

EVALUATION, MEASUREMENT & VERIFICATION OF CPS ENERGY'S FY 2016 DSM PROGRAMS

June 1, 2016

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1. EXECUTIVE SUMMARY

CPS Energy retained Frontier Associates ("Frontier") to conduct a comprehensive and independent evaluation, measurement, and verification (EM&V) of CPS Energy's Fiscal Year (FY) 2016 demand side management (DSM) programs. This report describes the EM&V methodology and process and presents the findings of the evaluation.

The evaluation focused primarily on calculating the energy and demand savings achieved by CPS Energy's FY 2016 DSM programs on an annualized basis. Additionally, the evaluation reviewed program expenditures to calculate program cost-effectiveness and recommended enhancements to program design and implementation for CPS Energy's consideration.

1.1 SUMMARY OF ENERGY AND DEMAND IMPACTS

Net energy and demand savings are listed in Table 1.2-1. The savings are represented on an annualized basis in order to simplify the reporting structure and for easy comparison from year to year.

1.2 SUMMARY OF ECONOMIC IMPACTS

Frontier's evaluation included collecting administrative, management, and marketing costs as well as total incentives paid. The following economic impact metrics were calculated:

- Cost of Saved Energy (CSE), which represents the levelized program cost per annual kWh saved, was $0.0646
- Net Reduction in Revenue Requirements (RRR), which represents the net reduction in utility costs due to the impact of the energy efficiency improvements, was $57,087,620.
- Benefit-Cost Ratio, which represents the output of the program administrator cost test, was 1.72.

For Demand Response (DR) programs, the summary table includes estimated savings from all active participants as of the end of FY 2016, including those who signed up in previous years, as this most accurately represents DR program capabilities in FY 2017 and beyond.

For DR program benefit-cost calculations, Frontier analyzed only the cohort of participants added in FY 2016. This approach is consistent with other program benefit-cost calculations, but caution is advised when comparing DR results to benefit-cost calculations from prior years. This is especially the case where there are significant differences between cohorts from FY 2016 and other years, since significant differences in the composition of cohorts from year to year affect the outcome.

Table 1.2-1: FY 2016 Net Energy and Demand Savings

Program	Net-to-Gross Ratio	Net Energy Savings (kWh)	Net Coincident Peak Demand Savings (kW)	Net Non-Coincident Demand Savings (kW)	Net ERCOT 4CP Demand Savings (kW)	Program and Rebate $	Admin and Marketing $	Total Program $	Program Admin. Benefit-Cost Ratio
Energy Efficiency Programs									
Home Efficiency	93%	1,931,079	505	930	466	$878,975	$49,240	$928,215	1.72
Air Flow Performance	90%	889,053	386	399	362	$789,090	$42,838	$831,927	1.22
Residential HVAC	95%	13,401,849	6,648	7,384	6,843	$3,706,733	$154,975	$3,861,708	4.44
Solar Initiative - Residential	100%	10,000,580	2,893	5,735	2,513	$9,315,955	$575,402	$9,891,358	1.20
New Homes Construction	100%	6,734,139	1,304	1,509	1,216	$1,144,500	$54,124	$1,198,624	5.10
Refrigerator	63%	402,432	57	57	58	$45,155	$76,704	$121,859	1.10
Weatherization	100%	13,758,521	3,843	13,337	3,615	$18,881,535	$2,922,249	$21,803,784	0.50
Residential Lighting (LED)	85%	2,054,729	65	4,814	79	$1,050,040	$67,736	$1,117,776	0.92
Residential Subtotal		**49,172,380**	**15,702**	**34,165**	**15,151**	**35,811,983**	**3,943,267**	**39,755,250**	**1.26**
Commercial Lighting	85%	47,723,649	7,194	11,901	6,933	$7,438,476	$454,737	$7,893,213	3.29
Commercial HVAC	96%	10,580,739	3,541	3,753	3,382	$2,851,072	$154,384	$3,005,455	3.99
Solar Initiative - Commercial & Schools	100%	2,929,448	887	1,685	773	$2,330,041	$156,661	$2,486,702	1.44
Commercial Custom	92%	4,001,682	87	647	108	$368,510	$31,090	$399,600	3.46
Commercial New Construction	92%	3,353,474	1,282	1,299	1,254	$390,573	$18,246	$408,819	8.80
Commercial Subtotal		**68,588,992**	**12,993**	**19,286**	**12,449**	**$13,378,671**	**$815,116**	**$14,193,788**	**3.28**
Energy Efficiency Subtotal		**117,761,373**	**28,695**	**53,450**	**27,601**	**$49,190,654**	**$4,758,383**	**$53,949,037**	**1.79**

Table continues on the next page.

Program	Net-to-Gross Ratio	Net Energy Savings (kWh)	Net Coincident Peak Demand Savings (kW)	Net Non-Coincident Demand Savings (kW)	Net ERCOT 4CP Demand Savings (kW)	Program and Rebate $	Admin and Marketing $	Total Program $	Program Admin. Benefit-Cost Ratio
Demand Response Programs									
Commercial Demand Response	100%	2,168,927	105,550	106,639	67,089	$4,928,551	$273,336	$5,201,887	2.81*
Auto Demand Response	100%	81,251	4,576	5,172	3,540	$1,720,079	$95,320	$1,815,399	0.46*
Emergency Demand Response	100%	19,833	19,833	19,833	4,958	$456,084	$25,274	$481,358	4.80*
Smart Thermostat	100%	1,002,740	43,103	47,266	37,512	$4,903,769	$231,488	$5,135,257	1.14*
Home Manager	100%	728,387	45,593	49,158	41,689	$3,150,298	$378,080	$3,528,379	1.74*
Bring Your Own Thermostat	100%	28,187	3,268	3,845	2,566	$441,454	$190,136	$631,590	1.92*
ThinkEco Air Conditioner	100%	1,152	204	256	188	$301,831	$21,548	$323,379	0.16*
Demand Response Subtotal		**4,030,475**	**222,127**	**232,169**	**157,543**	**$15,902,067**	**$1,215,183**	**$17,117,250**	**1.58***
Programs in Development									
SolarHostSA Pilot	100%	0	0	0	0	$222,489	$186,974	$409,463	0.00
Roofless Solar Pilot	100%	0	0	0	0	$0	$182,719	$182,719	0.00
In Development Subtotal		**0**	**0**	**0**	**0**	**$222,489**	**$369,693**	**$592,182**	**0.00**
Grand Total		**121,791,848**	**250,821**	**285,619**	**185,144**	**$65,315,210**	**$6,343,259**	**$71,658,469**	**1.72***

* The PACT for Demand Response Programs is calculated based on the net present value of avoided cost benefits divided by the net present value of program costs *attributable to new, incremental participants during the program year*. Because total program costs in the table represent the costs attributable to *all* participants, the PACT for Demand Response Programs cannot be directly calculated from data presented in the table.

Table notes:

- Net savings = gross savings * Net to Gross ratio / (1 – line loss factor).
- DR program net energy and demand savings (in lighter shade) represent end of year program capability, based on end of year enrollment.
- For the Residential Lighting (LED) program, we display maximum program capability in place of non-coincident peak demand savings to maintain consistency with past evaluation practice.

2. EVALUATION METHODS

2.1 ENERGY IMPACTS

Frontier's approach to this project has been to leverage existing EM&V work previously conducted for CPS Energy and other electric utilities in Texas. For the past fifteen years, investor-owned utilities, EM&V consultants, and stakeholder groups have collaborated to develop accurate and comprehensive "deemed" savings for hundreds of residential and commercial energy efficiency measures, under the auspices of the Public Utility Commission of Texas (PUCT). This extended effort has culminated in the publication of the *Texas Technical Reference Manual* (Texas TRM),[1] a compendium of algorithms, baseline efficiency data, efficiency standards, energy savings calculations and data tables. By utilizing the TRM, Frontier can provide CPS Energy with energy and demand impact estimates that have been vetted numerous times by independent third parties, and are consistent with impact estimates being used by all of the investor-owned utilities in Texas. For this analysis, Texas TRM version 2.1 was used except where noted. This version was used by utilities in Texas for their 2015 program year.

Because the Texas TRM does not include expected energy impacts that are specific to San Antonio, additional building energy use model simulations were performed to derive energy savings estimates for weather-sensitive energy efficiency measures. These new estimates are consistent with the TRM but better reflect equipment usage in San Antonio's climate.

2.2 PEAK DEMAND IMPACTS

To calculate coincident peak demand savings, Frontier employed a probabilistic analysis using San Antonio TMY3 hourly weather data.[2] This approach relates actual historical weather data for San Antonio, day-of-week, and time-of-day variables to Electric Reliability Council of Texas (ERCOT) zonal peak conditions. Those historical relationships are then applied to TMY3 hourly weather data to estimate the hours in a TMY data file most likely to coincide with hours of high demand in ERCOT's CPS-San Antonio zone. To determine hours of highest demand in this zone, Frontier used ERCOT data and added back in demand savings attributable to DR deployments. Estimates of the impacts of various energy efficiency measures during the top twenty hours associated with high demand in the TMY data are identified, and the probability-weighted estimate of an energy efficiency measure's demand savings during those peak hours is then calculated. This approach has been adopted for use in the Texas TRM v. 3.1, to be used by all investor-owned electric utilities beginning in 2016.

Based on Frontier's analysis, the hours presented in Table 2.2-1 have the highest probability of occurring during CPS Energy's peak (listed in order of probability, from highest to lowest). Additional hours are shown because some hours, such as those occurring on weekends or holidays, are eliminated for some measures.

[1] Public Utility Commission of Texas (PUCT) Technical Reference Manual (TRM) v. 2.1. Available for download at: http://texasefficiency.com/index.php/regulatory-filings/deemed-savings

[2] Typical Meteorological Year (TMY) are data sets of hourly values of solar radiation and meteorological elements for a 1-year period. TMY3 is the most recent version of this data. Data collected at the Kelly Field Air Force Base (Kelly AFB) station were generally used, since the temperature data series collected at the San Antonio International Airport is inexplicably higher than the readings collected at other local weather stations. (See Itron, CPS June 2014 Electricity Forecast, Sept. 2014, pp. 8-9.)

Table 2.2-1: Top Hours from Probabilistic Analysis

Month	Day	Hour (start)	Temp (°F)	Peak Probability (with DR addback)
6	19	15	104	0.939953
6	19	16	102.92	0.923473
6	20	16	102.92	0.923473
6	20	15	101.84	0.627406
6	19	14	102.92	0.600033
6	20	14	102.92	0.600033
6	19	17	100.94	0.411083
6	10	15	100.94	0.399418
6	18	15	100.94	0.399418
6	10	16	99.86	0.338925
7	31	15	102.02	0.311633
8	20	15	99.86	0.282339
8	19	16	98.96	0.267512
8	20	16	98.96	0.267512
8	17	15	98.96	0.134484
7	31	16	100.04	0.121139
8	18	16	97.88	0.106969
6	20	17	98.96	0.082923
6	17	15	98.96	0.079315
6	12	16	97.88	0.062276
6	16	16	97.88	0.062276
6	17	16	97.88	0.062276
6	18	16	97.88	0.062276
6	10	14	99.86	0.059918
6	18	14	99.86	0.059918
8	18	15	97.88	0.048491
8	19	15	97.88	0.048491
8	17	16	96.98	0.045171
8	23	16	96.98	0.045171
8	20	14	98.96	0.043431
8	23	14	98.96	0.043431
7	30	16	98.96	0.043252
7	31	14	100.94	0.041583
6	17	17	97.88	0.028802
6	18	17	97.88	0.028802
6	13	15	97.88	0.027479
6	14	15	97.88	0.027479
6	21	15	97.88	0.027479
6	5	16	96.98	0.025559

Month	Day	Hour (start)	Temp (°F)	Peak Probability (with DR addback)
6	11	16	96.98	0.025559
6	13	16	96.98	0.025559
6	21	16	96.98	0.025559
6	17	14	98.96	0.024555
8	18	17	96.98	0.020688
8	19	17	96.98	0.020688
8	20	17	96.98	0.020688
7	31	17	98.96	0.019788
7	30	14	100.04	0.016847
8	7	16	95.9	0.015279
8	28	16	95.9	0.015279

The estimated coincident peak savings is the probability-weighted average of the kW in the top twenty applicable time periods for each measure. This approach was used for all measures, except where noted.

2.3 NET IMPACTS

To derive net impacts, Frontier utilized Net-to-Gross (NTG) ratios provided by CPS Energy. For this year's report, separate line loss factors relating to energy and demand were provided by CPS Energy. Those line loss factors were applied to the gross energy and peak demand impacts for each measure.

2.4 AVOIDED COST BENEFITS

2.4.1 Avoided Capacity and Energy

Avoided cost benefits were calculated using CPS Energy-provided avoided energy and capacity costs, and CPS Energy's standard discount rate. For this year's analysis, CPS Energy provided avoided energy costs as the average (nominal $/MWh) of the marginal variable cost of production using load forecasts with and without STEP measures fully deployed. The Estimated Useful Life (EUL) values from the Texas TRM were utilized for all STEP measures, except where noted. For the purpose of calculating avoided energy benefits, annual kWh were allocated into one of the following time periods, based on season, day of the week, and hour of the day.

- Summer On-Peak
- Summer Mid-Peak
- Summer Off-Peak
- Non-Summer Mid-Peak
- Non-Summer Off-Peak

Frontier developed or adopted appropriate 8760-hour load shapes for each STEP measure, in

order to assign annual kWh to the appropriate cost periods.

Avoided capacity costs (nominal $/kW-yr) were developed for on-peak and off-peak STEP measures. On-peak avoided capacity cost was defined as the forecasted capital and fixed operation & maintenance cost of an LMS100 natural gas combustion turbine (NGCT) plant, annuitized over 35 years. Off-peak avoided capacity cost was defined as the blended cost of CPS Energy's forecasted capital and fixed operation & maintenance cost of an LMS100 NGCT and an SGT6-5000 natural gas combined cycle (NGCC); with the blending ratio defined as the ratio of the added NGCC/NGCT capacity in CPS Energy's 25-year expansion plan.

2.4.2 Avoided Transmission Charge (ERCOT 4CP TCOS)

ERCOT recovers the costs of transmission incurred by transmission service providers via a charge on load-serving entities, including CPS Energy. The charge is allocated to load-serving entities based on each entity's average demand during four ERCOT system peaks (known as four "coincident peaks," or "4CP events") from June to September each year. To minimize this charge, CPS Energy anticipates likely 4CP events and deploys demand response resources to reduce demand accordingly. Energy efficiency measures also contribute to demand reduction during 4CP events.

To estimate gross demand reduction during FY 2016 4CP events within each demand response program/subprogram we multiplied the estimated load reduction per participant by the number of active participants and a "deployment success rate," the rate at which CPS Energy correctly anticipated and deployed each resource during FY 2016 4CP events.[3]

For energy efficiency programs, we used hourly load shapes for each program measure to estimate the impacts during 4CP event hours for each weekday during the months of June through September. These monthly averages were then averaged to estimate the 4CP impact for each program. The evaluation of avoided transmission charges to energy efficiency programs is a new addition to the evaluation this year.

