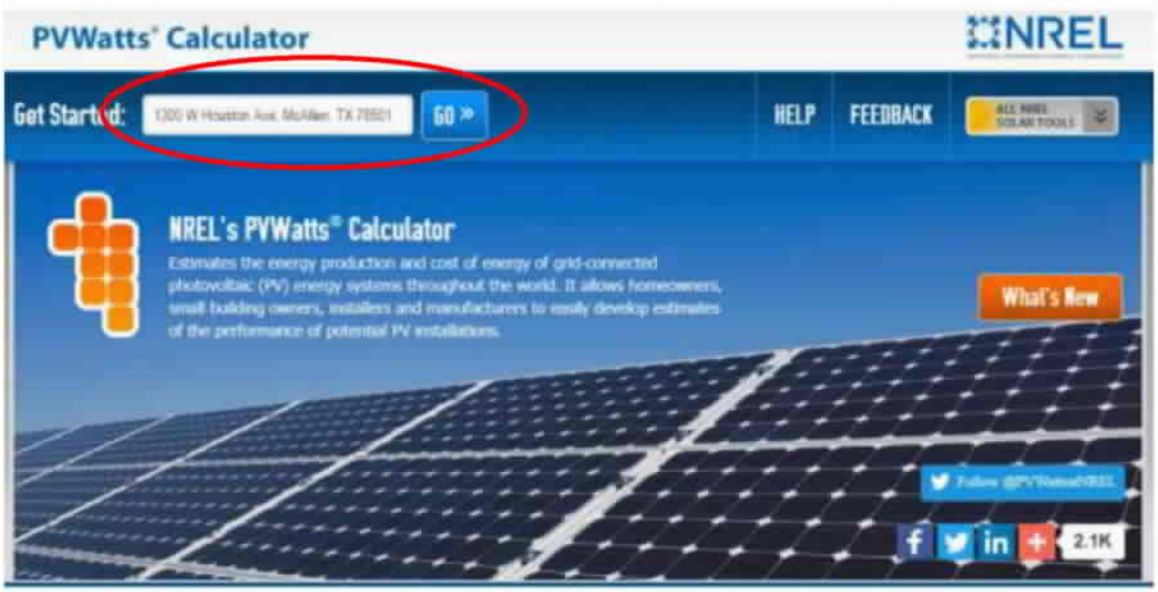
For systems with multiple arrays, users should derive annual energy savings for each array separately and sum them to obtain total annual energy savings.

A screenshot (or other save) of the ‘Results’ page, displaying both the annual energy production and model inputs, is typically required in PV incentive applications and is sufficient documentation for the annual energy savings estimate.

Example: A commercial customer at 1300 W. Houston Avenue, McAllen, TX 78501, installs a 50 kW_{dc} fixed array of standard crystalline silicon modules on their roof with a tilt of 5 degrees and an azimuth of 175 degrees.

Step 1. The user enters the full site address (rather than only the zip code) of the proposed PV system in PVWatts calculator and presses “Go.” See Figure 9.

Figure 9. Non-RES Solar PV—PVWatts Input Screen for Step 1



Step 2. PVWatts automatically identifies the nearest weather data source, defaulting to the NREL grid cell for your location. The user should change the default weather data source, as shown in Figure 10. Confirm the resulting location and proceed to system info, as shown in Figure 11.

Figure 10. Non-RES Solar PV—PVWatts Resource Data Map

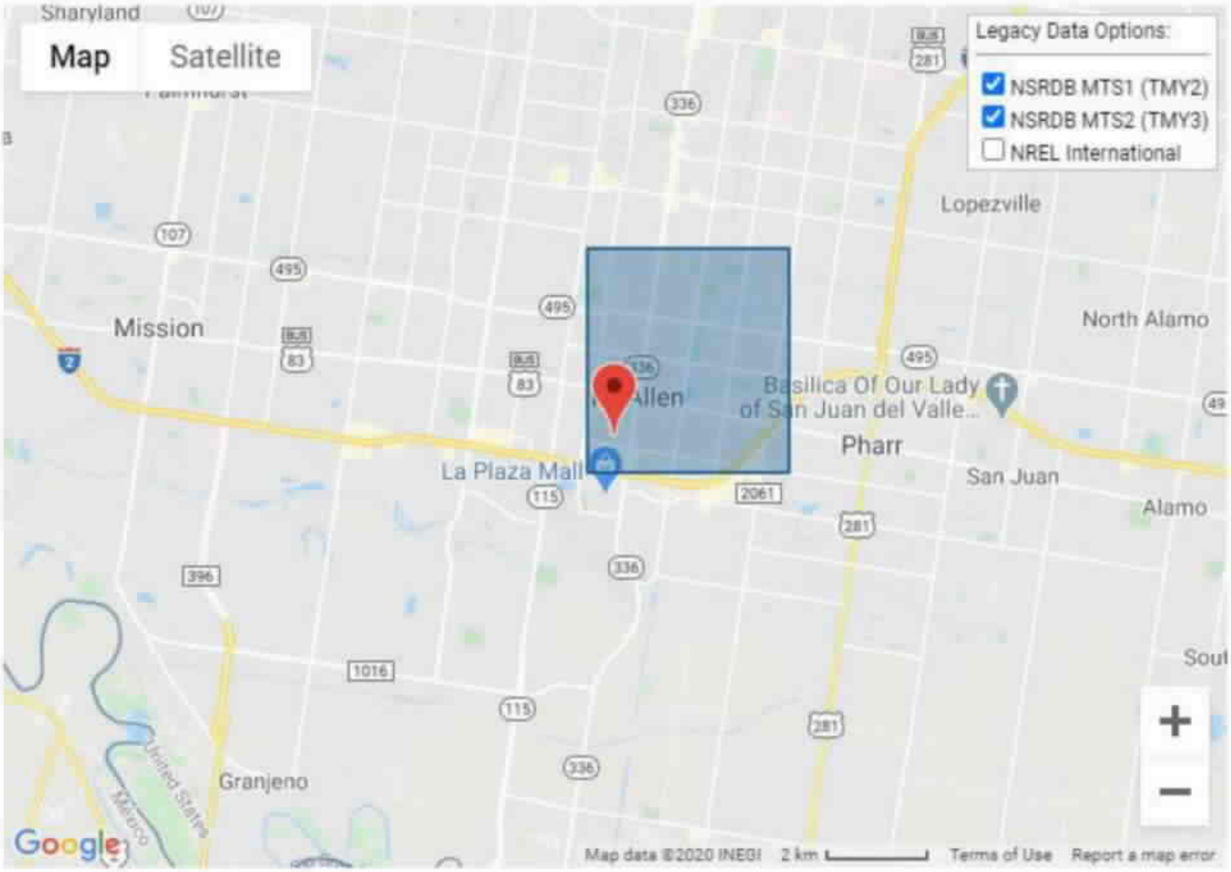
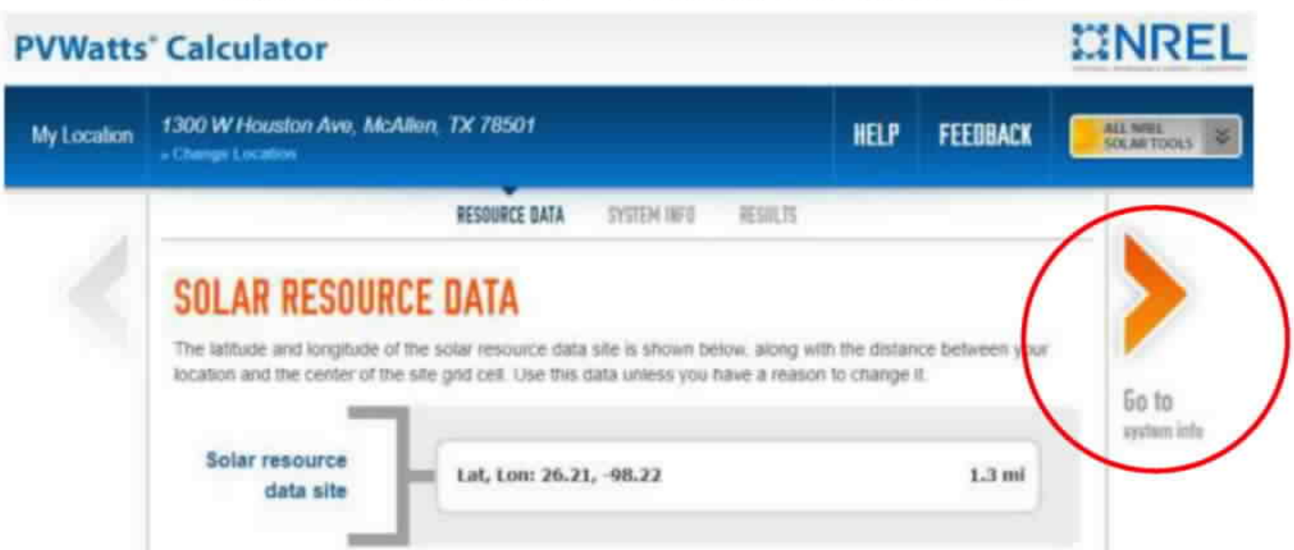


Figure 11. Non-RES Solar PV—PVWatts Input Screen for Step 2

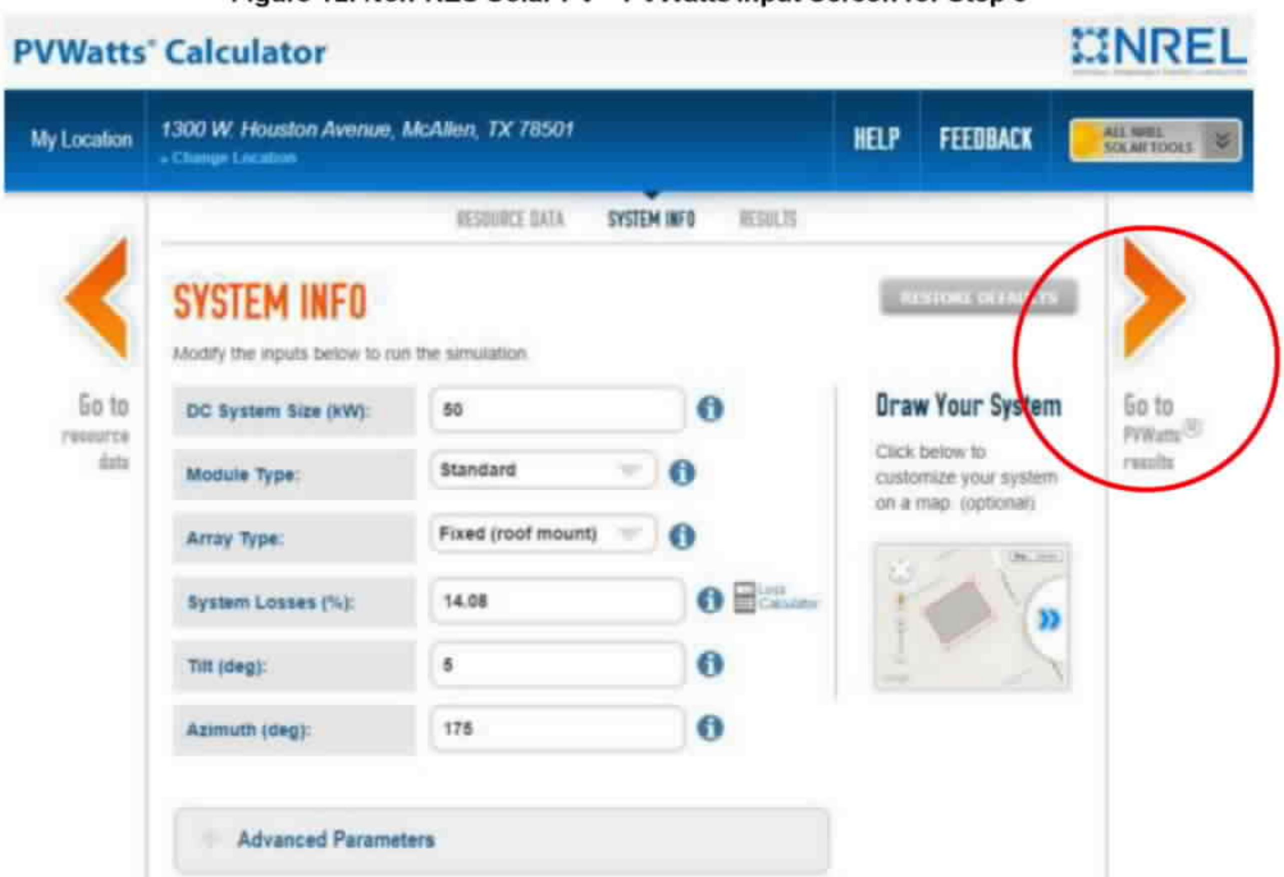


Step 3. The user enters system info as follows:

- DC system size (kW): 50.00
- Module type: Standard
- Array type: Fixed (roof mount)
- Tilt (deg): 5
- Azimuth (deg): 175

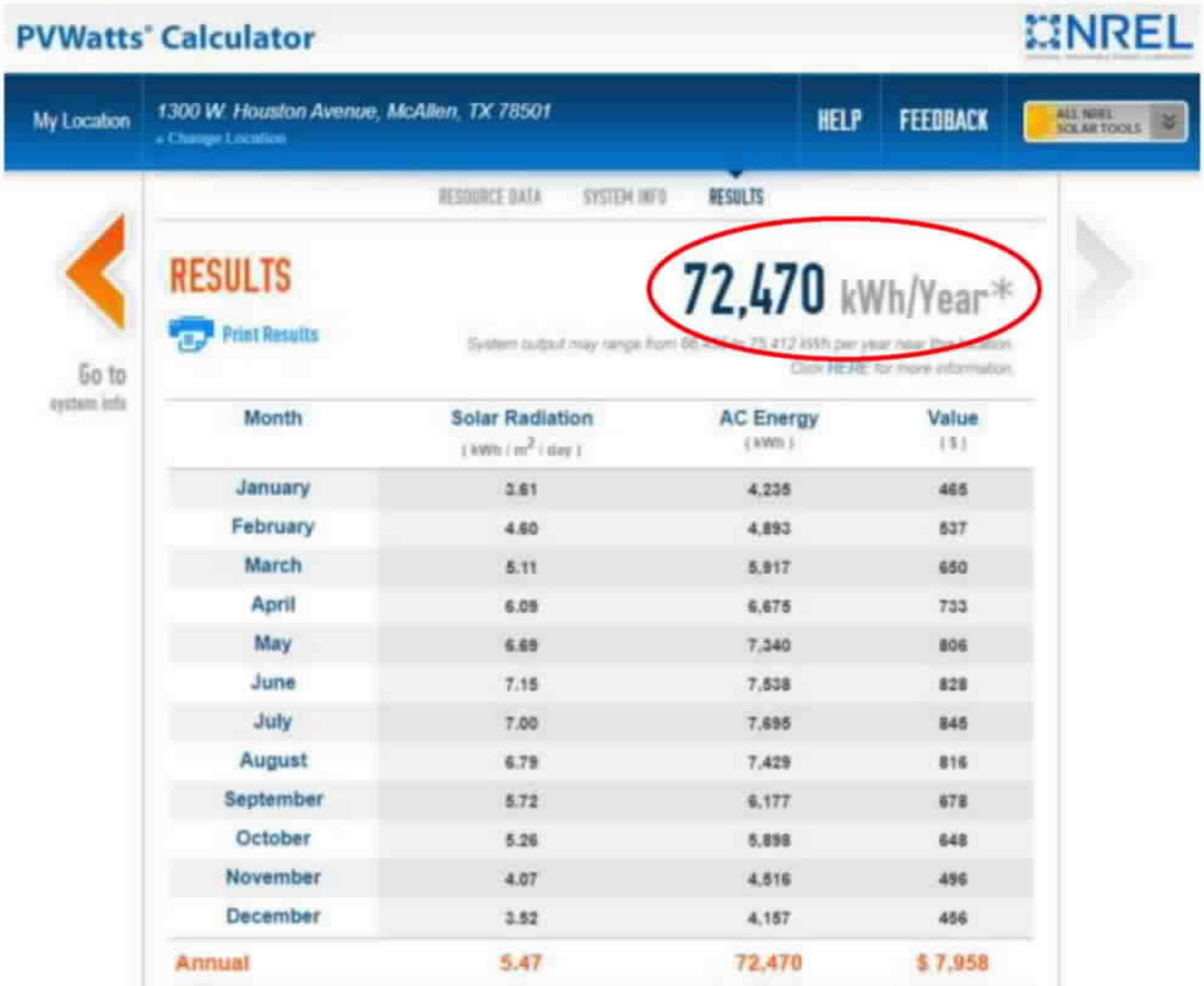
All other details (System Losses, Advanced Parameters, Initial Economics) are left at default values. Once entered, the user presses "Go to PVWatts results." See Figure 12.

Figure 12. Non-RES Solar PV—PVWatts Input Screen for Step 3



Step 4. PVWatts returns an estimate of annual energy production (kWh), in this case 72,470 kWh. See Figure 13.

Figure 13. Non-RES Solar PV—PVWatts Output Screen for Step 4



Month	Solar Radiation (kWh / m² / day)	AC Energy (kWh)	Value ($)
January	3.61	4,235	465
February	4.60	4,893	537
March	5.11	5,917	650
April	6.09	6,675	733
May	6.69	7,340	806
June	7.15	7,538	828
July	7.00	7,695	845
August	6.79	7,429	816
September	5.72	6,177	678
October	5.26	5,898	648
November	4.07	4,516	496
December	3.52	4,157	456
Annual	5.47	72,470	$ 7,958

Further down this output page, PVWatts returns a summary of model inputs (Figure 14).

Figure 14. Non-RES Solar PV—PVWatts Output Screen for Step 4 (continued)

Location and Station Identification	
Requested Location	1300 W. Houston Avenue, McAllen, TX 78501
Weather Data Source	Lat, Lon: 26.21, -98.22 1.3 mi
Latitude	26.21° N
Longitude	98.22° W
PV System Specifications *(Residential)*	
DC System Size	50 kW
Module Type	Standard
Array Type	Fixed (roof mount)
Array Tilt	5°
Array Azimuth	175°
System Losses	14.08%
Inverter Efficiency	96%
DC to AC Size Ratio	1.2
Economics	
Average Retail Electricity Rate	0.110 $/kWh
Performance Metrics	
Capacity Factor	16.5%

The coordinates (latitude and longitude) of the proposed system are presented and useful to determine the appropriate weather zone to use when estimating demand savings.

A screenshot (or .pdf) of the complete output page, displaying both the annual energy production and model inputs, is typically required in PV incentive applications and is sufficient documentation for annual energy savings estimate.

Summer Demand Savings Methodology

Deemed summer demand savings are determined using the weather zone map (Figure 15) and summer demand savings lookup values (Table 42) provided below. Deemed summer demand savings is the product of the system's DC system size and the appropriate lookup table value.

Deemed Summer Demand Savings

*Deemed summer demand savings = DC system size (kW) * Lookup Value*

Equation 56

For systems with multiple arrays, users should calculate summer demand savings for each array separately and sum them to obtain the total summer demand savings.

Commercial systems may be modeled using the alternative method described below.

Winter Demand Savings Methodology

Deemed winter demand savings are determined using the weather zone map (Figure 15) and winter demand savings lookup values tables (Table 42 through Table 51) provided below. Deemed winter demand savings is the product of the system's DC system size and the appropriate lookup table value.

Deemed Winter Demand Savings

*Deemed winter demand savings = DC system size (kW) * Lookup Value*

Equation 57

For systems with multiple arrays, users should derive winter demand savings for each array separately and sum them to obtain the total winter demand savings.

Commercial systems may instead be modeled using the alternative method described below.

