Table 28. 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 29. 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 30. 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 31. 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%

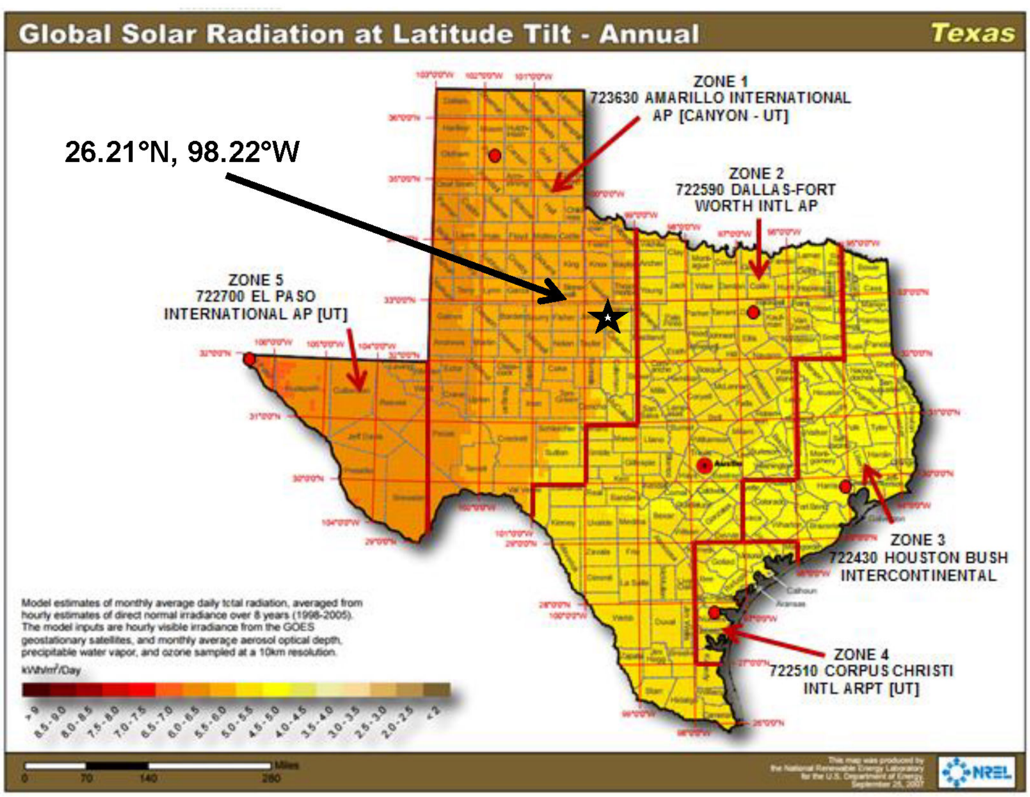
Deemed Summer and Winter Demand Savings—Example

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. 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 50,

  *Deemed summer demand = DC system size (kW) * lookup value*

  *Deemed summer demand = 5.000 kW * 49%*

  *Deemed summer demand = 5.000 kW * 0.49*

  Deemed summer demand = 2.450 kW

  Applying Equation 51,

  *Deemed winter demand = DC system size (kW) * lookup value*

  *Deemed summer demand = 5.000 kW * 2%*

  *Deemed summer demand = 5.000 kW * 0.02*

  Deemed summer demand = 0.100 kW

Summer and Winter Demand Savings—Alternative Method

An alternative method to estimate summer and winter demand savings is available to residential systems using trackers or systems for which deemed savings lookup values are not available due to extreme array of tilt or azimuth. To use the alternative method, follow these steps:

- **Step 1.** Determine the applicable weather zone for the proposed system using Figure 8 above.
- **Step 2.** Use PVWatts® to model the proposed system as described in the Annual Energy Savings (kWh) section above. However, instead of using the zip code/default weather file, select the TMY3 reference location and weather file associated with the applicable weather zone of the proposed system (e.g., a system in Abilene, weather zone 1, would be modeled based on the AMARILLO INTERNATIONAL AP [CANYON-UT], TX TMY3 weather file). Leave all other inputs the same.
- **Step 3.** On the PVWatts ‘Results’ page, select ‘Download Results: Hourly.’ Save the **pvwatts_hourly.csv** output file to your computer and open it using Microsoft Excel.
- **Step 4.** Open the provided calculation tool **TRM 4.0 PV tool YYYYMMDD_locked.xlsx** (in which the version date is indicated by the YYYYMMDD field) on your computer, and select the Alt. Method Inputs tab.

- **Step 5.** From the PVWatts hourly output file, highlight and copy the output data (A1:K8780). Paste this data to cell M1 on the Alt. Method Inputs tab in TRM 4.0 PV tool YYYYMMDD_locked.xlsx (in which the version date is indicated by the YYYYMMDD field).
- **Step 6.** On the Alt. Methods Outputs tab, the tool calculates and displays summer and winter demand savings as AC capacity (kW_{ac}) and as a percentage of the DC capacity of the modeled system.

Claimed Peak Demand Savings

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

Additional Calculators and Tools

TRM 4.0 PV tool YYYYMMDD_locked.xlsx (in which the version date is indicated by the YYYYMMDD field), provided by Frontier Energy, is used to determine summer and winter demand savings. The most current version is posted at the Texas energy efficiency website, http://www.texasefficiency.com/. Utilities have the option to create their own versions.

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
- 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 32. M&V Residential 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 revisions.
v3.0	04/10/2015	No revisions.
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 revisions.
v7.0	10/2019	No revisions.
v8.0	10/2020	Updated instructions for new version of PVWatts® and references to NREL National Solar Radiation Database (NSRD) (previously TMY3).
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 revisions.

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,[42] 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.

[42] 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®.[43] 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 33. Module Type Options

Type	Approximate efficiency	Module cover	Temperature coefficient of power
Standard (crystalline silicon)	15 percent	Glass	-0.47 %/°C
Premium (crystalline silicon)	19 percent	Anti-reflective	-0.35 %/°C
Thin film	10 percent	Glass	-0.20 %/°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.
- All other input variables: accept the PVWatts® default values.

[43] PVWatts® Calculator: https://pvwatts.nrel.gov/.

Annual Energy Savings (kWh)

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

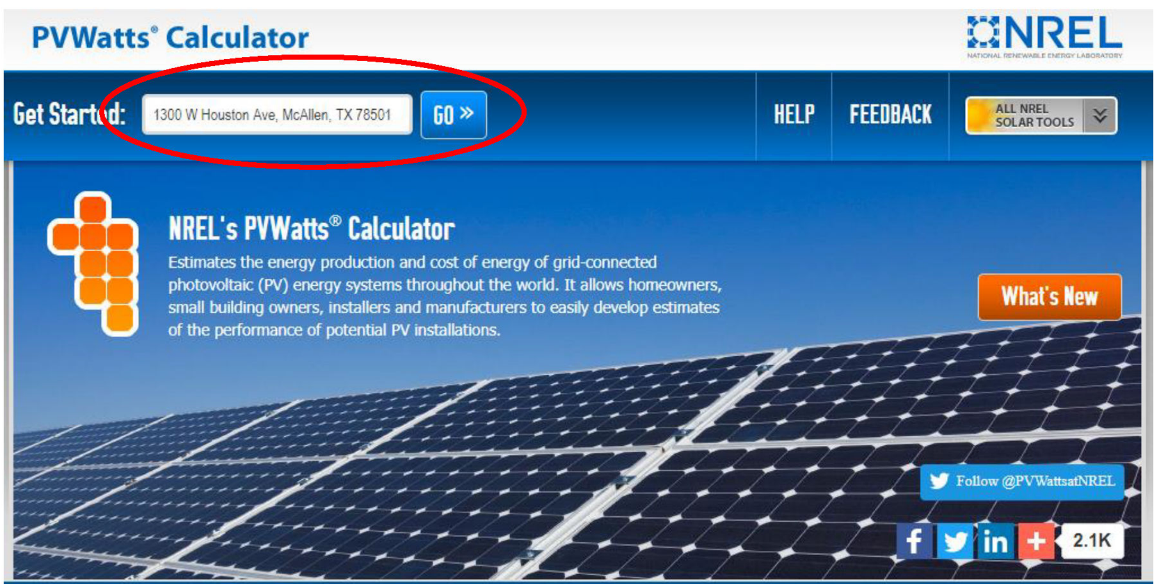
For systems with multiple arrays, users should derive annual energy savings for each array separately and sum them to obtain total annual energy savings.

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. 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. PVWatts® Resource Data Map

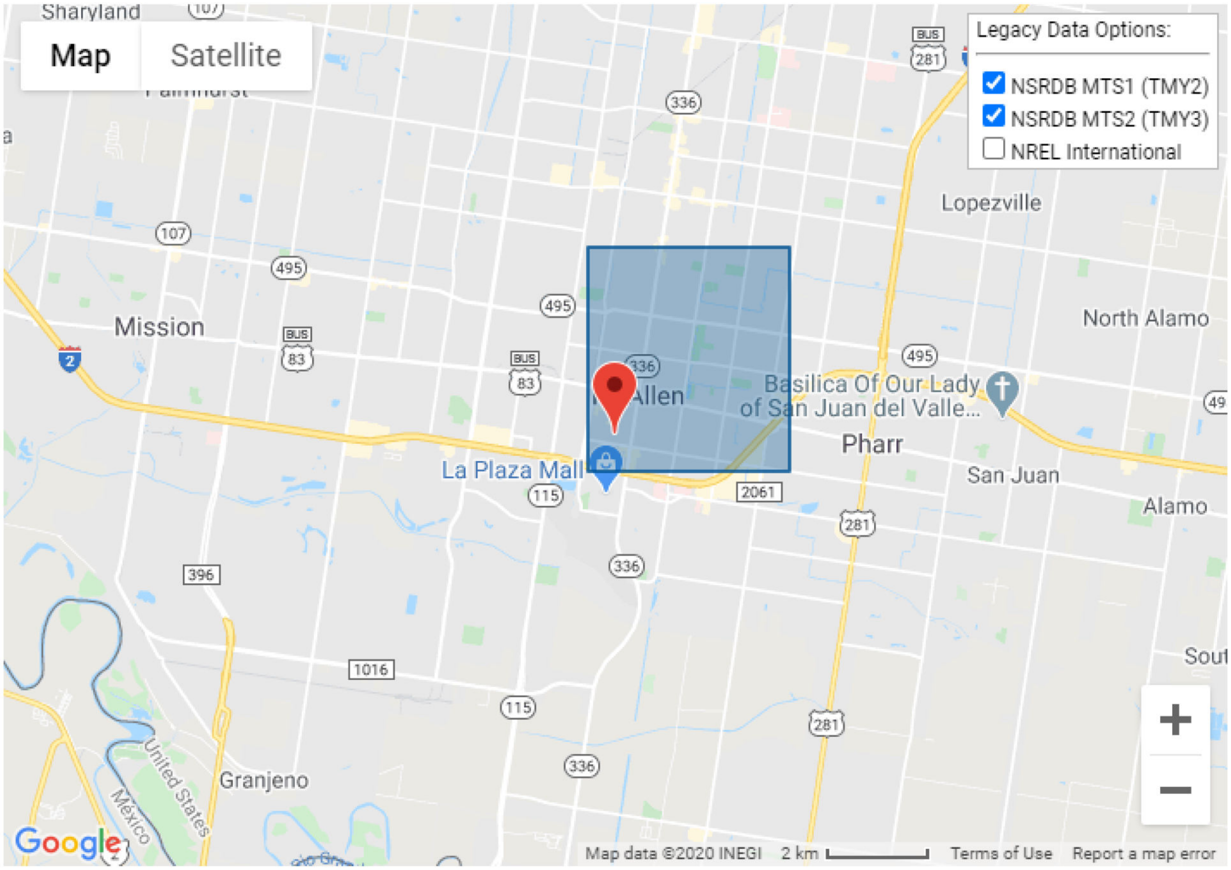
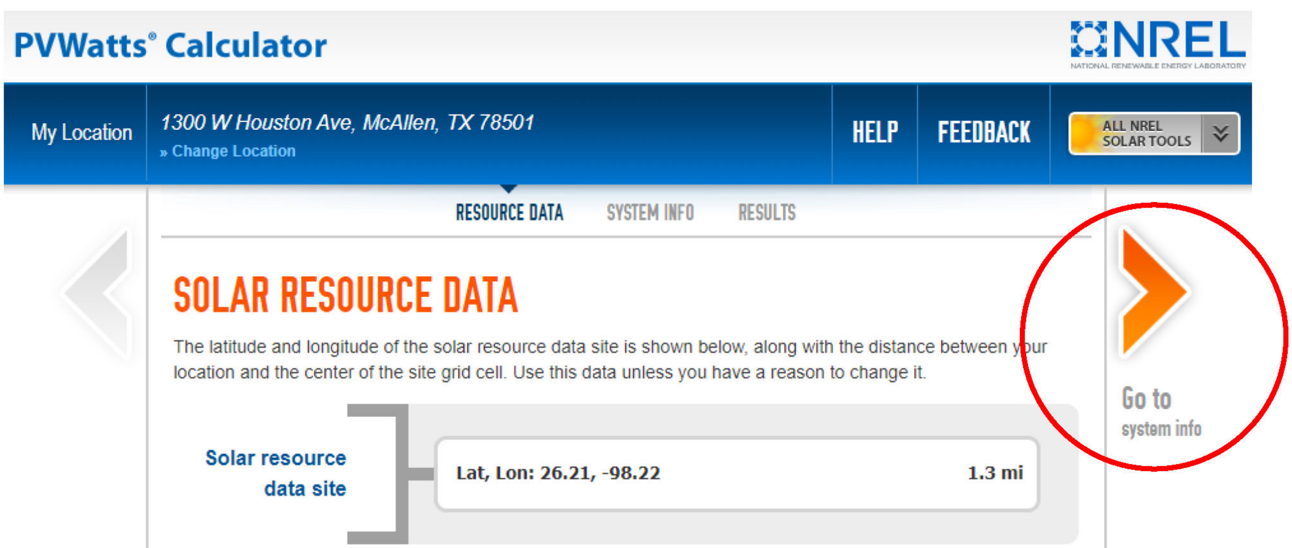