2.4.3 Avoided Price Spikes Savings (kWh)

Another potential benefit of demand response programs derives from avoiding intervals of especially high energy prices in the ERCOT market. In ERCOT energy prices may go up to $9,000/MWh ($9/kWh), which is over 200 times the average wholesale price of energy from 2010-2014. By reducing demand during price spikes, CPS Energy can benefit by avoiding high prices for energy it needs, or by selling energy from its own or contracted generation sources into the market. Avoided price spike savings were only calculated for DR programs.

Price spikes in the ERCOT market have a number of causes, occur irregularly, and are hard to predict. ERCOT prices hit peaks 68 times in CPS' load zone during 2011, but only 7 times in the combined three years that followed. [4] Price spikes are also harder to react to in a timely manner

[3] Please note, CPS Energy's Commercial Demand Response offering for Emergency Demand Response is not eligible for pursuing 4CP benefits. This section and the resulting benefit calculations exclude that program offering. For end of year and incremental evaluation of DR programs (the incremental evaluation is an input to the benefit-cost analysis), the FY 2016 deployment success rate was replaced with a two year deployment success rate representing a combination of FY 2015 and FY 2016.

[4] In this example, we define peak as a price of $3,000, the highest price allowed under ERCOT market rules prior to 2015.

with some demand response resources. For example, Nest thermostats in the Nest Rush Hour Rewards program require day-ahead notice to the program implementer, which makes rapid response to an unexpected price spike event impossible.

To estimate the value of energy (kWh) saved during FY 2016 price spike events, we compiled energy savings from all DR programs for every interval such programs were deployed, and multiplied the sum within each interval by the corresponding ERCOT load zone energy price less CPS Energy's avoided cost of energy during the summer peak period. This method estimates the value of energy savings achieved during DR events without double counting the value of avoided energy costs.

2.5 ECONOMIC ANALYSIS

The following cost-effectiveness metrics were calculated for CPS Energy's programs:

- *Program Administrator Benefit-Cost Ratio*. This is the ratio of the net present value (NPV) of avoided energy and capacity benefit, divided by the program's incentives and administrative costs, expressed as:

$$Benefit\ Cost\ Ratio = \frac{NPV\ of\ avoided\ cost\ benefit}{Program\ incentives + Admin\ Costs}$$

- *Cost of Saved Energy.* The Cost of Saved Energy (CSE) is the cost per kWh of energy efficiency and/or demand response program impact. The CSE is the ratio of the levelized program costs divided by the annual energy kWh savings. Levelized program costs are calculated using a Capital Recovery Factor (CRF), which incorporates the estimated useful life (EUL) of the savings (weighted by measure) and an annual discount rate.

$$CSE = \frac{Levelized\ Program\ Costs}{Annual\ kWh\ savings}$$

- *Net Avoided Cost Benefit.* The net reduction in utility costs from the energy and demand saved by CPS Energy's programs, calculated as the avoided cost benefit minus the total Program costs.

3. RESIDENTIAL PROGRAMS

3.1 SUMMARY OF RESIDENTIAL IMPACTS

CPS Energy offered the following energy efficiency and renewable programs for the residential sector in FY 2016:

- Home Efficiency
- Air Flow Performance
- Residential Heating, Ventilation, and Air Conditioning (HVAC)
- Solar Initiative – Residential
- New Homes Construction
- Refrigerator Program
- Weatherization
- Residential Lighting (LEDs)

CPS Energy's portfolio of residential programs addresses all markets and major residential end uses (Residential demand response programs are included in Section 5).

To evaluate energy impacts for most program measures, Frontier utilized the current version of the Texas TRM (version 2.1). For programs or measures where other methods were used, those are referenced in each section.

It should be noted that for some envelope measures, the non-coincident peak occurs during the non-summer months, since a significant number of measures were installed on homes with electric heating.

The contribution of each residential program to the portfolio's energy, peak demand, and non-coincident peak savings are shown in the following figures.

All values in the tables and charts throughout this section represent energy and demand savings from new FY 2016 program participants as measured at the participant or end-user level. These savings are adjusted in the program portfolio rollup table in the Executive Summary and in benefit-cost calculations to account for net-to-gross ratios and line losses.[5]

[5] Net-to-gross (NTG) ratios are estimated at the level of individual programs, and account for the net effects of free ridership and spillover. Free riders are defined as customers who would have delivered energy or demand savings without any program incentives but who received a financial incentive or rebate anyway. Spillover effects derive from customers who delivered energy or demand savings because of the program, but did not participate in the program or receive a financial incentive or rebate. Loss factors account for the fact that utilities must generate or import a greater amount of energy or demand than is required at the customer or end-user level because some energy is lost in distribution.

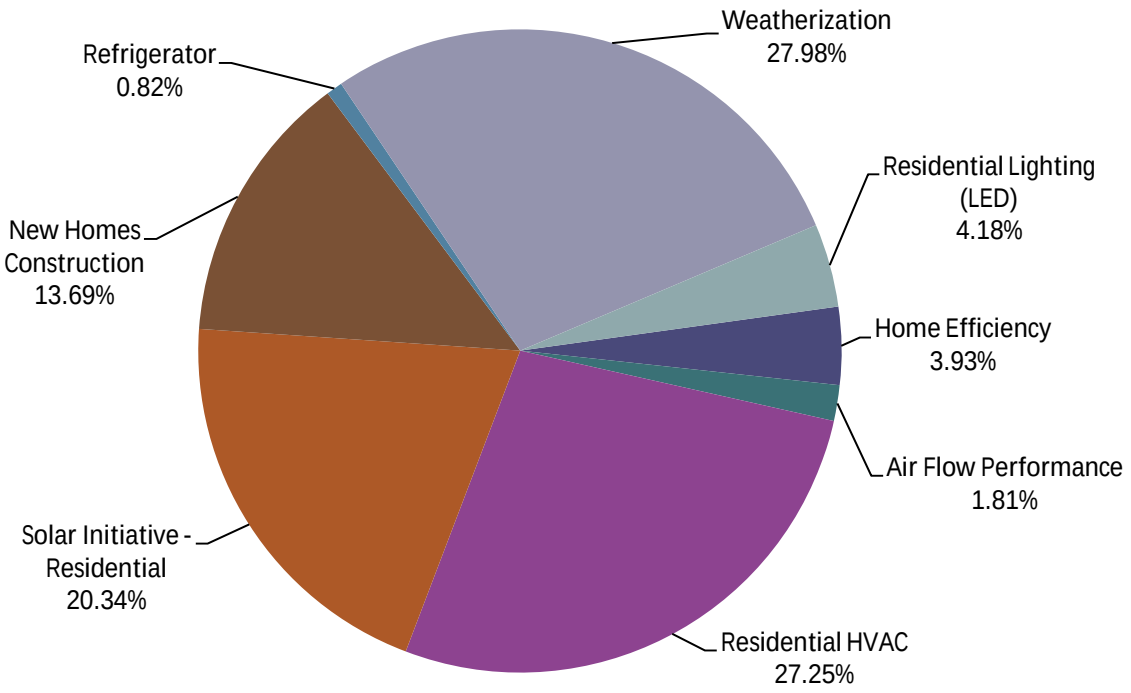


Figure 3.1-1: Summary of Residential Impacts – kWh by Program

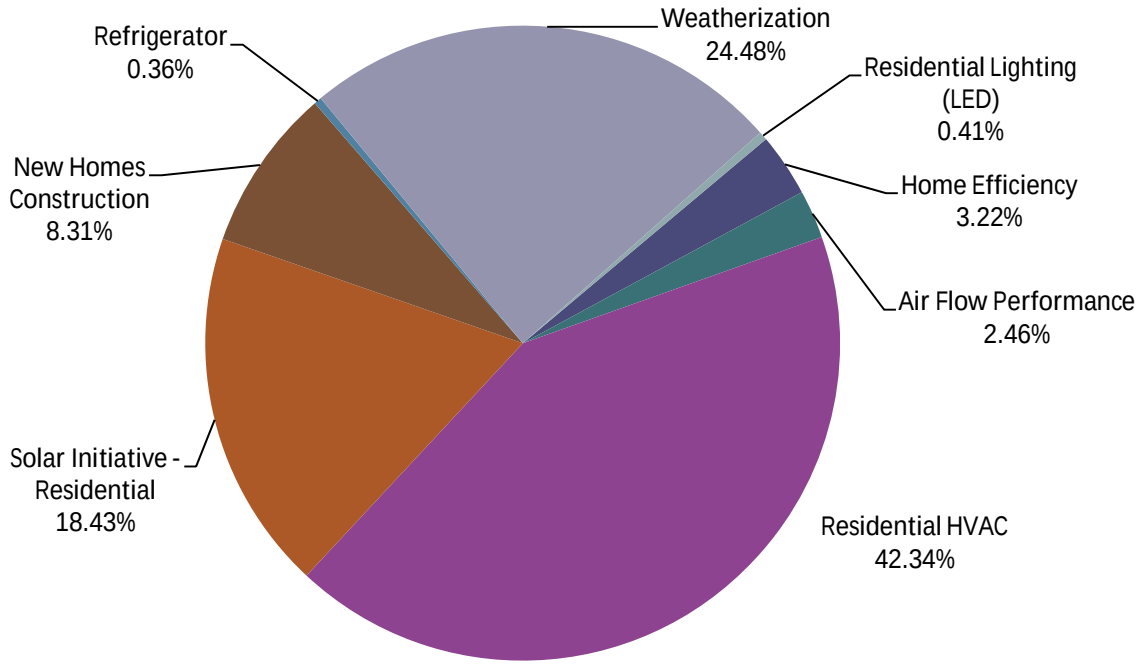


Figure 3.1-2: Summary of Residential Impacts – Coincident kW by Program

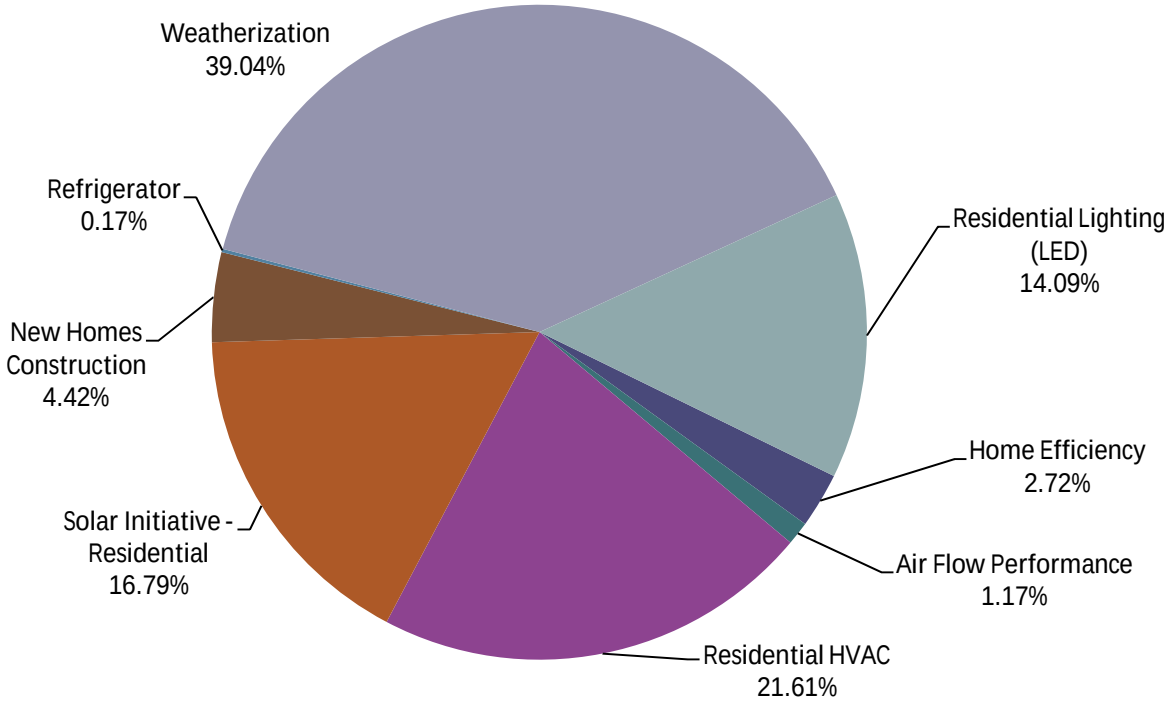


Figure 3.1-3: Summary of Residential Impacts – Non-Coincident kW by Program

3.2 HOME EFFICIENCY PROGRAM

3.2.1 Overview

CPS Energy's Home Efficiency program is composed of three elements:

- Ceiling insulation
- Heat pump water heaters
- Variable-speed pool pumps

The proportion of total energy savings is presented in Figure 3.2-1.

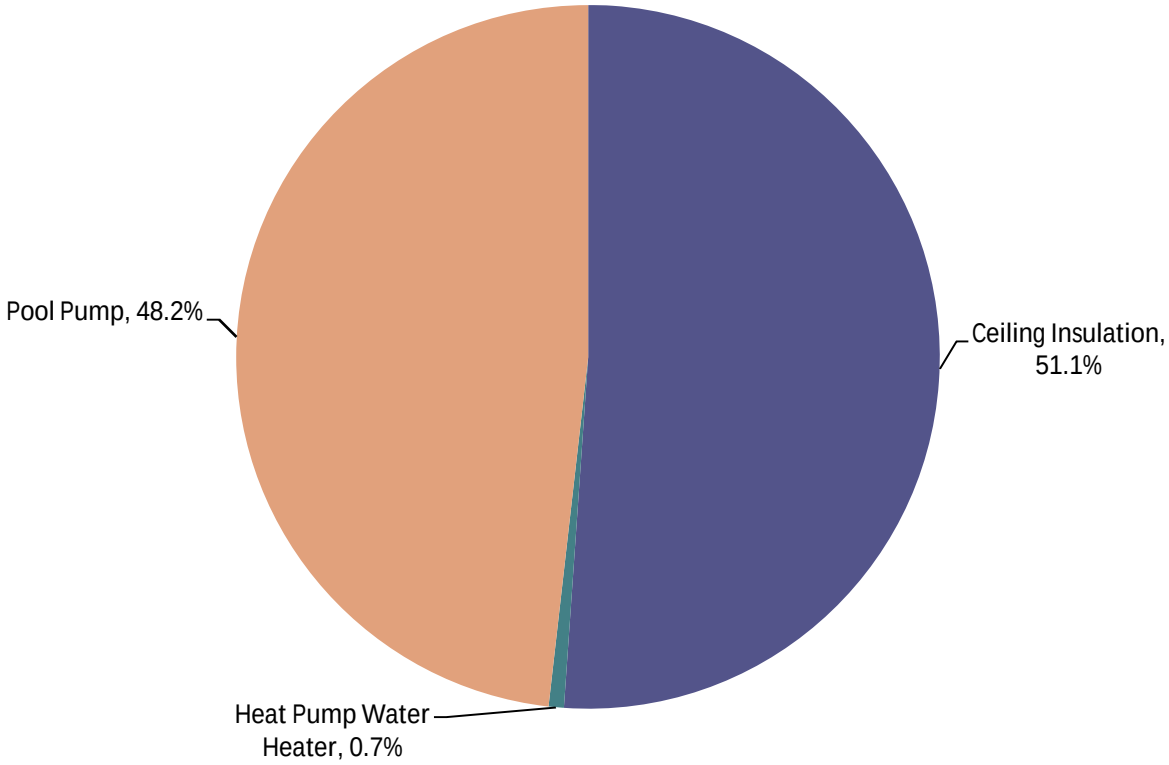


Figure 3.2-1: Home Efficiency – kWh by Measure

3.2.2 Savings Calculation Method

3.2.2.1 Ceiling Insulation

CPS Energy incentivized 1,666 ceiling insulation installations in FY 2016, compared with 1,877 ceiling insulation installations in FY 2015.