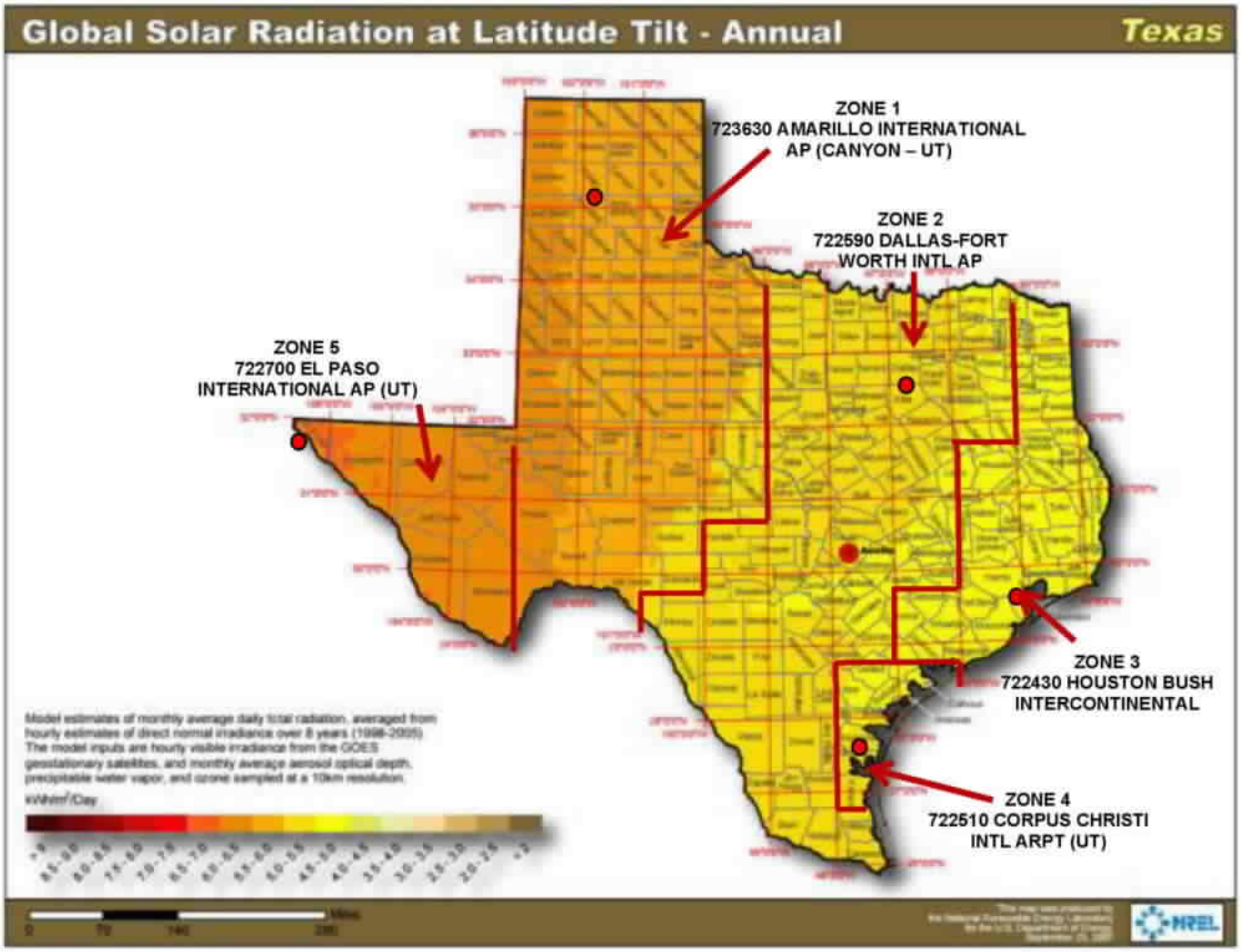
Deemed Energy Savings Tables

Not applicable.

Deemed Summer and Winter Demand Savings—Weather Zone Determination

The appropriate weather zone for each system can be determined by identifying the system's coordinates on the map in Figure 15 below. The map identifies weather zones, and the reference TMY3 weather station name and six-digit identifier used in calculating the lookup values within each weather zone. An example of how to use the weather zone map and tables to derive summer and winter peak demand savings is provided below the tables.

Figure 15. Non-RES Solar PV—Weather Zone Determination for Solar PV Systems[72]



Deemed Summer and Winter Demand Savings—Lookup Value Tables

The tables below provide lookup values used to calculate deemed summer and winter demand savings based on the weather zone, tilt, and azimuth. Table 42 through Table 51 present lookup values to determine deemed summer and winter demand savings given various array tilt/azimuth combinations. The values in the tables express summer and winter peak demand savings as a percentage of an array's DC rating at standard test conditions (STC).

Some rooftops are essentially flat but have a slight tilt (< 7.5 degrees) to facilitate runoff. If the azimuth of a slightly tilted (< 7.5 degrees) array falls outside the 67.5–292.5-degree azimuth ranges provided in the lookup tables below, the user should apply the deemed savings factors from the first line of the appropriate tables, corresponding to a tilt of 0 degrees. For example, in Amarillo, the summer demand factor for an array with a tilt of 4 degrees and an azimuth of 0 degrees (e.g., slightly tilted to the north) would be 48 percent, as shown in Table 42.

[72] NREL: https://openei.org/w/images/4/46/NREL-eere-pv-h-texas.pdf.

Table 42. Non-RES Solar PV—Climate Zone 1: Amarillo—Summer Demand kW Savings

Tilt (degrees)		Azimuth (degrees, center, and range)				
		90	135	180	225	270
Center	Range	>67.5-112.5	>112.5-157.5	>157.5-202.5	>202.5-247.5	>247.5-292.5
0	0-7.5	48%	48%	48%	48%	48%
15	>7.5-22.5	35%	40%	49%	56%	58%
30	>22.5-37.5	20%	30%	47%	60%	64%
45	>37.5-52.5	10%	18%	42%	61%	66%
60	>52.5-67.5	7%	10%	34%	59%	65%

Table 43. Non-RES Solar PV—Climate Zone 1: Amarillo—Winter Demand kW Savings

Tilt (degrees)		Azimuth (degrees, center, and range)				
		90	135	180	225	270
Center	Range	>67.5-112.5	>112.5-157.5	>157.5-202.5	>202.5-247.5	>247.5-292.5
0	0-7.5	1%	1%	1%	1%	1%
15	>7.5-22.5	3%	3%	2%	1%	0%
30	>22.5-37.5	4%	5%	3%	1%	0%
45	>37.5-52.5	6%	6%	4%	1%	0%
60	>52.5-67.5	6%	7%	4%	0%	0%

Table 44. Non-RES Solar PV—Climate Zone 2: Dallas—Summer Demand kW Savings

Tilt (degrees)		Azimuth (degrees, center, and range)				
		90	135	180	225	270
Center	Range	>67.5-112.5	>112.5-157.5	>157.5-202.5	>202.5-247.5	>247.5-292.5
0	0-7.5	46%	46%	46%	46%	46%
15	>7.5-22.5	35%	39%	46%	52%	54%
30	>22.5-37.5	22%	29%	43%	55%	59%
45	>37.5-52.5	12%	19%	38%	56%	60%
60	>52.5-67.5	8%	12%	31%	53%	58%

Table 45. Non-RES Solar PV—Climate Zone 2: Dallas—Winter Demand kW Savings

Tilt (degrees)		Azimuth (degrees, center, and range)				
		90	135	180	225	270
Center	Range	>67.5-112.5	>112.5-157.5	>157.5-202.5	>202.5-247.5	>247.5-292.5
0	0-7.5	3%	3%	3%	3%	3%
15	>7.5-22.5	5%	6%	4%	2%	1%
30	>22.5-37.5	8%	8%	5%	2%	1%
45	>37.5-52.5	9%	10%	6%	1%	1%
60	>52.5-67.5	10%	11%	6%	1%	1%

Table 46. Non-RES Solar PV—Climate Zone 3: Houston—Summer Demand kW Savings

Tilt (degrees)		Azimuth (degrees, center, and range)				
		90	135	180	225	270
Center	Range	>67.5-112.5	>112.5-157.5	>157.5-202.5	>202.5-247.5	>247.5-292.5
0	0-7.5	36%	36%	36%	36%	36%
15	>7.5-22.5	26%	29%	36%	42%	44%
30	>22.5-37.5	16%	21%	34%	45%	49%
45	>37.5-52.5	9%	14%	29%	46%	51%
60	>52.5-67.5	8%	9%	23%	44%	51%

Table 47. Non-RES Solar PV—Climate Zone 3: Houston—Winter Demand kW Savings

Tilt (degrees)		Azimuth (degrees, center, and range)				
		90	135	180	225	270
Center	Range	>67.5-112.5	>112.5-157.5	>157.5-202.5	>202.5-247.5	>247.5-292.5
0	0-7.5	6%	6%	6%	6%	6%
15	>7.5-22.5	10%	11%	8%	5%	3%
30	>22.5-37.5	14%	15%	10%	4%	1%
45	>37.5-52.5	17%	18%	11%	3%	1%
60	>52.5-67.5	18%	19%	12%	2%	1%

Table 48. Non-RES Solar PV—Climate Zone 4: Corpus Christi—Summer Demand kW Savings

Tilt (degrees)		Azimuth (degrees, center, and range)				
		90	135	180	225	270
Center	Range	>67.5-112.5	>112.5-157.5	>157.5-202.5	>202.5-247.5	>247.5-292.5
0	0-7.5	41%	41%	41%	41%	41%
15	>7.5-22.5	30%	33%	41%	48%	51%
30	>22.5-37.5	16%	23%	39%	52%	57%
45	>37.5-52.5	8%	14%	34%	53%	60%
60	>52.5-67.5	8%	9%	27%	51%	59%

Table 49. Non-RES Solar PV—Climate Zone 4: Corpus Christi—Winter Demand kW Savings

Tilt (degrees)		Azimuth (degrees, center, and range)				
		90	135	180	225	270
Center	Range	>67.5-112.5	>112.5-157.5	>157.5-202.5	>202.5-247.5	>247.5-292.5
0	0-7.5	5%	5%	5%	5%	5%
15	>7.5-22.5	8%	9%	7%	4%	2%
30	>22.5-37.5	11%	12%	8%	3%	1%
45	>37.5-52.5	13%	14%	9%	2%	1%
60	>52.5-67.5	13%	15%	9%	2%	1%

Table 50. Non-RES Solar PV—Climate Zone 5: El Paso—Summer Demand kW Savings

Tilt (degrees)		Azimuth (degrees, center, and range)				
		90	135	180	225	270
Center	Range	>67.5-112.5	>112.5-157.5	>157.5-202.5	>202.5-247.5	>247.5-292.5
0	0-7.5	49%	49%	49%	49%	49%
15	>7.5-22.5	40%	44%	49%	54%	55%
30	>22.5-37.5	29%	35%	47%	56%	58%
45	>37.5-52.5	16%	25%	42%	55%	58%
60	>52.5-67.5	10%	15%	34%	51%	55%

Table 51. Non-RES Solar PV—Climate Zone 5: El Paso—Winter Demand kW Savings

Tilt (degrees)		Azimuth (degrees, center, and range)				
		90	135	180	225	270
Center	Range	>67.5-112.5	>112.5-157.5	>157.5-202.5	>202.5-247.5	>247.5-292.5
0	0-7.5	0%	0%	0%	0%	0%
15	>7.5-22.5	0%	0%	0%	0%	0%
30	>22.5-37.5	0%	0%	0%	0%	0%
45	>37.5-52.5	0%	0%	0%	0%	0%
60	>52.5-67.5	0%	0%	0%	0%	0%

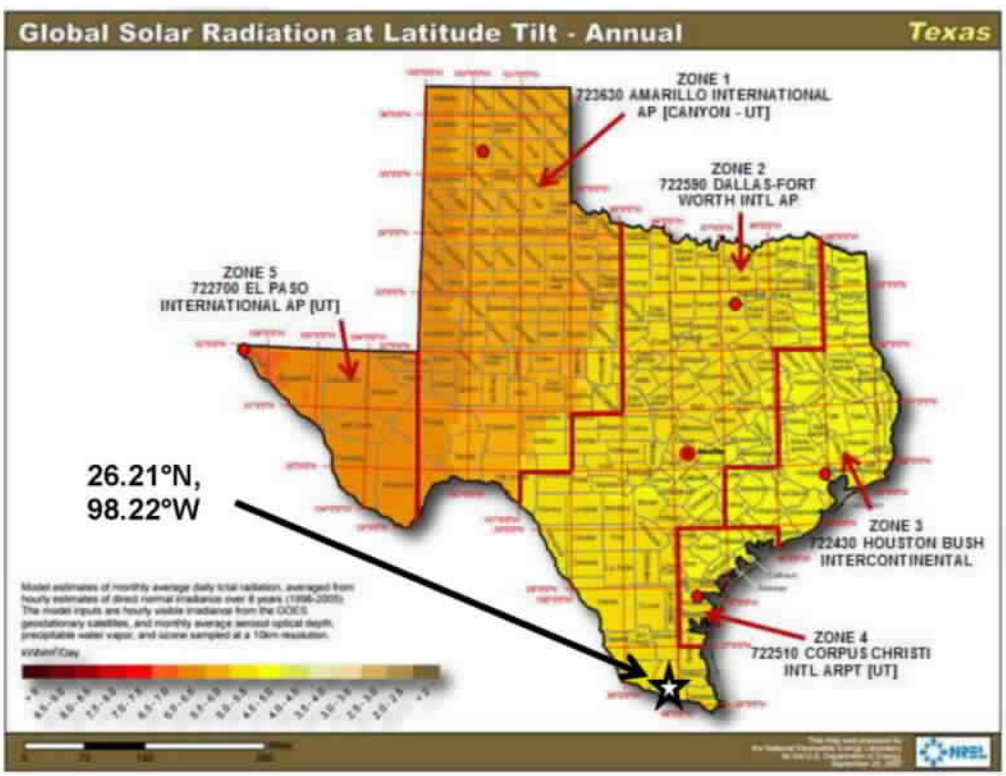
Deemed Summer and Winter Demand Savings—Example

Example: A commercial customer at 1300 W. Houston Avenue, McAllen, TX 78501, installs a 50 kW_{dc} fixed array comprised of standard crystalline Silicon modules on their rooftop with a tilt of 5 degrees and an azimuth of 175 degrees.

Step 1. Determine the appropriate weather zone. Geographic coordinates for this system (26.21°N, 98.22°W from Figure 14) were derived when determining the annual energy savings (kWh).

From the weather zone map, this location is in Zone 2. See Figure 16.

Figure 16. Non-RES Solar PV—Application of the Weather Zone Map



Step 2. Calculate the summer and winter demand savings. From the zone 2 lookup tables, 5 degree tilt falls within the 0-7.5 degree tilt range, and 175 degree azimuth falls within the 157.5-202.5 azimuth range. The summer lookup value is 46 percent, and the winter lookup value is 3 percent.

Applying Equation 56,

*Deemed summer demand = DC system size (kW) * Lookup Value*

*Deemed summer demand = 50.000 kW * 46%*

*Deemed summer demand = 50.000 kW * 0.46*

Deemed summer demand = 23.000 kW

Applying Equation 57,

*Deemed winter demand = DC system size (kW) * Lookup Value*

*Deemed summer demand = 50.000 kW * 3%*

*Deemed summer demand = 50.000 kW * 0.03*

Deemed summer demand = 1.500 kW

Claimed Peak Demand Savings

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

Measure Life and Lifetime Savings

The estimated useful life (EUL) of photovoltaic system is established at 30 years. This value is consistent with engineering estimates based on manufacturers' warranties and historical data.

Program Tracking Data and Evaluation Requirements

The following information will be required to determine the project eligibility.

- Project location (full address, including city, state, and zip code)
- Module type: Standard, premium, or thin film
- Array Type: Fixed (open rack), fixed (roof mount), one-axis tracking, one-axis backtracking, two-axis tracking, etc.
- Tilt, azimuth, and DC system size rating for each array
- Shading study, if not using PVWatts default value

- The calculation of electricity production through PVWatts can be completed by accessing the online calculator or utilizing an API application programming interface. The required documentation varies between the two methods.
  - Online Calculator: Date of PVWatts run and PVWatts printed results report (as a file retained with project documentation)
  - API: Date of API access and response, documentation of API programming (including the access endpoint and request parameters), and the response results.
- Selected climate zone and demand method used
- For projects using the alternative method, retention of the TRM 4.0 PV tool workbook for each array evaluated

References and Efficiency Standards

Petitions and Rulings

- PUCT Docket 36779—Provides estimate for EUL.

Relevant Standards and Reference Sources

- National Electric Code (NEC) 690, "Solar Photovoltaic Systems" or local building codes.
- P. Dobos. PVWatts Version 5 Manual. National Renewable Energy Laboratory. NREL/TP-6A20-62641. September 2014. http://www.nrel.gov/docs/fy14osti/62641.pdf. PVWatts calculator available at https://pvwatts.nrel.gov/index.php.

Document Revision History

Table 52. Non-RES Solar PV—Revision History

TRM version	Date	Description of change
v1.0	11/25/2013	TRM v1.0 origin.
v3.1	11/05/2015	Updated to reflect EPE's 2016 program and revised maximum incentivized size for EPE from 50 to 10 kW.
v4.0	10/10/2016	Removed deemed savings option for energy. Provided a new method for calculating summer and winter demand savings and provided deemed summer and winter demand savings lookup tables.
v5.0	10/10/2017	Corrected equation, figure, and table references.
v6.0	10/2018	No revision.
v7.0	10/2019	No revision.
v8.0	10/2020	Updated instructions for the new version of PVWatts and references to NREL National Solar Radiation Database (NSRD) (previously TMY3)
v9.0	10/2021	Clarified PVWatts kilowatt-hour modeling instructions and documentation requirements. Provided guidance for slightly tilted arrays that fall outside lookup table azimuth ranges.

TRM version	Date	Description of change
v10.0	10/2022	No revision.
v11.0	10/2023	Eliminated alternate savings method and adjusted premium module type requirements to match PVWatts. Clarified assumptions to use in PVWatts analysis.
v12.0	10/2024	No revision.

2.4.3 Solar Shingles Measure Overview

TRM Measure ID: R-RN-SS and NR-RN-SS

Market Sector: Residential and commercial

Measure Category: Renewables

Applicable Building Types: All

Fuels Affected: Electricity

Decision/Action Types: Retrofit (RET), new construction (NC)

Program Delivery Type: Custom

Deemed Savings Type: Prescribed simulation software EM&V

Savings Methodology: Software modeling tool and calculator-SAM

Streamlined measurement and verification of solar shingles installations shall consist of the development of a project-specific model of the installed solar shingle system using the System Advisor Model (SAM), developed by the National Renewable Energy Lab (NREL). A solar shingles system consists of all connected arrays, sub-arrays, and inverter(s).

Measure Description

A solar shingles system consists of all connected arrays, sub-arrays, and inverter(s). The M&V method used to estimate savings is a simulation model approach using the National Renewable Energy Laboratory's (NREL) System Advisor Model (SAM). Either version 2015.6.30 or a more recent version of the SAM software shall be used.

Eligibility Criteria

Solar shingle systems consisting of connected arrays, sub-arrays, and inverters.

The installation must meet the following requirements to be eligible for incentives:

- Systems shall be installed by a licensed electrical contractor or, in the case of a residential installation by the homeowner, with the approval of the electrical inspector in accordance with the National Electric Code (NEC 690, "Solar Photovoltaic Systems") and local building codes.
- If the system is utility interactive, the inverter shall be listed and certified by a national testing laboratory authority (e.g., UL 1741, "Static Inverters and Charge Controllers for Use in Photovoltaic Power Systems") as meeting the requirements of the Institute of Electrical and Electronics Engineers (IEEE) Standard 929-2000 "Recommended Practice for Utility Interface of Photovoltaic (PV) Systems."
- The estimated annual energy generation from the solar shingles system shall not exceed the customer's annual energy consumption.

Baseline Condition

PV system not currently installed (typical).