Figure 11. PVWatts® Input Screen for Step 2

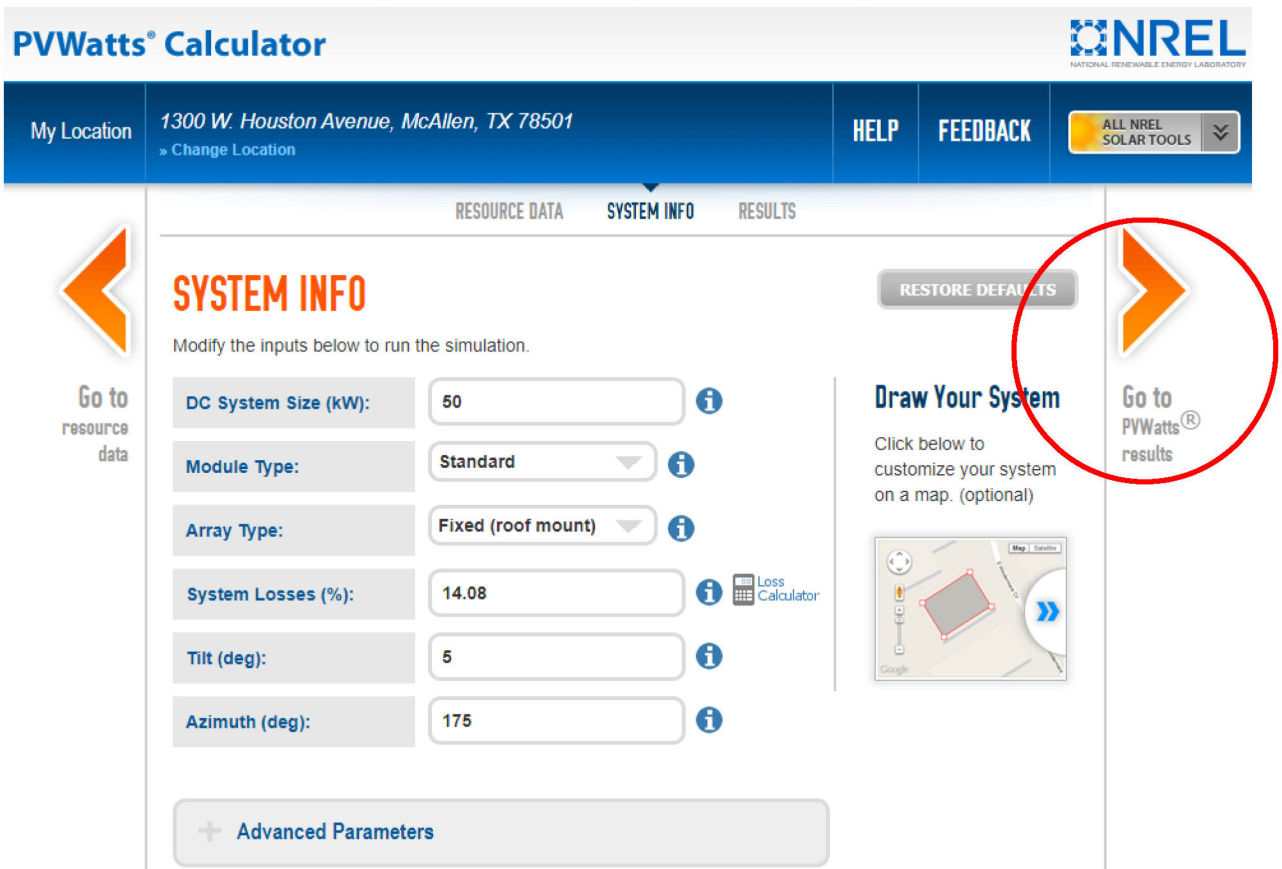


Step 3. The user enters system info as follows:

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

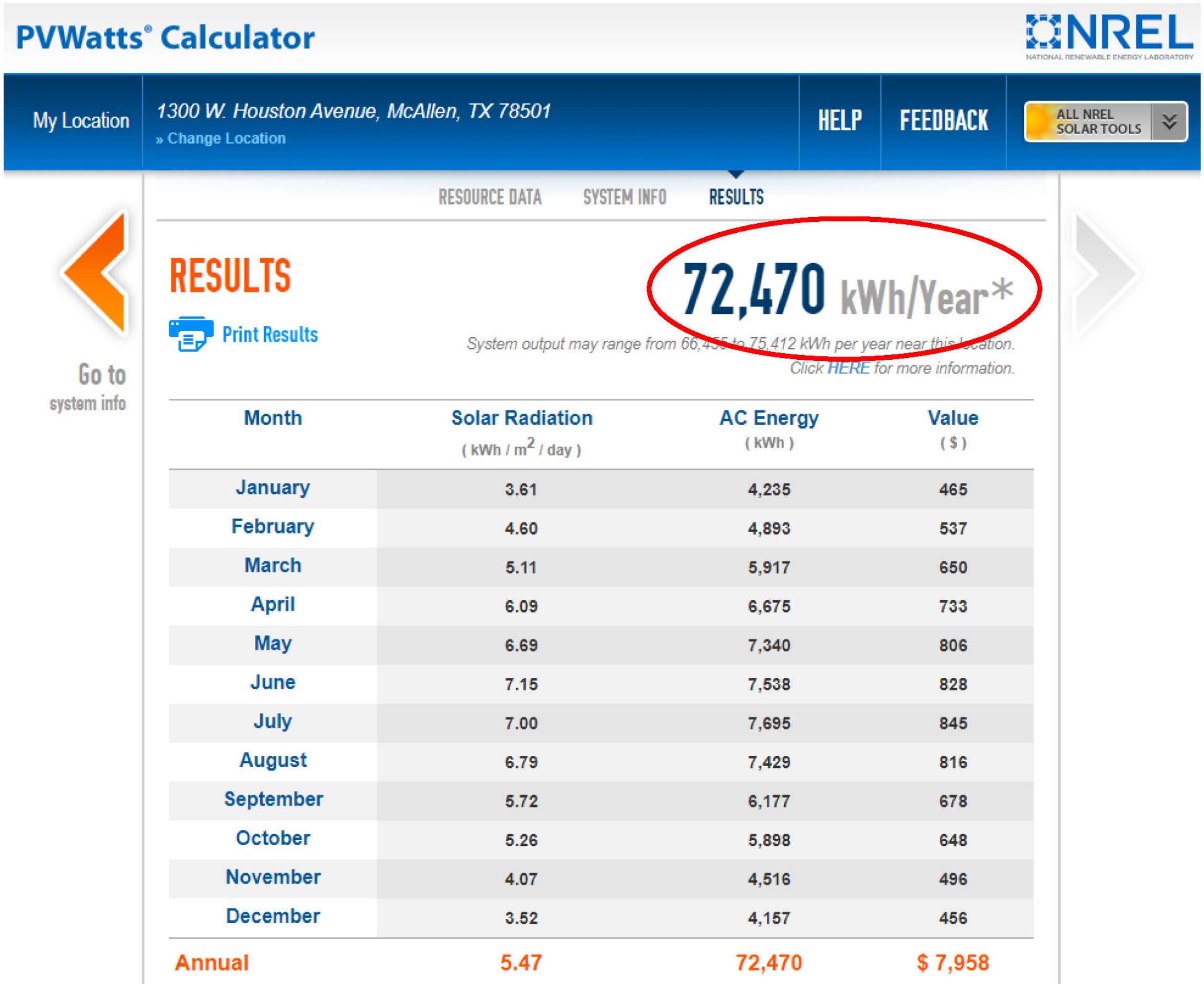
All other details (System Losses, Advanced Parameters, Initial Economics) are left at default values. Once entered, the user presses "Go to PVWatts® results." See Figure 12.

Figure 12. 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. 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. 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 34) 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 52

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 34 through Table 43) 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 53

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.

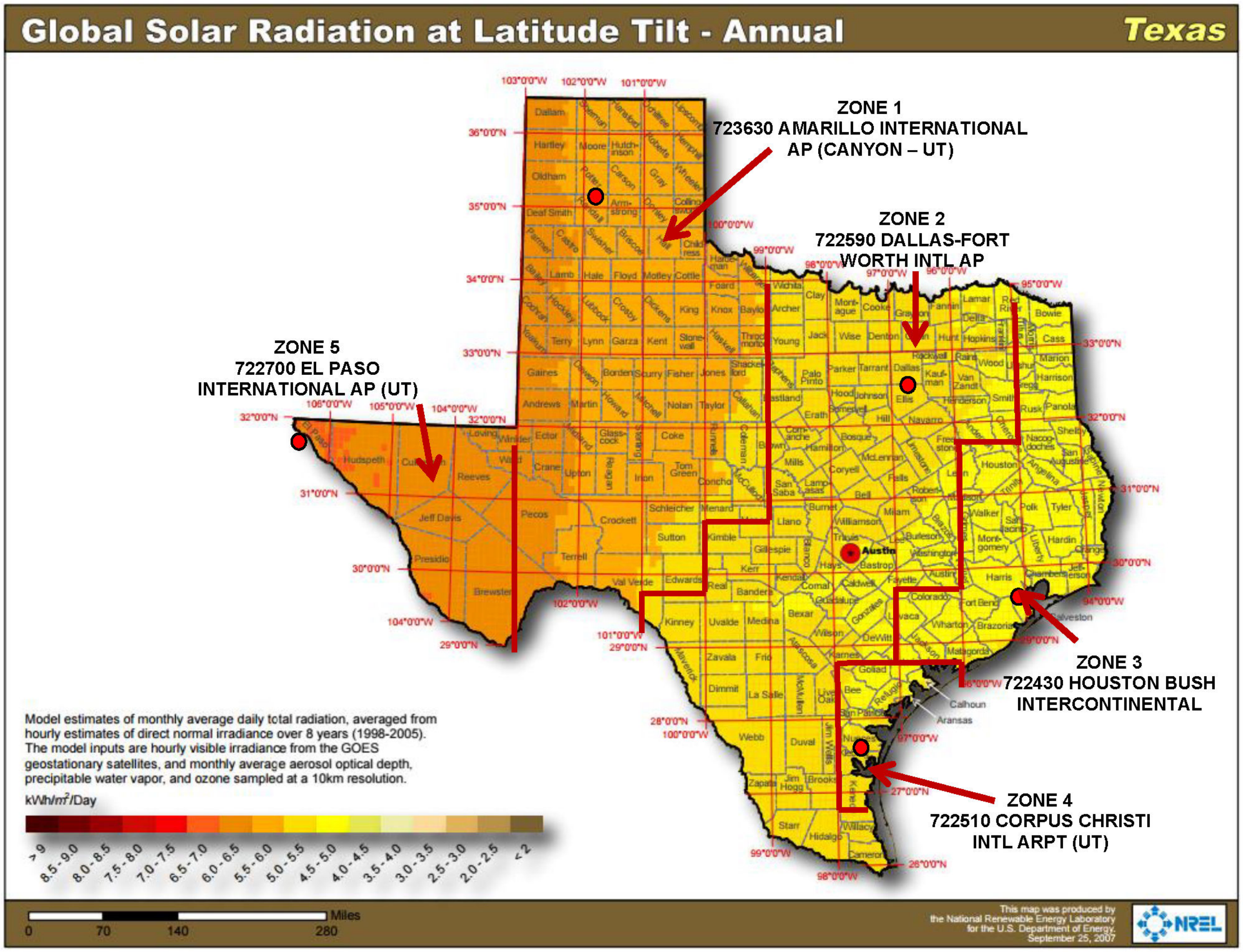
Deemed Energy Savings Tables

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. Weather Zone Determination for Solar PV Systems[44]



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 34 through Table 43 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 34.