Energy savings for this measure are calculated using Texas TRM v. 2.1 savings values.

Table 3.2-1: Home Efficiency Residential Ceiling Insulation Deemed Annual Energy Savings (kWh)

Ceiling Insulation Base R-value	Gas Heat (kWh per sq. ft.)	Electric Heat (kWh per sq. ft.)	Heat Pump (kWh per sq. ft.)
R-0	1	4.4	2.14
R-1 to R-4	0.64	2.81	1.4
R-5 to R-8	0.32	1.38	0.7
R-9 to R-14	0.17	0.72	0.36
R-15 to R-22	0.07	0.3	0.15

The savings values in Table 3.2-1 assume that the base R-value is within one of the five ranges listed above, that the final R-value is 30, and that there are three possible heating/cooling fuel types. The CPS Energy program has a much higher number of possible combinations of starting R-values, final R-values, and heating and cooling equipment combinations. In order to apply these savings values, Frontier mapped each of the program's insulation measures into the above categories, using each measure's estimated Btuh reduction per square foot. For homes listed as having "mixed" heating fuels, Frontier averaged the gas heat and electric heat savings values.

Coincident, non-coincident, and 4CP peak demand savings were calculated using residential heating and cooling load profiles developed using US Department of Energy's (DOE) BEopt and EnergyPlus residential simulation modeling software.

The EUL for ceiling insulation is 25 years, based on Texas TRM v. 2.1.

Savings for ceiling insulation are highly dependent on the base, or initial R-value, as can be noted in Table 3.2-1. Collecting additional data on the type, thickness, and overall condition of the existing insulation will help improve the process for estimating baseline R-values.

3.2.2.2 Heat Pump Water Heaters

The CPS Energy Home Efficiency program incentivized the installation of ten heat pump water heaters (HPWH) in FY 2016, compared with five from FY 2015. Heat pump water heaters work by using a small direct-exchange refrigeration system to remove heat from the ambient air and transfer that heat to the water in the storage tank. These units can provide Efficiency Factors (EF) in the 2.2 range, making them more than twice as efficient as conventional electric resistance water heaters.

Energy savings for this measure are calculated using Texas TRM v. 2.1.

Table 3.2-2: Home Efficiency Residential HPWH Deemed Annual Energy Savings (kWh)

Water Heater Location	Heating Type	HPWH Tank Size Range, Gallons			
		40	50	60	80
Conditioned Space	Gas	1,449	1,657	223	285
	Heat Pump	1,213	1,417	223	285
	Elec. Resistance	906	1,105	223	285
Unconditioned Space	N/A	1,273	1,481	219	280

The installations were assumed to be in unconditioned spaces. From Table 3.2-2, the average annual savings for the units installed is 1,361 kWh. This is a 16% reduction in savings per unit, compared to FY 2015, which is largely attributable to an increase in the baseline federal efficiency standard for water heaters greater than 55 gallons in size.

Coincident, non-coincident, and 4CP peak demand savings were calculated using a domestic hot water (DHW) load profile developed from the Building America Analysis Spreadsheet for existing homes.[6]

The EUL for heat pump water heaters is 13 years, based on Texas TRM v. 2.1.

3.2.2.3 Variable-Speed Pool Pumps

One of the most significant consumers of energy in a home with a swimming pool is the pool pump. The motors in these pumps are usually single-speed, standard-efficiency motors that are often oversized. Pool pumps can consume upwards of 5,000 kWh per year, depending on the size of the pool and operating conditions. Variable-speed pool pumps (VS Pool Pump) can reduce pool pump energy use by 50% to 75%. Through the Home Efficiency program, CPS Energy provided incentives for the installation of 402 variable-speed pool pumps in FY 2016, a significant increase over the 181 pumps installed in FY 2015.

For this measure Frontier utilized the algorithms and assumptions in the ENERGY STAR Pool Pump Calculator.[7] The calculator's default values were used for pool size, turnovers, months per year of operation, and existing pool pump motor horsepower. Using these values, the calculator produced an estimate of 2,338 kWh per year per installation.

To determine coincident peak demand savings, Frontier used load data collected through a metered study conducted by Southern California Edison.[8]

[6] Building America Analysis Spreadsheet for existing homes, accessed on March 10, 2016 from http://energy.gov/eere/buildings/downloads/building-america-analysis-existing-homes.

[7] Downloaded from http://www.energystar.gov/products/certified-products/detail/pool-pumps. Accessed 3/1/2015.

[8] "Pool Pump Demand Response Potential, Demand and Run-Time Monitored Data." Southern California Edison. June 2008.

The EUL of this measure is 10 years, based on the California Database of Energy Efficiency Resources (DEER).

3.2.3 Results and Recommendations

The total energy and demand savings for the Home Efficiency Program are as follows:

Table 3.2-3: Home Efficiency Gross Energy and Demand Savings

Measure	Energy Savings (kWh)	Peak Demand Savings (kW)	Non-Coinc. Demand Savings (kW)	ERCOT 4CP Demand Savings (kW)
Ceiling Insulation	996,547	329	684	308
HPWH	13,609	1.22	4	1.3
VS Pool Pump	940,026	160	252	143
Total	1,950,182	490	940	452

3.3 AIR FLOW PERFORMANCE PROGRAM

3.3.1 Overview

CPS Energy's Air Flow Performance Program offers incentives to promote energy efficiency improvements of heating, ventilation, and air conditioning (HVAC) distribution systems through duct leakage testing and subsequent duct repair or replacement.

The program had 402 projects in FY 2016. This corresponds to a 6% increase in program participation compared to FY 2015.

3.3.2 Savings Calculation Method

Energy and demand savings were estimated using algorithms developed by Frontier for the Texas TRM v. 2.1. For this measure, Frontier replaced any weather specific assumptions with San Antonio climate data.

The savings calculation method outlined in the Texas TRM relies heavily on pre and post installation duct leakage testing to measure duct leakage to the outside. For most homes participating in the program, leakage was measured using flow hoods. Flow hoods produce an estimate of total leakage as a percentage of fan flow, but do not directly measure duct leakage CFM. To estimate CFM leakage rates, Frontier multiplied the pre- and post-installation percent leakage rates by the reported pre and post installation total system fan flows. To adjust these total leakage rates to reflect leakage-to-outside values, Frontier applied a leakage-to-outside adjustment factor. To develop the adjustment factor, Frontier assumed that 100% of ducts are

Table 19. http://www.etcc-ca.com/sites/default/files/reports/dr07_01_pool_pump_demand_response_potential_report.pdf . Accessed 2/24/2015.

located in unconditioned space in single-story or split level homes, and that 50% of ducts are located in unconditioned space in two or three-story homes. Applying those assumptions against the estimated distribution of building types yielded a weighted adjustment factor of 0.85.

In accordance with Texas TRM v. 2.1, starting leakage values were capped at 35% of the total fan flow.

Coincident, non-coincident, and 4CP peak demand savings were calculated based on residential heating and cooling load profiles developed using US DOE's BEopt and EnergyPlus residential simulation modeling software.

3.3.3 Results and Recommendations

Total energy and demand savings for duct repairs and replacements are included in Table 3.3-1.

Table 3.3-1: Air Flow Performance Gross Energy and Demand Savings

Measure	Energy Savings (kWh)	Peak Demand Savings (kW)	Non-Coinc. Demand Savings (kW)	ERCOT 4CP Demand Savings (kW)
Duct Sealing/ Replacement	927,776	388	416	363

In FY 2016, nearly all projects participating in the program utilized flow hood testing while just 2% utilized duct blaster testing. Frontier recommends that all projects be required to complete leakage-to-outside testing using a duct blaster and blower door. This would eliminate the need for a leakage-to-outside adjustment factor and help ensure that the savings are only awarded for the prevention of air leakage to unconditioned spaces.

3.4 RESIDENTIAL HVAC PROGRAM

3.4.1 Overview

CPS Energy's Residential Heating, Ventilation, and Air Conditioning (HVAC) Program offers incentives to promote the installation of energy efficient HVAC equipment. The program covers the installation of central air conditioners (ACs), central heat pumps (HPs), window air conditioners (WACs), and ground source heat pumps (GSHPs).

The program had 9,437 projects in FY 2016, including 3,827 ACs, 2,479 HPs, 3,131 WACs and no GSHPs. This corresponds to an 11% increase in program participation compared to FY 2015.

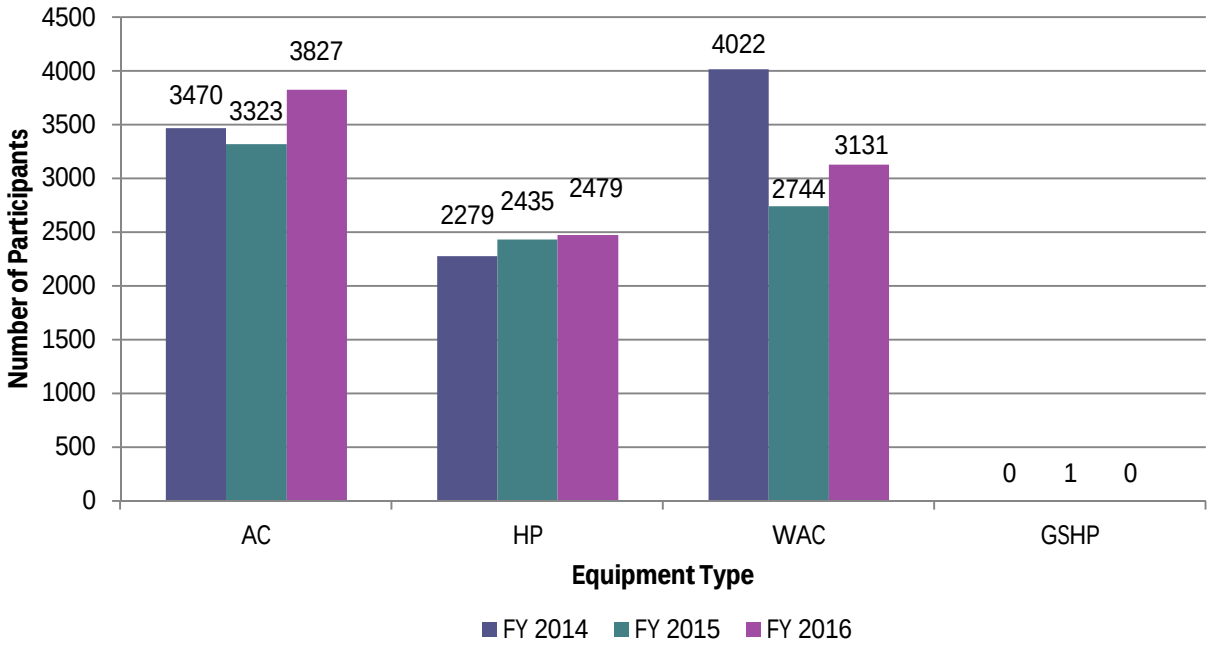


Figure 3.4-1: Residential HVAC – FY 2014, 2015, & 2016 Participation Comparison

3.4.2 Savings Calculation Method

Energy and demand savings for central air conditioners and heat pumps were estimated using algorithms developed by Frontier for Texas TRM v. 2.1.

Energy savings for window air conditioners were estimated using algorithms developed by Frontier for Texas TRM v. 2.1.

Frontier used approved deemed savings values for TRM climate zone 3 for central air conditioners and heat pumps. Frontier replaced any weather specific assumptions related to the window air conditioner measure with San Antonio climate data.

3.4.3 Equipment Verification

To verify the accuracy of the efficiency data listed in the program database, Frontier randomly selected sample projects to validate equipment capacity and efficiency based on manufacturer and model number. Reported AC and HP values were compared against equipment information maintained by the Air Conditioning, Heating, and Refrigeration Institute (AHRI).[9] Reported WAC values were compared to manufacturer specification sheets and/or equipment information maintained by ENERGY STAR.[10]

[9] AHRI Certification Directory: https://www.ahridirectory.org/ahridirectory/pages/home.aspx.
[10] ENERGY STAR Certified Room Air Conditioners: http://www.energystar.gov/productfinder/product/certified-room-air-conditioners/.

- 36 of 38 AC units were fully verified as having the correct capacity and cooling efficiency ratings. Of the remaining two units, each had a discrepancy in the reported EER, which had no impact on the verified savings. One of these units had a discrepancy in the reported SEER. Savings calculated using reported capacities and efficiency ratings were compared to savings calculated using the adjusted capacities and efficiency ratings. This comparison resulted in an average kW realization rate of 99.3% and an average kWh realization rate of 99.4%. Based on these results, no adjustments were made to reported savings for all AC units.

- 23 of 25 HP units were verified as having the correct capacity and cooling/heating efficiency ratings. Of the remaining two units, one had a discrepancy in the reported capacity, which was large enough to affect verified savings. The other unit had a discrepancy in the reported SEER, but the discrepancy was not large enough to have an effect on verified savings. Savings calculated using reported capacities and efficiency ratings were compared to savings calculated using the adjusted capacities and efficiency ratings. This comparison resulted in an average kW and kWh realization rate of 98.4%. Based on these results, no adjustments were made to reported savings for all HP units.

- 29 of 31 WAC units were verified as having the correct capacity and cooling efficiency ratings. Of the remaining two units, each had a discrepancy in the reported EER. One of the units had a discrepancy in the reported capacity. Each of these discrepancies affected verified savings for the respective units. Savings calculated using reported capacities and efficiency ratings were compared to savings calculated using the adjusted capacities and efficiency ratings. Because the adjusted efficiencies and capacities had a slight positive effect on verified savings, no adjustments were made to reported savings for WAC units.

3.4.4 Results and Recommendations

Total energy and demand savings for the installation of central heat pumps, central air conditioners and window air conditioners are included in Table 3.4-1.