High-Efficiency Condition

PV systems must meet the eligibility criteria shown above to be eligible for reporting claimed energy impacts. The high-efficiency conditions are estimated based on appropriate use of NREL's SAM software modeling tool for solar shingle installation analysis.

Energy and Demand Savings Methodology

Not applicable.

Savings Algorithms and Input Variables

SAM solar shingle installation data, modeling and analysis

SAM can be downloaded from the NREL website.[73]

SAM Data Input

The following steps present the information and sequence required to accurately model solar shingle projects using the SAM software tool.

- **Step 1.** Create a new solar PV project in SAM
- **Step 2.** Specify a Solar PV project and select a market segment (e.g., residential, commercial)
- **Step 3.** Solar systems are configured in the SAM main model interface that is organized across a number of screens, selected by a topics menu on the left-hand side of the window. The following items must be configured:

Location and Resource. An appropriate weather file must be specified in the subsequent screen. SAM is pre-loaded with a selection of weather files from the NREL NSRDB TMY3 datasets. The user should specify one of the five locations provided in Table 53, according to where in Texas the solar shingles are being installed. The map in Figure 17 indicates the delineation of the weather zones by county.

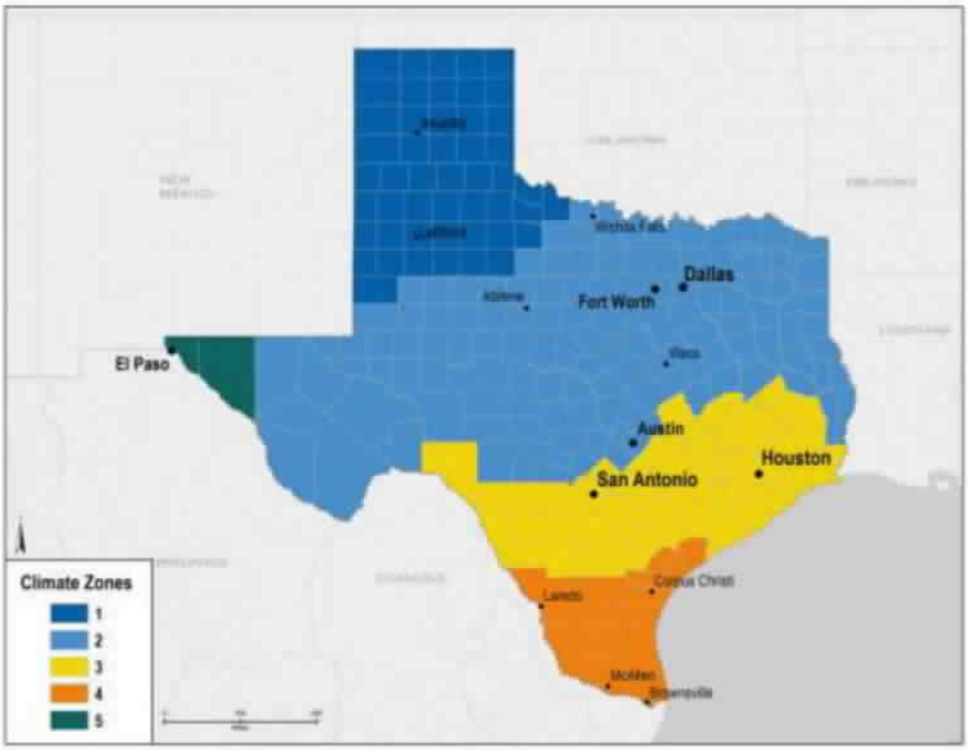
NOTE: It is critical that the TMY3 files are specified in the model for estimating peak demand impacts and that the corresponding set of peak hours and relative probabilities from TRM Volume 1, Section 4 shall be used to estimate peak demand impacts.

[73] As of publication of this version, the latest release of SAM is Version 2015.6.30. Instructions provided herein are intended to be sufficiently generic to allow for successful model creation in this and subsequent iterations of the software; however, it is impossible to anticipate the exact nature of future software revisions.

Table 53. Solar Shingles—TMY Data File by TRM Weather Zone

TRM weather zone		TMY3 file	TMY3 location
1	Panhandle Region	723630	Amarillo Intl AP (Canyon—UT)
2	North Region	722590	Dallas Fort Worth Intl AP
3	South Region	722430	Houston Bush Intercontinental
4	Valley Region	722510	Corpus Christi Intl AP (UT)
5	West Region	722700	El Paso International AP (UT)

Figure 17. Solar Shingles—Weather Zones



Module. The default action in the Module screen allows users to select a product with required performance data pre-loaded into SAM. Several CertainTeed Apollo modules and Dow DPS-XXX modules can be specified in this window. However, modeling options for the PV Module can be modified in SAM 2015.6.30 by selecting the dropdown menu that is set to "CEC Performance Model with Module Database" (at the top of this window). Other modeling options provide flexibility to adequately model products from other manufacturers.

Temperature correction. The module screen includes a 'Temperature Correction' window, in which one of two-cell temperature models must be specified. The 'Nominal operating cell temperature (NOCT) method' should be selected, and within the 'Nominal output cell temperature (NOCT) parameters' section, the 'Mounting standoff' should be specified as 'Building integrated.' The 'Building integrated' option accounts for solar shingles integrated on buildings.

Inverter. Inverter-specific information must be provided. Similar to the Module screen, an inverter can be selected from the Inverter CEC Database (default). Inverters not in the CEC database should use data from the manufacturer (Inverter Datasheet mode) or inverter efficiencies at different loading rates from inverter part load curves (Inverter Part Load Curve mode). Any of these methods is satisfactory. Note that the number of inverters can be specified on the following 'Array' screen, but only one inverter type can be specified here, so when multiple inverters are used with systems modeled in SAM, they must be the same make and model.

System design (array). The following array-level information shall be provided:

- System sizing: Specified by solar module capacity and count and inverter system losses.
- Configuration at reference conditions (modules and inverters) DC subarrays. SAM allows modeling up to 4 subarrays. If the system model has only one array, the data for this array is entered in the column for subarray 1; subarrays 2-4 should be left disabled. If there are multiple arrays, check the boxes to enable subarrays 2-4, as needed, and the number of strings in that subarray. Pre-inverter derates should be specified as appropriate.
- Estimate of overall land usage. Not needed (used for economic analysis only).
- PV subarray voltage mismatch. For CEC modules (true of CertainTEED and Dow DPS products), losses due to subarray mismatch can be estimated. For arrays with multiple orientations, this option should be selected.

Shading and snow. A good faith effort should be made to represent features likely to affect incidence of solar radiation on the solar shingle system. Appropriate shading for the installation site should be incorporated; however, it is not necessary to modify the annual average soiling, as first year generation values will be used.

Losses. Specify all DC and AC losses.

For the remaining topics/screens listed below, no data entry is required:

- Lifetime
- Battery storage
- System costs
- Financial parameters
- Incentives
- Electricity rates
- Electric load

Model Run and Data Output

Execute the model calculations (in 2015.6.30) by clicking "Simulate" in the bottom left corner. SAM generates many output data fields: create an 8,760 hourly output file by selecting "Time Series" at the top of the screen (option appears only after clicking "Simulate") and then select "Power generated by system (kW)" from the options on the right-hand side of the screen. Output data can be saved as Excel or .csv by right clicking on the generated plot and selecting the desired option.

Deemed Energy and Demand Savings Tables

There are no lookup tables available for this measure. See SAM software tool guidance in the previous section to calculate energy and demand savings.

Claimed Peak Demand Savings

Peak demand savings should be extracted from the hourly data file in a manner consistent with the peak demand definition and the associated methods to extract peak demand savings from models producing 8,760 hourly savings using Typical Meteorological Year (TMY) data. Refer to Volume 1, Section 4 for further details on peak demand savings and methodology.

Additional Calculators and Tools

Not applicable.

Measure Life and Lifetime Savings

The estimated useful life (EUL) of solar shingles is established at 20 years. This value is consistent with engineering estimates based on manufacturers' warranties and historical data.

Program Tracking Data and Evaluation Requirements

The following inputs should be collected in program databases to inform the evaluation and calculate energy savings accurately.

- Climate zone or county
- Decision/action type: retrofit, new construction
- Building type
- System latitude
- System tilt from horizontal
- System azimuth

The following files should be provided to the utility from which the project sponsor seeks to obtain an incentive for a solar shingles system installation:

- SAM model file (*.zsam format)
- 8,760 hourly output file (csv or similar format)
- Calculator with annual energy savings and peak demand savings estimate

References and Efficiency Standards

Not applicable.

Petitions and Rulings

Not applicable.

Relevant Standards and Reference Sources

- National Electric Code (NEC) 690, "Solar Photovoltaic Systems" or local building codes.
- Institute of Electrical and Electronics Engineers (IEEE) Standard 929-2000 "Recommended Practice for Utility Interface of Photovoltaic (PV) Systems." http://standards.ieee.org/findstds/standard/929-2000.html.
- System Advisor Model (SAM) Version 2014.1.14. National Renewable Energy Laboratory. SAM is available for registration and download at: https://sam.nrel.gov/download.

Document Revision History

Table 54. Solar Shingles—Revision History

TRM version	Date	Description of change
v3.0	4/10/2015	TRM v3.0 origin.
v3.1	11/05/2015	Major methodology updates include revising the reference to the latest version of SAM software and removal of TMY2 weather data file use. Revised measure details to match the format of TRM volumes 2 and 3. This included adding detail regarding Measure Overview, Measure Description, Measure Life, Program Tracking Data and Evaluation Requirements, References and Efficiency Standards, and Document Revision History.
v4.0	10/10/2016	No revision.
v5.0	10/10/2017	No revision.
v6.0	10/2018	No revision.
v7.0	10/2019	No revision.
v8.0	10/2020	No revision.

TRM version	Date	Description of change
v9.0	11/2021	TRM v9.0 update. Updated EUL.
v10.0	10/2022	No revision.
v11.0	10/2023	No revision.
v12.0	10/2024	No revision.

2.4.4 Solar Attic Fans Measure Overview

TRM Measure ID: R-RN-SF

Market Sector: Residential

Measure Category: Building envelope

Applicable Building Types: Residential

Fuels Affected: Electricity

Decision/Action Type: Retrofit

Program Delivery Type: Prescriptive

Deemed Savings Type: Deemed savings calculations

Savings Methodology: Engineering calculations and estimates

Measure Description

Solar attic fans increase the extraction rate of accumulated hot air in attics during the cooling season. Solar attic fans introduce no new electrical load to the home since they are powered by an attached photovoltaic (PV) panel. They save energy by reducing the load on air conditioning equipment, cooling the conditioned space directly underlying the attic, and by reducing heat exchange with supply ducts located in the attic when present.

Deemed savings are provided for a reduced air conditioning load.

Note: This measure was developed with limited savings information for Texas; therefore, solar attic fans should be implemented with the expectation of a savings methodology update in future TRMs as Texas-specific field information becomes available. This measure will be reconsidered on an annual basis. If sufficient M&V data is provided, this measure may be incorporated into Volume 2 as a fully-deemed measure.

Eligibility Criteria

The measure applies to existing homes with central- or mini-split-electric-refrigerated air conditioning. Ineligible applications include new homes, homes with tile roofs, homes with metal roofs, and evaporatively-cooled homes. Customers participating in hard-to-reach or low-income programs are also eligible to claim cooling savings for homes cooled by one or more room air conditioners by applying an adjustment factor to the provided deemed savings. Solar fans must have an automatic low-temperature shut-off to ensure cold outside air is not drawn into the attic during the heating season.

Baseline Condition

The baseline condition is an existing home with refrigerated air and a vented attic.

High-Efficiency Condition

The high-efficiency condition is the installation of sufficient solar attic fans to remove 400 cubic feet per minute (cfm) for every thousand square feet of attic floor space. A solar attic fan consists of an electric fan powered by an integrated PV panel installed for the exclusive purpose of powering the fan.

Energy and Demand Savings Methodology

Savings have been estimated by performing energy balances on the roof surface and on the attic airspace on an hourly time step. The energy balances account for heat flux from the roof into the attic and between the attic and the underlying conditioned space. Solar attic fans are assumed to operate in the cooling season in the hours of the day when there is incident solar irradiation on the panel. Deemed savings are based on replacing hot attic air with outside air using solar attic fans with a capacity of 400 cfm per thousand square feet of attic floor. Estimated savings are a function of the difference in heat transfer to conditioned space with and without solar attic fans, considering that the heat transferred to conditioned space must be removed by the air conditioning system. For homes with ducts in the attic, additional savings are estimated considering heat transfer to supply ducts.

Hourly data for the ambient conditions is from TMY3 files for the Texas TRM climate zones.

Savings Algorithms and Input Variables

The attic temperature for each hour is estimated according to the following equation for both the baseline and high-efficiency conditions:[74]

$$T_a = \frac{A_r * U_r * \frac{\alpha * I_s + h_o * T_o}{h_o + U_r} + Q * \rho * c_p * T_o + (A_c * U_c + A_d * U_d) * T_i}{\frac{A_r * U_r * h_o}{h_o + U_r} + Q * \rho * c_p + (A_c * U_c + A_d * U_d)}$$

Equation 58

Where:

A_r = *Roof surface area (ft²)*

U_r = *U-factor of the roof between the unconditioned attic and the exterior (Btu/ft²-hr-°F)*

α = *Absorption coefficient of the roof (dimensionless)*

I_s = *Solar irradiance (Btu/ft²-hr)*

h_o = *Convective heat transfer coefficient for air (Btu/ft²-hr-°F)*

[74] This equation results from solving the energy balance on the roof for Tr and inserting this value into the energy balance for the attic airspace, while solving for Ta. The equations are drawn from ASHRAE Fundamentals, Chapter 17, Residential Heat Load Guidebook. Approach originally derived by Tetra Tech, Inc. (see references section).

T_o = *Exterior temperature (°F)*

T_r = *Temperature of the roof (°F)*

T_a = *Temperature of the attic (°F)*

Q = *Ventilation airflow rate (CFM)*

ρ = *Density of air (lb/ft^3)*

c_p = *Specific heat of air (Btu/lb-°F)*

A_c = *Ceiling surface area (ft^2)*

U_c = *U-factor of the ceiling between the conditioned space and the unconditioned attic (Btu/ft^2-hr-°F)*

A_d = *Surface area of supply ducts in the attic (ft^2); set to zero if there are no supply ducts in the attic*

U_d = *U-factor of the insulation on the ducts, (Btu/ft^2-hr-°F)*

T_i = *Temperature of the conditioned space (°F)*

Once hourly attic temperatures are estimated for the baseline and high-efficiency conditions, hourly energy savings are estimated as follows:

$$Hourly\ Energy\ Savings\ (kWh) = \frac{(\mathrm{A}_c * \mathrm{U}_c + \mathrm{A}_d * \mathrm{U}_d)}{1000 * \mathrm{EER}} * \left(T_{a,b} - T_{a,he}\right) * 1\ hr$$

Equation 59

Where:

A_c = *Ceiling surface area (ft^2)*

U_c = *U-factor of the ceiling between the conditioned space and the unconditioned attic (Btu/ft^2-hr-°F)*

A_d = *Surface area of supply ducts in the attic (ft^2); set to zero if there are no supply ducts in the attic*

U_d = *U-factor of the insulation on the ducts (Btu/ft^2-hr-°F)*

EER = *Efficiency of the air conditioner (Btu/W-h)*

$T_{a,b}$ = *Temperature of the baseline attic, without solar-powered attic fan (°F)*

$T_{a,he}$ = *Temperature of the attic in the high-efficiency condition, with solar-powered attic fan (°F)*

Deemed Energy and Demand Savings Tables

Energy and demand savings are estimated for homes with ducts in the attic and for homes with no ductwork in their attics.

Table 55. Solar Attic Fans—Deemed Annual Energy Savings (kWh)

Climate zone	No ducts in attic	Ducts in attic
Climate Zone 1: Amarillo	147	245
Climate Zone 2: Dallas	212	350
Climate Zone 3: Houston	236	391
Climate Zone 4: Corpus Christi	260	431
Climate Zone 5: El Paso	252	420

Annual energy savings are simply the sum of the hourly energy savings:

$$Annual\ Energy\ Savings\ (kWh) = \sum_{hr=1}^{8760} Hourly\ Energy\ Savings \times CAF$$

Equation 60

Where:

CAF = *Cooling savings adjustment factor: set to 1.0 for homes with central refrigerated air; for homes with one or more room air conditioners, set to 0.6*

Table 56. Solar Attic Fans—Deemed Summer Peak Demand Savings (kW)

Climate zone	No ducts in attic	Ducts in attic
Climate Zone 1: Amarillo	0.16	0.26
Climate Zone 2: Dallas	0.12	0.20
Climate Zone 3: Houston	0.10	0.15
Climate Zone 4: Corpus Christi	0.15	0.24
Climate Zone 5: El Paso	0.17	0.28

The cooling adjustment factor is also applied to the demand savings:

$$Peak\ Demand\ Savings\ (kW) = Summer\ Peak\ Demand\ Savings \times CAF$$

Equation 61

Where:

The *Summer Peak Demand Savings* are the appropriate value from Table 56.

CAF	=	*Cooling savings adjustment factor: set to 1.0 for homes with central refrigerated air; for homes with one or more room air conditioners, set to 0.6*

Winter peak demand savings are not estimated. Solar attic fans that operate in the winter would likely require more space heating and produce negative savings by increasing the temperature gradient between conditioned space and the cooler attic air (while potentially creating condensation issues).

Claimed Peak Demand Savings

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

Measure Life and Lifetime Savings

The estimated useful life (EUL) of a solar attic fan is closely related to its motor. The US DOE Advanced Manufacturing Office's Motor Systems Tip Sheet #3 suggests motors should last approximately 35,000 hours. The average annual hours of operation for solar attic fans across the Texas TRM zones is about 2,300 hours. Accordingly, the EUL for solar attic fans in Texas is estimated to be 15 years.

Program Tracking Data and Evaluation Requirements

The below list of primary inputs and contextual data is recommended to be specified and tracked by the program database to inform the evaluation and apply the savings properly.

- Climate zone or county
- Attic floor area (ft^2)
- Installed capacity of installed solar attic fans (CFM)
- Absence/presence of ducts in attic space
- Absence/presence of A/C equipment in attic space
- Length and insulation R-value of ducts in the attic if applicable
- Attic insulation R-value
- Exterior roof type (e.g., black asphalt shingles, metal seam)
- Air conditioning type, age, and estimated EER
- Azimuth of fan solar panel

- Temperature measurements (for PY2020, 5 of the initial 10 projects in Texas and 10 percent of the subsequent 200 projects in Texas, not to exceed 25 installations); future program years' (PYs) measurement requirements will be determined on an annual basis.
    - Pre-installation spot measurements (near insulation level and underside of the roof)
    - Post-installation two-week logging, minimum on reading per hour (near insulation level and underside of roof)

References and Efficiency Standards

Petitions and Rulings

- TBD

Relevant Standards and Reference Sources

- 2017 ASHRAE Handbook-Fundamentals; Chapter 17, Residential Cooling and Heating Load Calculations.
- Tetra Tech Memorandum to the Independent Electricity System Operator (IESO) of Ontario, Canada. Attic Fan Measure Characterization. Authors Mark Bergum and Marc Collins. August 20, 2018.
- US Department of Energy, EERE Advanced Manufacturing Office. Motor Systems Tip Sheet #3. Online. Available: https://www.osti.gov/servlets/purl/15020347

Document Revision History

Table 57. Solar Attic Fans—Revision History

TRM version	Date	Description of change
v7.0	10/2019	TRM v7.0 origin.
v8.0	10/2020	Removed measure due to lack of M&V data collection to refine preliminary deemed savings estimates.
v9.0	10/2021	Reinstated measure requiring M&V data collection.
v10.0	10/2022	No revision.
v11.0	10/2023	No revision.
v12.0	10/2024	No revision.