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

Table 34. 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 35. 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 36. 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 37. 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 38. 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 39. 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 40. 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 41. 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 42. 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 43. 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%

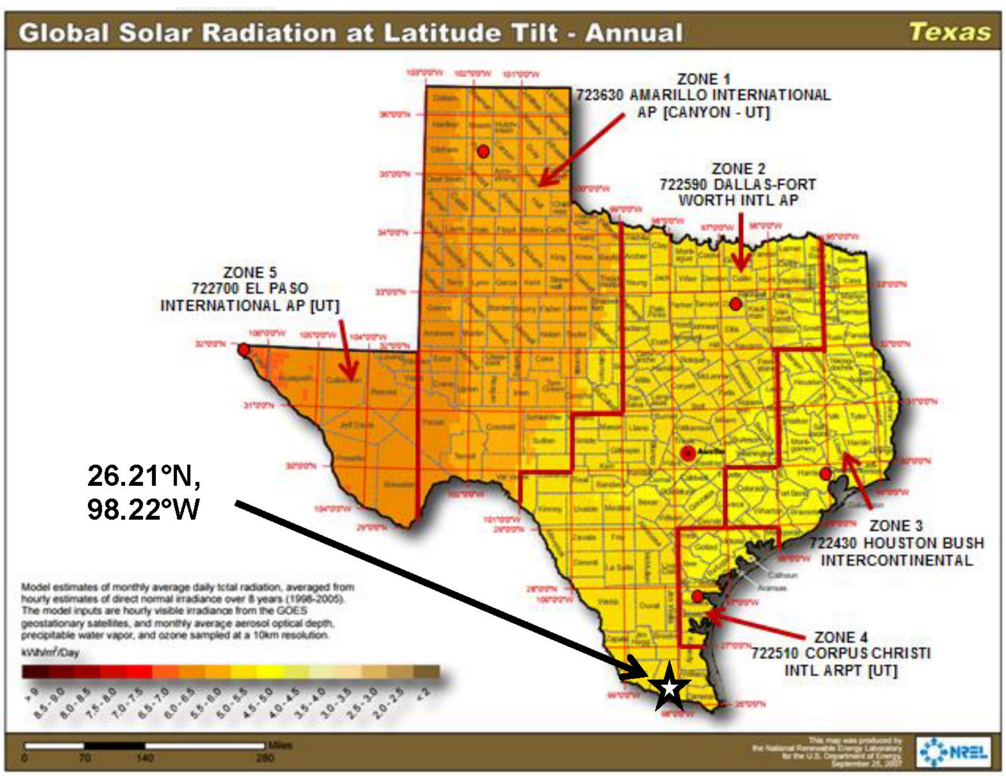
Deemed Summer and Winter Demand Savings—Example

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. 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 52,

*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 53,

*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

Summer and Winter Demand Savings—Alternative Method

An alternative method to estimate summer and winter demand savings is also available. To use the alternative method, follow these steps:

- **Step 1.** Determine the applicable weather zone of the proposed system using Figure 16 above.
- **Step 2.** Use PVWatts® to model the proposed system as described in the Annual Energy Savings (kWh) section above. However, instead of using the zip code/default weather file, select the TMY3 reference location and weather file associated with the applicable weather zone of the proposed system. (e.g., a system in McAllen in weather zone 1 would be modeled based on the DALLAS-FORT WORTH INTL AP, TX TMY3 weather file). Leave all other inputs the same.
- **Step 3.** On the PVWatts Results page, select Download Results: Hourly. Save the **pvwatts_hourly.csv** output file to your computer and open it using Microsoft Excel.
- **Step 4.** Open the provided calculation tool **TRM 4.0 PV tool YYYYMMDD_locked.xlsx** (in which the version date is indicated by the YYYYMMDD field) on your computer, and select the Alt. Method Inputs tab.
- **Step 5.** From the PVWatts hourly output file, highlight and copy the output data (A1:K8780). Paste this data to cell M1 on the Alt. Method Inputs tab in **TRM 4.0 PV tool YYYYMMDD_locked.xlsx** (in which the version date is indicated by the YYYYMMDD field).

- **Step 6.** On the Alt. Methods Outputs tab, the tool calculates and displays summer and winter demand savings as AC capacity (kW_{ac}) and as a percentage of the DC capacity of the modeled system.

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.

Additional Calculators and Tools

TRM 4.0 PV tool YYYYMMDD_locked.xlsx (in which the version date is indicated by the YYYYMMDD field), provided by Frontier Energy, is used to determine summer and winter demand savings. The most current version is posted at the Texas energy efficiency website, http://www.texasefficiency.com/. Utilities have the option to create their own versions.

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
- 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 44. M&V Nonresidential 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 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 revisions.
v7.0	10/2019	No revisions.
v8.0	10/2020	Updated instructions for new version of PVWatts® and references to NREL National Solar Radiation Database (NSRD) (previously TMY3)
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 revisions.

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.[45]

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 45, 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.

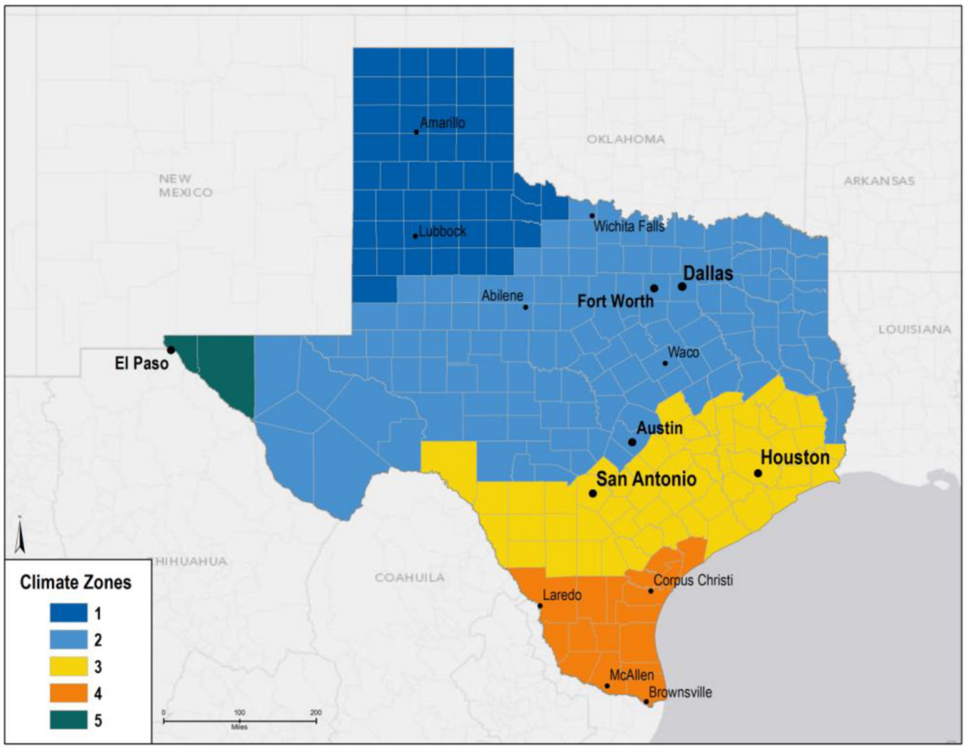
NOTE: It is critical that the TMY3 files are specified in the model for estimating peak demand impacts and that the corresponding set of peak hours and relative probabilities from TRM Volume 1, Section 4 shall be used to estimate peak demand impacts.

[45] 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 45. 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. Texas Technical Reference Manual 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.

- Decision/action type: retrofit, new construction
- Building type
- Climate/weather zone
- 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 46. M&V 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 latest version of SAM software and removal of TMY2 weather data file use. Revised measure details to match 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 revisions.
v5.0	10/10/2017	No revisions.
v6.0	10/2018	No revisions.
v7.0	10/2019	No revisions.
v8.0	10/2020	No revisions.
v9.0	11/2021	TRM v9.0 update. Updated EUL.
v10.0	10/2022	No revisions.

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 floorspace. 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

Attic temperature for each hour is estimated according to the following equation for both the baseline and high-efficiency conditions:[46]

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

Equation 54

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)*

[46] 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 55

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 47. 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 56

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 48. 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 57

Where:

The *Summer Peak Demand Savings* are the appropriate value from Table 48, and

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
- 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 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-install spot measurements (near insulation level and underside of roof)
    - Post-install 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 49. Residential Solar Attic Fans Revision History

TRM Version	Date	Description of change
v7.0	10/2019	TRM v7.0 origin.
v8.0	10/2020	Remove measure due to lack of M&V data collection to refine preliminary deemed savings estimates.
v9.0	10/2021	Reinstate measure requiring M&V data collection.
v10.0	10/2022	No revisions.

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-install and one year of post-install 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[47] 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-install and post-install 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)[48]. 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.

[47] Starting March 2019.
[48] 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[49]. 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.

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[49] 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:

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

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 50. M&V 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 revisions.
v6.0	10/2018	No revisions.
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.

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 51.

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 51.

High-Efficiency Condition

High-efficiency conditions for compressed air system are in Table 51.

Table 51. Air Compressor Energy Factors

Control type	ACEF	Source
Modulation	89.0 percent	LIPA Clean Energy Initiative[50]
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	

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

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.

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 58

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

Equation 59

Where:

kW_{PDPF}	=	*Compressor motor kW from metered data corresponding to PDPF period as outlined in TRM Volume 1*[51]
$kW_{avg,\ op}$	=	*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*

[51] 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.

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 60

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

Equation 61

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

Equation 62

Where:

$kW_{full\ load}$ = *Compressor motor full-load kW from CAGI data sheet; if baseline CAGI data isn't available, use Equation 62*

Hours = *Compressor total hours of operation per year; assumed to be the facility posted annual operating hours*

ACEF = *Air compressor energy factor from Table 51*

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*[52]

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.

[52] 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.

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.

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.

- Decision/action type: ER, ROB, NC, system type conversion
- Building type
- Climate zone
- 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 52. Air Compressors Less than 75 HP Revision History

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

2.5.3 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: EM&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 development of energy conservation measures (ECM).

Individual ECMs will vary but may include:

- Development of optimization strategies for existing systems, including correcting air balancing issues, control reductions of simultaneous heating/cooling operations, and incorrect control sequences.
- Implementation of control system strategies, or optimization of existing strategies, including economizer setpoint control, demand-controlled ventilation, HVAC occupancy schedules, hot water reset, chilled water reset, and system lockout temperatures.
- Upgraded or advanced control sequencing, sensors, or equipment to create more efficient operations.
- Replacement options for aged equipment or development of a plan for future replacement of equipment.
- Removal of unnecessary equipment by disconnecting[53] from the electric grid.

[53] 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, prior to implementing the ECM or initiating other energy conservation activities.

High-Efficiency Condition

The high-efficiency condition is the building or system energy use after the implementation of 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 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[54] 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.

Where a significant portion of energy/demand savings is expected to come from prescriptive measures or custom measures whose savings have been independently determined through sub-system modeling (greater than 50 percent from a preliminary assessment), savings should be claimed following this M&V methodology exclusively OR savings should be claimed for the prescriptive measures and custom measures ONLY, to prevent overstating savings due to interactive effects.

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[55]. This normalized file should be used with both the pre-install and post-install 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 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.

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)[56]. 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 described in Section 12.6 of the Core Concepts 2022.

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

[54] Starting March 2019.
[55] TMY3 files for climate zones: http://www.texasefficiency.com/index.php/regulatory-filings/deemed-savings.
[56] Coefficient of variation root mean squared error.

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 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 the selection of 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.[57] 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 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 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.

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 63

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

Equation 64

Where:

$kW_{PDPF,\ existing}$ = *Building or system level kW for the existing building/system*

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

$kW_{PDPF, new}$	=	*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 may be calculated in accordance with other commercial measures in TRM Volumes 3 and 4 if an initial assessment indicates they are less than 50 percent of the total project savings. However, 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. When complete, the M&V final savings will true-up the final savings (both positive and negative).

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.

The 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. 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 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.

Additional Calculators and Tools

Regression software used for estimating annual energy use and demand should be clearly specified within 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[58]
- 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:

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

[58] 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

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 and to be documented in the M&V plan and report

Document Revision History

Table 53. Nonresidential Retro-Commissioning 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.
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.

2.5.4 Thermal Energy Storage Measure Overview

TRM Measure ID: NR-MS-TS

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 thermal energy storage (TES) projects. TES projects are systems that use heat transfer to a medium during off-peak hours or non-critical seasonal periods and then use stored heat during the on-peak hours or critical seasonal period. TES systems often have non-energy benefits (economic, equipment sizing, etc.) while having negligible, or even negative, energy savings.

Measure Description

Thermal energy storage systems represent a wide range of available technologies. Potential TES systems under this protocol include, but are not limited to, solar energy storage, molten-salt technologies, ice-based technologies, general heat storage in any technology, miscibility gap alloy technology, cryogenic energy storage, and hot silicon technology.