Table 3.4-1: Residential HVAC Gross Energy and Demand Savings

Measure	Energy Savings (kWh)	Peak Demand Savings (kW)	Non-Coinc. Demand Savings (kW)	ERCOT 4CP Demand Savings (kW)
Heat Pump	4,217,174	1,360	1,879	1,727
Central AC	8,872,329	4,869	5,325	4,690
Window Air Conditioners	159,988	88	96	85
Total	13,249,491	6,317	7,300	6,502

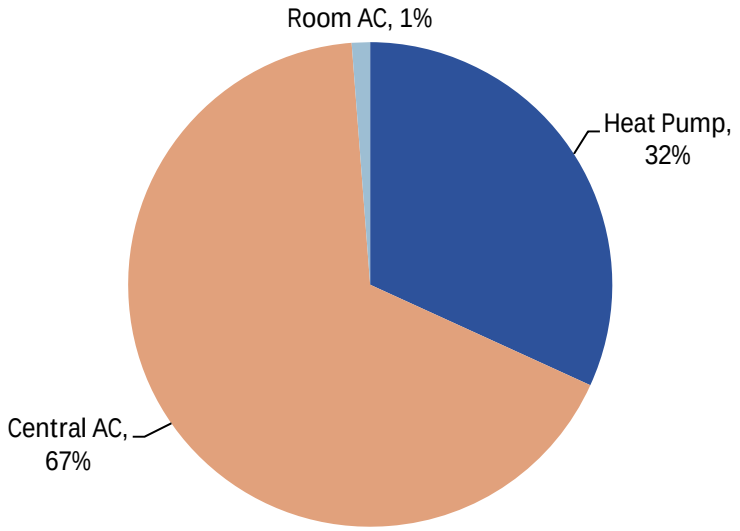


Figure 3.4-2: Residential HVAC – kWh by Measure

Frontier's recommendations for future implementation of the Residential HVAC Program:

- Require that an invoice be captured for each project, if possible, to assist in determining appropriate incremental costs for the measure. During FY 2016, an invoice amount was not collected for 37% of project installations.
- Ensure that program minimum efficiency requirements for central air conditioners are raised to reflect the updated federal efficiency standards that will be enforced beginning July 1, 2016.
- Ensure that program minimum efficiency requirements for window air conditioners are raised to reflect the updated room air conditioner efficiency.[11] Zero savings were reported for 504 of 3,131 (16%) of rebated window units because reported EER/CEER did not exceed the applicable minimum federal efficiency standard.

3.5 SOLAR INITIATIVE - RESIDENTIAL PROGRAM

3.5.1 Overview

CPS Energy offers rebates for residential solar photovoltaic (PV) and solar thermal (hot water) systems; however, during the FY 2016 program year there were no solar thermal systems installed. Residential solar PV rebates were offered at $1.60 per AC watt up to the lesser of $25,000 or 50% of the total installation price; and at $1.30 per AC watt for non-local installers. All residential solar PV systems were required to be installed by a CPS Energy-certified contractor. Rebates were not available for leased equipment.

All systems are required to be interconnected to the CPS Energy distribution system on the customer's side of the meter in a net metering arrangement. Systems must be permitted, pass

[11] Department of Energy Standards and Test Procedures for Residential Room Air Conditioners. http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/41.

all required inspections, and comply with CPS Energy's requirements for interconnection.

In FY 2016, 910 residential solar PV systems totaling 6,699 kWdc were installed, and $9.3 million in rebates distributed. The average residential solar PV system size was 7.4 kWdc. The figure below summarizes the residential solar PV program history in terms of capacity installed, average system prices and rebate levels annually.

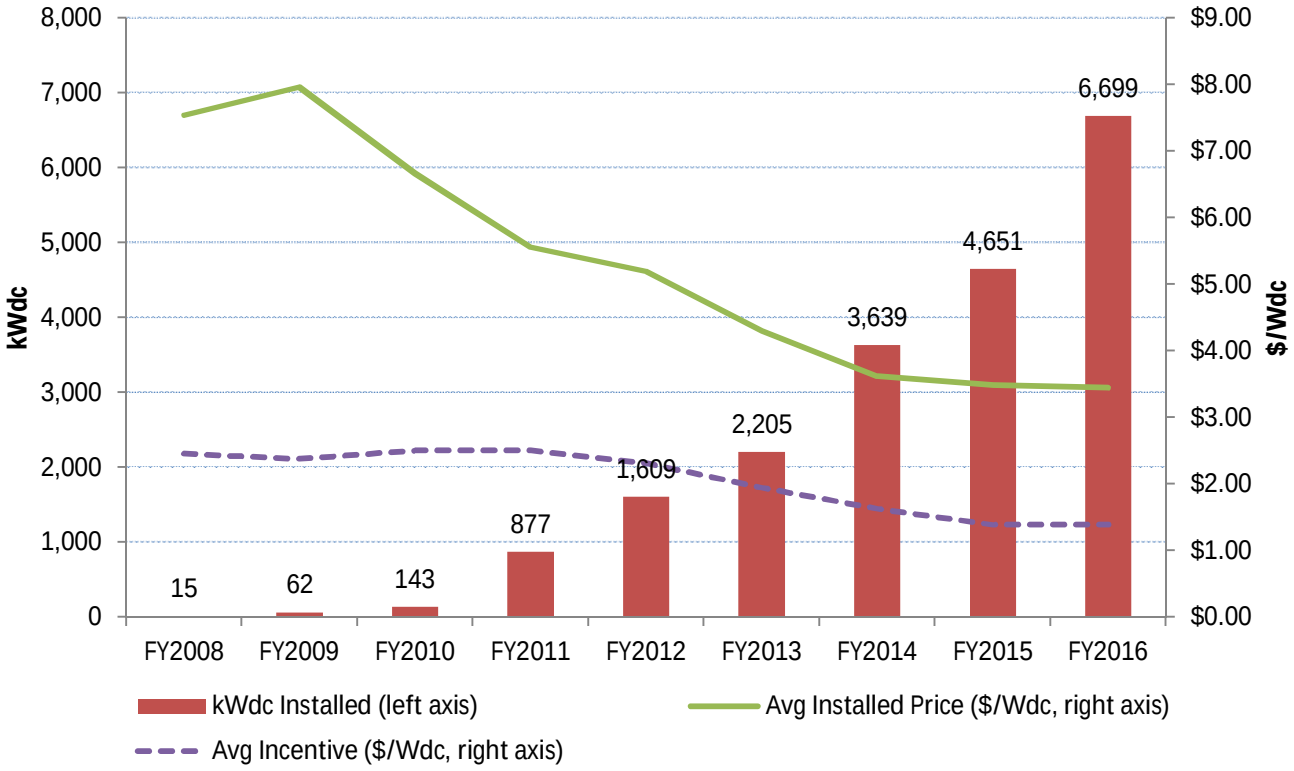


Figure 3.5-1: Residential Solar PV Program History - Annual Capacity Installed, Average System Price, and Average Rebate Levels

3.5.2 Savings Calculation Method

The following subsections describe Frontier's approach to estimating savings for residential PV installations.

3.5.2.1 Energy Savings (kWh)

Energy savings estimates were generated by modeling the annual energy production from a representative fleet of residential PV systems using the National Renewable Energy Laboratory's (NREL) PVWatts version 5 (released in November 2014) and Typical Meteorological Year version 3 (TMY3) weather data from the San Antonio Kelly Field Air Force Base (Kelly AFB) station.[12] The representative fleet was constructed from a weighted average of

[12] Frontier examined PV production as modeled using three different San Antonio TMY3 data sources and used Kelly AFB to be consistent with the probabilistic analysis for Demand Savings. Annual energy production estimates generated by PVWatts version 5 have been demonstrated to more closely match measured system performance data, and version 5 addresses concerns that

7 different array tilt and orientation combinations, with weightings conforming to expected residential distributions and producing an annual energy production estimate that was consistent with the sum of production estimates for individual systems produced by CPS Energy and stored in the CPS Energy program database.

3.5.2.2 Coincident Peak (CP) Demand Savings (kW)

Frontier's approach to estimating peak demand savings utilized a probabilistic analysis based on modeled system performance during the 20 highest probability summer peak hours. In essence, the approach relates actual historical weather data, day-of-week, and time-of-day variables to ERCOT zonal peak conditions, and applies those historical relationships to TMY3 hourly weather data to estimate the hours in a TMY data file most likely to coincide with hours of high demand in ERCOT's CPS zone. Estimates of CPS Energy's residential PV fleet energy production were derived using PVWatts, and hours associated with high demand in the TMY data were identified. We then calculate a probability-weighted estimate of PV production during those peak hours.

3.5.2.3 Non-Coincident Peak (NCP) Demand Savings (kW)

Non-coincident demand savings represent the maximum kW produced by the modeled representative fleet of residential PV systems installed in FY 2016 in any hour.

3.5.2.4 ERCOT 4CP Demand Savings (kW)

The ERCOT 4CP demand savings estimate represents the average estimated demand savings produced by the modeled representative fleet of residential PV systems installed in FY 2016 during ERCOT 4CP intervals from 2011-2015.

3.5.3 Results and Recommendations

The gross energy and demand savings for the Residential Solar Initiative are presented in Table 3.5-1.

Table 3.5-1: Residential Solar Initiative Gross Energy and Demand Savings

Measure	Energy Savings (kWh)	Peak Demand Savings (kW)	Non-Coinc. Demand Savings (kW)	ERCOT 4CP Demand Savings (kW)
Residential Solar PV	9,392,544	2,612	5,386	2,268

CPS Energy has committed an additional $30 million to the residential and commercial solar rebate programs starting in FY 2017, to be divided into three tranches:

- Tranche 1 – first $10 million at a rebate level of $1.20 per watt
- Tranche 2 – next $10 million at a rebate level of $1.00 per watt

PVWatts version 1 tended to under-predict PV system performance given the default input assumptions. See http://pvwatts.nrel.gov/version_5.php for more information.

- Tranche 3 – last $10 million at a rebate level of $0.80 per watt

Projects will be rebated based on the applicable rebate tier at the time of commissioning. For projects submitted after February 1, 2016, the rebate amount will apply equally to residential and commercial projects. The current rebate limits of $25,000 for residential projects and $80,000 for commercial remain in place. Rebates are also capped at 50% of project cost.

Frontier's recommendations pertaining to an extended rebate program are:

- A substantially expanded rebate program will require additional administrative effort. Investments toward automating the incentive application process could reduce administrative burdens and speed the process for customers and installers.
- Moving to PVWatts v5 for estimating energy savings would produce more accurate results.
- CPS Energy should ensure that interconnection inspectors and/or M&V contractors verify installed equipment in addition to performing a backfeed test when they visit the site, at least for larger installations and for a randomly-selected sample of smaller installations.
- The accuracy of energy savings estimates could be enhanced over time with access to meter data, including data from both solar meters and customer revenue meters.

3.6 NEW HOMES CONSTRUCTION PROGRAM

3.6.1 Overview

CPS Energy's FY 2016 new homes program provided incentives for 1,393 new homes completed in FY 2016, down from the 2,139 homes participating in the program in FY 2015. The 1,393 new homes built through the program were built by seventeen builders working with three ratings companies.

CPS Energy's new homes program had to adapt to a significant transition in FY 2016: the city of San Antonio adopted IECC 2015 as its residential energy code effective July 15, 2015. This code change necessitated a mid-year shift in program eligibility requirements. After July 15, CPS Energy revised the reference codes against which new homes had to be compared to achieve the tier one or tier two incentives offered for the FY 2016 residential new construction program. The change is shown in Table 3.6-1.

Table 3.6-1: New Homes Construction – Change in Eligibility Requirements, FY 2016 New Homes Program

Incentive	Amount ($)	Before July 15	After July 15
Tier 1	$800	- 15% better than IECC 2009	- 18% better than IECC 2012, or - 15% better than IECC 2015
Tier 2	$1,500	- 30% better than IECC 2009	- 31% better than IECC 2012 or IECC 2015

Participants can also qualify by obtaining certification through the Build San Antonio Green program. Level 1 certification with the Build San Antonio Green program also requires achieving the 15 percent improvement threshold over the currently-relevant code.

3.6.2 Participation Trends

Participation slowed significantly after the code change took effect. There were 45 homes built in FY 2016 that exceeded the 30 percent improvement threshold and obtained the $1,500 Tier 2 incentive. However, all 45 of these homes (about 3 percent of total program participants) were built prior to the July 15 change in reference criteria.

Table 3.6-2: New Homes Construction – Program Participation by Tier, Before and After Code Change

Tier	Before July 15	After July 15	Total
Tier 1	1,134	214	**1,348**
Tier 2	45	0	**45**
Total	**1,179**	**214**	**1,393**

3.6.3 Savings Calculation Methods

For projects completed prior to the July 15 code change, Frontier reviewed the demand and energy savings estimated according to the same formulae employed for the FY 2015 M&V Report:[13]

- Demand Savings (kW): NCP Demand savings are estimated to be 1.1 kW per project. Peak-coincident (CP) demand savings were estimated by applying the ratio of CP:NCP savings from the delta load shapes developed for evaluating homes built against the IECC 2015 baseline to the 1.1 kW NCP demand savings estimate.

- Energy Savings (kWh): Energy savings are estimated according to a formula that relates the percent improvement over code to kWh.

$$kWh = {[\,\%\ improvement\ over\ code]}/{100}\ x\ 23{,}886$$

- Essentially, every percent improvement over IECC 2009 provides approximately 240 kWh in annual energy savings. HERS ratings are similarly related to percent improvement over code by a formula:

$$\%\ improvement\ over\ code = [-1.143\ x\ HERS] + 99.4$$

[13] The demand and energy savings estimates for the IECC 2009 baseline were derived for CPS Energy by Nexant, Inc. Due to time limitations in preparing the FY 2015 M&V Report, Frontier was not able to analyze or revise these estimates. Given the retirement of the IECC 2009 baseline, for the FY 2016 M&V Report Frontier opted to focus on evaluating and revising savings estimates for the new IECC 2015 reference case.

3.6.3.1 IECC 2015 Reference Home

The Energy Systems Lab's (ESL) International Code Compliance Calculator (IC3) and REM/Rate, the software used to establish Energy Star program compliance, provide both site and source energy savings estimates. Source energy savings estimates are the basic requirement for establishing whether program guidelines have been met and the incentive tier for a given project. Neither tool provides the coincident peak (CP) or non-coincident peak (NCP) demand savings needed for benefit-cost analysis of the new homes program. As such, Frontier employed BEopt residential building energy use simulation software to develop models representative of the general suite of measures being incorporated into participating homes in order to verify the energy savings estimates from the IC3 calculator and to estimate CP and NCP demand savings. The Frontier model is a simple 2,500 square foot single-story square home with unfinished attic, built on a slab. The reference model is designed in accordance with the requirements for creating a standard reference model in Section R405 of the IECC 2015.

Energy savings estimated by the IC3 software for a sample of homes completed after the IECC 2015 code went into effect are first compared to those estimated using the above-referenced formula. On average, savings estimated by IC3 were about 30 percent of those estimated using the previous formula. This is to be expected; 15 percent of a smaller number (reference home expected annual energy use) should produce a smaller number (energy savings).

Frontier reviewed a sample of participating homes completed after July 15, 2015 that were evaluated using IC3. Frontier's review indicates that builders are using a relatively limited set of improvements to meet program requirements: the suite of measures being incorporated into participating homes is summarized in Table 3.6-3.