2.5 M&V: MISCELLANEOUS

2.5.1 Behavioral Measure Overview

TRM Measure ID: NR-MS-BC

Market Sector: Commercial

Measure Category: Miscellaneous

Applicable Building Types: Commercial

Fuels Affected: Electricity

Decision/Action Types: Operation and maintenance (O&M)

Program Delivery Type: Custom

Deemed Savings Type: Not applicable

Savings Methodology: M&V and whole facility measurement

This protocol is used to estimate savings for various behavioral changes that remain persistent and reliable long term. The purpose of this measure is to create a framework to provide verified savings within standards currently applied to other commercial energy savings measures.

Measure Description

This measure is not defined but requires that any behavioral project develop an M&V plan and report. The project may include associated equipment installation. The M&V plans and reports should include a description of the proposed behavioral changes, how the changes will save energy, and why the behavioral change should be considered a permanent change, similar to other high-efficiency equipment retrofits.

One example is to establish an authorized facility-wide energy policy with an implementation plan and quality assurance processes. Another example is to establish electric fleet vehicle energy charging policies to shift energy consumption to off-peak periods and reduce peak demand.

M&V plans and reports should describe how changes in operations and/or sequence of operations translate into energy savings. The measure description should include how initial energy savings estimates will be verified by IPMVP-compliant M&V.

Eligibility Criteria

This measure applies to behavioral measures that provide persistent energy reductions that are measurable at the facility level and comply with IPMVP Option C. Projects shall meet the model fit metrics based on one year of pre-installation and one year of post-installation hourly consumption data. Alternate methodologies or data availability of less than hourly increments will be considered on a case-by-case basis with prior approval from the evaluation team.

For projects with smaller savings (typically < 20 kW) where standard M&V efforts may be cost prohibitive, the simplified M&V energy and demand savings may be used with prior evaluation-team approval.

Baseline Condition

The baseline condition for each behavioral measure has two aspects: 1) the existing operating parameters (e.g., temperatures, hours of operation, loads) and existing energy use for each behavior change and 2) the proposed new case for each behavior change with equations that meet the model fitness requirements to quantify energy savings.

The M&V plan should document the source and accuracy/confidence of the parameters used in the proposed equations to estimate baseline and new case energy use for each behavior impact (e.g., interior lights are to be turned off). The M&V plan should explain assumptions for both baseline and behavior change cases, citing sources.

High-Efficiency Condition

Demonstrated by conclusive energy savings following IPMVP protocols.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Not applicable.

M&V Methodology

The evaluation, measurement, and verification (EM&V) methodology presents a plan to determine (i.e., calculate and verify) energy savings due to significant and persistent facility-wide behavioral changes for a commercial facility, following IPMVP Option C. Whole facility guidance is found in IPMVP Core Concepts EVO 10000-1:2022. CalTRACK 2.0 technical appendix should be used to support the development of consistent normalized energy consumption models.

A measurement and verification (M&V) plan and M&V report shall document the methodology selected and include assumptions and details regarding model development, testing, handling of errors, and information to validate regression model(s).

Model documentation should be transparent and allow for repeating modeling steps and results, including the use of any adjustments made outside of the primary modeling method. Procedures and their results should be documented and may include:

- Describe how modeling outliers were identified and addressed
- Describe how missing data errors were addressed and document what changed from the original model. Any data removed or changed should be annotated with a cause.

- Describe non-routine events and adjustments across the measurement periods. The COVID-19 pandemic[75] altered many commercial and industrial (C&I) customer operations in multiple ways, and each significant adjustment in operation should be described, such as full shutdown periods, partial operation periods, and full operation periods.

M&V energy savings should be normalized to climatological and other features, such as production volume or occupancy. The weather-dependent factors are normalized to fixed Typical Meteorological Year 3 (TMY3) weather data files organized by Climate Zone 2. This normalized file should be used with both the pre-installation and post-installation consumption energy model from the regression analysis.

M&V Plan and M&V Report

Preparation of an M&V plan and report is required to determine savings. An M&V plan ensures that collected data and information necessary to determine savings will be available after implementation of the behavioral change(s). The M&V plan and report should follow the template in the IPMVP Core Concept 2022 Section 13, excluding the budget section. Documentation of assumptions and modeling should be complete, readily available, clearly organized, and easy to understand. It is critical that the behavioral M&V plans and reports detail the individual actions, measurement boundary, and the multi-year measurement and savings analysis protocols in the plan and update in the report.

Changes to required documentation may be possible if a viable comparison group can be used. The EM&V team will review M&V plans that include the make–up and selection of the comparison group in lieu of required documentation.

Normalized Energy Model Fit Metrics

The model should be designed to develop the most accurate normalized metered energy consumption using a replicable method. The models used for the baseline and performance periods should be the simplest model available with the best R^2 and CV (RMSE)[76]. It is required that selected variables are reasonably understood to impact consumption levels and not coincidental during a measurement period. The least-squares regression method is most common and should be completed separately for electric consumption (kWh) and electric demand (kW). Other methods are acceptable if the least squares method is not sufficient. The model shall attempt to meet the following model fitness metric requirements:

- Energy savings is greater than ten percent of baseline consumption
- R^2 value greater than or equal to 0.75

Advanced models may develop alternative fit metrics or error levels at specific confidence levels as described in Section 12.6 of the Core Concepts 2022.

[75] Starting March 2019.
[76] Coefficient of Variation Root Mean Squared Error.

The electric demand model based on one-hour interval consumption data will lead to the best model to determine peak demand savings. The model shall be evaluated to determine if the peak demand is accurately represented during the peak conditions as described in TRM Volume 1. An alternate regression model for the peak demand is required when the measured peak demand varies from the modeled peak demand at the high and low measured temperature period by greater than 20 percent. If the one-hour interval consumption data is unavailable, the evaluation team must approve the M&V plan before implementation.

Baseline Data and Model

The participants baseline data shall be used to create a baseline model equation. The M&V plan should document the data used to determine the baseline completely and accurately, including the selection of constants and independent variables. The baseline and independent variables shall be derived based on the historical electric consumption 12 months immediately prior to the engagement, the nearest actual weather data file, and other relevant variables, such as floor area or operating profile[77]. Historic electricity consumption is expected to be an hour interval to support the development of the peak demand savings detailed in Volume 1.

Baseline energy models can be used for multiple years for long-term behavior engagements. A baseline normalized energy model can be used for a maximum five years from the start of the baseline period to the start of the performance period. Although the baseline period may be reset earlier if non-routine adjustments are unable to be identified or quantified.

Reporting Period Data and Model

The participants' consumption data starts immediately after commissioning all project components to create a performance period model equation. The M&V plan should document the data used to determine the consumption completely and accurately, including the selection of constants and independent variables. The independent variables shall be derived based on the historical electric consumption of 12 months, the actual weather data file from the same source as the baseline, the TMY3 weather data file specified for the climate zone, and other relevant variables. Actual electricity consumption is expected to be an hour interval to support the development of the peak demand savings detailed in Volume 1, Section 4.

Deemed Energy and Demand Savings Tables

Not applicable.

Claimed Peak Demand Savings

The methodology used to determine peak demand savings should be consistent with the methodology of energy savings. The calculation of peak demand savings should include the weather-dependent peak demand probability factors, as outlined in Volume 1, Section 4. The methodology should be documented clearly in the M&V plan and report. Because models are developed for a normalized year, the factors outside the date, time, and temperature should be assumed to be the maximum for the date and time combination, such as considering the date a weekday operation day for an office building.

[77] CalTRACK 2.0 provides a compliance checklist that can be used as best practices during model development, https://www.caltrack.org/caltrack-compliance.html.

Additional Calculators and Tools

Regression software used for estimating annual energy use and demand should be clearly specified in the M&V plan and report.

Measure Life and Lifetime Savings

The estimated useful life (EUL) is one year.

Program Tracking Data and Evaluation Requirements

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

- Climate zone or county
- Decision/action type: Operations and maintenance
- Building type

The following inputs and data should be documented and available for evaluation review:

- Baseline equipment types affected by behavior change
- Baseline equipment capacities
- Baseline equipment efficiency ratings
- Baseline number of units
- Baseline operating practice
- Efficient operating practice
- Actual one-hour interval consumption data
- Actual weather data file
- Actual alternate operations or other variable documentation
- Model development inputs and outputs for baseline and post-install analysis
- Normalized energy consumption and peak demand reduction estimates
- Normalized energy consumption data file based on TMY3 and other variables

References and Efficiency Standards

Not applicable.

Petitions and Rulings

- Behavioral programs are allowed energy efficiency programs as specified in the Energy Efficiency Rule (16 TC 25.181 (c)(12))

Relevant Standards and Reference Sources

- International Performance and Measurement Verification Protocol Core Concepts 2022 https://evo-world.org/en/products-services-mainmenu-en/protocols/ipmvp
- CalTRACK 2.0 Technical Appendix: http://docs.caltrack.org/en/latest/technical-appendix.html
- Standard and references unique to each project and to be documented in the M&V plan and report

Document Revision History

Table 58. Behavioral—Revision History

TRM version	Date	Description of change
v3.1	11/05/2015	TRM v3.1 origin.
v4.0	10/10/2016	Updated documentation of methodology and measure life.
v5.0	10/10/2017	No revision.
v6.0	10/2018	No revision.
v7.0	10/2019	Transferred relevant guidance language from Vol. 5.
v8.0	10/2020	Added hourly interval data as a requirement, added CalTRACK2.0 technical appendix as a guide to normalize consumption models, and clarified guidance on normalized energy model fitness, baseline development, and reporting period.
v9.0	10/2021	Updated model requirements to account for pandemic and other non-routine events.
v10.0	10/2022	Updated to comply with IPMVP Core Concepts 2022.
v11.0	10/2023	No revision.
v12.0	10/2024	No revision.

2.5.2 Air Compressors Less than 75 hp Measure Overview

TRM Measure ID: NR-MS-CA

Market Sector: Commercial

Measure Category: Miscellaneous

Applicable Building Types: Commercial

Fuels Affected: Electricity

Decision/Action Types: Early retirement (ER), new construction (NC), and replace-on-burnout (ROB)

Program Delivery Type: Custom

Deemed Savings Type: Not applicable

Savings Methodology: EM&V and whole facility measurement

This protocol is used to estimate savings for compressed air system controls measures for systems with less than 75 horsepower in total compressor power. The compressed air methodology is a framework to provide high quality verified savings for smaller compressed air projects. This measure uses site collected data, follows savings methodologies as outlined by the Ohio Technical Reference Manual, and uses research on compressed air systems conducted by the Long Island Power Authority.

Measure Description

This measure requires the installation of flow controls on existing compressed air systems with a total compressor power of less than 75 hp. This methodology limits the amount of savings that can be claimed to 20 kW and 100,000 kWh for a project. For projects that are expected to exceed 20 kW or 100,000 kWh savings, full M&V is recommended.

Applicable controls measure types include:

- Load/unload controls: allow the motor to run continuously at a constant speed but unloads the compressor when adequate pressure has been achieved. Efficient load/unload controls use storage tank(s) to increase the available compressor air capacity without requiring compressor operation during all load periods. This protocol provides estimated savings for systems that exceed 3 gal/CFM or 5 gal/CFM in storage capacity.
- Modulating inlet controls: restricts inlet air to the compressor to progressively reduce compressor output to meet the flow requirements of the system. Also referred to as throttling or capacity control. The amount of capacity reduction is limited by the potential for surge and minimum throttling capacity.
- Variable displacement systems: have compressors that operate in two or more partially loaded conditions. Since the compressor can operate efficiently at multiple output points, it can more closely align with the load of the system.

- Variable speed with unloading: controls the compressor motor to match the load of the system, offering the highest efficiency gains. During periods of low demand, the compressor is unloaded and operates at the minimum variable speed until the flow and pressure demand exceeds the minimum output of the compressor.

Eligibility Criteria

This measure applies to retrofitting an existing compressed air system with new, higher efficiency flow controls or the installation of a new compressed air system with eligible flow controls.

Baseline Condition

Existing System Retrofit: The baseline for existing system retrofit shall be the applicable control type from the pre-existing system, from Table 59.

Replace-on-Burnout (ROB) and New Construction (NC): The baseline for ROB and NC projects is assumed to be a modulating air compressor with blow down (a standard industry practice). The baseline efficiency is given from the Modulation category in Table 59.

High-Efficiency Condition

High-efficiency conditions for compressed air system are in Table 59.

Table 59. Air Compressors—Energy Factors

Control type	ACEF	Source
Modulation	89.0 percent	LIPA Clean Energy Initiative[78]
Load/No Load with 3 gal/CFM	83.1 percent	
Load/No Load with 5 gal/CFM	80.6 percent	
Variable Displacement	76.9 percent	
Variable Speed with Unloading	67.5 percent	

Energy and Demand Savings Methodology

Whole Facility EM&V Methodology (Used to Estimate FINAL Savings Potential)

Standard IPMVP Option A procedures will be used to compare stipulated values to actual site conditions to confirm or adjust values found in the Ohio TRM, Long Island Power Authority's Clean Energy Initiative, Arkansas C&I program, and Texas Pilot program. Savings are determined by comparing measured energy use before and after implementation of a project, with adjustments for changes in conditions.

[78] Data obtained from Long Island Power Authority's Clean Energy Initiative, See ACEF Development section for more details.

Option Type and Measurement Boundary

The M&V plan will follow the guidelines of the 2012 International Performance Measurement and Verification Protocol (IPMVP) Option A—Retrofit Isolation: Key Parameter Measurement. This method calculates energy savings using key energy consumption parameters before the equipment retrofit begins and after the retrofit is completed. The Option A guidelines are described in the latest version of the IPMVP Core Concepts EVO 10000-1:2022.

The key parameter being measured is interval true power (kW).

Baseline and Reporting Period

Two weeks of logging data before and two weeks of logging data after the controls upgrade.

Savings Methodology—Measured Data Analysis

The following equations will be used to calculate energy and demand saving estimates:

$$Peak\ Demand\ Savings\ (kW) = kW_{PDPF,existing} - kW_{PDPF,new}$$

Equation 62

$$Annual\ Energy\ Savings\ (kWh) = (kW_{avg\ op,existing} - kW_{avg\ op,new}) * Hours$$

Equation 63

Where:

kW_{PDPF}	=	*Compressor motor kW from metered data corresponding to PDPF period as outlined in TRM Volume 1*[79]
$kW_{avg,\ op}$	=	*Average compressor motor kW from metered data during the operating hours*
Hours	=	*Compressor total hours of operation per year; assumed to be the facility-posted annual operating hours*

Savings Methodology—Stipulated Analysis

The following equations will be used to calculate energy and demand saving estimates:

$$Peak\ Demand\ Savings\ (kW) = (kW_{full\ load,existing} * ACEF_{existing} - kW_{full\ load,new} * ACEF_{new}) * CF_{PDPF}$$

Equation 64

[79] TRM Volume 1, Section 4.7 provides a basis for estimating peak coincident demand reductions attributable to the implementation of energy efficiency measures in Texas. This is based on measure-specific load during the identified peak hours according to Section 4.2.2.

$$Annual\ Energy\ Savings\ (kWh) = (kW_{full\ load,existing} * ACEF_{existing} - kW_{full\ load,new} * ACEF_{new}) * Hours$$

Equation 65

$$kW_{full\ load,existing} = \frac{0.7456 * Motor\ Nominal\ HP_{existing} * LF_{rated}}{Motor\ Nominal\ Efficiency_{existing}}$$

Equation 66

Where:

$kW_{full\ load}$	=	*Compressor motor full-load kW from CAGI data sheet; if baseline CAGI data isn't available, use Equation 66*
Hours	=	*Compressor total hours of operation per year; assumed to be the facility posted annual operating hours*
ACEF	=	*Air compressor energy factor from Table* 59
LF_{rated}	=	*Total annual energy consumption as reported in utility meter data for the post-retrofit measurement year*
CF_{PDPF}	=	*Coincident factor determined from peak demand probability factors; for projects whose business hours encompass the entire PDPF period for the building's climate zone, the factor is 1.0*[80]

Deemed Energy and Demand Savings

There are no deemed energy or demand savings for this measure.

Claimed Peak Demand Savings

A summer peak period value is used for this measure. Refer to Volume 1, Section 4 for further details on peak demand savings and methodology.

Additional Calculators and Tools

The regression software used for estimating annual energy use and demand should be clearly specified within the M&V plan and report.

ACEF Development

As part of the Long Island Power Authority (LIPA) Clean Energy Initiative, a study of air compressors was conducted with collected data on the operating capacity of the compressed air systems. LIPA provided data from this study, which was used as the basis for the ACEF development.

[80] TRM Volume 1, Section 4.2 provides a basis for estimating peak coincident demand reductions attributable to the implementation of energy efficiency measures in Texas. This is based on measure-specific load during the identified peak hours according to Section 4.2.2.

The capacity data was divided into percent of full-load capacity bins to determine average system loading across the population. This data was weighted by the brake horsepower of each compressor in the population. For each capacity bin, the percent power was determined for the control schemes from the Department of Energy air compressor savings calculator (no longer publicly available). The percent power curves were used with the load profile (from the study data) to develop average compressor energy factors for each control scheme for this measure.

Measure Life and Lifetime Savings

The estimated useful life (EUL) for commercial air compressors is 10 years, pending further research.

Program Tracking Data and Evaluation Requirements

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

- Climate zone or county
- Decision/action type: ER, ROB, NC, system type conversion
- Building type
- Baseline equipment type
- Baseline equipment controls
- Baseline number of units
- Baseline compressor CAGI data sheets
- For ER only: Baseline age and method of determination (e.g., nameplate, blueprints, customer reported, not available)
- Installed equipment type
- Installed equipment controls
- Installed equipment make and model
- Installed number of units
- Installed compressor CAGI data sheets
- A description of the actual building type, the primary business activity, the business hours, and the operating schedule

Petitions and Rulings

Not applicable.

Relevant Standards and Reference Sources

- State of Ohio Energy Efficiency Technical Reference Manual, https://focusonenergy.com/sites/default/files/Focus%20on%20Energy%20TRM%20-%20PY2017_1%28Archive%29.pdf#page=52

Document Revision History

Table 60. Air Compressors—Revision History

TRM version	Date	Description of change
v5.0	10/10/2017	TRM v5.0 origin.
v6.0	10/2018	No revision.
v7.0	10/2019	No revision.
v8.0	10/2020	No revision.
v9.0	10/2021	No revision.
v10.0	10/2022	No revision.
v11.0	10/2023	No revision.
v12.0	10/2024	No revision.

2.5.3 Nonresidential Custom

TRM Measure ID: NR-MS-CS

Market Sector: Commercial

Measure Category: Miscellaneous

Applicable Building Types: All commercial and industrial

Fuels Affected: Electricity, natural gas

Decision/Action Types: Operational/maintenance and retrofit

Program Delivery Type: Custom retrofit

Deemed Savings Type: Not applicable

Savings Methodology: Engineering calculations

This protocol guides the custom calculation of energy savings for projects that do not require whole building or sub-system monitoring.

Measure Description

A custom project is an energy efficiency improvement where the energy savings impact is calculated with engineering-based equations and not described as a measure in Volume 3. It can be used on any commercial and industrial building on any project type. Projects that require measurement and verification (M&V) protocols should follow the associated measures.

Eligibility Criteria

Custom projects are eligible if the scope of impact can be identified and quantified based on documented assumptions or site monitoring. The EM&V team may provide pre-approval for calculation methods and data collection requirements.

Baseline Condition

The baseline condition is the existing equipment or system energy use before implementing the energy conservation activities.

High-Efficiency Condition

The high-efficiency condition is the equipment or system energy use after implementing energy conservation equipment or other energy conservation activities. A start-up or commissioning period after implementation is not considered part of the high-efficiency condition.

Energy and Demand Savings Methodology

Calculation Methodology

The calculation methodology should identify the engineering equations and concepts to determine energy savings. The calculation should be capable of determining annual energy consumption and peak demand in accordance with Volume 1, Section 4 (PDPF method). The assumptions, operating conditions, and documented measurements necessary to complete the proposed methodology should be documented and supported. The calculation should use documented measurements or operating set points whenever possible to eliminate the use of assumptions. Measurements may be spot measurements or short-term monitoring.