Eligibility Criteria

TES 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 thermal energy storage system and affected systems is expected. For Option A, the assumptions that support monitoring of only key datapoints 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.

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 thermal energy storage system.

Energy and Demand Savings Methodology

Whole Facility EM&V Methodology

IPMVP Option C can be used as the basis of analysis for thermal energy storage systems. If the thermal 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. The expected peak demand reduction from the TES must exceed 10 percent to attempt an Option C analysis, and analyzed trends must exceed an R^2 of 0.75. 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.

For projects that follow, or need to follow, IPMVP Option A or B, all necessary parameters must be directly metered, or the assumptions need to be approved by the EM&V team. These may include the power use of affected systems, temperatures of storage mediums, and flow rates of liquids. An M&V plan for Option A or B projects should be developed and approved by the EM&V team prior to conducting metering.

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:

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

Equation 65

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

Equation 66

Where:

$kW_{PDPF,\ existing}$ = *Building or system level kW for the existing building/system from metered data corresponding to PDPF period as outlined in TRM volume 1*[59]

$kW_{PDPF,\ new}$ = *Building or system level kW for the post TES building/system from metered data corresponding to PDPF period as outlined in TRM volume 1*[59]

[59] 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.

$kWh_{existing}$	=	*Building or system level kWh for the existing building/system from metered data*
kWh_{new}	=	*Building or system level kWh for the post TES 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 TES 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 thermal energy storage (TES) projects is 15 years, pending further research for specific TES measures.

Program Tracking Data and Evaluation Requirements

The following should be documented in the M&V plan and M&V report:

- Decision/action type
- Building type

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

- U.S. Department of Energy: M&V Guidelines: Measurement and Verification of Performance-Based Contracts (Version 4.0) https://www.energy.gov/sites/prod/files/2016/01/f28/mv_guide_4_0.pdf

Document Revision History

Table 54. Thermal 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 revisions.
v10.0	10/2022	No revisions.

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.[60] 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 to participate in a load management program that involves the curtailment of an interruptible load during the summer peak period. Measures participating in a residential load management program may be air-conditioners, heat pumps, swimming pool pumps, 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 55.
- Each meter has a continuous demand interval recording capability (30-minute intervals or less)

[60] 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 55. 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.[61]

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 67

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.

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,

[61] 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).

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

Table 56. 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

In the case that individual meters fail to record data sufficient for applying the *High 3 of 5* calculation method, savings may still be calculated under the following conditions and method[62]:

- 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
- Savings for the residential segment will be calculated using the average savings of the segment as calculated via the *High 3 of 5* method for the balance of the program or segment.

When selecting baseline days in the *High 3 of 5* method, in some cases it is possible that some days have the same load for an individual participant, potentially leading to more than three days that could be selected for the baseline days. If four or 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.

Program year kW load management event savings will be calculated as the average savings of all events.

<u>Rounding</u>

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).

<u>Meters</u>

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.

If there are random, non-systematic errors in smart meter data for less than two percent of total participants, the 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. Utilities should notify the EM&V team in these circumstances to discuss the approach for determining and applying average savings for those customers with incomplete meter data.

[62] The EM&V team is working with the utilities on clarifying the methodology for addressing individual meters with limited or no data.

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.

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 57. M&V Residential Load Management 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 revisions.
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.

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.[63] 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 58) during the peak demand periods outlined in Table 59.

[63] 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 58. Minimum Facility Demand Savings by Utility

Utility	Minimum demand savings (kW)
AEP SWEPCO	50
AEP Texas (Central & North)	5
CenterPoint	100
El Paso Electric	100
Entergy	250
Oncor (summer / winter)	100 / 50
TNMP[64]	50
Xcel[65]	100

Table 59. Peak Demand Periods

Hours[66]	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.
- Project sponsors must commit to making the curtailable load available during the summer or winter peak periods for the program.

[64] TNMP prefers that project sponsors be capable of providing at least 50 kW of peak demand reduction at each site for which load reduction is offered; however, TNMP may accept applications including sites providing less than 50kW of peak demand reduction in the interest of meeting its peak load reduction targets.

[65] 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.

[66] 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.

- 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 back-up 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 60 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.[67] These options are shown in Table 57 through
Table 63.

Table 60. Utility Program Details Overview

Utility	Options available	Scheduled interruption length	Maximum length	Notification required	Maximum unscheduled interruptions
AEP SWEPCO	See Table 62	1 hour	2 hours or 4 hours	1 hour	4 or 12 interruptions
AEP Texas (Central & North)	See Table 61	1 hour	2 hours or 4 hours	30 minutes	4, 8, or 12 interruptions
CenterPoint	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	No	1-2 hours	4 hours	30 minutes	4 interruptions; 18 hours
Xcel[68]	See Table 63	—	4 hours	1 hour	6 or 12 interruptions; 24 or 48 hours

Table 61. AEP (TNC & TCC) 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

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

[68] 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 62. 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 63. 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.[69] 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 68

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*

[69] 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).

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 64 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 64. 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

In the case that individual meters fail to record data sufficient for applying the High 5 or 8 of 10 calculation method, savings will not be calculated.

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.

Program year kW load management event savings will be calculated as the sum of each sponsor's average savings of all events in which the sponsor participated.

<u>Rounding</u>

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.

Meters

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.

Without complete interval meter data to calculate the baseline and event impacts, 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 version of the current 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.

Measure Life and Lifetime Savings

The estimated useful life (EUL) is 1 year.

Program Tracking Data and Evaluation Requirements

- 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 at 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.

References and Efficiency Standards

Petitions and Rulings

Not applicable.

Relevant Standards and Reference Sources

- **AEP SWEPCO:** Manual not available online.
- **AEP Texas:** Load Management Standard Offer Program Manual can be found under Load Management at https://aeptexasefficiency.com/#/commercial
- **CenterPoint**: Commercial Load Management Program Manual can be found under Commercial Load Management at https://www.centerpointenergy.com/en-us/business/services/commercial-industrial/efficiency-programs?sa=ho
- **El Paso Electric**: Load Management Program Manual can be found at https://www.epelectric.com/business/save-money-and-energy/texas-load-management-program
- **Entergy**: Load Management Manual can be found at https://www.entergy-texas.com/your_business/save_money/ee/load-management/
- **Oncor**: Commercial Load Management Program Manual 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**: Load Management Program Manual can be found under Resources at https://www.tnmpefficiency.com/commercial.php#load-management
- **Xcel Energy**: Load Management Program Manual can be found at http://www.xcelenergyefficiency.com/TX/Business/LM/

Document Revision History

Table 65. M&V Nonresidential Load Management 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 revisions.
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. Updated Reference Sources section.

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. Air Flow Method 1: Handheld Anemometer
b. Air Flow Method 2: Generic Fan Chart

2.3 Air Flow 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 Air Flow—Use same method as Test In
4.2 Air Flow 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[70]	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

[70] 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		

Public Utility Commission of Texas

Texas Technical Reference Manual

Version 10.0

Volume 5: Implementation Guidance

Program Year 2023

Last Revision Date:

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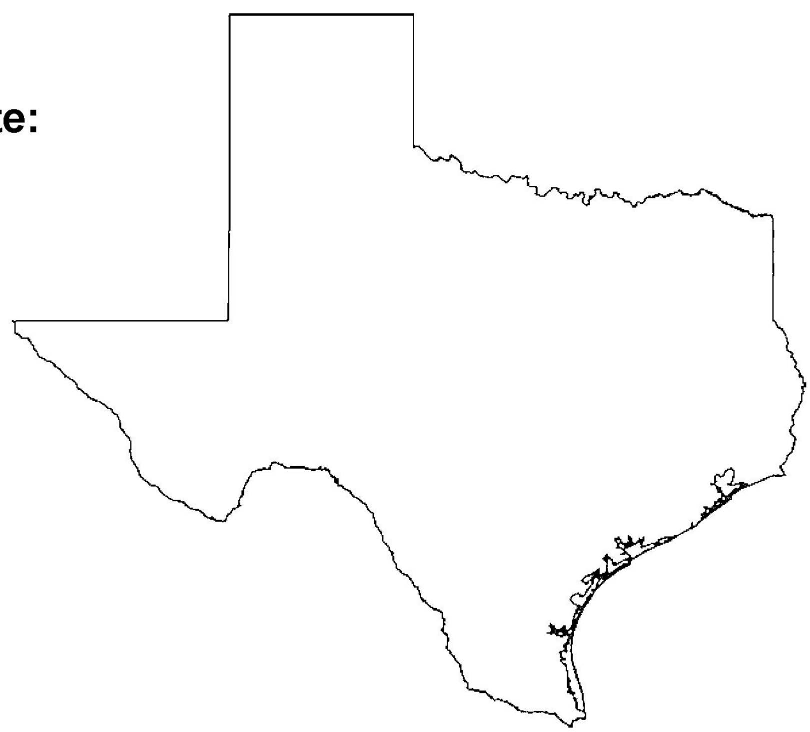

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Acknowledgments

The Texas Technical Reference Manual (TRM) is maintained by the Public Utility Commission of Texas' (PUCT) independent evaluation, monitoring, and verification (EM&V) contractor, Tetra Tech.

This version of the TRM was primarily developed from program documentation and measure savings calculators used by the Texas electric utilities and their energy efficiency services providers (EESPs) to support their energy efficiency efforts, and original source material from petitions filed with the Public Utility Commission of Texas by the utilities, their consultants, and EESPs such as Frontier Associates (TXu 1-904-705), ICF, CLEAResult, and Nexant. Portions of the TRM are copyrighted 2001–2017 by the Electric Utility Marketing Managers of Texas (EUMMOT), while other portions are copyrighted 2001–2018 by Frontier Energy. Certain technical content and updates were added by the EM&V team to provide further explanation and direction as well as consistent structure and level of information.

TRM Technical Support

Technical support and questions can be emailed to the EM&V team's project manager (lark.lee@tetratech.com) and PUCT staff (therese.harris@puct.texas.gov).

1. INTRODUCTION

This volume of the technical reference manual (TRM) contains evaluation, measurement, and verification (EM&V) team recommendations regarding program implementation that may affect claimed savings. The EM&V contractor drafts guidance memos for the electric utilities' energy efficiency programs to provide clear direction on calculating or claiming savings. Guidance memos are consistent with the Energy Efficiency Rule P.U.C. SUBSET. R. 25.181 (16 TAC § 25.181) and the TRM but address areas where additional direction is needed for consistency and transparency across utilities' claimed savings from the programs. This volume compiles the various guidance memos produced during the EM&V effort.

Implementation guidance contained in this volume is summarized by sector below:

Commercial

- Project documentation
- Additional savings
- New construction

Residential

- Low-Income Income-Eligible verification forms

Cross-Sector

- Load management programs
- Commercial and residential HVAC split-systems without AHRI certification
- Measurement and verification claimed savings
- Upstream/midstream program cross-sector savings
- Data model

2. COMMERCIAL

2.1 PROJECT DOCUMENTATION

This section summarizes the progress and current status of the evaluation, measurement, and verification (EM&V) team's assessment of the utilities' efforts to meet and conform to project documentation standards and provides additional guidance for areas still in need of improvement as part of the annual EM&V statewide report.

2.1.1 Background

For all energy efficiency programs, critical inputs and methodologies needed to replicate claimed savings calculations are captured in a combination of the TRM, program manuals, program tracking data systems, and individual project documentation. Project-level documentation is critical to the transparency of claimed savings and facilitates efficient third-party EM&V at the project, program, and portfolio levels. This section specifically addresses individual project documentation needs; individual project documentation includes all relevant site-specific details (e.g., audit reports, worksheets, program applications, invoices, project overviews and descriptions, photos, installation reports).

We provide detail on documentation best practices currently incorporated into many Texas programs (based on information gathered during PY2014 evaluation activities) and recommendations for improvement. The objective is to support the utilities in achieving industry-standard degrees of documentation rigor, clarity, and efficacy; these standards are necessary to organize and manage such information to yield transparency and facilitate efficient and effective evaluation.

2.1.2 Additional Documentation Guidance

In this section, we provide guidance geared specifically to help improve CSOP program documentation scores. However, the guidance may also be used to support the continued improvement of program documentation for other programs.

Recommendation 1: Clearly organize project files.

Organized project files are critical for many reasons, including:

- clear and transparent reporting of documentation used to support claimed savings,
- ease of identification of related program project files that may not have made the data transfer,
- backup support for information within tracking data systems,
- support custom parameter usage, and
- support deviation or enhancement of methodologies to gain greater accuracy.