Table 3.6-3: New Homes Construction - Measures Employed in Participating Homes vs. Requirements of IECC 2015

Component	Characteristic	IECC 2015	Sample Homes
Windows	SHGC	0.25	0.22
	U-factor	0.4	0.35
Roof	Radiant Barrier	Not Required	Installed
	Ceiling Insulation	R-38	R-30
HVAC	AC SEER	14	15, 16
Air Infiltration	Leakage (ACH50)	5	3, 4
Duct Leakage	CFM_{25} per 100 ft^2	4	~2.5

Broadly, builders met program requirements by installing windows that were slightly better than code requirements, installing radiant barriers, applying ceiling insulation that was actually below the code required R-38, installing more efficient air conditioners, and doing a better job sealing the homes and the ducts than required by code. The windows, radiant barrier, and ceiling

insulation used were common to all homes, while some variation existed in the HVAC SEER installed and leakage (whole home and duct) reductions achieved.

3.6.3.2 Energy Savings (kWh)

Energy savings for the homes completed prior to July 15 were estimated according to the formula for estimating energy savings presented in section 3.6.3, above. Annual energy savings for these homes is estimated to be about 6.2 MW.

For estimating the savings attributable to homes completed after July 15, Frontier developed two models to represent the permutations observed in the as-built homes:

- Tier 1a: 15 SEER, 4 ACH50, 2.5 CFM_{25}/100 ft^2 (finished floor area, or FFA)
- Model Tier 1b: 15 SEER, 3 ACH50, 2.5 CFM_{25}/100 ft^2 (finished floor area, or FFA)

Participating homes employing the characteristics incorporated into the Tier 1a group were deemed to be 21 percent above code on average, while those that achieved the additional ACH of air leakage reduction (Tier 1b) beat code by 25 percent on average.

Table 3.6-4: New Homes Construction - Site Electric Energy Savings Estimates

Model	Est. Percent **Improvement** over Code	IC3 Ave. Site Energy Savings (kWh/100 ft^2)	BEopt Site Energy Savings (kWh/100 ft^2)	Percent Difference
Model Tier 1a	15-23	47.9	18.6	64%
Model Tier 1b	23-30	55.3	19.6	61%

Frontier's on-site electric energy savings estimates are between 35 and 40 percent of those estimated by the code compliance calculator. Frontier performed basic desktop engineering calculations to confirm the reasonableness of the lower savings estimates from the BEopt models.

Based on these results, Frontier applies its model-derived energy savings estimates to participating homes completed after July 15, 2015. The average conditioned floor area of sample homes is about 2,900 square feet, resulting in energy savings estimates of 540 kWh and 570 kWh per home with program-estimated savings greater than and less than 23%, respectively.

3.6.3.3 Coincident Peak (CP) Demand Savings (kW)

Frontier used delta load shapes from model runs to extract energy use in likely coincident peak (CP) hours and estimate CP demand savings for homes completed after July 15. CP demand savings for the typical post-July 15 participant home are estimated to be just under 0.4 kW. In all, homes completed after July 15 are estimated to provide 101 kW of CP demand savings.

For those homes completed prior to July 15, delta load shapes were not developed, so the CP demand savings are estimated as a function of the NCP demand savings. The NCP demand savings estimate of 1.1 kW was multiplied by the ratio of CP demand savings to NCP demand savings for the post-July 15 homes, on the basic assumption that the pattern of savings from homes being compared to the IECC 2015 standard reference home should be relatively similar to that of homes built to beat the prior code baseline. On this basis, CP demand savings of 1,077 kW were estimated for the homes completed prior to July 15.

In all, FY 2016 participating new homes are estimated to provide 1,178 kW of CP demand savings.

3.6.3.4 Non-Coincident Peak (NCP) Demand Savings (kW)

For those homes completed prior to July 15, NCP demand savings were estimated using the previously-derived estimate of 1.1 kW NCP demand savings per home. The 1,179 homes completed prior to July 15 are therefore estimated to provide 1,297 kW of NCP demand savings.

Frontier extracted the maximum hourly value from the delta load shapes from its model runs to estimate the NCP demand savings for homes completed after July 15. NCP demand savings for the typical post-July 15 participant home are estimated to be about 0.5 kW. In all, homes completed after July 15 are estimated to provide 120 kW of NCP demand savings.

FY 2016 participating new homes are estimated to provide 1,417 kW of NCP demand savings.

3.6.3.5 ERCOT 4CP Demand Savings (kW)

Frontier used the delta load shapes from its model runs to extract energy use in likely ERCOT 4CP hours and estimate the 4CP demand savings for homes completed after July 15. ERCOT 4CP demand savings for the typical post-July 15 participant home are estimated to be 0.45 kW. In all, homes completed after July 15 are estimated to provide 93 kW of 4CP demand savings.

For those homes completed prior to July 15, delta load shapes were not developed, so the CP demand savings are estimated as a function of the NCP demand savings. The NCP demand savings estimate of 1.1 kW was multiplied by the ratio of 4CP demand savings to NCP demand savings for the post-July 15 homes, on the basic assumption that the pattern of savings from homes being compared to the IECC 2015 standard reference home should be relatively similar to that of homes built to beat the prior code baseline. On this basis, 4CP demand savings of 1,004 kW were estimated for the homes completed prior to July 15.

FY 2016 participating new homes are estimated to reduce demand by 1,098 kW during the ERCOT 4CP.

3.6.4 Impact Analysis Results

FY 2016 estimated energy savings and coincident peak, non-coincident peak, and ERCOT 4CP demand savings for the new homes program are presented in Table 3.6-5.

Table 3.6-5: New Homes Construction Gross Energy and Demand Savings

Participant Type	Participant Count	Energy Savings (kWh)	Peak Demand Savings (kW)	Non-Coinc. Demand Savings (kW)	ERCOT 4CP Demand Savings (kW)
IECC 2009 Baseline	1,179	6,181,341	1,077	1,297	1,004
IECC 2015 Tier 1a	160	105,522	73.9	88	68.4
IECC 2015 Tier 1b	54	37,840	26.6	32.4	25
Total	**1,393**	**6,324,703**	**1,177**	**1,417**	**1,098**

3.6.5 Recommendations

Given the gap between estimates of typical new homes savings derived using IC3 and BEopt simulation tools, CPS Energy should continue considering the impacts associated with using different tools for estimating future savings. There may be a need to revise the certification approach, participation requirements, or incentive payments to maintain program cost-effectiveness.

3.7 REFRIGERATOR PROGRAM

3.7.1 Overview

CPS Energy implements a refrigerator efficiency program that incorporates two elements: (1) a rebate program to encourage the purchase of ENERGY STAR new refrigerators and; (2) a recycling program to remove older, less-efficient units. Customers receive a $65 incentive for recycling a working refrigerator, and $35 for the purchase of an ENERGY STAR model.

Unlike other programs to promote the purchase of energy-efficient products, energy savings from programs to incentivize the purchase of more-efficient refrigerators are not immediately realized upon the installation of the more-efficient unit. This is because older units often are kept operating as secondary units. According to the most recent US EIA Residential Energy Consumption Survey (RECS),[14] 21% of Texas households have two or more refrigerators. These secondary units are often located in unconditioned spaces, which results in increased summer peak demand.

In FY 2016, 517 units were recycled, compared with 620 from FY 2015. In FY 2016, 330 customers received an incentive for the purchase of an ENERGY STAR model, down from 384 in FY 2015.

3.7.2 Savings Calculation Method

For the refrigerator replacement measure, energy savings are estimated using a methodology

[14] US Energy Information Administration. “Residential Energy Consumption Survey.” Accessed April 27, 2016. http://www.eia.gov/consumption/residential/index.cfm

from Texas TRM v. 2.1. This methodology was updated from earlier versions of the TRM, since the ENERGY STAR standard was updated in 2014. A replace-on-burnout scenario is assumed. Market shares of product types and adjusted volumes came from the 2011 Technical Support Document.[15]

Table 3.7-1: Refrigerator Program ENERGY STAR Deemed Energy Savings

	Top-Freezer	Bottom Freezer	Side-by-Side
Market Share	53.9%	13.6%	32.4%
Adjusted Volume	21.44	23.12	31.45
Baseline kWh	406.7	521.6	701.4
Energy Star kWh	366.0	469.5	631.2
kWh Savings	40.7	52.2	70.1
Average kWh	51.7		
Average kW	0.0075		

Texas TRM v. 2.1 contains a method for calculating energy and peak demand savings associated with refrigerator recycling and refrigerator replacement.

Energy savings are calculated as follows:

$$\boldsymbol{kWh_{savings} = kWh_{existing} \times ISAF \times PUF}$$

Where*:*

$kWh_{existing}$ = *Average annual energy consumption*[16] *= 1,308 kWh*

$ISAF$ = *In Situ Adjustment Factor*[17] *= 0.942*

PUF = *Part Use Factor*[18] *= 0.915*

$kWh_{savings}$ = *1,227*

Coincident, non-coincident, and 4CP peak demand savings were calculated using a refrigerator

[15] https://www1.eere.energy.gov/buildings/appliance_standards/pdfs/refrig_finalrule_tsd.pdf

[16] The Cadmus Group, Inc. "Residential Retrofit High Impact Measure Evaluation Report". Prepared for California Public Utilities Commission Energy Division. February 8, 2010. Average of DOE-Based Full-Year Unit Energy Consumption (weighted by representative utility survey participation).

[17] Ibid. Factor to account for variation between site conditions and controlled DOE testing conditions (90 °F test chamber, empty refrigerator and freezer cabinets, and no door openings). Appliances in warmer climate zones use more energy than those in cooler climate zones; utilized SCE data (highest percentage of warm climate projects) to best approximate Texas climate, p. 139-140.

[18] Ibid. Factor to account for the number of refrigerators that were running, running part time, or not running at the time of recycling, p. 142-143 (weighted by representative utility survey participation, p. 117).

load profile developed from the Building America Analysis Spreadsheet for existing homes.[19]

3.7.1 Results and Recommendations

The EUL for ENERGY STAR refrigerators is 17 years, based on Texas TRM v. 2.1. For the recycling measure, the EUL is 8 years, based on the assumed remaining service life of the recycled unit.

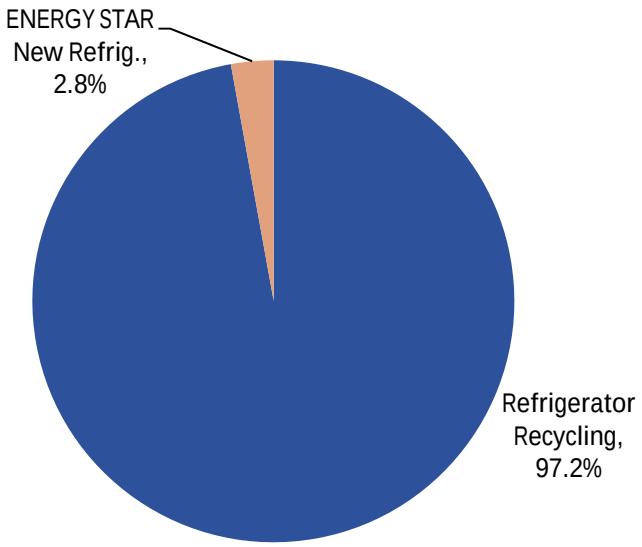


Figure 3.7-1: Refrigerator Program – kWh by Measure

The benefit-cost ratio for the program in FY 2016 was 1.16, compared with 1.52 in FY 2015. Much of this difference is due to the reduction in per-unit savings for new units, a result of the change in federal efficiency and ENERGY STAR standards. Savings for refrigerator recycling are highly dependent on the age of the units being recycled. Federal refrigerator efficiency standards were revised in 1994, 2001 and 2011. Per-unit consumption was reduced by approximately 30% in both 1994 and 2001. As the population of recycled units includes an increasing number of post-1994 and post-2001 units, the per-unit average energy savings can be expected to decrease.

Table 3.7-2: Refrigerator Program Gross Energy and Demand Savings

Measure	Energy Savings (kWh)	Peak Demand Savings (kW)	Non-Coinc. Demand Savings (kW)	ERCOT 4CP Demand Savings (kW)
Refrigerator Recycling	582,868	79.3	82.2	80.4
ENERGY STAR Replacements	17,075	2.3	2.4	2.4
Total	**599,943**	**81.6**	**84.6**	**82.8**

[19] Building America Analysis Spreadsheet for existing homes, accessed on March 10, 2016 from http://energy.gov/eere/buildings/downloads/building-america-analysis-existing-homes.

3.8 WEATHERIZATION PROGRAM

3.8.1 Overview

CPS Energy's residential weatherization program provides comprehensive retrofits for income-eligible customers. In FY 2016, the program provided a range of services to 4,051 customers, compared with 2,957 customers in FY 2015. A total of 93,168 individual measures were installed in FY 2016. These measures included repair, health & safety, and energy-saving measures. The energy-saving measures may be categorized as follows:

- CFL light bulbs
- LED light bulbs
- Wall insulation
- Ceiling insulation
- Floor insulation
- Solar screens
- Water heater pipe insulation
- Water heater insulation
- Low-flow showerheads
- Air infiltration reduction
- Duct system improvement