Custom energy savings calculations should be normalized to the expected normalized operation. This may mean incorporating production volume, occupancy, or Typical Meteorological Year (TMY) weather data files to adjust operating conditions. The production volume and occupancy should adjust to the expected immediate steady state based on past operations. Projects that require projection should identify the expected steady state operation 90 days post-installation for the calculation. Calculations must also incorporate the interactive effects between the implemented improvements, assuming conservative energy efficiency improvements when the interactive effects are unknown.

Custom Calculation Report

A prepared report is not necessary for custom-calculated energy savings. However, the calculation sheet documentation of the calculation methodology, baseline and improved operating characteristics, measured results, and assumptions should be complete, clearly organized, and easily understood in the calculator.

Deemed Energy and Demand Savings

There are no deemed energy or demand savings for this measure. Prescriptive savings for individual measures calculated following other commercial measures in TRM Volumes 3 and 4 should be claimed by the project, and the custom calculation should identify the remaining savings associated with the components outside the prescriptive savings.

Claimed Peak Demand Savings

The methodology used to determine peak demand savings should be consistent with the methodology of energy savings. The calculation of peak demand savings should include the weather-dependent peak demand probability factors, as outlined in TRM Volume 1, Section 4. The methodology should be documented clearly in the custom calculations, and the operating characteristics and assumptions for the PDPF hours should be documented per hour.

Additional Calculators and Tools

Third-party software used for estimating annual energy use and demand is acceptable, provided that the tool is available to the EM&V team or the calculation methodology of the software is documented.

Measure Life and Lifetime Savings

The estimated useful life (EUL) for M&V projects varies based on the ECM or equipment installed. The EUL from similar equipment in Volume 3 of the TRM should guide EUL determination. The following ECMs are not defined in the TRM:

- Custom project equipment: 10 years or similar EUL to equipment in Volume 3
- Setpoint adjustments on existing controls: 5 years
- New advanced controls and sensors: 10 years
- Variable frequency drives (VFD) in non-HVAC applications[81]: 12.5 years

Program Tracking Data and Evaluation Requirements

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

- Climate zone or county
- Decision/action type: Custom, operations and maintenance, other
- Building type

The following inputs and data should be documented and available for evaluation review:

- Custom calculations
- Equipment, sensor, and control system specifications
- Photos of pre-installation and post-installation equipment and control screens
- Actual operating characteristic data files (weather data, control settings, production volumes, etc.)
- Operating conditions of interactive effects
- Alternate operations or other variable measurements
- Calculation inputs and outputs for baseline and post-installation energy consumption
- Calculation inputs and outputs for baseline and post-installation peak demand
- Standard and references unique to each project
- Other relevant documentation relevant to the custom calculation

References and Efficiency Standards

Not applicable.

Petitions and Rulings

Not applicable.

[81] Set equal to EUL specified in Volume 3 *Measure 2.7.1* for VFDs used in water pumping applications.

Relevant Standards and Reference Sources

Not applicable.

Document Revision History

Table 61. Non-RES Custom—Revision History

TRM version	Date	Description of change
v11.0	10/2023	TRM v11.0 origin.
v12.0	10/2024	Added EUL for VFDs in non-HVAC applications.

2.5.4 Nonresidential Measurement and Verification

TRM Measure ID: NR-MS-MV

Market Sector: Commercial

Measure Category: Miscellaneous

Applicable Building Types: All commercial

Fuels Affected: Electricity, natural gas

Decision/Action Types: Operational/maintenance and Retrofit

Program Delivery Type: Custom Retrofit and Retro-commissioning

Deemed Savings Type: Not applicable

Savings Methodology: M&V and whole facility measurement

This protocol estimates savings for projects that require custom development of energy savings, such as retro-commissioning (RCx) and advanced control equipment projects. This protocol provides a framework to calculate savings involving whole building or sub-system monitoring.

Measure Description

The measurement and verification (M&V) protocol can be used on any project where energy calculations require assumptions about operations, maintenance, controls, interactive effects or other unique components of the project. The process usually begins with a review of the pre-installation condition, an inventory of energy-use equipment, and the development of energy conservation measures (ECM).

Individual ECMs will vary but may include:

- Optimization strategy development for existing systems, including correcting air balancing issues, control reductions of simultaneous heating/cooling operations, and incorrect control sequences.
- Implement control system strategies or optimize existing strategies, including economizer setpoint control, demand-controlled ventilation, HVAC occupancy schedules, hot water reset, chilled water reset, and system lockout temperatures.
- Upgraded control sequencing, sensors, or equipment to create more efficient operations.
- Replace aged equipment or develop a plan for future replacement of equipment.
- Remove unnecessary equipment by disconnecting[82] from the electric grid.

[82] Tag-out/lock-out of the electric breaker is acceptable to confirm disconnection from the electric grid.

Eligibility Criteria

Comprehensive projects must comply with IPMVP Option C. Limited scope projects may be compliant with Options A, B, or C. Projects shall meet the model fit metrics based on one year of pre-installation and one year of post-installation hourly consumption data. Alternate methodologies or data availability of less than hourly increments will be considered on a case-by-case basis with prior approval from the evaluation team.

For projects with smaller savings typically (< 20 kW) where standard M&V efforts may be cost prohibitive, the simplified M&V energy and demand savings may be used with prior EM&V team approval.

Baseline Condition

The baseline condition is the existing building energy use before implementing the ECM or initiating other energy conservation activities.

High-Efficiency Condition

The high-efficiency condition is the building or system energy use after implementing ECMs and other energy conservation activities. A start-up or commissioning period after implementation is not considered part of the high-efficiency condition.

Energy and Demand Savings Methodology

M&V Methodology

The M&V methodology presents a plan to determine (i.e., calculate and verify) energy savings. The whole-facility methodology follows Option C, and ECM-specific methodology follows Option A or B found in IPMVP Core Concepts EVO 10000-1:2022.

An M&V plan and M&V report should document the selected methodology and include assumptions and details regarding model development, testing, handling of errors, and information to validate regression model(s).

Model documentation should be transparent and allow for repeatable modeling steps and results, including any adjustments made outside the primary modeling method. Procedures and their results should be documented and may include:

- Describe how modeling outliers were identified and addressed.
- Describe how missing data errors were addressed and document what changed from the original model. Any data removed or changed should be annotated with a cause.

- Describe non-routine events and adjustments across the measurement periods. The COVID-19 pandemic[83] altered many commercial and industrial (C&I) customer operations in multiple ways, and each significant adjustment in operation should be described, such as full shutdown periods, partial operation periods, and full operation periods.

M&V energy savings should be normalized to climatological and other features, such as production volume or occupancy. The weather-dependent factors are normalized to fixed Typical Meteorological Year 3 (TMY3) weather data files organized by climate zone[84]. This normalized file should be used with both the pre-installation and post-installation consumption energy model from the regression analysis.

M&V Plan and M&V Report

Preparation of an M&V plan and report is required to determine savings. An M&V plan ensures that collected data and information necessary to determine savings will be available after implementing the ECM. The M&V plan and report should follow the IPMVP Core Concept 2022 Section 13 template, excluding the budget section. Documentation of assumptions and modeling should be complete, readily available, clearly organized, and easy to understand.

Normalized Energy Model Fit Metrics

The model should be designed to develop the most accurate normalized metered energy consumption using a replicable method. The model should be the simplest model available with the best R^2 and CV(RMSE)[85]. The most common is the least-squares regression method completed separately for electric consumption (kWh) and demand (kW). The model shall attempt to meet the following model fitness metric requirements:

- Energy Savings is greater than 10 percent of baseline consumption.
- R^2 value greater than or equal to 0.75

Advanced models may develop alternative fit metrics or error levels at specific confidence levels, as Section 12.6 of the Core Concepts 2022 describes.

The electric demand model based on one-hour interval consumption data will lead to the best model to best determine peak demand savings. The model shall be evaluated to determine if the peak demand is accurately represented during the PDPF peak conditions described in TRM Volume 1. In order to achieve the best model fitness, the peak demand model may need to isolate portions of the consumption data relevant to the summer or winter peak demand periods or temperatures. The reduced consumption data may be based on performance during only the potential weekday peak hours in the measurement period or may focus on the hourly demand when the temperatures reach near the peak temperatures from the PDPF tables. Alternate regression analysis is also acceptable.

83 Starting March 2019.
84 TMY3 files for climate zones: http://www.texasefficiency.com/index.php/regulatory-filings/deemed-savings.
85 Coefficient of variation root mean squared error.

It is acceptable that the peak demand model does not meet the fit metrics identified above. The goal of the model is to reduce the variation between the model and the actual measured highest demand, not the overall fit of the energy model. The error of the model results should be reviewed at the peak demand hours to determine that the baseline and performance period models have a similar adjustment from the actual measured. For example, it is acceptable if the baseline and performance period models underestimate the peak demand by similar percentages because the difference will be similar. It is not acceptable if one model underestimates the peak consumption and the other overestimates because that will create a model variation that is not supported by actual consumption.

If the one-hour interval consumption data is unavailable, the evaluation team must approve the M&V plan before implementation.

Baseline Data and Model

The participant baseline data should be used to create a baseline model equation. The M&V plan should document the data used to determine the baseline completely and accurately, including selecting constants and independent variables. The baseline and independent variables shall be derived based on the historical electric consumption 12 months immediately before the capital project, the nearest actual weather data file, and other relevant variables, such as floor area or operating profile.[86] Historic electricity consumption is expected to be an hour interval to support the development of the peak demand savings detailed in Volume 1.

Performance Period Data and Model

The participant's consumption data starts immediately after commissioning all project components to create a performance period model equation. The M&V plan should document the data used to determine consumption completely and accurately, including the selection of constants and independent variables. Independent variables shall be derived based on the historical electric consumption of 12 months, the actual weather data file from the same source as the baseline, a TMY3 weather data file specified for the climate zone, and other relevant variables. Actual electricity consumption is expected to be an hour interval to support the development of the peak demand savings detailed in Volume 1, Section 4.

Rounding

Data rounding to the nearest whole number should only occur at the annual consumption of the baseline or performance period. The hourly or daily results should not be rounded in calculations.

[86] CalTRACK 2.0 provides a compliance checklist that can be used as best practices during model development, https://www.caltrack.org/caltrack-compliance.html.

Savings Methodology—Measured Data Analysis

The following equations will be used to calculate energy and demand saving estimates:

$$Peak\ Demand\ Savings\ (kW) = kW_{PDPF,existing} - kW_{PDPF,new} \pm kW_{adjustments} - kW_{other\ mees}$$

Equation 50

$$Energy\ Savings\ (kWh) = kWh_{existing} - kWh_{new} \pm kWh_{adjustments} - kWh_{other\ mees}$$

Equation 51

Where:

$kW_{PDPF,\ existing}$	=	*Building or system level kW for the existing building/system*
$kW_{PDPF,\ new}$	=	*Building or system level kW for the post retro-commissioning building/system*
$kWh_{existing}$	=	*Building or system level kWh normalized for the existing building/system from metered data*
kWh_{new}	=	*Building or system level kWh normalized for the post retro-commissioning building/system from metered data*
$kW/kWh_{adjustments}$	=	*Adjustments to the kW and kWh building/system metered data results that account for operational changes which are not attributable to the project*
$kW/kWh_{other\ meas}$	=	*Adjustments to the kW and kWh building/system metered data results that account for prescriptive and custom measures which are calculated independently*

Deemed Energy and Demand Savings

There are no deemed energy or demand savings for this measure. Prescriptive savings for individual measures calculated following commercial measures in TRM Volumes 3 and 4 should be claimed first. When complete, the M&V determined savings will true-up the project-claimed savings (both positive and negative). Projects may claim up to 40 percent of the estimated energy savings from the proposed ECMs prior to the completion of the M&V protocol.

Simplified M&V Energy and Demand Savings

For smaller-scale RCx projects resulting in smaller savings (typically <20 kW), a simplified M&V approach may be used, pending EM&V team pre-approval. Simplified project approaches are considered on a case-by-case basis.

The simplified M&V approach can provide custom calculations incorporating all required data collection, spot measurements, and weather data to create detailed energy savings estimates. Calculations must determine the demand at the specific hour and temperature detailed in the peak demand savings methodology. Calculations must also incorporate the interactive effects between the implemented improvements, assuming conservative energy efficiency improvements when the interactive effects are unknown.

A description of the baseline and efficient condition in the Simplified M&V plan is required. It is required that improvements and assumptions are documented to support the calculations.

Claimed Peak Demand Savings

The methodology used to determine peak demand savings should be consistent with the methodology of energy savings, though other models and variables may be used to better estimate the peak demand, as outlined in TRM Volume 1, Section 4. The methodology should be documented clearly in the M&V plan and report. Because models are developed for a normalized year, the factors outside the date, time, and temperature should be assumed to be the maximum for the date and time combination, such as considering the date in the PDPF table as the closest weekday operation day for an office building.

Additional Calculators and Tools

Third-party software used for estimating annual energy use and demand is acceptable, provided that the tool is available to the EM&V team or the calculation methodology of the software is clearly documented in the M&V plan and M&V report.

Measure Life and Lifetime Savings

The estimated useful life (EUL) for M&V projects varies based on the ECM or equipment installed. The EUL from similar equipment in Volume 3 of the TRM should guide EUL determination. The following ECMs are not defined in the TRM:

- Custom project Equipment: 10 years or similar EUL to equipment in Volume 3
- RCx: 5 years, pending further research for O&M measures[87]
- Advanced Controls and Sensors: 10 years

Program Tracking Data and Evaluation Requirements

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

- Climate zone or county
- Decision/action type: Custom, operations and maintenance, other
- Building type

[87] Kolwey, Neil. SWEEP Industrial Re-commissioning: Not Just a Building Tune-up. February 2017. https://www.swenergy.org/data/sites/1/media/documents/publications/documents/SWEEP%20Industrial%20Recommissioning%20Feb%202017.pdf.

The following inputs and data should be documented and available for evaluation review:

- Actual one-hour interval consumption data
- Actual weather data file
- Actual alternate operations or other variable documentation
- Model development inputs and outputs for baseline and post-install analysis.
- Normalized energy consumption and peak demand reduction estimates
- Normalized energy consumption data file based on TMY3 and other variables
- Standard and references unique to each project

References and Efficiency Standards

Not applicable.

Petitions and Rulings

Not applicable.

Relevant Standards and Reference Sources

- International Performance and Measurement Verification Protocol Core Concepts 2022: https://evo-world.org/en/products-services-mainmenu-en/protocols/ipmvp
- CalTRACK 2.0 Technical Appendix: http://docs.caltrack.org/en/latest/technical-appendix.html

Standard and references unique to each project should be documented in the M&V plan and report.

Document Revision History

Table 62. Non-RES M&V—Revision History

TRM version	Date	Description of change
v6.0	10/2018	TRM v6.0 origin.
v7.0	10/2019	TRM v7.0 update. Clarifications for small project exemptions and proper use of IPMVP Option C. Correction for erroneous eligibility criteria in v6.0.
v8.0	10/2020	Updated model fitness requirements, added CalTRACK2.0 technical appendix as a guide to normalize consumption models, and clarified guidance on normalized energy model fitness, baseline development, and reporting period.
v9.0	10/2021	Updated model requirements to account for pandemic and other non-routine events. Added alternate calculation method.

TRM version	Date	Description of change
v10.0	10/2022	Updated measure to apply to M&V beyond RCx. Added reference to IPMVP Core Concepts 2022. Added evaluator preapproval for projects without one-hour incremental data or less than one year pre- and post-measurement data. Added a 40 percent pre-analysis energy savings claim option.
v11.0	10/2023	Minor clarifications.
v12.0	10/2024	Adjusted fit metrics for peak demand calculations.

2.5.5 Energy Storage Measure Overview

TRM Measure ID: NR-MS-ES

Market Sector: Commercial

Measure Category: Miscellaneous

Applicable Building Types: Commercial

Fuels Affected: Electricity, natural gas

Decision/Action Types: Retrofit (RET), new constriction (NC)

Program Delivery Type: Custom

Deemed Savings Type: Not applicable

Savings Methodology: EM&V

This protocol is used to estimate savings for energy storage (ES) projects. ES projects are systems that use various methods to store energy on-site that will offset energy consumption during on-peak hours or critical seasonal periods. ES systems often have non-energy benefits (economic, equipment sizing, etc.) while having negligible, or even negative, energy savings and can not be used for demand response or load management.

Measure Description

Energy storage systems represent a wide range of available technologies. Potential ES systems under this protocol include, but are not limited to, solar energy storage, compressed air storage, molten-salt technologies, ice-based technologies, or general heat storage in any technology.

Eligibility Criteria

ES projects must be compliant with IPMVP Option A, B, or C. For Option C, the project should save more than 10 percent of peak demand with 30-minute (or more frequent) interval data. For Option B, full M&V of the energy storage system and affected systems is expected. For Option A, the assumptions that support monitoring of only key data points should be discussed with the EM&V team prior to M&V plan development. An M&V plan should be developed when using Options A or B and approved by the EM&V team prior to the conducting of any metering for the project.

Systems that are designed for on-call load curtailment and participation in load management programs do not meet the efficiency conditions of this measure.

Baseline Condition

The baseline condition is the existing building energy use systems (retrofit) or minimal code-compliant systems (new construction).

High-Efficiency Condition

The high-efficiency condition is the building with the energy storage system that is not participating in load management programs.

Energy and Demand Savings Methodology

Whole Facility EM&V Methodology

IPMVP Option C can be used as the basis of analysis for energy storage systems. If the energy storage system is expected to have daily cycling, metering intervals must be 30 minutes or less (preferably 15 minutes) for all affected fuel types. Options A or B can be used when interval data is not available. Further, all hours defined in Volume 1 PDPF tables for the project's climate zone must be directly metered, as well as representative weather periods must be observed during the monitoring period. For TES systems with seasonality cycling, the monitoring interval can be increased and must be approved by the M&V team on a case-by-case basis.

The other parameters and acceptance criteria for the M&V plan and results should follow Measure 2.5.4 Nonresidential Measurement and Verification.

Baseline and Reporting Period

The baseline and reporting periods for TES systems will be approved on a case-by-case basis by the EM&V team.

Savings Methodology

The following equations will be used to calculate energy and demand saving estimates. Energy consumption savings may be negative because of the energy storage efficiency loss; the negative savings must be claimed in association with the peak demand reduction. If the energy storage system is part of a larger project, the other measures should claim energy savings available without the ES system, and the efficiency loss should be attributed to the ES system.

$$Peak\ Demand\ Savings\ (kW) = kW_{PDPF,existing} - kW_{PDPF,new} \pm kW_{adjustments} - kW_{other\ mees}$$

Equation 69

$$Energy\ Savings\ (kWh) = kWh_{existing} - kWh_{new} \pm kWh_{adjustments} - kWh_{other\ mees}$$

Equation 70

Where:

$kW_{PDPF,\ existing}$ = *Building or system level kW for the existing building/system from metered data corresponding to the PDPF period as outlined in TRM volume 1*[88]

[88] TRM volume 1, section 4.2 provides a basis for estimating peak coincident demand reductions attributable to the implementation of energy efficiency measures in Texas. This is based on measure-specific load during the identified peak hours according to section 4.2.2.

$kW_{PDPF,\ new}$	=	*Building or system level kW for the post-ES building/system from metered data corresponding to PDPF period as outlined in TRM volume 1*[88]
$kWh_{existing}$	=	*Building or system level kWh for the existing building/system from metered data*
kWh_{new}	=	*Building or system level kWh for the post-ES building/system from metered data*
$kW/kWh_{adjustments}$	=	*Adjustments to the kW and kWh building/system metered data results that account for operational changes, which are not attributable to the ES project*
$kW/kWh_{other\ meas}$	=	*Adjustments to the kW and kWh building/system metered data results that account for prescriptive and custom measures, which are calculated independently*

Deemed Energy and Demand Savings

There are no deemed energy or demand savings for this measure.