An important part of organized project folders, files, and documents is clear naming conventions; this helps keep files organized and improves consistency in document placement and locating critical documents to support the EM&V efforts. Below are some examples of the difficulty the EM&V team has had with project-level folders and files received:

- The project folders often contained inconsistencies regarding file and document names, locations, and contents. Files with similar names often contained disparate information, while seemingly identical files contained dissimilar information.
- The project folders included multiple copies of project documents. Locating the final documents used to support the reported savings proved difficult for many projects. For example, when numerous photos are provided, locating those that support the key savings assumptions is difficult. Distinguishing between pre- and post-equipment photos was also, at times, difficult.
- Project folders contained documents labeled as verification reports when they were still actually measurement and verification (M&V) plans with no completed verification data. Such plans provided the methodology to verify project savings estimates yet did not document that project savings estimates were complete.

The project file organization example below provides a list of potential project subfolders and documents that would be ideal for collecting information to determine whether a pre- and post-inspection has been completed. Many documents listed are key elements necessary to support custom project assumptions and review.

Table 1. Project File Organization Example

Stage	Retrofit and new construction
Pre-project*	• Pre-project calculator • Plans (e.g., drawings, fixture list) • Pre-project inspection photos • Pre-project audit reports • Project descriptions, sponsor agreements, etc.
Post-project	• Post-project inspection calculator • Post-inspection field notes • Post-project inspection photos • As-built plans • Installation reports
Supporting documents	• Calculators (old and archived) • Spreadsheets or other backup documentation (especially those to support custom calculations) • Specifications, cut sheets, certifications • Check requests to utility • Partner letters or savings summaries • Material purchase orders and invoices • Email communication • M&V plan for custom key input assumptions (e.g., operating hours) or custom savings methodologies

Stage	Retrofit and new construction
Final documents**	• Final calculator • Final M&V plan for custom projects • Final verification documents for custom projects • Final project notes

* New construction projects may not necessarily include these documents.
** These documents also support EM&V on-site minimum requirements for data collection needs.

Recommendation #2: Use photo verifications to support key measure assumptions.

When on-site fieldwork is complete—whether by trade allies, implementation staff, or utility staff—representative photos can help document and support key measure attributes and assumptions. Most programs include some form of photo documentation to support projects. Some programs in Texas even use tablets in the field whereby the project site and equipment photos are taken by trade allies and automatically uploaded to tracking systems and project folders. The table below outlines how photos can support project documentation for some of the most common commercial project types (i.e., lighting- and HVAC-based projects).

Table 2. Project Verification Applications and Examples

Stage	Lighting projects*	HVAC projects
Pre-project	• Existing lighting system types (e.g., lamp, ballast, fixture) • Existing lighting equipment quantities • Existing control type • Existing lighting equipment operability and inoperability • Building type • Air conditioning type	• Existing HVAC equipment types and sizes • Existing HVAC equipment quantities • Existing HVAC equipment operability and inoperability (e.g., setpoint, load display shots) • Building type
Post-project	• New lighting system types (e.g., lamp, ballast, fixture) • New lighting equipment quantities • New control type • New control schedule automation (e.g., building and lighting automation system screenshots) • New lighting equipment operability • Building type • Air conditioning type	• New HVAC equipment types and sizes • New HVAC equipment quantities • New HVAC equipment operability (e.g., setpoint, load display shots) • Building type

* Note that some of these project parameters may not be possible to capture for all lighting quantities for large lighting projects. In these cases, alternative project documentation types may be preferred.

Recommendation #3: Include clear descriptors of measure type as well as quality assurance/quality control (QA/QC) inspections in the tracking system.

Different projects (e.g., retrofit versus new construction projects, inspected versus not inspected sites) have different documentation needs. Capturing participant descriptors can aid evaluation efforts immensely, keep cost burdens low, and facilitate transparency.

Many commercial programs continue to track and describe measure-level savings at the measure-category level (or savings calculator level) instead of the measure-specific level. For example, the tracking system will document the savings associated with a lighting project captured within a lighting calculator (e.g., Lighting Equipment Survey Form version 9.02). However, the calculator includes many different lighting fixture types, effective useful lives, and related savings. Tracking project data at the measure-specific level (e.g., integrated-ballast LED lamps, linear fluorescent, lighting controls) rather than the measure-category level will improve the data's transparency to readily assess measure types and individual claimed savings. This structure also supports ease for calculating cost-effectiveness.

As another example, new construction projects may not have pre-inspection forms or field notes. In contrast, retrofit projects may have many pre-project documentation types (e.g., pre-project calculator, pre-project plans, pre-inspection photos). Providing information regarding "greenfield" or complete demolition and rebuild projects as a differentiator from retrofits and small remodels upfront is a valuable population segmenting descriptor. When tracking systems use descriptors like these, they become a valuable screening tool; they can inform evaluators not to request certain documentation (that may not exist), which can misdirect time and resources. It also allows better budgeting and allocation of resources, improving overall efficacy. Another example is those sites or program participants that receive internal QA/QC versus those that do not. Some programs have modified their tracking systems to begin logging this data and provide a list as part of the EM&V data collection process; this list notifies the EM&V team that a site will not have specific project-level documentation because it was not site-inspected or verified, etc.

Recommendation #4: Complete M&V plans and reports needed for custom projects.

The industry standard for M&V plans and reports is based on the guidelines of Efficiency Valuation Organizations (EVO) International Performance Measurement and Verification Protocol (IPMVP). IPMVP Core Concepts EVO 10000-1:2022 is the current version available; it includes clear recommendations for meeting the minimum information requirements for complying with IPMVP protocols, including those specific to the M&V plan contents summarized in Chapter 5 and M&V reporting summarized in Chapter 6.

Utilities and their implementation contractors are encouraged to engage and collaborate with the EM&V team to discuss issues and options, obstacles, and possible solutions for M&V plans as new technologies or offerings become part of the Texas portfolios.

2.2 INCENTIVES AND CLAIMED SAVINGS

This section provides guidance on claiming savings when a financial incentive does not cover all project savings during the implementation of energy efficiency measures.[1]

2.2.1 Background

To meet various program objectives, it is common practice for utilities to set a ceiling or cap for the financial incentive any one energy efficiency service provider (EESP) or project can receive. These "individual incentive caps" are set as an overall percentage of the total incentive budget or as a dollar amount. The established caps vary by utility and are noted in their program manuals.

Individual incentive caps are different from a "set incentive." During the application phase, utilities calculate a project incentive based on pre-installation estimated savings; reserving incentive funds are at that time. Once the project is complete, there may be some variation in the initial agreed-upon savings estimates while setting the incentive and the actual post-installation savings. This variation is due to changes in efficiency levels, quantities, or equipment types that take place between the project planning phase and the project implementation phase.

2.2.2 Considerations

In the case of incentive caps, the EM&V team has some concerns regarding claiming all project savings when reaching an incentive cap. Since all project savings are not being incentivized at the project planning phase, claiming all project savings may result in increased free-ridership. A free-rider is "a program participant who would have implemented the program measure or practice in the absence of the program." (16 TAC § 25.181 (c) (24)).[2]

In the case of set incentives, the EM&V team has some concerns that spillover could be claimed incorrectly during post-project inspections. Spillover is "reductions in energy consumption and demand caused by the presence of an energy efficiency program, beyond the program-related gross savings of the participants and without financial or technical assistance from the program." ((16 TAC § 25.181 (c) (53)). Spillover is a component of net savings, and claimed savings are based on gross savings. Therefore, spillover should not be included in claimed savings if found on-site during post-project inspections.

[1] This guidance does not apply to behavioral, code or other market transformation programs where the primary program strategy is technical assistance and/or education that results in behavioral or operational changes for energy and demand savings.

[2] In addition to the incentive caps or set incentives at the individual EESP or customer-level, utilities may also set caps on incentives a customer can receive at the measure level. For example, a utility may cap lighting incentives at 50 percent of the total project incentive. The EM&V team does not have the same concerns regarding free-ridership for measure-level caps and the recommendations in this memo do not apply to these situations.

2.2.3 Recommendations

Establish greater consistency in the treatment of projects where claimed savings exceed incentive amounts and most accurately represent the savings results from these projects. The EM&V team recommends utilities either only claim the savings from the incentivized measures or the utilities apply the most updated net-to-gross (NTG) research[3] to the total project savings for the claimed savings[4] as follows:

For projects where the *claimed savings are more than 10 percent higher than the "set incentive*," the NTG ratio inclusive of free-ridership and spillover should be applied to the total project savings. No NTG ratio should be applied for projects where the set incentive and claimed savings differ by 10 percent or less to allow for normal variation between project planning and implementation.

For projects where *claimed savings exceed the "incentive cap" savings up to 20 percent of incentivized savings*, the NTG ratio inclusive of free-ridership and spillover should be applied to the total project savings.

$$NTG\ ratio_{projects\ exceeding\ set\ incentive} = 1 - Free\ Ridership + Spillover$$

Equation 1

For projects where total *claimed savings exceed the "incentive cap" by more than 20 percent of incentivized savings*, the NTG ratio only accounting for free-ridership should be applied to the total project savings. Applying the NTG ratio that is also inclusive of spillover to projects that exceed incentive amounts by a percentage of incentivized savings this large would likely result in double-counting spillover.

$$NTG\ ratio_{projects\ exceeding\ incentive\ cap} = 1 - Free\ Ridership$$

Equation 2

The PY2021 EM&V research updated NTG ratios for the commercial standard offer (CSOP) and market transformation programs (CMTP). The PY2021 NTG research accounts for free-riders; spillover rates were derived from the PY2017 EM&V research. The CSOP NTG ratio is 100 percent for kWh and 99 percent for kW. The CMTP NTG ratio is 100 percent for kWh and kW.

Table 3. PY2021 Commercial Statewide NTG Ratios by Program Type

Program type/weighting	Free-ridership	Spillover	NTG
CSOP kWh	23%	24%	100%
CSOP kW	22%	21%	99%
CMTP kWh	19%	22%	100%
CMTP kW	20%	32%	100%

[3] The use of a net to gross adjustment to account for free-riders is addressed in § 25.181 (e)(5)(B)(ii).

[4] This recommendation does not apply to behavioral, code or other market transformation programs where the primary program strategy is technical assistance and education that results in behavioral or operational changes for energy and demand savings.

Projects might have multiple measures with different effective useful lives (EULs) that are taken into account when calculating lifetime savings; for these cases, the EM&V team provides the following additional guidance for adjusting claimed savings that exceed incentive levels:

1. Determine the total calculated savings by EUL.
2. Determine the percent of total project savings attributed to each EUL.
3. Adjust savings as recommended above.
4. Distribute adjusted savings to various project EULs using the percentages calculated in Step 2.

The following is an example of a project with 50 kW and 50,000 kWh of calculated savings. An RTU HVAC project with a 15-year EUL attributes twenty percent of those savings, and a chiller project with a 25-year EUL attributes the remaining 80 percent. The adjusted savings are 40 kW and 40,000 kWh. Those adjusted savings would be attributed to each EUL as follows:

1. 40 kW x 20% = 8 kW and 40,000 kWh x 20% = 8,000 kWh attributed to the 15-year EUL
2. 40 kW x 80% = 32 kW and 40,000 kWh x 80% = 32,000 kWh attributed to the 25-year EUL

2.3 NEW CONSTRUCTION

This section provides additional guidance to select the appropriate baseline for commercial new construction projects.

2.3.1 Overview

Utility programs include incentives for a variety of projects applicable to commercial new construction such as lighting, HVAC, and roofs. To effectively implement new construction energy efficiency projects, utility programs need to reach decision-makers during the project design phase. However, it is common for several years to pass between the project design phase and project completion in commercial new construction. Since baselines change, this situation raises the question of what baseline utilities should use commercial new construction projects to claim savings. For example, in PY2016, Texas' new construction baseline was IECC 2009 based on the state code in effect at that time. In PY2023, the baseline is now IECC 2015 based on the state code in effect.

2.3.2 Recommendation

For commercial new construction projects, utilities should use the building permit date to determine the applicable version of the Texas TRM and baseline to calculate savings.

3. LOW-INCOME

3.1 LOW-INCOME INCOME-ELIGIBLE VERIFICATION FORMS

This section provides implementation recommendations for the program year (PY) 2023 (PY2023) eligibility verification for low-income and hard-to-reach programs.

3.1.1 Background

Texas utilities provide energy efficiency services to low-income customers through a combination of hard-to-reach and low-income programs as specified in 16 Tex. Admin. Code (TAC) § 25.181, relating to the energy efficiency goal. All regulated Texas electric utilities are required to achieve no less than 5 percent of their total demand reduction goal through programs serving hard-to-reach customers (16 TAC § 25.181(e)(3)(F)). In addition, the ERCOT utilities are required to spend no less than 10% of each program year's energy efficiency budget on a targeted low-income efficiency program (16 TAC § 25.181(r)). The qualifying income level of 200% federal poverty level is the same for hard-to-reach and low-income programs though the programs are implemented differently.