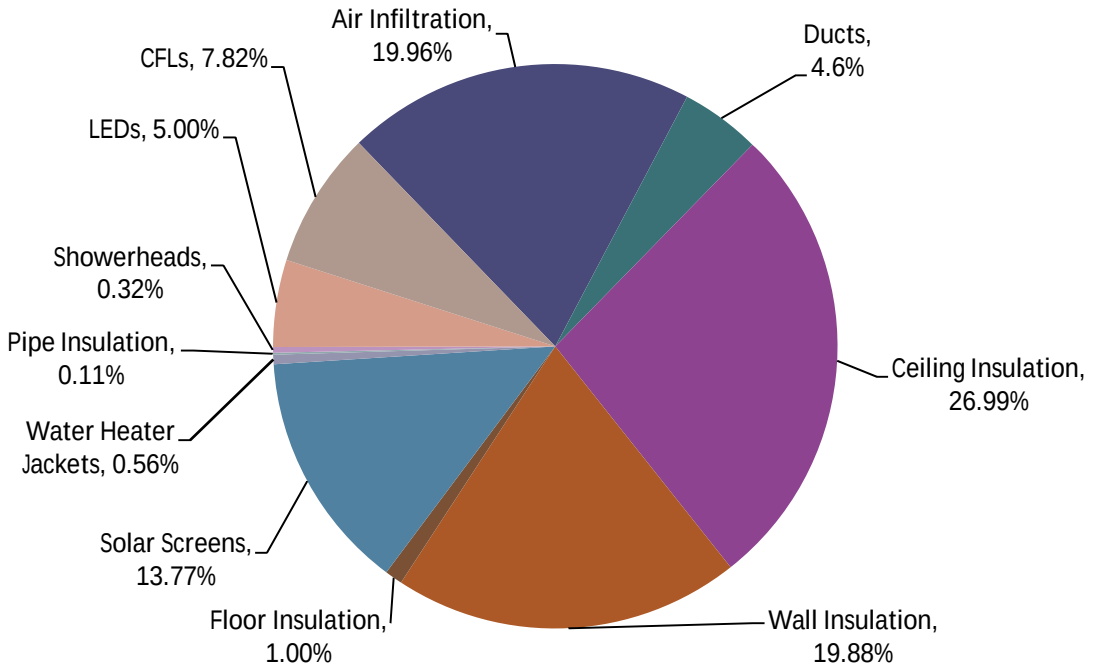


Figure 3.8-1: Weatherization – kWh by Measure

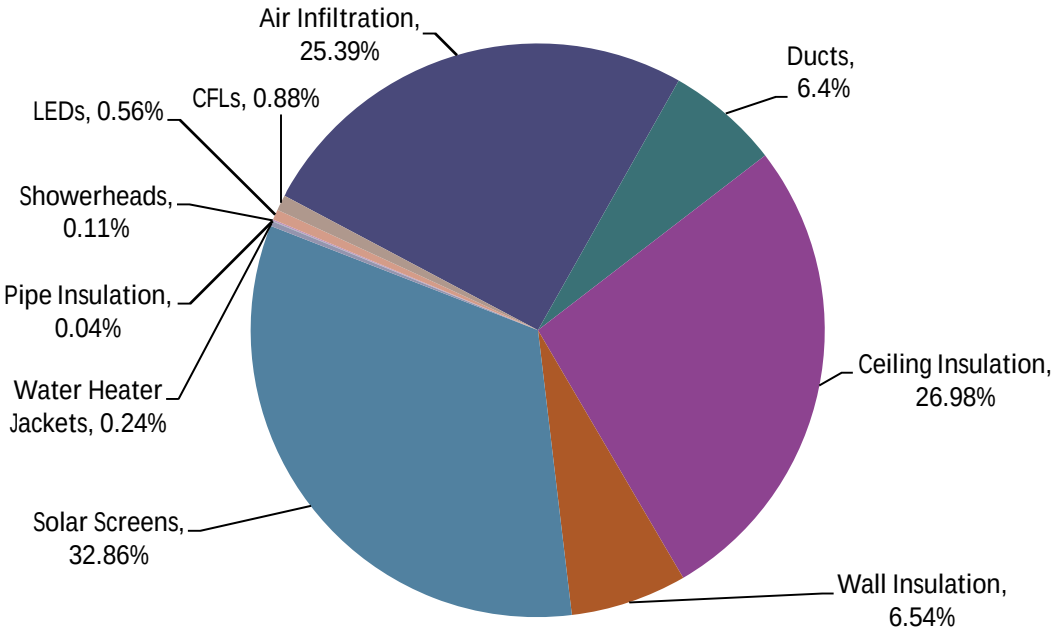


Figure 3.8-2: Weatherization – Coincident kW by Measure

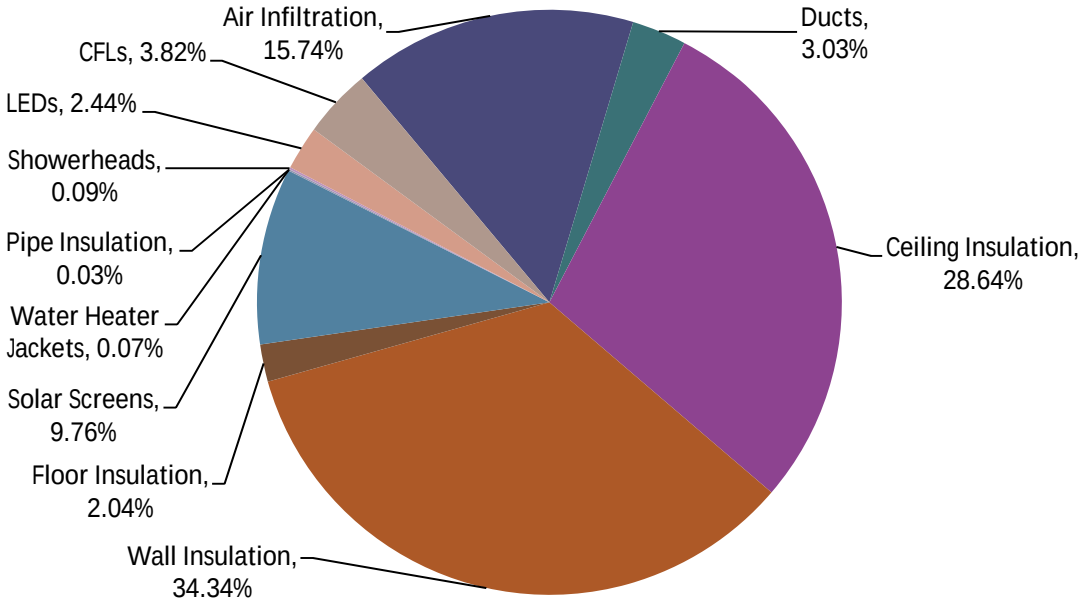


Figure 3.8-3: Weatherization – Non-Coincident kW by Measure

3.8.2 Savings Calculation Method

For each of the measures except LEDs and duct improvement, Frontier calculated energy savings using methods from Texas TRM v. 2.1.

Non-coincident peak demand savings were calculated using lighting, water heating, or HVAC load profiles. Coincident peak savings were calculated using the top 20 hour method outlined in Section 2.2, Peak Demand Impacts.

3.8.2.1 Compact Fluorescent Lamps (CFLs)

As part of the program, CPS Energy installed 41,942 thirteen-watt CFLs in FY 2016. Energy savings estimates are based on the assumption that each CFL replaces an incandescent lamp of roughly equivalent lumen output. The baseline wattages for lamps have been reduced over the past several years, to reflect the phase-in of the Energy Security and Independence Act of 2007 (EISA) standards.

Per-unit energy savings are from Texas TRM v. 2.1.

Table 3.8-1: Weatherization – CFL Per-Unit Energy Savings

Measure CFL (Watt)	Measure CFL (Range of Watts)	Comparable Incandescent Light (Watt)	Lumen Output	Daily Usage (Hrs/Day)	Annual Energy Savings (kWh)
13	12 to 16	43	750–1049	2.2	24.1

Coincident, non-coincident, and 4CPpeak demand savings were calculated using a residential lighting load profile developed from the Building America Analysis spreadsheet for existing homes.

The EUL for residential CFLs is 7.7 years, based on Texas TRM v. 2.1.

3.8.2.2 LED Lamps

As part of the program, CPS Energy installed 45,161 9.5 watt LEDs in FY 2016. Energy savings estimates are based on the assumption that each LED replaces an incandescent lamp of roughly equivalent lumen output. The baseline wattages for lamps have been reduced over the past several years, to reflect the phase-in of the Energy Security and Independence Act of 2007 (EISA) standards.

Residential LED savings were not included in Texas TRM v. 2.1. However, they were added to TRM 3.1, so the LED savings are based on those calculation methodologies. The TRM savings for this measure are in the following table.

Table 3.8-2: Weatherization – ENERGY STAR Omni-Directional LEDs – EISA Baselines

Minimum Lumens	Maximum Lumens	Incandescent Equivalent Pre-EISA 2007	Incandescent Equivalent 1st Tier EISA 2007 (W_{base})	Incandescent Equivalent 2nd Tier EISA 2007	Effective Dates for 2nd Tier EISA 2007 Baselines
750	1,049	60	43	20	1/1/2020

There is a two-step savings calculation for this measure, due to the baseline change that is scheduled to occur in 2020. For the period ending in 2020, the assumed baseline is 43 watts, based on the first-tier EISA 2007 baseline. For the remaining service life after 2020, the savings calculation assumes a baseline of 20 watts, from the federal standard that becomes effective in 2020. The Texas TRM also incorporates an interactive effects factor, to account for the impacts on cooling and heating loads. For installations in which the heating system fuel type is not known, a factor of 1.08 is used to adjust the kWh savings, and a factor of 1.46 is used to adjust the summer peak kW savings.

Assuming 2.2 hours of daily usage, the annual kWh savings values are:

- Tier 1—first 5 years, to 2020: 28.18 kWh per year
- Tier 2—remaining 15 years of service: 8.83 kWh per year

Using a method to calculate the lifetime avoided cost benefit based on CPS Energy's projected avoided energy costs, a weighted average lifetime annual savings of 14.3 kWh per year is derived.

Coincident, non-coincident, and 4CP peak demand savings were calculated using a residential lighting load profile developed from the Building America Analysis spreadsheet for existing homes.[20]

The EUL for residential LEDs is 20 years, based on Texas TRM v. 3.1.

[20] Building America Analysis Spreadsheet for existing homes, accessed on March 10, 2016 from http://energy.gov/eere/buildings/downloads/building-america-analysis-existing-homes.

3.8.2.3 Wall Insulation

CPS Energy installed wall insulation in 1,798 homes in FY 2016. Energy savings for this measure are calculated using Texas TRM v. 2.1 savings values and are based on the assumption that a previously-uninsulated wall cavity is insulated to R-13, typically by blowing in cellulose insulation. The estimated energy savings varies significantly based on reported heating and cooling system combinations:

Table 3.8-3: Weatherization – Wall Insulation Deemed Energy Savings

Electric A/C, Gas Heat (per sq. ft.)	Electric A/C, Electric Heat (per sq. ft.)	Electric A/C, Heat Pump (per sq. ft.)
0.24	4.53	1.73

Coincident, non-coincident, and 4CP peak demand savings were calculated using residential heating and cooling load profiles developed using US DOE's BEopt and EnergyPlus residential simulation modeling software.

The EUL for wall insulation is 25 years, based on Texas TRM v. 2.1.

3.8.2.1 Ceiling Insulation

As part of the weatherization program, CPS Energy installed 3,106 ceiling insulation measures in FY 2016. The number of measures exceeds the number of homes in the program because some homes received multiple insulation measures. For example, if a home had flat attic areas in which blown-in insulation was used, and sloping areas where batt insulation was used, these would be recorded as separate measures.

Energy savings for this measure are calculated using Texas TRM v. 2.1 savings values:

Table 3.8-4: Weatherization – Ceiling Insulation Deemed Annual Energy Savings (kWh)

Ceiling Insulation Base R-value	Gas Heat (per sq. ft.)	Electric Heat (per sq. ft.)	Heat Pump (per sq. ft.)
R-0	1	4.4	2.14
R-1 to R-4	0.64	2.81	1.4
R-5 to R-8	0.32	1.38	0.7
R-9 to R-14	0.17	0.72	0.36
R-15 to R-22	0.07	0.3	0.15

The above savings values assume that the base R-value is within one of the five ranges listed above, the final R-value is 30, and that there are three possible heating/cooling fuel types. The CPS Energy program has a much higher number of possible combinations of starting R-values, final R-values, and heating and cooling equipment combinations. In order to apply these savings values, Frontier mapped each of the program's insulation measures into the above categories, using each measure's estimated Btuh reduction per square foot.

Coincident, non-coincident, and 4CP peak demand savings were calculated using residential heating and cooling load profiles developed using US DOE's BEopt and EnergyPlus residential simulation modeling software.

The EUL for ceiling insulation is 25 years, based on Texas TRM v. 2.1.

3.8.2.2 Floor Insulation

As part of the Weatherization program, CPS Energy installed floor insulation in 219 homes during FY 2016. The baseline is assumed to be a house with pier and beam construction and no floor insulation against the floor of the conditioned area.

Energy savings for this measure are calculated using Texas TRM v. 2.1 savings values.

Table 3.8-5: Weatherization – Floor Insulation Deemed Annual Energy Savings (kWh)

Electric A/C and Heating Type	Site Built Home (per sq. ft.)	Manufactured Home (per sq. ft.)
Gas Heat	0	0
Electric Heat	1.71	1.66
Heat Pump	0.58	0.56

Note that for this weather zone, the Texas TRM doesn't indicate any cooling energy savings. For homes listed as having "mixed" heating fuels, Frontier averaged the gas heat and electric heat savings values.

Coincident, non-coincident, and 4CP peak demand savings were calculated using residential heating and cooling load profiles developed using US DOE's BEopt and EnergyPlus residential simulation modeling software.

The EUL for floor insulation is 25 years, based on Texas TRM v. 2.1.

3.8.2.3 Solar Screens

As part of the Weatherization program, CPS Energy installed solar screens on 3,788 homes during FY 2016. The baseline is a single pane, clear glass, unshaded, east-, west-, or south-facing window with a solar heat gain coefficient of 0.75.

Energy savings for this measure are calculated using Texas TRM v. 2.1 savings values.

Table 3.8-6: Weatherization – Solar Screens Deemed Energy Savings (kWh) per Square Foot

Gas Heat (per sq. ft.)	ER Heat (per sq. ft.)	Heat Pump (per sq. ft.)
5.83	3.79	4.73

For homes listed as having "mixed" heating fuels, Frontier averaged the gas heat and electric resistance heat savings values. Note that for this measure, the Texas TRM applies a heating penalty to homes with electric or heat pump heat, to account for the reduction in solar heat gain during the heating season.

For this measure, installed quantity was provided in united inches (window width plus height, in inches). This is the typical pricing unit for contractors. Texas TRM savings values are per square foot of treated window area. To convert united inches to square feet, Frontier assumed an average dimension of three feet by five feet. To reduce the potential error in the savings estimate resulting from this assumption, Frontier recommends that total square feet of solar screens installed per home be captured, in addition to united inches.

Coincident, non-coincident, and 4CP peak demand savings were calculated using residential heating and cooling load profiles developed using US DOE's BEopt and EnergyPlus residential simulation modeling software.

The EUL for solar screens is 10 years, based on Texas TRM v. 2.1.

3.8.2.4 Water Heater Pipe Insulation

As part of the Weatherization program, CPS Energy installed water heater pipe insulation in 459 homes during FY 2016. A total of 2,531 linear feet of pipe insulation was installed, for an average of 5.5 feet per installation. The baseline assumption is an electric water heater with no heat traps and no existing pipe insulation.

Energy savings for this measure are calculated using a Texas TRM v. 2.1 savings algorithm. Inputs to the algorithm include:

- Linear feet of pipe insulation installed.
- Surface area of the pipe to be insulated. (A pipe diameter of 0.5 inches is assumed.)
- R-value of the added insulation.
- Seasonal average ambient temperature. (Location is assumed to be in a conditioned space.)
- Water heater tank temperature. (120 degrees assumed for this calculation)
- Water heater efficiency.

From the above calculation, the annual savings for this measure are estimated as 32 kWh per installation.

Coincident, non-coincident, and 4CP peak demand savings were calculated using a DHW load profile developed from the Building America Analysis spreadsheet for existing homes.[21]

The EUL for water heater pipe insulation is 13 years, based on Texas TRM v. 2.1.

3.8.2.5 Water Heater Insulation

As part of the Weatherization program, CPS Energy installed water heater insulation on 455 water heaters during FY 2016. The baseline is assumed to be a typical electric water heater with no insulation, manufactured prior to the current federal efficiency standard.

Energy savings for this measure are calculated using a Texas TRM v. 2.1 savings algorithm. Inputs to the algorithm include the:

- Pre-installation R-value of the tank.
- Post-installation R-value. (Assumes a minimum R-5 added insulation.)
- Surface area of the water heater. (For a 40 gallon water heater of standard height and diameter this value is provided by the Texas TRM as 21.81 square feet.)
- Seasonal average ambient temperature. (Location assumed to be in conditioned space.)
- Water heater tank temperature. (120 degrees assumed for this calculation.)
- Water heater efficiency.