Claimed Peak Demand Savings

The methodology used to determine peak demand savings should be consistent with the methodology of the energy savings. Furthermore, the calculation of peak demand savings should into account the weather dependent peak demand probability factors, as outlined in Volume 1, Section 4. The methodology should be documented clearly in the M&V plan and M&V report.

Additional Calculators and Tools

Any regression software used for estimating annual energy use and demand should be clearly specified within the M&V plan and report.

Measure Life and Lifetime Savings

The estimated useful life (EUL) for energy storage (ES) projects is 15 years, pending further research for specific ES measures.

The EUL for M&V projects varies based on the ECM or equipment installed. The EUL from similar equipment in Volume 3 of the TRM should guide EUL determination. The following ECMs are not defined in the TRM:

- Custom project equipment: 10 years or similar EUL to equipment in Volume 3
- Advanced controls and sensors: 10 years

Program Tracking Data and Evaluation Requirements

The documentation in the M&V plan and M&V report should match the Program Tracking Data and Evaluation Requirements in Measure 2.5.4 Nonresidential Measurement and Verification.

Petitions and Rulings

Not applicable.

Relevant Standards and Reference Sources

- International Performance and Measurement Verification Protocol Core Concepts 2022 https://evo-world.org/en/products-services-mainmenu-en/protocols/ipmvp
- Standard and references unique to each project should be documented in the M&V plan and report

Document Revision History

Table 63. Energy Storage—Revision History

TRM version	Date	Description of change
v7.0	10/2019	TRM v7.0 origin.
v8.0	10/2020	Added 30-minute interval data as a requirement when using IPMVP Option C
v9.0	10/2021	No revision.
v10.0	10/2022	No revision.
v11.0	10/2023	Revised measure to be for energy storage, not just thermal energy storage.
v12.0	10/2024	No revision.

2.5.6 ENERGY STAR® Uninterruptible Power Supply Overview

TRM Measure ID: NR-MS-UP

Market Sector: Commercial

Measure Category: Miscellaneous

Applicable Building Types: Telecommunications or other continuous operation

Fuels Affected: Electricity

Decision/Action Type: Retrofit, new construction

Program Delivery Type: Custom

Deemed Savings Type: Deemed savings calculation

Savings Methodology: Engineering algorithms and estimates

Measure Description

This measure is for the installation of an ENERGY STAR uninterruptible power supply (UPS) in a telecommunications application or similar facilities with continuous operation.[89] UPS equipment protects vital connected equipment from power outages, providing backup power and constantly drawing power to keep their batteries charged.

Note: This measure has the potential to yield negative savings, including for ENERGY STAR-certified equipment. This measure will be reconsidered on an annual basis until the negative savings scenario is reconciled. If sufficient M&V data is provided, this measure may be incorporated into Volume 3 as a fully-deemed measure.

Eligibility Criteria

Eligible UPS equipment must be compliant with the current ENERGY STAR v2.0 specification, effective January 1, 2019.[90] For single-normal mode UPSs, the installed system must meet or exceed the average loading-adjusted efficiency values required by ENERGY STAR.

Baseline Condition

The current Department of Energy (DOE) federal minimum efficiency standard is only applicable to consumer UPSs.[91]

[89] ENERGY STAR UPS qualified product listing. https://www.energystar.gov/productfinder/product/certified-uninterruptible-power-supplies/results.

[90] ENERGY STAR Program Requirements for UPS. Version 2.0. https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Uninterruptible%20Power%20Supplies%20Final%20Version%202.0%20Specification_2.pdf.

[91] DOE 10 CFR Part 430. https://www.regulations.gov/document/EERE-2016-BT-STD-0022-0035.

The baseline condition for retrofit and new construction applications is the minimum efficiency requirement specified in the current ENERGY STAR v2.0 specification in Table 64. If available, the actual efficiency of the replaced UPS may be used as the applicable baseline efficiency.

Table 64. UPS—ENERGY STAR Minimum Efficiency Requirements

UPS product class	Rated output power (W)	Efficiency requirement[92]
VFD	0 < P ≤ 350	$5.71 \times 10^{-5} \times \mathrm{P} + 0.962$
	350 < P ≤ 1,500	0.982
	1,500 < P ≤ 10,000	$0.981 - \mathrm{E_{MOD}}$
	P > 10,000	0.970
VI	0 < P ≤ 350	$5.71 \times 10^{-5} \times \mathrm{P} + 0.964$
	350 < P ≤ 1,500	0.984
	1,500 < P ≤ 10,000	$0.980 - \mathrm{E_{MOD}}$
	P > 10,000	0.940
VFI	0 < P ≤ 350	$0.011 \times \ln(\mathrm{P}) + 0.824$
	350 < P ≤ 1,500	
	1,500 < P ≤ 10,000	$0.0145 \times \ln(\mathrm{P}) + 0.8 - \mathrm{E_{MOD}}$
	P > 10,000	$0.0058 \times \ln(\mathrm{P}) + 0.886$

High-Efficiency Condition

The high-efficiency condition is the ENERGY STAR-rated efficiency.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

The deemed savings values are calculated using the following algorithms:

$$Energy\ Savings\ [kWh_{savings}] = \frac{P}{1{,}000} \times \left(\frac{1}{\eta_{base}} - \frac{1}{\eta_{UPS}}\right) \times EFLH$$

Equation 71

$$Summer\ Peak\ Demand\ Savings\ [kW_{savings}] = \frac{kWh_{savings}}{hours} \times CF_S$$

Equation 72

[92] E_{MOD} represents a 0.004 allowance for modular UPS applicable in the commercial 1,500-10,000 W range. On the ENERGY STAR certificate, modular UPS are identified as “Multiple-normal-mode” for number of normal modes. Non-modular UPS are identified as “Single-normal-mode”.

$$Winter\ Peak\ Demand\ Savings\ [kW_{savings}] = \frac{kWh_{savings}}{hours} \times CF_W$$

Equation 73

Where:

P	=	*UPS-rated output power, W*
1,000	=	*Constant to convert from W to kW*
η_{base}	=	*ENERGY STAR minimum efficiency requirement or actual rated efficiency (see Table 64)*[93]
η_{UPS}	=	*ENERGY STAR-rated efficiency*
EFLH	=	*Equivalent full-load hours accounting for ENERGY STAR loading assumptions (see Table 65)*
$CF_{S/W}$	=	*Seasonal peak coincidence factor = 1 based on continuous operation*

Table 65. UPS—Loading Assumptions and Equivalent Full-Load Hours[94]

UPS product class	Rated output power (W)	% Load				EFLH
		25%	50%	75%	100%	
VFD	0 < P ≤ 1,500	0.2	0.2	0.3	0.3	5,913
VI or VFI		0.0	0.3	0.4	0.3	6,570
All	1,500 < P ≤ 10,000	0.0	0.3	0.4	0.3	6,570
All	P > 10,000	0.25	0.5	0.25	0.0	4,380

Deemed Energy Savings Tables

There are no deemed energy savings tables for this measure.

Deemed Summer and Winter Demand Savings Tables

There are no deemed demand savings tables for this measure.

Claimed Peak Demand Savings

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

[93] If available, the actual efficiency of the replaced UPS may be used as the applicable baseline efficiency.

[94] ENERGY STAR Program Requirements for UPS. Version 2.0. Table 1. https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Uninterruptible%20Power%20Supplies%20Final%20Version%202.0%20Specification_2.pdf.

Measure Life and Lifetime Savings

The estimated useful life (EUL) for UPS equipment is 10 years.[95]

Program Tracking Data and Evaluation Requirements

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

- Facility/application type
- UPS quantity
- UPS manufacturer and model number
- Copy of ENERGY STAR certificate matching manufacturer and model number
- UPS product class (VFD, VI, VFI)
- UPS number of modes (single, multiple)[96]
- UPS rated power (W)
- UPS rated efficiency
- Proof of purchase: invoice showing model number; a photo of the model number on product packaging and/or installed product; OR an evaluator pre-approved inspection approach

Document Revision History

Table 66. UPS—Revision History

TRM version	Date	Description of change
v11.0	10/2023	TRM v11.0 origin.
v12.0	10/2024	No revision.

[95] California Municipal Utilities Association. Savings Estimation Technical Reference Manual 2017, Third Edition. Section 8.12. Page 8-15. https://www.cmua.org/files/CMUA-POU-TRM_2017_FINAL_12-5-2017%20-%20Copy.pdf.

[96] Used to identify whether a UPS is modular. On the ENERGY STAR certificate, modular UPS are identified as "Multiple-normal-mode" for number of normal modes. Non-modular UPS are identified as "Single-normal-mode".

2.5.7 Low Pressure Irrigation Systems Measure Overview

TRM Measure ID: NR-MS-LP

Market Sector: Commercial

Measure Category: Miscellaneous

Applicable Building Types: Agriculture/golf course

Fuels Affected: Electricity

Decision/Action Type(s): Retrofit

Program Delivery Type(s): Custom

Deemed Savings Type: Savings calculation

Savings Methodology: Engineering algorithms and estimates

Measure Description

This measure involves the installation of a low pressure irrigation system, which reduces the amount of energy required to apply the same amount of water as a baseline system. The amount of energy saved per acre will depend on the actual operating pressure decrease, the pumping plant efficiency, the amount of water applied, and the number of nozzles, sprinklers, or micro irrigation system conversions made to the system.

Eligibility Criteria

This measure requires a minimum of 50 percent reduction in irrigation pumping pressure through the installation of a low-pressure irrigation system in agriculture or golf course applications. The pressure reduction can be achieved in several ways, such as nozzle or valve replacement, sprinkler head replacement, alterations or retrofits to the pumping plant, or drip irrigation system installation, and is left up to the discretion of the owner. Pre- and post-retrofit pump pressure measurements are required.

Baseline Condition

The baseline condition is the pump pressure at the operating plant before any alterations, retrofits, or adjustments are made to the irrigation system.

High-Efficiency Condition

The high-efficiency condition is the pump pressure at the operating plant after any alteration, retrofits, or adjustments are made to the irrigation system.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Energy and deemed savings are calculated based on the specific application pressure reduction and flow rate.

Energy Savings Algorithms

$$Energy\ Savings\ [\Delta kWh] = \frac{(Head_{base} - Head_{eff}) \times GPM}{3{,}960 \times (\eta_{pump} \times \eta_{motor})} \times 0.746 \times AIH$$

Equation 1

Where:

$Head_{base}$	=	*Baseline pressure head (ft), actual value*
$Head_{eff}$	=	*Efficient reduced pressure head (ft), actual value*
GPM	=	*Pump flow rate [gal/min]*
3,960	=	*Conversion from horsepower to pressure head and flow*
η_{pump}	=	*Pump efficiency (default = 70%) or from system design*
η_{motor}	=	*Motor efficiency (see Table 67)*
0.746	=	*Conversion from HP to kW*
AIH	=	*Annual irrigation hours (collected from records or calculated[97])*

Table 67. Low Pressure Irrigation—Motor Efficiencies[98]

Motor horsepower	Full load efficiency
1	0.855
2	0.865
3	0.895
5	0.895
7.5	0.910

[97] See *Irrigation Pump VFD* measure for calculation method.

[98] Code of Federal Regulations, Title 10, Chapter II, Subchapter D, Part 431.25 Table 1, Nominal Full-Load efficiencies of General Purpose Electric Motors (Subtype 1), 4 pole motors. https://www.ecfr.gov/cgi-bin/retrieveECFR?n=pt10.3.431#se10.3.431_125.

Motor horsepower	Full load efficiency
10	0.917
15	0.930
20	0.930
25	0.936
30	0.941
40	0.941
50	0.945
60	0.950
75	0.950
100	0.954

Demand Savings Algorithms

Not applicable.

Claimed Peak Demand Savings

No peak demand savings have been estimated for this measure.

Measure Life and Lifetime Savings

The estimated useful life (EUL) is five years, as specified in the California Database of Energy Efficiency Resources (DEER) READI tool for EUL ID Agr-LPSNperm.[99]

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:

- Motor-rated horsepower, type, and efficiency
- Motor nameplate photo
- Design pressure and flow for the irrigation system
- Design pump efficiency at irrigation system pressure and flow
- Pump nameplate photo
- Baseline and efficient irrigation system pressure, with date of measurement
- Proof of purchase and installation of low-pressure irrigation components, including quantity, make, and model information (e.g., specification sheets, invoices, photos)

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

- Facility type: agriculture or golf course
- Average annual operating hours of irrigation pump

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 68. Low Pressure Irrigation—Revision History

TRM version	Date	Description of change
v12.0	10/2024	TRM v12.0 origin.

2.5.8 Irrigation Pump Variable Frequency Drives Measure Overview

TRM Measure ID: NR-MS-IP

Market Sector: Commercial

Measure Category: Miscellaneous

Applicable Building Types: Agricultural

Fuels Affected: Electricity

Decision/Action Type(s): Retrofit

Program Delivery Type(s): Custom

Deemed Savings Type: Savings calculation

Savings Methodology: Engineering algorithms and estimates

Measure Description

This measure involves the application of variable frequency drives (VFD) that are installed on irrigation pump motors for the agricultural industry. The VFD will modulate the speed of the motor when it does not need to run at full load, which will result in energy savings since the power of the motor is proportional to the cube of the speed for these types of applications. This application does not apply to positive displacement pumps.

Eligibility Criteria

This measure applies to a VFD that is installed on an existing irrigation pump motor that does not already have a VFD. The irrigation pump system must have a variable load and pump directly to the irrigation system nozzles. The installation of the measure must include controls that adjust the VFD based on flow and/or pressure at critical points. Savings for this measure are based on the application of VFDs to a range of baseline load conditions. This measure cannot be used for well pumps filling a reservoir or discharging directly into a canal or a mixed flow pump (high volume, low head).

Baseline Condition

The retrofit baseline is an existing motor operating as-is and may or may not include guide vanes, throttling valves, or other methods of control. Installations of new equipment with VFDs are not eligible to claim savings under this measure.

High-Efficiency Condition

The high-efficiency condition is the installation of a VFD on irrigation pump motors, along with the proper controls to appropriately modulate pump speed.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Energy Savings Algorithms

$$\Delta kWh = kWh_{Base} - kWh_{VFD}$$

Equation 1

$$kWh_{base} = \sum_{1}^{n} HP_{base,n} \times 0.746 \times AIH \times \%Hours_n$$

Equation 2

$$kWh_{VFD} = \sum_{1}^{n} HP_{VFD,n} \times 0.746 \times AIH \times \%Hours_n$$

Equation 3

$$HP_{base,n} = \frac{Flow_n \times Head_{base,n}}{3{,}960 \times (\eta_{pump} \times \eta_{motor})}$$

Equation 4

$$\boldsymbol{HP_{VFD,n}} = \frac{\boldsymbol{Flow_n} \times \boldsymbol{Head_{VFD,n}}}{\boldsymbol{3,960} \times (\boldsymbol{\eta_{pump}} \times \boldsymbol{\eta_{VFD}} \times \boldsymbol{\eta_{motor}})}$$

Equation 5

$$AIH = \frac{A \times GRI}{12 \times 60 \times GPM/(7.481 \times 43{,}560)}$$

Equation 6

Where:

kWh_{base}	=	*Annual energy required for the baseline pump condition*
kWh_{VFD}	=	*Annual energy required with a VFD pump installed*
$HP_{n,base}$	=	*Baseline brake horsepower required for a given flow rate*
$HP_{VFD,n}$	=	*Brake horsepower required for a given flow rate with VFD installed*
AIH	=	*Annual irrigation hours (collected from records or calculated)*
0.746	=	*Constant to convert from hp to kW*
$\%Hours_n$	=	*Percentage of time the pump will be operating at a given operating point*
n	=	*Number of operating points for flow and pressure*
$Flow_n$	=	*Flow rate at operating point (GPM), actual value*

$Head_{base,n}$	=	*Baseline pressure head (ft) at operating point, actual value*
$Head_{VFD,n}$	=	*VFD pressure head (ft) at operating point, actual value*
3,960	=	*Conversion from hp to pressure head and flow*
η_{pump}	=	*Percentage efficiency of the pump*[100]
η_{motor}	=	*Percentage efficiency of the pump motor (see Table 69)*
η_{VFD}	=	*Percentage efficiency of the VFD = 97%*[101]
A	=	*Irrigated field area [acres]*
GRI	=	*Gross required irrigation [in/year]*
12	=	*Constant to convert from inches to feet*
60	=	*Constant to convert from minutes to hours*
7.841	=	*Constant to convert from cubic feet to gallons*
43,560	=	*Constant to convert from square feet to acres*
GPM	=	*System designed flow rate in [gal/min]*

Table 69. Irrigation Pump VFD—Motor Efficiencies[102]

Motor horsepower	Full load efficiency
1	0.855
2	0.865
3	0.895
5	0.895
7.5	0.910
10	0.917
15	0.930
20	0.930
25	0.936

[100] From the manufacturer's pump curve or field testing.
[101] Estimated typical VFD efficiency, as sourced from; "Chapter 18: Variable Frequency Drive Evaluation Protocol," The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures, NREL, December 2014 (pg.2).
[102] Code of Federal Regulations, Title 10, Chapter II, Subchapter D, Part 431.25 Table 1, Nominal Full-Load Efficiencies of General Purpose Electric Motors (Subtype 1), 4 pole motors. https://www.ecfr.gov/cgi-bin/retrieveECFR?n=pt10.3.431#se10.3.431_125.

Motor horsepower	Full load efficiency
30	0.941
40	0.941
50	0.945
60	0.950
75	0.950
100	0.954

Demand Savings Algorithms

None.

Claimed Peak Demand Savings

No peak demand savings have been estimated for this measure.

Measure Life and Lifetime Savings

The estimated useful life (EUL) is 12.5 years, consistent with the Volume 3 measure for *Variable Frequency Drives for Water Pumping* applications.

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:

- VFD proof of purchase, including quantity, make, and model information
- Motor-rated horsepower, type, and efficiency (pre- and post)
- Motor nameplate photo
- Design pressure and flow for the irrigation system
- Design pump efficiency at irrigation system pressure and flow
- Pump nameplate photo
- Manufacturer pump curve or field test results at multiple operating points
- Pressure and flow at *n* operating points (pre- and post)
- Area irrigated in acres
- Annual irrigation volume in inches per year on area irrigated
- Average annual operating hours of irrigation pump

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 70. Irrigation Pump VFD—Revision History

TRM version	Date	Description of change
v12.0	10/2024	TRM v12.0 origin.

2.6 M&V: LOAD MANAGEMENT

2.6.1 Residential Load Curtailment Measure Overview

TRM Measure ID: R-LM-LM

Market Sector: Residential

Measure Category: Load management

Applicable Building Types: Single-family, multifamily, and manufactured

Fuels Affected: Electricity

Decision/Action Types: Operation and maintenance (O&M)

Program Delivery Type: Custom

Deemed Savings Type: Not applicable

Savings Methodology: EM&V

Utilities operate residential load management programs to obtain demand savings: energy savings are estimated as a function of the estimated demand savings.[103] Demand savings calculations are performed using utility customer interval energy demand data from IDRs or advanced meters. Measured and verified demand savings for the curtailment period is presented here.

Measure Description

This document presents the M&V savings methodology for participating in a load management program that involves the curtailment of an interruptible load during the summer peak period. Examples of end-uses participating in a residential load management program may include space conditioning equipment, water heating equipment, swimming pool pumps, electric vehicle chargers, or other electricity loads as specified by utility programs. Specific methods of load management for this measure are not defined and are determined by individual programs. The savings reflect the cumulative effect of all participant actions to reduce residence-wide demand during a load management event.