The utilities use program eligibility certification forms maintained by the PUCT on their website. The forms differ by single-family and multi-family, but both include a way to qualify for the programs through other low-income programs and services (Category 1) as well as through self-reported income (Category 2). The PUCT has revised the income eligibility annually based on updated federal poverty level information, but the forms have not had major changes for over a decade. Due to the importance of these forms in determining program eligibility, PUCT Staff and the EM&V team agreed to incorporate the forms into Volume 5 of the Texas Technical Reference Manual (TRM) starting with program year (PY) 2022. Forms will be updated as part of the annual TRM update process. As part of integrating the eligibility certification forms into the TRM, PUCT Staff and the EM&V team worked with the utilities to review the forms and certification processes in-depth. Appendix A contains the Single-Family and Multifamily Income Eligibility for Full-Incentive Energy Efficiency Services forms.

The objectives of the in-depth process review were to, "Revise low-income/hard-to-reach eligibility verification to increase the confidence program services are going to intended customers, improve program outreach and address participation barriers, and develop efficient administration processes," as presented at the March 2021 Energy Efficiency Implementation Project (EEIP) meeting. The PY2023 TRM forms expand Category 1 options to support streamlined participation through an expanded list of qualifying programs and services (1A), direct social service or community action agency qualification (1B), and geographic qualification (1C). If a customer does not qualify through any of the three options, income information may be used to determine eligibility (Category 2). Both Category 1A and Category 2 require customers to submit supporting documentation. Because Category 2 requires income information, all parties recognize this information can be more sensitive for customers to provide and for service providers to store securely although all personal identifying information (PII) should be redacted, except name and address of customer. Given concerns about income information as a participation barrier, Category 1 is the preferred method to verify customer eligibility whenever possible.

3.1.2 Quality Assurance/Quality Control (QA/QC)

Utilities should audit a minimum of 10% of all program year projects submitted through each category (1A, 1B, 1C and 2) to ensure the processes are working correctly and the required documentation was submitted and verified to be correct. In the cases where utilities find an error in the process or documentation during their QA/QC processes, utilities should identify a solution to remedy the error. The EM&V team encourages utilities to integrate the program eligibility audit into their existing QA/QC practices to the extent possible to facilitate the most streamlined and effective implementation of this recommendation.

While utilities are not required to store customer documentation on their systems audited as part of the QA/QC process, they should provide contact information of the auditor who has verified the documentation through a visual inspection.

While audit processes can differ to best integrate with utilities' current QA/QC processes, the following are recommended practices by category:

- Category 1A: Verify form is completed and supporting program documentation was provided
- Category 1B: Verify form is completed and signed by social service or community action agency
- Category 1C: Verify address of serviced home is within one of the two qualifying geographic designations; forms are not required for geographical qualification under 1C as long as the relevant information is in the tracking data (service address, geographic qualifier)
- Category 2: Verify form is completed and supporting income information was submitted to service provider/landlord/property manager

Utilities can either conduct the audits themselves or hire a third-party to do so on their behalf. The EM&V team will request a summary of audit results at the end of each program year. The audit result summary should identify solutions to address any errors found during the audit.

A. Program Tracking and Documentation

Utilities should add a field(s) to their program tracking data to clearly track how a low-income and hard-to-reach participant was qualified for the program (Category 1A, 1B, 1C and 2). This will allow both the utility and the EM&V team to sample projects from each category for auditing purposes.

For Category 1A, 1B and 2, all completed forms and supporting documentation, if applicable, should be stored for all projects. Forms are not required for geographical qualification under 1C as long as the relevant information is in the tracking data (service address, geographic qualifier). Forms and supporting documentation should be maintained for a minimum of 24 months.

B. Claiming Master-Metered Savings

Because master-metered complexes are a commercial rate class, costs and savings should be claimed in the commercial sector. However, if the master-metered complex qualifies for hard-to-reach or low-income program services, these costs and savings may be counted toward the utilities' goals (5 percent of total demand reduction goal for hard-to-reach customers (16 TAC § 25.181(e)(3)(F)), and no less than 10% of each program year's energy efficiency budget on a targeted low-income efficiency program (16 TAC § 25.181(r)).). To avoid double-counting, master-metered projects counted toward the goal should be a separate line item.

3.1.3 New Program Strategies

Some utilities are working on partnerships to distribute energy efficiency measures to low-income and hard-to-reach customers such as distributing LEDs at food banks. In these cases, utilities should meet with the EM&V team to agree on an approach for verifying customer eligibility and claiming savings, which will then be presented to Commission Staff. The goal of these discussions is to support the new strategies in keeping with the overall objective of the in-depth process review stated above.

4. CROSS-SECTOR

4.1 LOAD MANAGEMENT PROGRAMS

This section summarizes guidance from the EM&V team on two load management issues raised by one or more utilities during PY2014–PY2015 EM&V: (1) rounding of demand impacts and (2) meter issues.

4.1.1 Rounding

During the EM&V contractor's evaluation efforts on commercial load management programs, the EM&V contractor has found some differences in rounding in the commercial load management programs' demand impacts. These rounding differences are minor and are not a concern in the accuracy of the reporting of impacts. However, in response to a request for guidance to address rounding consistently, the EM&V team recommends utilities round commercial load management impacts consistently with how incentives are awarded, which is at the customer level.

4.1.2 Meter Issues

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.

Commercial load management programs. Without complete interval meter data to calculate the baseline and event impacts, savings may not be claimed. However, if a customer has alternate interval meter data available, it can be used in lieu of program meter data to calculate claimed savings. Using customer meters for the load management program savings requires that the data meet interval metering requirements presented in the version of the Texas TRM for the program year. 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 cover both the event day data and the baseline data.

The EM&V team requests utilities notify them 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 using program meter data. 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.

Residential load management programs. If there are random, non-systematic errors in smart meter data for less than one percent of total participants, the 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.

The EM&V team requests utilities notify them in these circumstances to discuss the approach for determining and applying average savings for those customers with incomplete meter data.

4.2 COMMERCIAL AND RESIDENTIAL HVAC SPLIT-SYSTEMS WITHOUT AHRI CERTIFICATION

This section provides guidance in determining efficiency levels of eligible HVAC split systems that do not have AHRI certification. The methodology outlined in this memo can be used starting in PY2023.

Constructing AC and heat pump systems can be done using outdoor units and indoor units from different manufacturers; not all these combinations are certified by AHRI. Savings should be calculated and reported consistently across utilities and in agreement with industry-standard practice and the Energy Efficiency Rule 16 TAC § 25.181.

Projects in PY2020 were affected by changes in supply chains due to COVID-19, leading to project equipment and timeline adjustments; supply chain issues are expected to continue into PY2023. In addition to the AHRI certification, the process outlined in this guidance memo may guide HVAC project efficiency calculations impacted by supply chain issues. Coordination with the evaluation team for alternate applications of the process is recommended.

4.2.1 Background

Texas TRM 10.0 allows air conditioning and heat pump split systems to be either AHRI-certified or listed on the DOE Compliance Certification Management System (CCMS). Split systems consist of an outdoor unit and an indoor unit, which can be made by the same manufacturer or separate manufacturers. The system's efficiency and size are driven primarily by the outdoor unit, although various indoor units can slightly affect the system efficiency.

Texas TRM 10.0 clarifies the allowable efficiency levels for outdoor and indoor unit pairs listed in the DOE CCMS and not AHRI-certified. The TRM states that the claimed efficiency for these non-certified pairs should not exceed the AHRI-certified pairs' average. The guidance below provides an example to identify the not-to-exceed value.

4.2.2 Guidance

The following guidance should be applied if paired outdoor and indoor HVAC units are not in the AHRI certification list and only have DOE CCMS testing results. In that case, the high-efficient condition's capacity and efficiency shall not exceed the average of the AHRI-certified pair listing for the matching outdoor (condenser) unit. The DOE CCMS listing provides documentation of the results that are on the AHRI certification listing and can be downloaded and filtered based on listings that use a similar condenser and various indoor units.

The following is an example scenario designed to direct the user on interpreting the guidance in this memo.

Example: A split system is listed in DOE CCMS and is not AHRI certified.

<u>*Analysis scenario:*</u> A high-efficiency split-system heat pump is installed with a Goodman GSZ16 outdoor unit (condenser) and a third-party indoor unit (air handler). The specific pair is not listed in the AHRI database.

Step 1: Access the DOE CCMS[5] and select the appropriate measure category for the product pair. In this example, it is the *Air Conditioners and Heat Pump – Central* measure category.[6] Search for the critical component to the system's efficiency (the outdoor unit (condenser)), with model number GSZ160241B*. The * is added near the end of the model number to allow for different condenser unit variations.

Step 2: Identify the specific air handler match and record the specifications from the DOE CCMS. In this example, the Airmark GES244 indoor unit pairs with the Goodman GSZ160241B outdoor unit with the following specifications:

Table 4. Specification of an Example Split System

Cooling capacity (Btu/h)	24,000
Heating capacity (Btu/h)	24,000
SEER	16
EER	13
HSPF	9
Link to FTC Energy Guide label	(blank)*

*(blank) indicates the pair is not listed in the AHRI database.

The *Link to FTC Energy Guide label* column will identify other certifications obtained by this equipment pair. In the example, the column is blank, indicating it is not listed in the AHRI database.

Step 3: Filter the DOE CCMS database to match the specification of the installed pair. Filter the *product code description*, *cooling capacity*, and *Link to FTC Energy Guide Label* to find a representative sample of similar AHRI-listed units. Table 5 details the filter selected for the example. Figure 1 shows the filter on the CCMS database interface.

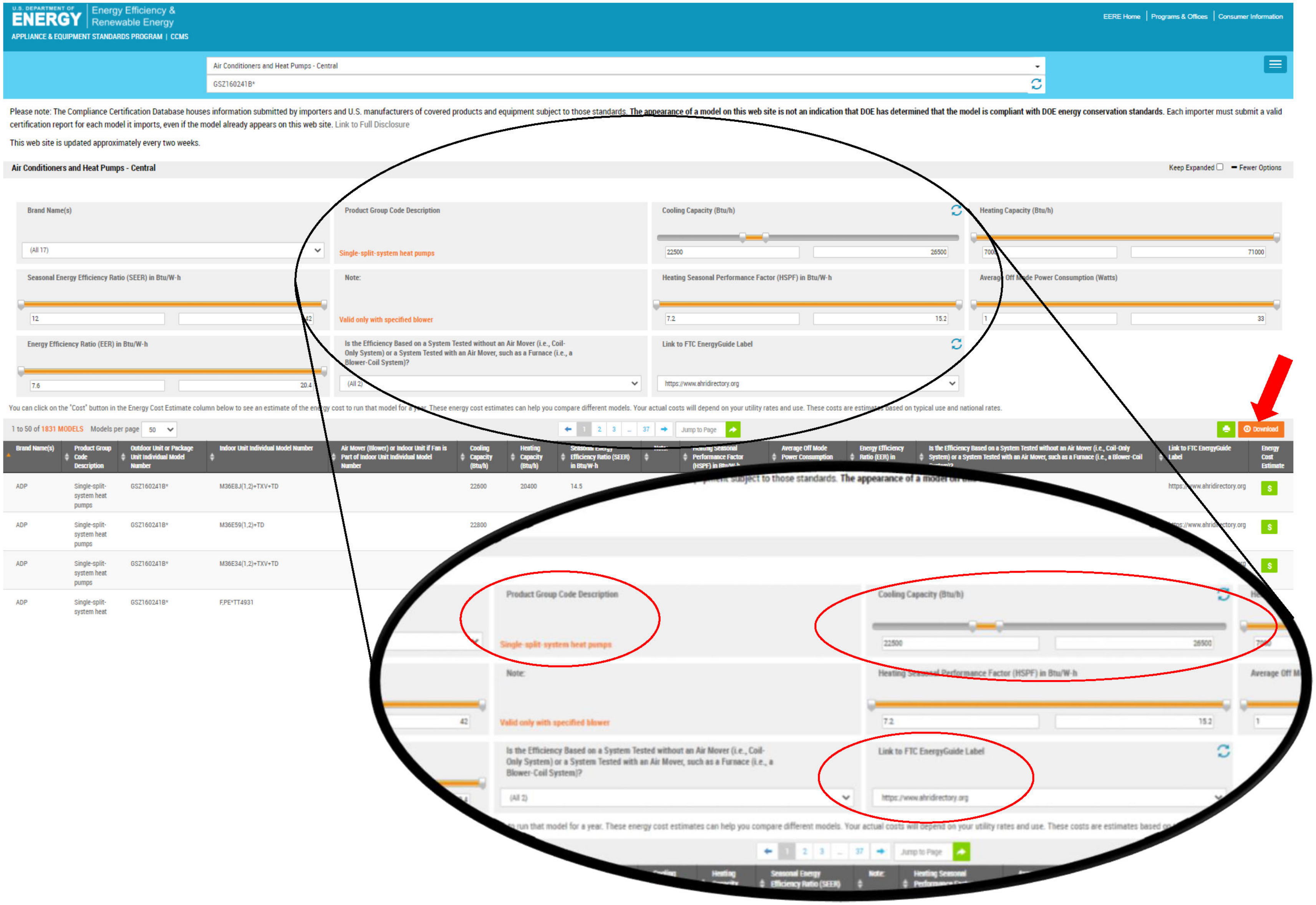
Table 5. Example DOE CCMS Filter to Similar Equipment

Product code description	Single-split-system-heat-pump
Cooling capacity	22,500 to 26,500
Link to FTC Energy Guide Label	www.ahridirectory.org

[5] DOE Compliance Certification Database. https://www.regulations.doe.gov/certification-data/#q=Product_Group_s%3A*

[6] Note that the measure categories are based on technology and not use. The example is for a split system, but the category in the database is central system because the condenser technology meets that definition.