Using the algorithm, the annual savings for this measure are estimated to be 155 kWh per water heater insulated.

Coincident, non-coincident, and 4CP peak demand savings were calculated using a DHW load profile developed from the Building America Analysis spreadsheet for existing homes.[22]

The EUL for water heater insulation is 7 years, based on Texas TRM v. 2.1.

3.8.2.6 Low-Flow Showerheads

As part of the Weatherization program, CPS Energy installed 340 low-flow showerheads in homes with electric water heaters during FY 2016. The baseline is assumed to be a 2.5 gallons per minute (GPM) showerhead. The replacement showerhead is assumed to have a flow rate no higher than 2.0 GPM.

[21] Building America Analysis Spreadsheet for existing homes, accessed on March 10, 2016 from http://energy.gov/eere/buildings/downloads/building-america-analysis-existing-homes.
[22] Building America Analysis Spreadsheet for existing homes, accessed on March 10, 2016 from http://energy.gov/eere/buildings/downloads/building-america-analysis-existing-homes.

Energy savings for this measure are calculated using a Texas TRM v. 2.1 savings algorithm. This algorithm includes a derivation of the reduction in annual hot water used per showerhead, based on several studies. The value for all Texas weather zones is 1,074 gallons of hot water per year per showerhead. Using this value, annual savings are estimated using an algorithm that includes the following inputs.

- Water mains temperature (an average annual value of 74.7 is used for San Antonio)
- Water heater efficiency
- Water heater tank temperature (assumed to be 120 degrees)

Using the algorithm, the annual savings for this measure are estimated to be 121 kWh per showerhead.

Coincident, non-coincident, and 4CP peak demand savings were calculated using a DHW load profile developed from the Building America Analysis spreadsheet for existing homes.[23]

The EUL for low-flow showerheads is 10 years, based on Texas TRM v. 2.1.

3.8.2.7 Air Infiltration Reduction

A key element of the Weatherization program is the installation of air infiltration control measures. This measure was implemented on 4,050 homes in FY 2016. The average leakage rate reduction was 1,454 cubic feet per minute (CFM), measured at 50 Pascal.

The savings for this measure are calculated using Texas TRM v. 2.1 savings values:

Table 3.8-7: Weatherization – Air Infiltration Reduction Deemed Energy Savings per CFM_{50} Reduction

Gas Heat	Resistance Heat	Heat Pump Heat
0.27	0.79	0.44

For homes listed as having “mixed” heating fuels, Frontier averaged the gas heat and resistance heat savings values.

Coincident, non-coincident, and 4CP peak demand savings were calculated from residential heating and cooling load profiles developed using US DOE’s BEopt and EnergyPlus residential simulation modeling software.

The EUL for this measure is 11 years, based on Texas TRM v. 2.1.

[23] Building America Analysis Spreadsheet for existing homes, accessed on March 10, 2016 from http://energy.gov/eere/buildings/downloads/building-america-analysis-existing-homes.

3.8.2.8 Duct System Improvement

Another key element of the Weatherization program is duct system repair. During FY 2016, the program installed duct sealing and/or repair measures on 1,355 homes. The duct measures included:

- Replacing sections of flex duct
- Adding duct insulation
- Adding tape and mastic
- Sealing returns with foam board

Evaluating the energy savings of these measures directly using the Texas TRM is not possible, since the TRM savings calculations are based on pre- and post-installation duct leakage-to-outside measurements using a Duct Blaster™ or similar, and these measurements were not typically performed as part of the program.

The 1,355 homes with duct measures reported were reviewed to determine which of these homes had measures installed that would be likely to produce significant reductions in duct leakage. One of the measures is "Duct Seal (Tape & Mastic)." Frontier assumed that 25% or more of the estimated linear feet of duct length would need to be sealed in order to be included in the savings estimate. Linear feet of duct length was estimated based on duct system assumptions in the *Building America Benchmark Definition*.[24] Four hundred forty seven homes weatherized in FY 2016 (33%) met this standard.

To evaluate the impact of the duct sealing measures installed as part of the FY 2016 program, Frontier conducted field testing for a sample of sixteen homes. Pre- and post-duct leakage-to-outside measurements were made using a Duct Blaster™ and blower door. For the homes in the sample, an average reduction of 17.3% in duct leakage to outside was measured.

For each of the 447 homes, the CFM leakage reduction estimate was derived by multiplying the home's CFM fan flow by the estimated 17.3% leakage reduction.

The EUL for this measure is 18 years, based on Texas TRM v. 2.1.

For the FY 2016 program year, Frontier attributed savings to approximately one third of the homes that reported duct improvement measures. To better evaluate the energy savings of the duct sealing measures installed, Frontier recommends the following:

- For homes in which significant duct leakage is observed, pre and post installation leakage-to-outside testing is recommended. Leakage-to-outside testing should be performed at the same time as blower door testing.
- For duct insulation, pre and post installation R-values should be recorded, as well as duct location (conditioned, unconditioned or semi-conditioned space).

[24] Building America Research Benchmark Definition, accessed on March 24, 2016 from http://www.nrel.gov/docs/fy10osti/47246.pdf

3.8.3 Results and Recommendations

The following are the gross energy and demand savings for the Weatherization program, by measure.

Table 3.8-8: Weatherization Gross Energy and Demand Savings

Measure	Energy Savings (kWh)	Peak Demand Savings (kW)	Non-Coinc. Demand Savings (kW)	ERCOT 4CP Demand Savings (kW)
CFLs	1,010,802	31	479	37
LEDs	645,802	20	306	24
Wall Insulation	2,568,934	227	4,302	212
Ceiling Insulation	3,487,291	936	3,587	877
Floor Insulation	128,791	-	256	-
Solar Screens	1,779,338	1,140	1,223	1,067
DHW Pipe Insulation	14,489	1	4	1
Water Heater Insulation	72,275	8	8	8
Showerheads	41,209	4	11	4
Air Infiltration	2,579,052	881	1,971	825
Duct Measures	594,020	222	379	208
Total	**12,922,003**	**3,469**	**12,526**	**3,264**

3.9 RESIDENTIAL LIGHTING (LED) PROGRAM

3.9.1 Overview

In FY 2016, CPS Energy implemented a program to promote the adoption of LED lighting through a campaign with H.E.B. As part of this program, CPS Energy customers received a total of $6.00 off the purchase of a 9.5-watt LED, with CPS Energy contributing $5.00 per lamp, and H.E.B. contributing $1.00. The light output of 800 lumens is roughly equivalent to a conventional 60-watt incandescent A-lamp.

During the program year, 200,000 units were scanned by H.E.B. In addition, 10,008 units were distributed by CPS Energy through various outreach activities. Using a leakage rate of 10% and an estimated installation rate of 84%, savings estimates are based on a total of 158,766 installed units.

3.9.2 Savings Calculation Method & Results

Energy savings calculations are based on the Texas TRM v.3.1, since residential LEDs are not a measure in the TRM v. 2.1. The TRM savings for this measure are in the following table.

Table 3.9-1: Residential Lighting ENERGY STAR Omni-Directional LEDs – EISA Baselines

Minimum Lumens	Maximum Lumens	Incandescent Equivalent Pre-EISA 2007	Incandescent Equivalent 1st Tier EISA 2007 (W_{base})	Incandescent Equivalent 2nd Tier EISA 2007	Effective Dates for 2nd Tier EISA 2007 Baselines
750	1,049	60	43	20	1/1/2020

There is a two-step savings calculation for this measure, due to the baseline change that is scheduled to occur in 2020. For the period ending in 2020, the assumed baseline is 43 watts, based on the first-tier EISA 2007 baseline. For the remaining service life after 2020, the savings calculation assumes a baseline of 20 watts, from the baseline that becomes effective in 2020. The Texas TRM also incorporates an interactive effects factor, to account for the impacts on cooling and heating loads. For installations in which the heating system fuel type is not known, a factor of 1.08 is used to adjust the kWh savings, and a factor of 1.46 is used to adjust the summer peak kW savings.

Assuming 2.2 hours of daily usage, the annual kWh savings values are:

- Tier 1—first 5 years, to 2020: 28.18 kWh per year.
- Tier 2—remaining 15 years of service: 8.83 kWh per year.

Using a method to calculate the lifetime avoided cost benefit based on CPS Energy's projected avoided energy costs, a weighted average lifetime annual savings of 14.3 kWh per year is derived.

Coincident, non-coincident, and 4CP peak demand savings were calculated using a residential lighting load profile developed from the Building America Analysis spreadsheet for existing homes.[25]

The EUL for residential LEDs is 20 years, based on Texas TRM v. 3.1.

To calculate the maximum potential kW savings, the difference between the pre installation wattage (the EISA Tier 1 baseline value of 43 watts) and the post installation wattage (9.5 watts) was multiplied by the number of installed units (158,766). This produced a maximum potential savings value of 5,319 kW.

Table 3.9-2: Residential Lighting (LED) Gross Energy and Demand Savings

Measure	Energy Savings (kWh)	Maximum Potential Savings (kW)	Peak Demand Savings (kW)	Non-Coinc. Demand Savings (kW)	ERCOT 4CP Demand Savings (kW)
Residential LED	2,270,354	5,319	69	1,076	83

[25] Building America Analysis Spreadsheet for existing homes, accessed on March 10, 2016 from http://energy.gov/eere/buildings/downloads/building-america-analysis-existing-homes.

4. COMMERCIAL PROGRAMS

4.1 SUMMARY OF COMMERCIAL IMPACTS

CPS Energy offered the following programs for the Commercial sector in FY 2016:

- Commercial Lighting
- Commercial Heating, Ventilation, and Air Conditioning (HVAC)
- Solar Initiative – Commercial & Schools
- Commercial Custom
- Commercial New Construction

CPS Energy's portfolio of commercial programs addresses most markets and major commercial end uses.

To evaluate energy impacts for most program measures, Frontier utilized the Texas TRM v. 2.1 intended for use with calendar year 2015 implementation in the state of Texas. For programs or measures where other methods were used, those are referenced in each section.

Except where noted, coincident peak values were calculated using the weighted-average 20-hour probability method, as outlined in Section 2.2.

All values in the tables and charts throughout this section represent energy and demand savings from new FY 2016 program participants as measured at the participant or end-user level. These savings are adjusted in the program portfolio rollup table in the Executive Summary and in benefit-cost calculations to account for net-to-gross ratios and distribution line losses[26].

The contribution of each commercial program to the portfolio's energy, peak demand and non-coincident peak savings are shown in the following charts.

[26] Net-to-gross (NTG) ratios are estimated at the level of individual programs, and account for the net effects of free ridership and spillover. Free riders are defined as customers who would have delivered energy or demand savings without any program incentives but who received a financial incentive or rebate anyway. Spillover effects derive from customers who delivered energy or demand savings because of the program, but did not participate in the program or receive a financial incentive or rebate. Distribution line losses account for the fact that utilities must generate or import a greater amount of energy or demand than is required at the customer or end-user level because some energy is lost on the distribution system.

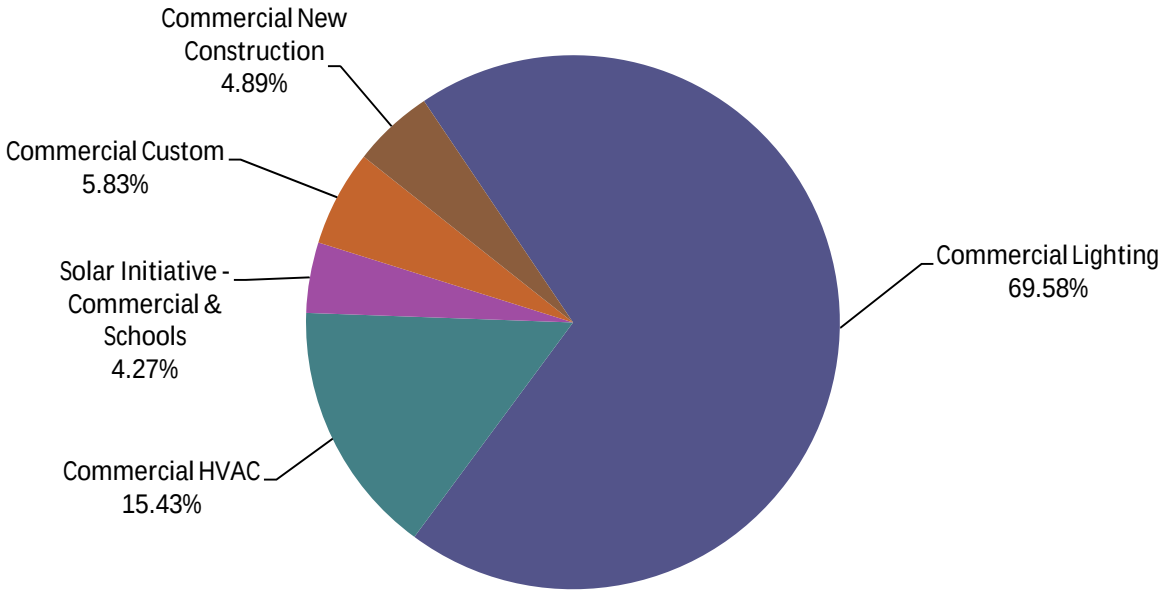


Figure 4.1-1: Summary of Commercial Impacts – kWh by Program

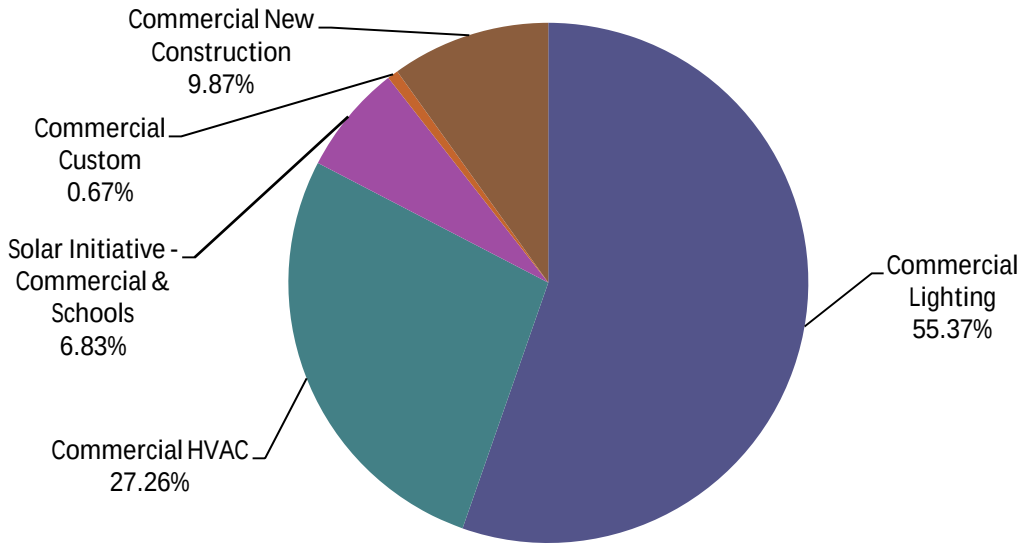


Figure 4.1-2: Summary of Commercial Impacts – Coincident kW by Program

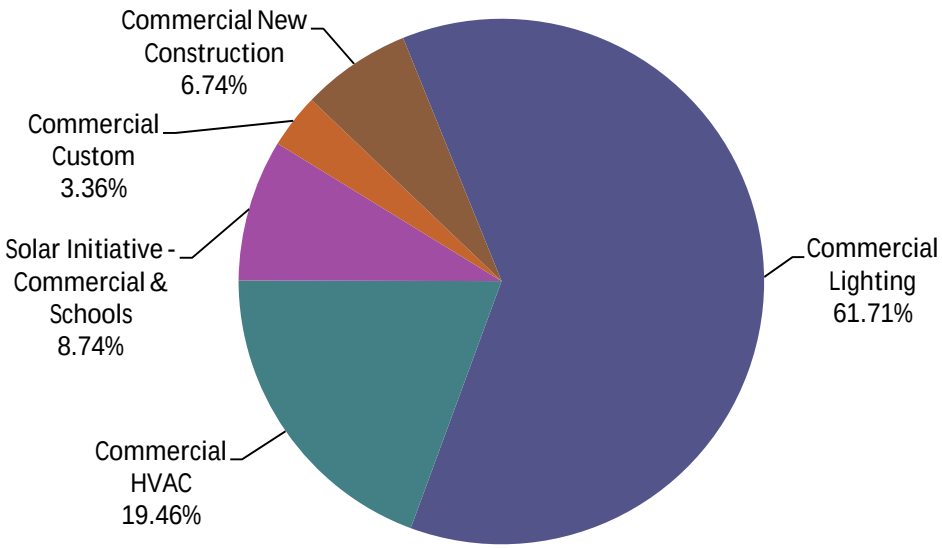


Figure 4.1-3: Summary of Commercial Impacts – Non-Coincident kW by Program

4.2 COMMERCIAL LIGHTING PROGRAM

4.2.1 Overview

In FY 2016, a total of 699 lighting projects received incentive funding in the Commercial Lighting program. This is a 183% increase from the 381 commercial lighting projects in FY 2015.