Eligibility Criteria

A project will be eligible for incentives and reporting demand and energy savings if the following criteria are met:

- Participants are homes and reduce their demand during curtailment events throughout the summer peak demand period outlined in Table 71.
- Each meter has a continuous demand interval recording capability (30-minute intervals or less)

[103] Some utilities may determine energy savings associated with load management events, which would be calculated as the difference between the baseline and curtailment kW values times the length of the event(s).

- Sufficient interval data exists to measure and verify sufficient comparison-days to establish demand baselines and interval demands during load management events.

Table 71. RES Load Curtailment—Peak Demand Period

Hours	Months	Exceptions
1:00 p.m.—7:00 p.m.	June, July, August, September	Weekends, federal holidays

Baseline Condition

The baseline condition is an individual participants' load that would have occurred had the load management event and subsequent load management activities not taken place.[104]

High-Efficiency Condition

Not applicable.

Energy and Demand Savings Methodology

Not applicable.

Savings Algorithms and Input Variables

$$Verified\ Demand\ Savings = Baseline\ Period\ kW - Curtailment\ kW$$

Equation 74

Where:

$Baseline\ Period\ kW$ = *Baseline average demand calculated according to the High 3 of 5 Baseline Method*

$Curtailment\ kW$ = *Average demand measured during the curtailment period*

High 3 of 5 Baseline with Day-of Adjustment

A high X of Y baseline considers the Y most recent days preceding an event and uses the data from the X days with the highest load within those Y days to calculate the baseline. Day-of adjustments are used to scale the baseline load estimate to the load conditions on the day of the event using data from the two hours prior to the time on the event day when participants were notified of the pending call for curtailment.

[104] Some utilities may determine energy savings associated with load management events, which would be calculated as the difference between the baseline and curtailment kW values times the length of the event(s).

Applying this concept to the residential load management measure, the High 3 of 5 baseline for a given curtailment event is estimated by first identifying the five non-holiday weekdays immediately preceding the event in which no prior program curtailment events were called, and calculating each participant's average demand during the same hours as the hours for which the curtailment event was implemented on each of those five days. The three highest of these five average-like day demand values are then averaged to estimate the "unadjusted high three baseline."

The day-of baseline adjustment is estimated by comparing participants' average demand for electricity on the day of the event during the two hours prior to notification of the pending event (the "adjustment period") to participants' average demand for electricity on the "high three" days during those same two hours. In the situation where notification may not be given, the two hours preceding one hour before the event begins on the event day and baseline days will be used as the adjustment period. The average load of the adjustment period on the event day are compared to the average load of the adjustment periods from the baseline days. The difference (positive or negative) between day-of demand and high three baseline day demand in the adjustment period is the uncapped additive adjustment. To apply the adjustment period to the unadjusted baseline, one of two options are selected in the following steps:

- **Step 1.** Calculate an uncapped additive adjustment. The uncapped additive adjustment is the difference of the adjustment period hours' load of the event day subtracted from the baseline days' average adjustment period load. For example, if the baseline days have an adjustment period average load of 3.20 kW and the event day has an adjustment period load of 3.80 kW, the uncapped additive adjustment is 3.80 kW (-) 3.20 kW = 0.60 kW.
- **Step 2.** Calculate an adjustment cap. The adjustment cap is 80 percent of the baseline days' average load during the event hours. For example, if a participant has a load of 4.00 kW during the baseline days' event hours, the adjustment cap is 4.00 kW (x) 0.80 = 3.2 kW.
- **Step 3.** Select the lowest of the adjustment cap and the absolute value of the uncapped additive adjustment to be the additive adjustment. Using the examples of the preceding two steps, the uncapped additive adjustment (0.60 kW) has the lowest magnitude between the two numbers and is selected as the additive adjustment.
- **Step 4.** Add the additive adjustment to the unadjusted High 3 of 5 baseline to calculate the final baseline used for calculating changes to consumption for the load management event.

Following the calculation of the baseline using the High 3 of 5 method, the following steps are taken to arrive at an event's total savings and program savings for the year:

- **Step 1.** For an individual meter, the change in consumption is calculated by subtracting the baseline from the average load recorded during the event. If the result is positive, the meter exhibits savings, whereas a negative result indicates an increase in consumption during the event.

- **Step 2.** For a given load management event, sum the change in consumption of all participating meters. If documented, those meters enrolled in the program that opt-out of an event may be removed from the summation. If opt-out meters are not documented, an enrolled meter will be considered to have participated in the event. The sum represents the event's total change in consumption, presumed to be positive and representing savings.
- **Step 3.** With each event's savings results, average the event-level savings. The average of the events' savings represents the program year savings.

An example below illustrates the entirety of applying the High 3 of 5 method to calculate load management savings for a single residential participant.

Example Calculation

Table 72 illustrates the steps of the High 3 of 5 baseline calculation method. Specific participant's results may vary.

Table 72. RES Load Curtailment—High 3 of 5 Example Load Management Event Data

Event day and potential baseline days	Potential baseline day 5	Potential baseline day 4	Potential baseline day 3	Potential baseline day 2	Potential baseline day 1	Load mgmt. event date
Event hours	1500-1600	1500-1600	1500-1600	1500-1600	1500-1600	1500-1600
Average kW during event hours	5.67	5.96	4.95	4.58	6.01	5.12
Notification hour						1400
Adjustment period hours	1200-1400	1200-1400	1200-1400	1200-1400	1200-1400	1200-1400
Adjustment period average kW	5.54	5.87	4.86	4.44	5.89	6.03

Calculation Steps:

- **Step 1.** Unadjusted High Three Baseline = Average kW during event times in three highest days of five prior to event day (kW)

  Unadjusted High Three Baseline = (5.67+5.96+6.01)/3 = 5.88 kW

- **Step 2.** Uncapped Additive Adjustment = Average kW during adjustment time on event day (kW)—Average kW during adjustment time in the same three highest days of five prior to event day

  Uncapped Additive Adjustment = 6.03 - (5.54+5.87+5.89)/3 = 0.26 kW

- **Step 3.** Adjustment Cap = 80% of Unadjusted High Three Baseline (kW)

  Adjustment Cap = 0.8 * 5.88 = 4.7 kW

- **Step 4.** Choose Additive Adjustment = Minimum {Absolute value of Uncapped Additive Adjustment, Adjustment Cap} (kW)

  Additive Adjustment = Minimum {0.26, 4.7} = 0.26 kW

- **Step 5.** Final Baseline = Additive Adjustment + Unadjusted High Three Baseline (kW)

  Final Baseline = 0.26 + 5.88 = 6.14 kW

- **Step 6.** kW Savings = Final Baseline—Curtailment kW (kW)

  kW Savings = 6.14—5.12 = 1.02 kW

Additional Calculation Considerations

Meters, test events, and missing data

- Utilities are responsible for calling a test event each program year for the load management programs. The test event has several purposes, including assuring the proper functioning of program meters. Utilities are responsible for maintaining working program meters.
- In the case that individual meters fail to record data sufficient for applying the High 3 of 5 calculation method (e.g., due to random, non-systematic errors), savings may still be calculated under the following conditions and method:
  - Less than two percent of participating residential customers experience meter recording failures
  - The customer can be confirmed as having participated via the practices of the sponsor operating the program or lack of opt-out notification
  - The EM&V team is engaged to discuss applying the average savings and any program participation segmentation, and the specific cases are documented

  Average savings from a similar group of participants (e.g., single-family, multifamily) may be used for claimed savings if (1) the control event technology and intervention are the same, and (2) the control event intervention can be confirmed based on standard program practices for event confirmation.

Rounding

Data rounding to the nearest whole number should only occur at the event and program levels for residential load management programs (NOT at the customer level). Utilities that prefer not to round the savings should document that in their calculations and inform the EM&V team (see Volume 5, Section 3.1 for more details).

Deemed Energy and Demand Savings Tables

Not applicable.

Claimed Peak Demand Savings

A summer peak period value is used for this measure, based on calculation methodology described for this measure.

Additional Calculators and Tools

Not applicable.

Measure Life and Lifetime Savings

The estimated useful life (EUL) is 1 year.

Program Tracking Data and Evaluation Requirements

The following data and information shall be tracked and provided to the EM&V team to enable savings verification:

- For each participant for which savings are being claimed, kWh consumption at intervals no greater than 30-minutes for each event day and for no less than five non-holiday and non-weekend days prior to each event day. Interval data shall be time-stamped with the date and no less than the time period ending the interval.
- Documentation describing the time stamp and whether the time stamp reflects the forward-looking period or period preceding the time stamp
- A list of all load management events affecting residential participants, describing their date, the time the event started, and the time the event ended.
- A list of all participants and addresses with a variable linking to the load or energy consumption interval data and that describes their enrollment date, load management control commissioning date, and any events in which the participant did not participate due to enrollment or equipment installation timing, equipment failures, or other factors known to the implementer or utility.
- Tools, calculators or other datasets that may be useful to the EM&V team, based on discussion between the EM&V team, utilities, and/or program implementer. The process for calculating kW and kWh savings should be provided in the program documentation, including any summation and rounding practices.
- Memos, reports, or results of any equipment test or metering data that provides perspectives, calculations, or metrics related to failure rates of load control receivers, thermostats or similar devices used to control participant loads during events.

Load management programs shall be tracked and reported separately from energy efficiency programs. The EM&V team may conduct participant-level independent metering studies to inform the verification of load management program savings.

References and Efficiency Standards

Not applicable.

Petitions and Rulings

Not applicable.

Relevant Standards and Reference Sources

- Oncor: Residential Load Management Program Manual can be found under Residential Load Management at https://eepm.oncor.com/Residential.aspx
- CenterPoint: Residential Load Management Program Guidelines https://cnprlm.programprocessing.com

Document Revision History

Table 73. RES Load Curtailment—Revision History

TRM version	Date	Description of change
v2.1	3/31/2015 revised 6/2015	Memo to PUCT staff initiating and establishing *High 3 of 5* baseline with day-of adjustment.
v3.1	11/05/2015	TRM v3.1 Volume 4 origin.
v4.0	10/10/2016	Clarified language related to applying the adjustment factor to the *High 3 of 5* baseline and additional data provision details
v5.0	10/10/2017	Further clarified the baseline calculation using the *High 3 of 5* method.
v6.0	10/2018	No revision.
v7.0	10/2019	Transferred metering and rounding guidance from Vol. 5.
v8.0	10/2020	Added guidance on rounding, ensuring meters are functioning prior to an event, and changing the error threshold from one to two percent of total participants
v9.0	10/2021	Added peak demand period by utility. Added links to program manuals.
v10.0	10/2022	Added footnote for Additional Calculation Considerations section. Updated Reference Sources section.
v11.0	10/2023	No revision.
v12.0	10/2024	Clarified eligible end-uses. Added guidance on tracking and reporting load management programs separately from energy efficiency programs.

2.6.2 Nonresidential Load Curtailment Measure Overview

TRM Measure ID: NR-LM-LM

Market Sector: Nonresidential

Measure Category: Load management

Applicable Building Types: Any building that meets minimum facility demand requirements

Fuels Affected: Electricity

Decision/Action Type: Operation and maintenance (O&M)

Program Delivery Type: Custom

Deemed Savings Type: Not applicable

Savings Methodology: EM&V

Utilities operate nonresidential load management programs to obtain demand savings. Energy savings are estimated as a function of the estimated demand savings.[105] Demand savings calculations are performed using utility customer interval energy demand data from IDRs or advanced meters. Measured and verified demand savings for the curtailment period is presented here.

Measure Description

This document presents the M&V savings methodology for participation in a load management program that involves the curtailment of an interruptible load during the summer or winter peak periods. Project sponsors, who have agreed to deliver demand savings to the utility from the utility's customer, must commit to an availability of curtailed load throughout the summer or winter peak demand periods. These project sponsors may include national or local energy efficiency service providers (EESPs), retail electricity providers (REPs), or individual customers. Different utilities offer different details on their programs, but they all have similar eligibility criteria, listed below:

Eligibility Criteria

A project will be eligible for incentives under the load management standard offer program (SOP) if the following criteria are met:

- Each meter included in a project must include a total potential demand savings of a specified minimum kW (varies by utility, as seen in Table 74) during the peak demand periods outlined in Table 75.

[105] Some utilities may determine energy savings associated with load management events, which would be calculated as the difference between the baseline and curtailment kW values times the length of the event(s).

Table 74. Non-RES Load Curtailment—Minimum Facility Demand Savings by Utility

Utility	Minimum demand savings (kW)
AEP SWEPCO	50
AEP Texas[106] (summer/winter)	5 / 100
CenterPoint (summer/winter)	100
El Paso Electric	100
Entergy	250
Oncor (summer/winter)	100
TNMP[107] (summer/winter)	40 / 100
Xcel[108]	100

Table 75. Non-RES Load Curtailment—Peak Demand Periods

Hours[109]	Months	Exceptions
1:00 p.m.—7:00 p.m.	June, July, August, September	Weekends, federal holidays
6:00 a.m.—10:00 a.m., 6:00 p.m. —10:00 p.m.	December, January, February	No exceptions, 24/7 curtailment period

- A single project may involve identifying curtailable load at more than one customer facility, provided the curtailment demand savings at the facilities are recorded using a single interval data recorder (IDR).
- The project sponsor agrees to verify that the curtailable load that is being used in its application will not be used and counted in any other curtailable load or load management program during the duration of the customer contract. The project sponsor will notify the utility company within 15 business days of any change in the status of the curtailable load or its inclusion in another load management program.
- Curtailable load must produce demand savings through a curtailment of electrical consumption during the performance period.

[106] AEP Central and AEP North

[107] TNMP prefers that project sponsors be capable of providing at least 40 kW (summer) or 100 kW (winter) of peak demand reduction at each site for which load reduction is offered; however, TNMP may accept applications including sites providing less than 40 kW (summer) or 100 kW (winter) of peak demand reduction in the interest of meeting its peak load reduction targets.

[108] The utility prefers that project sponsors be capable of providing at least 100 kW of peak demand reduction at each site for which load reduction is offered; however, the utility may accept applications including sites providing less than 100 kW of peak demand reduction in the interest of meeting its peak load reduction targets.

[109] Xcel's period hours are 12:00 p.m. to 8:00 p.m. Note that although Xcel starts and ends events outside the 1:00 p.m. to 7:00 p.m. period, Xcel only claims savings for deliveries during the rule-defined 1:00 p.m. to 7:00 p.m. peak period.

- Project sponsors must commit to making the curtailable load available during the summer or winter peak periods for the program.
- Be served by an interval data recorder (IDR) and/or smart meter that is monitored by the utility. A sponsor owned meter may be substituted in the event of a non-systemic utility-owned IDR meter failure. When using a sponsor-owned meter, all data must otherwise conform to the High 5 of 10 method and be used for both the baseline and event-day calculations. Documentation of the case must be provided along with all supporting meter data.
- Customer agrees to respond to at least one event (scheduled or unscheduled) per year for the purpose of verifying the load reduction is available for potential calls. Scheduled events are used to provide an estimate of the load reduction in the event that no unscheduled interruptions occur during the season.
- For sponsors on a curtailment tariff, if the event or baseline periods include a tariff-based curtailment, the event day performance for the load management program will be net of firm delivery under the tariff. Documentation must be provided to describe the overlap of load management and tariff-based curtailments along with supporting firm delivery contract amounts.

The following loads are excluded from consideration:

- A customer who has load contracted with a REP where that contract prevents the load from participating in a curtailment.
- Loads where curtailment would result in negative environmental or health effects.
- Curtailable load that receives an incentive through any other energy efficiency program.
- Curtailable load that takes electric service at transmission voltage and that serves a for-profit end-use customer.
- A customer that is categorized as a critical load customer (an exception may be if the customer has backup generation and can still curtail when requested).

Baseline Condition

Standard facility operation.

High-Efficiency Condition

Load management customers are required to participate in a number of unscheduled interruptions. Programs will provide a minimum of 30 minutes advanced notice, allowing facility managers time to use non-automated approaches. Another option is for facilities to install a load-control device on specific end-uses, equipment, or circuit loads.

Additional Utility Program Details

Each utility in Texas provides slightly different guidelines for its load management program. These details differ in the length of the unscheduled interruptions (also called curtailments), the maximum number or maximum number of hours of unscheduled interruptions, and the length of notification provided to the project sponsor. Table 76 highlights these differences.

Each utility states that participants will be willing to participate in a maximum number of unscheduled interruptions or a maximum number of scheduled (test) interruption hours. In addition to these, all utilities require that a scheduled interruption be performed. The purpose of this is to ensure that the project sponsor will be able to curtail the requested kW within the required notification time and to provide an estimate of the load reduction in the event that no unscheduled interruptions occur during the season. Additionally, some of the utilities offer different baseline methods or options for their customers to choose from.[110] These options are shown in Table 76 through Table 79.

Table 76. Non-RES Load Curtailment—Utility Program Details Overview

Utility	Options available	Scheduled interruption length	Maximum length	Notification required	Maximum unscheduled interruptions
AEP SWEPCO	See Table 78	1 hour	2 hours or 4 hours	1 hour	4 or 12 interruptions
AEP Texas (summer)	See Table 77	1 hour	2 hours or 4 hours	30 minutes	4, 8, or 12 interruptions
AEP Texas (winter)	No	1 hour	4 hours	30 minutes	4 interruptions
CenterPoint (summer/winter)	No	1-3 hours	4 hours	30 minutes	4 interruptions
El Paso Electric	No	1-5 hours	5 hours	1 hour	4 interruptions; 20 hours
Entergy	No	1 hour	4 hours	—	4 interruptions
Oncor (summer)	No	3 hours	4 hours	At least 30 minutes	25 hours
Oncor (winter)	No	3 hours	12 hours	30 minutes	25 hours
TNMP (summer)	No	1-2 hours	4 hours	30 minutes	4 interruptions; 18 hours
TNMP (winter)	No	1-4 hours	4 hours	30 minutes	4 interruptions; 16 hours
Xcel[111]	See Table 79	—	4 hours	1 hour	6 or 12 interruptions; 24 or 48 hours

[110] More details about the utility programs can be found in the program manuals (see Relevant Standards and Reference Sources).

[111] At the discretion of the program manager, Xcel may also choose to execute a one-hour test event during the performance period, either in lieu of or in addition to unscheduled interruptions.

Table 77. Non-RES Load Curtailment—AEP Texas (Summer) Interruption Options

Option	Maximum number of unscheduled interruptions	Minimum length (hours)	Maximum length (hours)
A	4	1	4
B	12	1	4
C	12	1	2
D	8	1	4
E	8	1	2

Table 78. Non-RES Load Curtailment—AEP SWEPCO Interruption Options

Option	Maximum number of unscheduled interruptions	Minimum length (hours)	Maximum length (hours)
A	4	1	4
B	12	1	4

Table 79. Non-RES Load Curtailment—Xcel Interruption Options

Option	Maximum number of unscheduled interruptions	Maximum length (hours)
A	6	4
B	12	4

Energy and Demand Savings Methodology

Not applicable.

Savings Algorithms and Input Variables

Utilities operate load management programs to obtain demand savings: to the extent energy savings are also estimated, they are estimated as a function of the estimated demand savings.[112] Demand savings calculations are performed using utility customer interval energy usage data from IDRs or advanced meters. The verified demand savings for the curtailment period uses the following algorithm:

$$Verified\ Demand\ Savings = Baseline\ Period\ kW - Curtailment\ kW$$

Equation 75

[112] Some utilities do determine energy savings, which would be calculated as the difference between the baseline and curtailment kW values times the length of the event(s).

Where:

$Baseline\ Period\ kW$	=	*Baseline average demand calculated according to the High 5 of 10 for summer or High 8 of 10 for winter baseline method, detailed below*
$Curtailment\ kW$	=	*Average demand measured during the curtailment period*

High X of Y method with day-of adjustment:

For summer peak periods, a High X of Y baseline considers the Y most recent days preceding an event and uses the data from the X days with the highest load within those Y days to calculate the baseline. For winter peak periods, to accommodate the greater variability in winter weather patterns, a High X of Y baseline considers the Y most recent days directly preceding and/or succeeding an event and uses the data from the X days with the highest load within those Y days to calculate the baseline. Day-of adjustments are used to scale the baseline load estimate to the load conditions on the day of the event using data from the hours prior to the time on the event day when participants were notified of the pending call for curtailment.