Figure 1. Example Filter of DOE CCMS Database

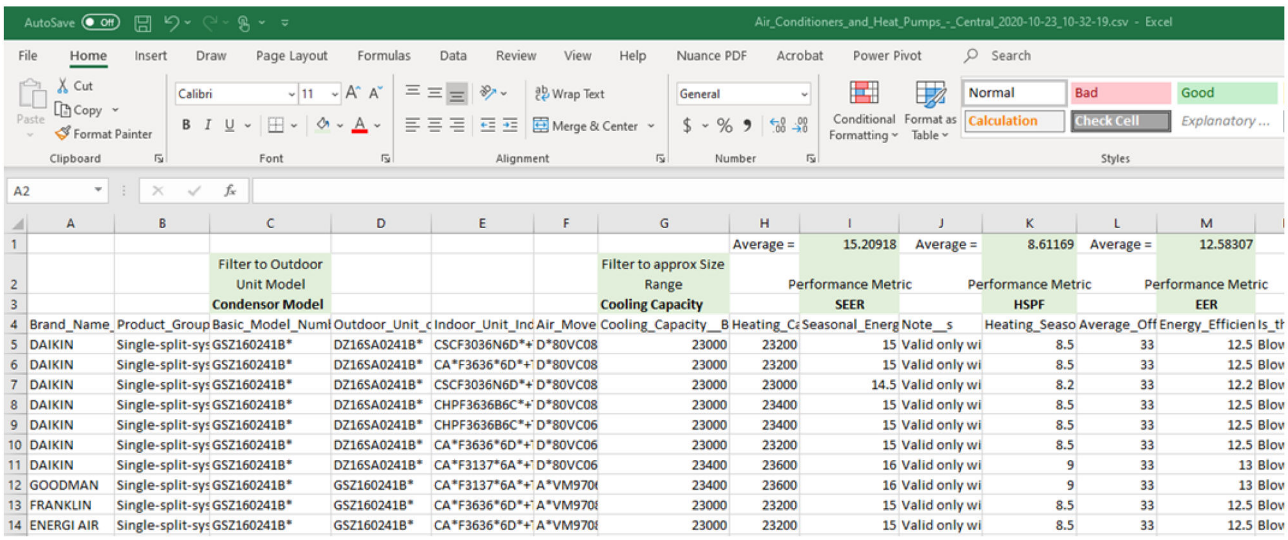


Step 4: Download the filtered database using the *download* button on the right side of the screen. A .csv spreadsheet will download. Project documentation should include a copy of the downloaded .csv file with the download date in the file name. Since the DOE CCMS is constantly updated, this file is the record of the DOE CCMS entries on the date of application review.

Figure 2 below shows the downloaded spreadsheet with three rows added above. Rows 2 and 3 identify the filters and the performance metric columns. Column C is the filter for the outdoor unit in Step 1. Columns G and Q (not shown) are the filters applied in Step 3.

Columns I, K, and M contain the performance metrics for the filtered products and represent the AHRI-certified performance metrics for similar split-system pairs with the matching outdoor unit (condenser).

Figure 2. Sample Downloaded Spreadsheet with Calculation



	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1								Average =	15.20918	Average =	8.61169	Average =	12.58307	
2			Filter to Outdoor Unit Model				Filter to approx Size Range		Performance Metric		Performance Metric		Performance Metric	
3			**Condensor Model**				**Cooling Capacity**		**SEER**		**HSPF**		**EER**	
4	Brand_Name_	Product_Group	Basic_Model_Numl	Outdoor_Unit_c	Indoor_Unit_Inc	Air_Move	Cooling_Capacity__B	Heating_Ca	Seasonal_Energ	Note__s	Heating_Seaso	Average_Off	Energy_Efficien	Is_th
5	DAIKIN	Single-split-sys	GSZ160241B*	DZ16SA0241B*	CSCF3036N6D*+	D*80VC08	23000	23200	15	Valid only wi	8.5	33	12.5	Blov
6	DAIKIN	Single-split-sys	GSZ160241B*	DZ16SA0241B*	CA*F3636*6D*+	D*80VC08	23000	23200	15	Valid only wi	8.5	33	12.5	Blov
7	DAIKIN	Single-split-sys	GSZ160241B*	DZ16SA0241B*	CSCF3036N6D*+	D*80VC08	23000	23000	14.5	Valid only wi	8.2	33	12.2	Blov
8	DAIKIN	Single-split-sys	GSZ160241B*	DZ16SA0241B*	CHPF3636B6C*+	D*80VC08	23000	23400	15	Valid only wi	8.5	33	12.5	Blov
9	DAIKIN	Single-split-sys	GSZ160241B*	DZ16SA0241B*	CHPF3636B6C*+	D*80VC06	23000	23400	15	Valid only wi	8.5	33	12.5	Blov
10	DAIKIN	Single-split-sys	GSZ160241B*	DZ16SA0241B*	CA*F3636*6D*+	D*80VC06	23000	23200	15	Valid only wi	8.5	33	12.5	Blov
11	DAIKIN	Single-split-sys	GSZ160241B*	DZ16SA0241B*	CA*F3137*6A*+	D*80VC06	23400	23600	16	Valid only wi	9	33	13	Blov
12	GOODMAN	Single-split-sys	GSZ160241B*	GSZ160241B*	CA*F3137*6A*+	A*VM970	23400	23600	16	Valid only wi	9	33	13	Blov
13	FRANKLIN	Single-split-sys	GSZ160241B*	GSZ160241B*	CA*F3636*6D*+	A*VM970	23000	23200	15	Valid only wi	8.5	33	12.5	Blov
14	ENERGI AIR	Single-split-sys	GSZ160241B*	GSZ160241B*	CA*F3636*6D*+	A*VM970	23000	23200	15	Valid only wi	8.5	33	12.5	Blov

Column I, K, and M are the DOE CCMS logged values of SEER, HSPF, and EER, respectively. Row 1 uses the =*Average()* function in Microsoft Excel to identify the average performance metrics from the data in the database. Record these values rounded to one decimal point.

Table 6. Average Performance Metrics of Similar Certified Units

SEER (AHRI average)	15.2
EER (AHRI average)	12.6
HSPF (AHRI average)	8.6

Step 5: Identify the performance metrics used for TRM energy efficiency calculations. The installed unit pair's performance metrics for the calculation shall not exceed the similar-sized unit pair's performance metrics in the AHRI database.

Table 7. TRM Calculation Performance Metrics Determination

Performance metric	DOE CCMS (actual)	AHRI certification average	TRM calculation value[7]
SEER	16	15.2	15
EER	13	12.6	12.5
HSPF	9	8.6	8.6

Step 6: Complete the TRM energy savings calculation using the TRM calculation values determined in Table 7.

Include (1) the additional documentation of the original downloaded .csv file and (2) the average efficiency calculation spreadsheet file with the project documentation required in TRM Volume 2 and Volume 3.

[7] TRM calculation was determined using the rounding for EER and HSPF values to matched deemed tables. If the calculator can handle more detail, using the values rounded to the nearest tenth is acceptable.

4.3 MEASUREMENT AND VERIFICATION CLAIMED SAVINGS

This section provides guidance on claiming savings for projects implemented in one program year with measurement and verification (M&V) methodologies across two program years. This guidance aims to balance the level of savings claimed in the same year as the project activities with savings claimed once the M&V is completed.

4.3.1 Introduction

The annual reporting of program savings poses a challenge to accurately estimate impacts when the M&V methodology requires information across program years (such as 12 months of post-project consumption data to see seasonal effects or summer peak metering to estimate kW reductions). Projects extending beyond program years are a common challenge for behavioral programs and complex custom commercial and industrial projects.

Volume 4 of the TRM includes an M&V protocol for behavioral programs based on 12 months of pre-install and post-install data to determine energy savings accurately. Although savings can be estimated through custom calculations, the final amount of energy savings needs to be *trued-up* once all 12 months of post-install data is collected and analyzed. Trueing-up project savings is also common for custom commercial projects where M&V is required across program years. Utilities have employed the standard practice for custom projects of awarding 40 percent of the incentives and claiming 40 percent of the savings in the first program year based on the initially-estimated savings. In the subsequent program year, when M&V post-install data is fully collected and analyzed, the remaining 60 percent, or *trued-up* amount, is awarded and savings claimed. We refer to this as a *40/60* split though the percentage claimed in the second year may be less than or greater than 60.

In addition to these two common examples, this claimed savings guidance could also apply to any program wanting to claim savings through an M&V protocol as opposed to TRM deemed savings.

4.3.2 Recommendation

We recommend a 40/60 split of incentives and claimed savings is employed whenever M&V spans two program years. In other words, award 40 percent of incentives and savings claimed in the first program year—and the true-up, whether it is greater or less than 60 percent—would be awarded and claimed in the second program year. The true-up is required, whether it is to claim the remainder of the estimated savings or increases and decreases to the previously claimed energy savings. For example, if a project is estimated to reduce the peak kW by 100 kW, the project should claim 40 kW at project completion. Once the M&V is completed, the full savings may be claimed. For this example, we assume the M&V found the peak demand reductions were 110 kW. The true-up claim would be 70 kW in the second program year instead of the 60 kW as initially estimated in the 40/60 split. However, if the completed M&V analysis instead finds the total peak demand reduction is 30 kW, the true-up claim would be negative 10 kW.

This 40/60 split balances the first program year implementation of the measure and its planned savings with what savings are found actually to be in the second year once M&V is complete. There may be instances when a utility feels a different balance, such as a 50/50 split, which may be more appropriate. The utility should seek the PUCT EM&V contractor's review and approval of a different split of incentives and claimed savings across program years than the standard recommendation of 40/60 in this guidance section.

4.4 UPSTREAM/MIDSTREAM PROGRAM CROSS-SECTOR SAVINGS

This section provides guidance to calculate and allocate savings at the sector-level for upstream and midstream programs where installation location is not identified. The methodology that was reviewed and approved for use in PY2023 is also outlined.

4.4.1 Background

TRM v8.0 updated methods to calculate and allocate savings for lighting equipment sold through participating upstream and midstream programs. The TRM v8.0 method attempted to simplify the process for equipment sold when the installation location is not known, although several unintended consequences require adjustment. The recommendations below apply to programs when installation location must be generalized. If location installation is known at the time of sale, the assumptions for building type and lamp watts from the TRM should be used.

4.4.2 Recommendations

Claimed savings by sector. To account for the cross-over between commercial and residential applications in an upstream or midstream delivery method, the EM&V team recommends that five percent of upstream and midstream lighting program benefits and costs are allocated to commercial customers, with the remaining 95 percent allocated to residential customers. This recommendation agrees with the guidance memo put forth by the EM&V team, dated April 28, 2016.

Residential savings. The EM&V team recommends that the calculation methodology outlined in TRM v10.0 Volume 2 be used for the residential portion of the savings. Savings should be calculated using the TRM stipulated average HOU per year for residential applications, 803 hours, and the coincidence factors summarized in Table 5 and Table 11.

Residential low-income savings determination. Programs that are able to determine low-income and hard-to-reach eligibility by collecting customer information are permitted to use the ten-year low-income EUL to claim savings. For PY2023, utilities should continue documenting low-income accounts using the program eligibility certification forms maintained by the PUCT. Updated requirements are incorporated when implemented.

Commercial savings. The commercial lighting savings per lamp can be determined using commercial midstream assumptions identified in Table 12 of PY2023 TRM v10.0 Volume 3. This table identifies the annual operating hours (AOH), coincidence factors, and in-service rates (ISR). Table 8 below is an updated version of Table 12 in PY2023 TRM v10.0 Volume 3 and is recommended to determine assumptions for energy savings calculations.

Table 8. Upstream/Midstream Assumptions by Lamp Type[8]

Lamp type	AOH	Coincidence factors[9]					ISR
		Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	
General service lamp	3,748	0.69	0.69	0.73	0.73	0.71	0.98
Directional/reflector	3,774	0.78	0.79	0.78	0.79	0.82	1.00
LED tube	3,522	0.74	0.75	0.84	0.84	0.76	1.00
High-bay fixture	3,796	0.78	0.79	0.83	0.84	0.80	1.00
Garage	7,884	1.00	1.00	1.00	1.00	1.00	1.00
Outdoor	4,161	0.67	0.71	0.61	0.75	1.00	1.00

The interactive effects should be standardized across all commercial midstream lamp types. All locations should be considered refrigerated air; see Table 9 below (Table 11 from PY2023 TRM v10.0 Volume 3 of the TRM is unchanged by this guidance).

Table 9. Deemed Energy and Demand Interactive HVAC Factors[10]

Space conditioning type	Energy interactive HVAC factor	Demand interactive HVAC factor
Refrigerated air	1.05	1.10
Evaporative cooling[11]	1.02	1.04
Medium temperature refrigeration (33 to 41ºF)	1.25	1.25
Low-temperature refrigeration (-10 to 10ºF)	1.30	1.30
None (unconditioned/uncooled)	1.00	1.00

[8] 2012 CBECS and 2014 MECS.

[9] Outdoor coincidence factors are specified for winter peak. All other values reference summer peak.

[10] PUCT Docket 39146. Table 7 (page 17) and Table 12 (page 24).

[11] These factors are only applicable for projects in climate zones 1 and 5. They are derived by taking a ratio of total HVAC energy use for spaces with evaporative and refrigerated cooling then applying that ratio against the IEF factors specified for refrigerated air.

4.5 DATA MODEL

With the goal of easing the interpretation of the TRM by database and tracking system developers, the EM&V team worked with EUMMOT and Texas eTRM providers (i.e., Frontier Energy, ANB Systems) to develop a standard data model that outlines common data collected for each prescriptive measure. The data model is for all residential measures in Volume 2 and a variety of commercial measures in Volume 3, which are not already utilizing savings calculators.

For example, the current data model for an ENERGY STAR® clothes dryer includes weather zone, unit type (front-loading, top-loading, compact), capacity (standard, compact), quantity installed, and date of purchase.

A benefit of a standard data model is to improve program and project analytics across service providers and implementers. A standard data model will also standardize project collection forms (e.g., on-site inspection forms) and reduce the time cleaning large data sets.

For more information, please contact an EUMMOT representative.

APPENDIX A: LOW-INCOME INCOME-ELIGIBLE VERIFICATION FORMS

Single-Family (four or less units or owner-occupied)
Income Eligibility for Full-Incentive Energy Efficiency Services

This statement is made to verify my household income eligibility. The Public Utility Commission of Texas has authorized energy efficiency programs to reduce the utility bills of income-eligible households. Contractors participating in the programs receive higher incentive payments when you are income-eligible. The purpose of the higher payment is to enable the contractor to provide the improvements at a very low cost or no cost to you. **Participating in this program will not affect your eligibility for other program benefits listed below**.

The information provided below will be used solely for the purpose of determining household eligibility and will be kept confidential by the investor-owned utility contractor or other representative and by the Public Utility Commission of Texas and their contractor. It will not be sold or provided to any other party.

Name		
Street Address	Apartment Number	
City	State TX	Zip Code
Phone Number with Area Code ( ) -	Number of Persons in Household	

☐ **Category 1A:** Eligible through other programs or services

At least one member of my household received benefits from one or more of the programs listed below (☑ check all that applies, **digital or paper copy of proof of participation such as award letter required with this form):**

- ☐ Bureau of Indian Affairs (BIA) General Assistance
- ☐ Federal Public Housing Assistance (FPHA)
- ☐ Food Distribution Program on Indian Reservations (FDPIR)
- ☐ Health Benefit Coverage under Child Health Plan (CHIP)
- ☐ Low-Income Energy Assistance Program (LIHEAP) or Comprehensive Energy Assistance Program (CEAP)
- ☐ Medicaid (includes CHIP)
- ☐ Medicare, Qualified Beneficiary
  - QMB (Qualified Medicare Beneficiary)
  - SLMB Specific Low-Income Medicare Beneficiary)
  - QI (Qualified Individual Program)
  - QDWI (Qualified Disabled & Working Individual Program)
- ☐ National School Lunch Program—Free Lunch Program
- ☐ Section 8 Housing Voucher
- ☐ Supplemental Nutrition Assistance Program (SNAP) (Food Stamps)
- ☐ Supplemental Security Income (SSI)
- ☐ Temporary Assistance for Needy Families (TANF)
- ☐ Texas Lifeline Discount
- ☐ Tribal Head Start (only households that meet the income-qualifying standard)
- ☐ Tribal Temporary Assistance for Needy Families (Tribal TANF)
- ☐ Veterans Pension Benefit or Survivors Pension Benefit
- ☐ Veterans Pension or Survivors Benefit Programs

Your signature is required on the last page of this form.

☐ **Category 1B:** Eligible through community action or social service agency
(**COMPLETED BY UTILITY, COMMUNITY ACTION, OR SOCIAL SERVICE AGENCY**)

I certify the named household participates in one of the programs in Category 1A or other low-income program service (such as Weatherization Assistance), which our agency qualifies participation.

Agency Name	Contact Name	Contact Phone Number with Area Code
		( ) -

☐ **Category 1C:** Eligible through geographic location
(**COMPLETED BY UTILITY OR THEIR REPRESENTATIVE OR PROVIDER**)

(☑ check box if applicable): Form is not required for geographical qualification as long as the relevant information is in the utility's tracking data (service address, geographic qualifier)

☐ Housing and Urban Development (HUD) Low-Income Housing-Qualified Census Tract or Block—GEO ID:______________

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Single-Family (four or less units or owner-occupied)
Income Eligibility for Full-Incentive Energy Efficiency Services

☐ **Category 2:** Eligible through income verification
(**DO NOT COMPLETE IF 1A, 1B, OR 1C COMPLETED ABOVE**)

*To accurately determine your **household income**, you must include the income of all persons residing in your home from all sources. To determine the amount of income in each category, enter the amount(s) on the check or benefit statement.* **Supporting documentation must be provided (all personal identifying information may be redacted except name and address).**

STEP 1: Fill out the Income Calculation table below.

Amounts listed are shown (☑ check one): ☐ Annually ☐ Monthly ☐ Weekly

Income Calculation Table

Source of income	Amount ($)
Wages from full- or part-time employment as shown on a paystub or W-2 form	
Unemployment or worker's compensation	
Social security	
Retirement income	
Child support or alimony	
All other earnings	
Total household income *(add the amount entered on each line to figure your total household income)*	

STEP 2: Compare your total household income per week, month, or year to the amount shown in the table below for the number of persons in your household.
If your total household income is equal to or less than the amount shown in the table, you are income-eligible.

200 Percent of Health and Human Services (HHS) Poverty Guidelines

Size of family unit	Annual income	Monthly income	Weekly income
1	$ 27,180	$ 2,265	$ 523
2	$ 36,620	$ 3,052	$ 704
3	$ 46,060	$ 3,838	$ 886
4	$ 55,500	$ 4,625	$ 1,068
5	$ 64,940	$ 5,412	$ 1,249
6	$ 74,380	$ 6,198	$ 1,431
7	$ 83,820	$ 6,985	$ 1,612
8	$ 93,260	$ 7,772	$ 1,794
Each additional person, add:	$ 9,440	$787	$ 182

* **Notice:** Income ceilings are for February 1, 2022—January 31, 2023.
Annual updates are posted on http://www.puc.texas.gov/industry/electric/forms/

(Electronic) By typing my name below, I certify the above statements to be true and correct to the best of my knowledge, and that this information can be used for the purpose of processing my Single-Family Income Eligibility for Full-Incentive Energy Efficiency Services Form.
(Non-Electronic) If filling out the delineation by hand, please provide your original signature and date.

I understand that the information is subject to audit and investigation by the investor-owned utility or representative providing the program services.

Applicant Signature	Date
Contractor Signature	Date

Keep a copy of this form for your records.

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Multifamily Apartment Complex (five or more units)
Income Eligibility for Full-Incentive Energy Efficiency Services

This form is to verify that at least 75 percent of the units are rented by income-eligible customers. The Public Utility Commission of Texas has authorized energy efficiency programs to reduce the utility bills of income-eligible tenant households. Contractors participating in the programs receive higher incentive payments when at least 75 percent of the tenants qualify as income-eligible. **One form must be filled out for each qualifying multifamily apartment complex.**

The information provided below will be used solely for the purpose of determining household eligibility and will be kept confidential by the investor-owned utility contractor or other representative and by the Public Utility Commission of Texas and their contractor. It will not be sold or provided to any other party.

Name of Applicant (Property Owner or Agent)	Name of Property Owner
Name of Multifamily Apartment Complex	Number of Units in Complex
Name of Management Company	Name of On-Site Property Manager
Complex Street Address	Suite Number
City	State TX / Zip Code
Property Owner or Agent's Phone Number with Area Code ( ) -	Fax Number with Area Code ( ) -
Management Company's Phone Number with Area Code ( ) -	Fax Number with Area Code ( ) -

☐ **Category 1A:** Eligible through other programs or services

The multifamily apartment complex qualifies in one or more of the programs listed below (☑ check all that apply, **digital or paper copy of proof of participation such as the land use restriction agreement required with this form**):

- ☐ Affordable Housing Disposition Program
- ☐ HOME Rental Housing Development
- ☐ Low-Income Housing Tax Credit Program
- ☐ Multifamily Bond Program
- ☐ Public Housing Authority (Texas Housing Association)
- ☐ Project-Based Section 8
- ☐ Rural Rental Section 515 (FMHA)
- ☐ Section 811 Project Rental Assistance Program
- ☐ Texas Housing Trust Fund
- ☐ Other income-qualifying housing program
  Program name: ________________________

Your signature is required on the last page of this form.

☐ **Category 1B:** Eligible through community action or social service agency
(**COMPLETED BY UTILITY, COMMUNITY ACTION, OR SOCIAL SERVICE AGENCY**)

I certify the named multifamily complex or 75 percent or more of tenants participate in one of the programs in Category 1A or other low-income program service (such as LIHEAP/CEAP and Weatherization Assistance), which our agency qualifies participation.

Agency Name	Contact Name	Contact Phone Number with Area Code
		( ) -

☐ **Category 1C:** Eligible through geographic location
(**COMPLETED BY UTILITY OR THEIR REPRESENTATIVE OR PROVIDER**)

(☑ check box if applicable): Form is not required for geographical qualification as long as the relevant information is in the utility's tracking data (service address, geographic qualifier).

☐ Housing and Urban Development (HUD) Low-Income Housing-Qualified Census Tract or Block—GEO ID: ________________

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Multifamily Apartment Complex (five or more units)
Income Eligibility for Full-Incentive Energy Efficiency Services

☐ **Category 2:** Eligible through income verification
(DO NOT COMPLETE IF 1A, 1B, OR 1C COMPLETED ABOVE)

For an apartment complex to be eligible, at least 75 percent of the tenant household incomes before taxes are at or below 200 percent of the federal poverty guidelines.

STEP 1: Fill out the Apartment Complex Income Calculation Worksheet. (Excel or hard copy must be included with this form)
*To accurately determine tenant **household income,** you may use the tenant rental application showing the number of individuals residing in the unit and the household income dated from within the past 18 months. If the rental application does not show the required information or the information is over 18 months old, then the tenant(s) must complete the **Single-Family Income Eligibility for Full-Incentive Energy Efficiency Services*** **form.** Supporting documentation for each unit must be available for utility audit.

STEP 2: Compare the tenant's total household income per week, month, or year to the amount shown in the table below for the number of persons residing in the unit.
If the total household income is equal to or less than the amount shown in the table, the unit is income-eligible for the full incentive. If the unit is not income-eligible, the unit is eligible for the residential incentive level.

200 Percent of Health and Human Services (HHS) Poverty Guidelines

Size of family unit	Annual income	Monthly income	Weekly income
1	$ 27,180	$ 2,265	$ 523
2	$ 36,620	$ 3,052	$ 704
3	$ 46,060	$ 3,838	$ 886
4	$ 55,500	$ 4,625	$ 1,068
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Each additional person, add:	$ 9,440	$787	$ 182

* **Notice:** Income ceilings are for February 1, 2022—January 31, 2023.
Annual updates are posted on http://www.puc.texas.gov/industry/electric/forms/

STEP 3: Fill out the Apartment Complex Income Calculation Summary below.

Apartment Complex Income Calculation Summary

Apartment complex income calculation summary	Number of units
Number of income-eligible units	
Number of non-income-eligible units, including vacant units	
Total number of units	
Percentage of income-eligible units *(income-eligible units divided by the total number of units)*	

STEP 4: If "percentage of income-eligible units" is 75 percent or higher, please certify the eligibility of the apartment complex with your signature below.

(Electronic) By typing my name below, I certify the above statements to be true and correct to the best of my knowledge and that this information can be used for the purpose of processing my Multifamily Apartment Complex Income Eligibility for Full-Incentive Energy Efficiency Services Form.
(Non-Electronic) If filling out the delineation by hand, please provide your original signature and date.

I understand that the information is subject to audit and investigation by the investor-owned utility or representative providing the program services.

Applicant Signature (Property Owner or Agent)	Date
Contractor Signature	Date

Keep a copy of this form for your records.

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The Apartment Complex Income Calculation Worksheet is posted on Texas PUC Sharepoint.