Applying this concept to the load management measure, the High 5 of 10 baseline (summer) or High 8 of 10 baseline (winter) for a given curtailment event is estimated by first identifying the 10 non-holiday weekdays immediately preceding or preceding/succeeding the event depending on summer or winter peak as described above in which no prior program curtailment events were called, and calculating each participant's average demand during the same hours as the hours for which the curtailment event was implemented on each of those 10 days. The five highest of these ten average demand values are then averaged to estimate the "unadjusted High 5 for summer or 8 for winter baseline".

The day-of baseline adjustment is estimated by comparing participants' average demand for electricity on the day of the event during the two hours prior to notification of the pending event (the "adjustment period") to participants' average demand for electricity on the "High 5 or 8" days during those same two hours. The difference (positive or negative) between day-of demand and "High 5 or 8" demand in the adjustment period is the "uncapped additive adjustment". In the situation where notification may not be given, the two hours preceding one hour before the event begins on the event day and baseline days will be used as the adjustment period. The average load of the adjustment period on the event day are compared to the average load of the adjustment periods from the baseline days. The difference (positive or negative) between day-of demand and "High 5 or 8" baseline day demand in the adjustment period is the uncapped additive adjustment. To apply the adjustment period to the unadjusted baseline, one of two options are selected in the following steps:

- **Step 1.** Calculate an uncapped additive adjustment. The uncapped additive adjustment is the difference of the adjustment period hours' load of the event day subtracted from the baseline days' average adjustment period load. For example, if the baseline days have an adjustment period average load of 530.20 kW and the event day has an adjustment period load of 575.80 kW, the uncapped additive adjustment is 575.80 kW (-) 530.20 kW = 45.60 kW.

- **Step 2.** Calculate an adjustment cap. The adjustment cap is 50 percent of the baseline days' average load during the event hours. For example, if a participant has a load of 504.00 kW during the baseline days' event hours, the adjustment cap is 504.00 kW (x) 0.50 = 252.00 kW.
- **Step 3.** Select the lowest of the adjustment cap and the absolute value of the uncapped additive adjustment to be the additive adjustment. Using the examples of the preceding two steps, the uncapped additive adjustment (45.60 kW) has the lowest magnitude between the two numbers and is selected as the additive adjustment.
- **Step 4.** Add the additive adjustment to the unadjusted High 5 of 10 baseline (summer) or High 8 of 10 baseline (winter) to calculate the final baseline used for calculating savings.

An example below illustrates the entirety of applying the High 5 of 10 summer method to calculate load management savings for a single participant.

Example Calculation

Table 80 serves to illustrate the steps of the High 5 of 10 summer baseline calculation method. Specific participant's results may vary. Numbers from the table in bold font represent data selected for the calculation.

Table 80. Non-RES Load Curtailment—High 5 of 10 Example Load Management Event Data

Event day and potential baseline days	Load mgmt. event date	Potential baseline day 1	Potential baseline day 2	Potential baseline day 3	Potential baseline day 4	Potential baseline day 5
Event hours	1500-1600	1500-1600	1500-1600	1500-1600	1500-1600	1500-1600
Average kW during event hours	1078.89	990.57	919.45	926.36	892.42	880.13
Notification hour	1400					
Adjustment period hours	1200-1400	1200-1400	1200-1400	1200-1400	1200-1400	1200-1400
Adjustment period average kW	959.39	752.26	672.08	637.98	695.12	698.88
Event day and potential baseline days	**Potential Baseline day 6**	**Potential Baseline day 7**	**Potential Baseline day 8**	**Potential Baseline day 9**	**Potential baseline day 10**	
Event hours	1500-1600	1500-1600	1500-1600	1500-1600	1500-1600	
Average kW during event hours	950.63	842.19	1008.69	795.80	1049.24	
Notification hour						
Adjustment period hours	1200-1400	1200-1400	1200-1400	1200-1400	1200-1400	
Adjustment period average kW	657.64	539.75	801.02	647.12	850.18	

Calculation steps:

- **Step 1.** *Unadjusted High 5 baseline* = Average kW during event times in five highest days of ten prior in summer prior to event day (kW)

  Unadjusted High 5 baseline = (990.57+926.36+950.63+1008.69+1049.24)/5 = 985.10 kW

- **Step 2.** *Uncapped additive adjustment* = Average kW during adjustment time on event day (kW)—Average kW during adjustment time in the same five highest days of ten prior to event day

  Uncapped additive adjustment = 959.39—(752.26+637.98+657.64+801.02+850.18)/5 = 219.57 kW

- **Step 3.** *Adjustment cap* = 50% of *Unadjusted High 5 baseline* (kW)

  Adjustment cap = 0.5 * 985.10 = 492.55 kW

- **Step 4.** Choose *Additive adjustment* = Minimum {Absolute value of *Uncapped additive adjustment, Adjustment cap*} (kW)

  Additive adjustment = Minimum {219.57, 492.55} = 219.57 kW

- **Step 5.** *Final baseline = Additive adjustment + Unadjusted High 5 baseline* (kW)

  Final baseline = 219.57 + 985.10 = 1204.67 kW

- **Step 6.** kW Savings = *Final baseline—Curtailment kW* (kW)

  kW Savings = 1204.67—1078.89 = 125.78 kW

Additional Calculation Considerations

Meters, test events, and missing data

- Program year kilowatt load management event savings will be calculated as the sum of each sponsor's average savings of all events in which the sponsor participated.
- Utilities are responsible for calling a test event each program year for the load management programs. If a program has both a winter and summer peak component, a test event needs to be called in each applicable peak period. The test event has several purposes, including assuring the proper functioning of program meters. Utilities are responsible for maintaining working program meters.
- In the case that individual meters fail to record data sufficient for applying the High 5 or 8 of 10 calculation method, savings may not be claimed. However, if a customer has alternate interval meter data available, this can be used in lieu of program meter data to calculate claimed savings. Using customer meters for load management program savings requires that the data meet interval metering requirements presented in the current version of the TRM. In general, it is recommended that customer-owned interval meters should only be used if utility interval meters fail. Data from each meter should not be combined for claiming savings for a specific event and must be able to cover both the event-day data and baseline data.

Utilities should notify the EM&V team in these circumstances. All calculations and data stemming from the use of customer meters should be provided as part of the EM&V data request, similar to when program meter data is used. If requested by the utility, the EM&V team is available to review the use of customer meter data in advance of a program claiming savings from customer meters.

Baseline days

When selecting baseline days in the High 5 or 8 of 10 method, it is possible that some days have the same load for an individual participant, potentially leading to more than five or eight days that could be selected for the baseline days. If more days could be selected as baseline days based on their loads during event hours, the days with the highest loads and closest to the event should be picked for the baseline.

Rounding

Data rounding to the nearest whole number should only occur at the customer and program levels for commercial load management programs. Without this standard practice, utilities should document when rounding is occurring in their calculations (e.g., no rounding or rounding at the event level) and inform the EM&V team (see Volume 5, Section 3.1 for more details). Utilities should round commercial load management impacts consistent with how incentives are awarded, which is at the customer-sponsor level for each event.

Measure Life and Lifetime Savings

The estimated useful life (EUL) is one year.

Program Tracking Data and Evaluation Requirements

The following data and information shall be tracked and provided to the EM&V team to enable savings verification:

- IDR or Advanced Meter data associated with the project will be provided by the project sponsor or retrieved by the utility following an event. Depending on the utility, the data will be provided in 30-minute increments (or smaller) to evaluate both baseline demand usage and demand usage during curtailment.
- Documentation describing the time stamp and whether the time stamp reflects the forward-looking period or period preceding the time stamp.
- Utilities should provide a description of their practices related to whether scheduled or test events are or are not included in their program year kW savings results. kWh savings will be calculated from all events.
- A list of all load management events affecting nonresidential participants within the program year, describing the date of each event, the time the event started, and the time the event ended.
- A list of all participants and addresses with a variable linking to the load or energy consumption interval data and that describes their enrollment date, load management control commissioning date, and any events in which the participant did not participate due to enrollment or equipment installation timing, equipment failures, or other factors known to the implementer or utility.

- Tools, calculators, or other datasets that may be useful to the EM&V team, based on discussion between the EM&V team, utilities, and/or program implementer. The process for calculating kW and kWh savings should be provided in the program documentation, including any summation and rounding practices.

Load management programs shall be tracked and reported separately from energy efficiency programs.

References and Efficiency Standards

Petitions and Rulings

Not applicable.

Relevant Standards and Reference Sources

- **AEP SWEPCO:** Manual not available online.
- **AEP Texas:** Commercial summer and winter load management program manuals can be found under Load Management at https://aeptexasefficiency.com/#/commercial
- **CenterPoint**: Commercial summer and winter load management program information can be found under *Load Management* at https://www.centerpointenergy.com/en-us/business/services/commercial-industrial/efficiency-programs?sa=ho

  or at https://cnpwlm.customerapplication.com/
- **El Paso Electric**: Commercial load management program manual can be found at https://www.epelectric.com/business/save-money-and-energy/texas-load-management-program
- **Entergy**: Commerical load management manuals can be found at https://www.entergy-texas.com/your_business/save_money/ee/load-management/
- **Oncor**: Commercial load management program manuals can be found under Commercial Load Management for the summer program and under Winter Emergency Load Management for the winter program at https://eepm.oncor.com/Commercial.aspx
- **TNMP**: Commercial summer and winter load management program manuals can be found under Resources at https://tnmpefficiency.com/commercial.php#load-management

Xcel Energy: Commercial load management program manual can be found at http://www.xcelenergyefficiency.com/TX/Business/LM/

Document Revision History

Table 81. Non-RES Load Curtailment—Revision History

TRM version	Date	Description of change
v3.0	4/10/2015	The baseline calculation methodology was modified to be the highest 5 of 10 prior days for all the programs. In addition, a new day-of adjustment factor was added with an adjustment cap.
v3.1	11/05/2015	TRM v3.1 Volume 4 origin.
v4.0	10/10/2016	Clarified language related to applying the adjustment factor to the High 5 of 10 baseline and additional data provision details.
v5.0	10/10/2017	Updated equation, figure, and table references.
v6.0	10/2018	No revision.
v7.0	10/2019	Transferred metering and rounding guidance from Vol 5.
v8.0	10/2020	Added guidance on rounding.
v9.0	10/2021	Added eligibility exclusion for critical load customers, updated links to program manuals and updated for winter peak.
v10.0	10/2022	Updated Utility Program Details Overview section (added one winter load management program). Updated Reference Sources section.
v11.0	10/2023	Updated utility program details (added three winter load management programs). Added guidance on selecting baseline days when there is a tie between the days used to calculate the baseline.
v12.0	10/2024	Added guidance on tracking and reporting load management programs separate from energy efficiency programs.

APPENDIX A: M&V METERING SCHEDULE

1.0 Arrive on site and meet customer

1.1 Turn unit on to stabilize and make sure the unit is in full cooling mode (Variable speed blowers are on high and all compressors in multi-compressor systems are operating).

1.2 Record customer information:

a. Address
b. City
c. Zip
d. County
e. Email
f. Utility account number (from utility bill)
g. Altitude (ft)
h. Residential program or commercial program
i. Building type
j. Phone number

2.0 Test In: Perform TI procedure to determine system's baseline cooling capacity and energy efficiency ratio (EER).

2.1 Record Unit Information

2.2 Measure and record airflow using 1 of the following methods:

a. Airflow Method 1: Handheld Anemometer
b. Airflow Method 2: Generic Fan Chart
c. Airflow Method 3: Manufacturer Fan Chart

2.3 Airflow Power Consumption

a. Determine the blower motor type as either "PSC" or "ECM."
b. Measure and record the blower voltage and current.

2.4 Condenser and Compressor Measurements

a. Compressor Type (Scroll or Reciprocating)
b. Refrigerant Type (R22 or R410)
c. Metering Device (Fixed Orifice, TXV or Capillary Tube)
d. Condenser Model Number
e. Condenser Serial Number
f. Compressor Phase (Single or Three)
g. Multiple Compressor System (Check box for participating utilities)
h. Measure and Record Compressor Volts
i. Measure and Record Compressor Current
j. Measure and Record Ambient Air Dry-Bulb Temperature
k. Measure and Record Ambient Air Wet-Bulb Temperature if Required

2.5 Enter Information from Refrigerant Analyzer:

a. Suction Pressure (PSI)
b. Discharge Pressure (PSI)
c. Evaporator Temperature (ºF)
d. Condenser Temperature (ºF)
e. Vapor Line Temperature (VLT) (ºF)
f. Liquid Line Temperature (LLT) (ºF)
g. Superheat (ºF)
h. Subcooling (ºF)

2.6 Measure and Record Supply and Return Air Conditions:

a. Return Air Dry-Bulb Temperature (ºF)
b. Return Air Wet-Bulb Temperature (ºF)
c. Supply Air Dry-Bulb Temperature (ºF)
d. Supply Air Wet-Bulb Temperature (ºF)

2.7 Review System Performance

3.0 Perform Corrective Measures as Needed

3.1 Clean Condenser—required
3.2 Clean Evaporator—required
3.3 Clean Blower—required
3.4 Verify clean filter: change or clean as needed—required
3.5 Verify Airflow within range (+/- 15% of 400 cfm/ton)—required
3.6 Check refrigerant charge; adjust to Manufacturer’s Spec’s as needed

4.0 Test Out: The Test Out (TO) procedure requires measurements that are used to determine the performance characteristics of the cooling system after all corrective measures have been implemented.

4.1 Airflow—Use same method as Test In
4.2 Airflow Power Consumption
   a. For ECMs, make sure it is operating in full cooling mode during the entire tune-up.
   b. Measure and record the blower voltage and current.
4.3 Measure and record Supply and Return Air Conditions:
   a. Return Air Dry-Bulb Temperature (ºF)
   b. Return Air Wet-Bulb Temperature (ºF)
   c. Supply Air Dry-Bulb Temperature (ºF)
   d. Supply Air Wet-Bulb Temperature (ºF)
4.4 Condenser and Compressor Measurements
   a. Compressor Volts
   b. Compressor Current
   c. Ambient Air Dry-Bulb Temperature
   d. Ambient Air Wet-Bulb Temperature
4.5 Information from Refrigerant Analyzer:
   a. Suction Pressure (PSI)
   b. Discharge Pressure (PSI)
   c. Evaporator Temperature (ºF)
   d. Condenser Temperature (ºF)
   e. Vapor Line Temperature (VLT) (ºF)
   f. Liquid Line Temperature (LLT) (ºF)
   g. Superheat (ºF)
   h. Subcooling (ºF)
4.6 Review System Performance

5.0 Generate invoice: A customer signed invoice is required for participation in the program. The following information must be shown on the invoice:

5.1 Customer Address
5.2 Contractor Name and Address
5.3 Project Number Listed on the DCVF
5.4 Corrective Measures Performed
5.5 Charge for Services Performed
5.6 Rebate Amount Applied to Charges

APPENDIX B: COUNTIES BY WEATHER ZONE ASSIGNMENT

County name	Zone	County name	Zone	County name	Zone	County name	Zone
Anderson	2	Brown	2	Cooke	2	Falls	2
Andrews	2	Burleson	3	Coryell	2	Fannin	2
Angelina	2	Burnet	2	Cottle	1	Fayette	3
Aransas	4	Caldwell	3	Crane	2	Fisher	2
Archer	2	Calhoun	4	Crockett	2	Floyd	1
Armstrong	1	Callahan	2	Crosby	1	Foard	1
Atascosa	3	Cameron	4	Culberson[113]	2 & 5	Fort Bend	3
Austin	3	Camp	2	Dallam	1	Franklin	2
Bailey	1	Carson	1	Dallas	2	Freestone	2
Bandera	2	Cass	2	Dawson	2	Frio	3
Bastrop	3	Castro	1	De Witt	3	Gaines	1
Baylor	2	Chambers	3	Deaf Smith	1	Galveston	3
Bee	3	Cherokee	2	Delta	2	Garza	1
Bell	2	Childress	1	Denton	2	Gillespie	2
Bexar	3	Clay	2	Dickens	1	Glasscock	2
Blanco	2	Cochran	1	Dimmit	3	Goliad	3
Borden	2	Coke	2	Donley	1	Gonzales	3
Bosque	2	Coleman	2	Duval	4	Gray	1
Bowie	2	Collin	2	Eastland	2	Grayson	2
Brazoria	3	Collingsworth	1	Ector	2	Gregg	2
Brazos	3	Colorado	3	Edwards	2	Grimes	3
Brewster	2	Comal	3	El Paso	5	Guadalupe	3
Briscoe	1	Comanche	2	Ellis	2	Hale	1
Brooks	4	Concho	2	Erath	2	Hall	1

[113] El Paso Electric may treat residents of Van Horn, TX in Culberson County as Climate zone 5 even though the rest of the county is classified as Climate zone 2.

County name	Zone	County name	Zone	County name	Zone	County name	Zone
Hamilton	2	Jasper	2	Leon	2	Montague	2
Hansford	1	Jeff Davis	2	Liberty	3	Montgomery	3
Hardeman	1	Jefferson	3	Limestone	2	Moore	1
Hardin	3	Jim Hogg	4	Lipscomb	1	Morris	2
Harris	3	Jim Wells	4	Live Oak	3	Motley	1
Harrison	2	Johnson	2	Llano	2	Nacogdoches	2
Hartley	1	Jones	2	Loving	2	Navarro	2
Haskell	2	Karnes	3	Lubbock	1	Newton	2
Hays	2	Kaufman	2	Lynn	1	Nolan	2
Hemphill	1	Kendall	2	Madison	3	Nueces	4
Henderson	2	Kenedy	4	Marion	2	Ochiltree	1
Hidalgo	4	Kent	1	Martin	2	Oldham	1
Hill	2	Kerr	2	Mason	2	Orange	3
Hockley	1	Kimble	2	Matagorda	3	Palo Pinto	2
Hood	2	King	1	Maverick	3	Panola	2
Hopkins	2	Kinney	3	McCulloch	2	Parker	2
Houston	2	Kleberg	4	McLennan	2	Parmer	1
Howard	2	Knox	1	McMullen	3	Pecos	2
Hudspeth	5	La Salle	3	Medina	3	Polk	3
Hunt	2	Lamar	2	Menard	2	Potter	1
Hutchinson	1	Lamb	1	Midland	2	Presidio	2
Irion	2	Lampasas	2	Milam	3	Rains	2
Jack	2	Lavaca	3	Mills	2	Randall	1
Jackson	3	Lee	3	Mitchell	2	Reagan	2

County name	Zone	County name	Zone	County name	Zone	County name	Zone
Real	2	Shackelford	2	Titus	2	Wharton	3
Red River	2	Shelby	2	Tom Green	2	Wheeler	1
Reeves	2	Sherman	1	Travis	2	Wichita	2
Refugio	4	Smith	2	Trinity	3	Wilbarger	1
Roberts	1	Somervell	2	Tyler	3	Willacy	4
Robertson	2	Starr	4	Upshur	2	Williamson	2
Rockwall	2	Stephens	2	Upton	2	Wilson	3
Runnels	2	Sterling	2	Uvalde	3	Winkler	2
Rusk	2	Stonewall	1	Val Verde	3	Wise	2
Sabine	2	Sutton	2	Van Zandt	2	Wood	2
San Augustine	2	Swisher	1	Victoria	3	Yoakum	1
San Jacinto	3	Tarrant	2	Walker	3	Young	2
San Patricio	4	Taylor	2	Waller	3	Zapata	4
San Saba	2	Terrell	2	Ward	2	Zavala	3
Schleicher	2	Terry	1	Washington	3		
Scurry	2	Throckmorton	2	Webb	4		