In the figures below, Frontier has broken out these projects according to the major commercial building type of each project and the kWh savings contributed by the major commercial building types.

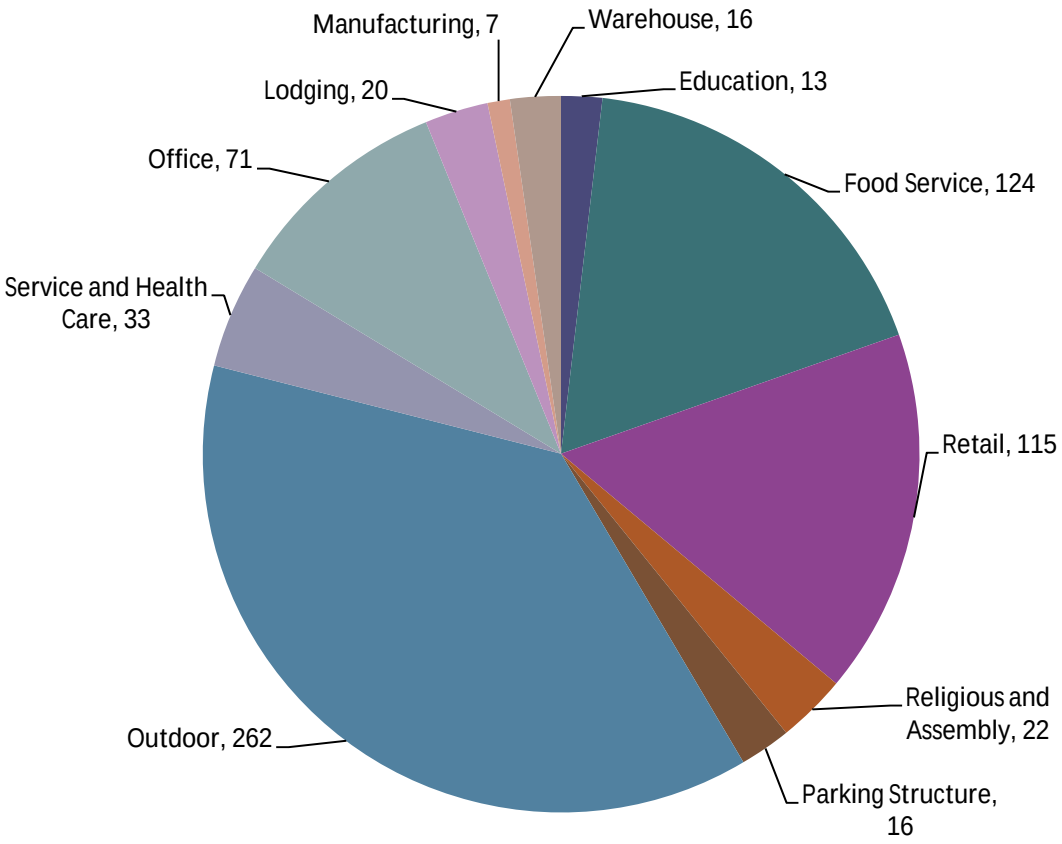


Figure 4.2-1: Commercial Lighting – Number of Projects by Commercial Building Type

According to Figure 4.2-1, most projects were outdoor, retail or food service. However, Figure 4.2-2 shows that although outdoor and retail contributed the most to kWh savings, education provided more kWh savings than food service despite the greater number of food service projects.

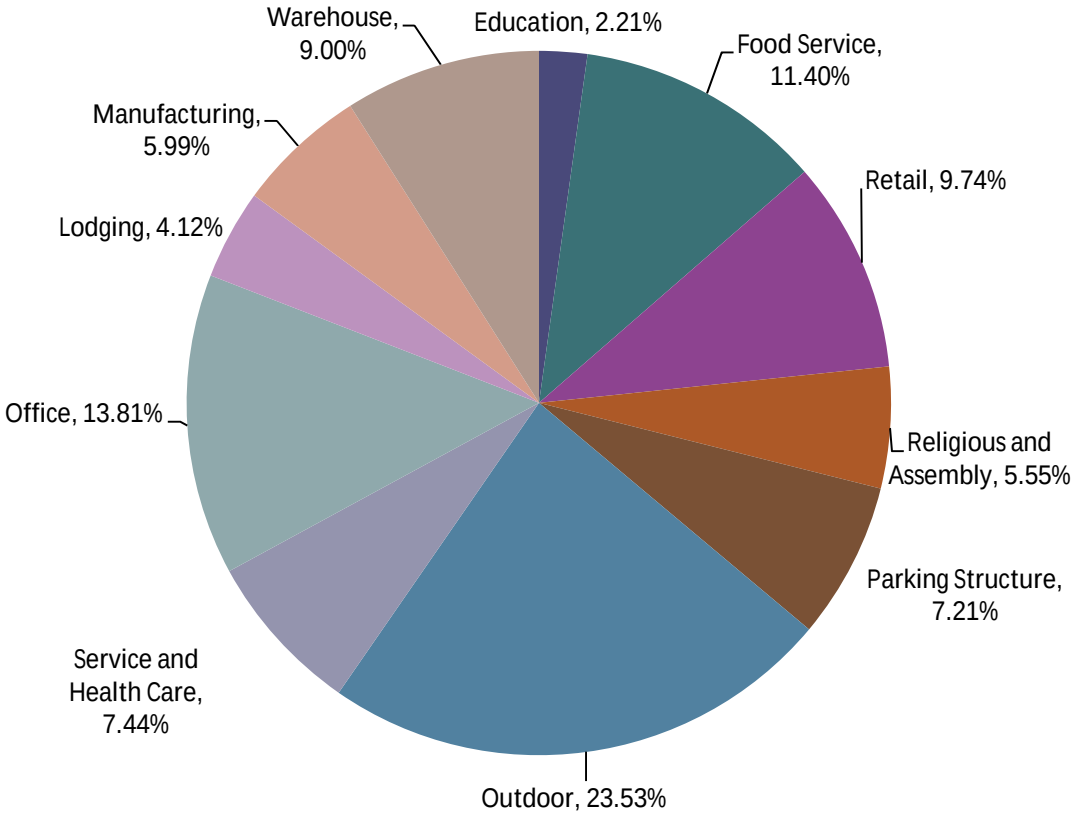


Figure 4.2-2: Commercial Lighting – Percentage of kWh Savings by Commercial Building Type

4.2.2 Savings Calculation Method

Frontier randomly selected 63 lighting projects, which provided a sample size with a 90% confidence level and +/- 10% confidence interval of all commercial lighting projects. Frontier analyzed the commercial building types and the HVAC/refrigeration interactive effects of each project.

In order to estimate interactive effects for high-efficiency lighting installed in cooled spaces, Frontier applied the following deemed factors to the applicable projects.

Table 4.2-1: Commercial Lighting Interactive Effects Factors[27]

Space Cooling Type	Demand Factor	Energy Factor
HVAC	1.10	1.05
Refrigerated	1.25	1.25
No Cooling	1.00	1.00

Retrofit project energy and demand savings were calculated using the algorithms for commercial lighting outlined in the Texas Technical Reference Manual 3.1 Volume 3.

4.2.3 Results and Recommendations

After analyzing the sample of projects, Frontier calculated a realization rate of 108% for kW savings and 106% for kWh savings. Using these realization rates, Frontier calculated the total energy and demand savings for the FY 2016 Commercial Lighting program.

Table 4.2-2: Commercial Lighting Gross Energy and Demand Savings

Measure	Energy Savings (kWh)	Peak Demand Savings (kW)	Non-Coinc. Demand Savings (kW)	ERCOT 4CP Demand Savings (kW)
Commercial Lighting	52,731,825	7,640	13,150	7,363

CPS Energy currently asks participants to provide data on pre and post wattages, fixture types, burn hours, fixture counts, and indoor/outdoor installation in a spreadsheet or PDF. Frontier makes the following recommendations to enhance the data collected from participants in order to improve energy and demand savings calculations in future programs.

- Frontier suggests that CPS Energy enhance their own lighting forms to require participants to provide information about the commercial building type (selected from a list of deemed commercial building types provided in the workbook), the type of cooling (either HVAC, refrigeration [33-41°F] or freezer [-10-10°F]), and control device descriptions.
    - Frontier recommends that participants be required to complete this information in an Excel Workbook in order to ease the data collection process for program implementation and evaluation.

[27] Texas Technical Reference Manual Version 2.0. Volume 3: Nonresidential Measures Guide for PY 2015 Implementation. Public Utility Commission of Texas. Last Revision Date: April 18, 2014.

- Alternately, participants could be required to complete a user-friendly lighting savings workbook that would calculate savings. This workbook would:
    - Provide a standardized fixture wattage lookup table for participants to select their pre and post lighting retrofit information.
    - Use deemed operational hours and coincidence factors based on the facility type.
    - Calculate savings that would include interactive HVAC effects in the savings calculation.
    - Collect and utilize information about control devices to calculate control-attributed savings.

4.3 COMMERCIAL HVAC PROGRAM

4.3.1 Overview

CPS Energy's Commercial Heating, Ventilation, and Air Conditioning (HVAC) program offers incentives to promote the installation of energy efficient HVAC equipment. The program covers the installation of split/unitary air conditioners and heat pumps (ACs/HPs), packaged terminal air conditioners and heat pumps (PTACs/PTHPs), and air/water cooled water chilling packages (chillers).

The program had 74 unique project sites in FY 2016, including 167 direct expansion (DX) split/unitary ACs, 29 DX split/unitary HPs, 20 PTACs, 28 air cooled chillers (ACCs), and 24 water cooled chillers (WCCs) for a total of 268 installed HVAC systems. This corresponds to a 13% decrease in unique project sites and a 15% increase in total HVAC systems installed compared to FY 2015.

Table 4.3-1: Commercial HVAC – Average Manufacture Year of Replaced Equipment by System Type

System Type	Average Year
Split/Unitary AC, HP, PTAC, and PTHP	1999
Air Cooled Chillers	1991
Water Cooled Chillers	1992

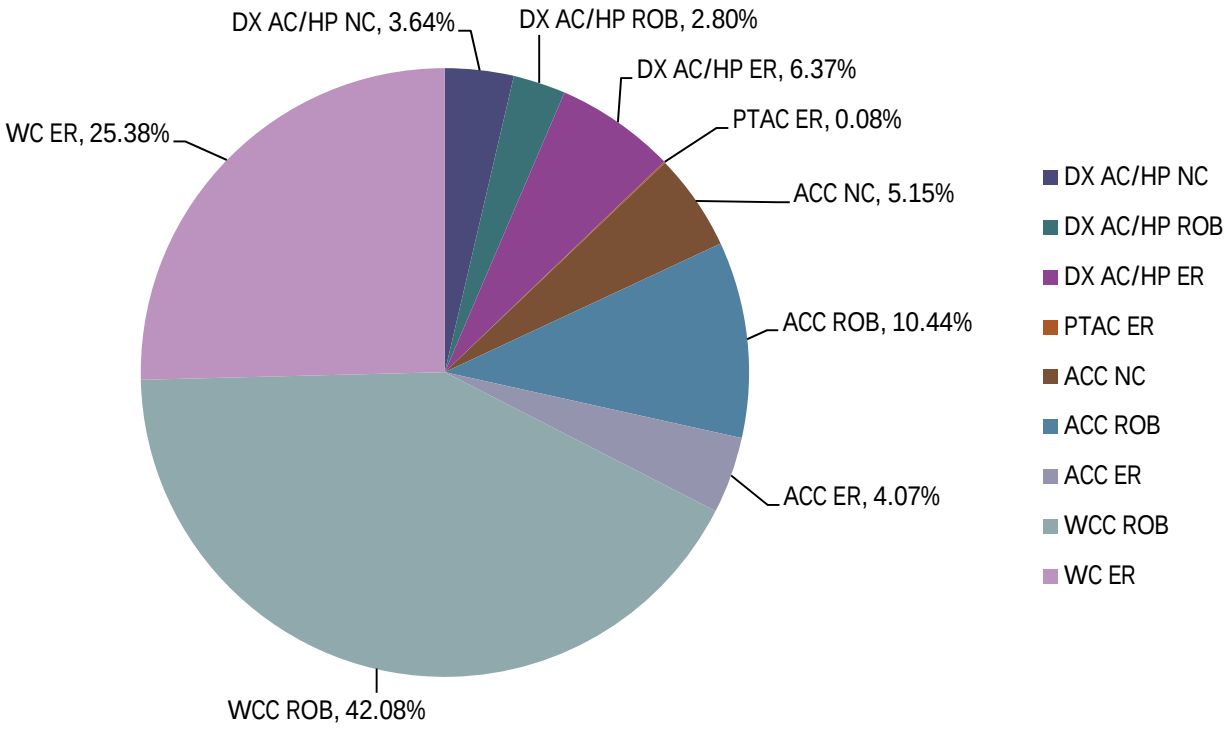


Figure 4.3-1: Commercial HVAC – Percentage of Total Tonnage for New Construction (NC), Replace-on-Burnout (ROB), and Early Retirement (ER) Projects by Equipment Type

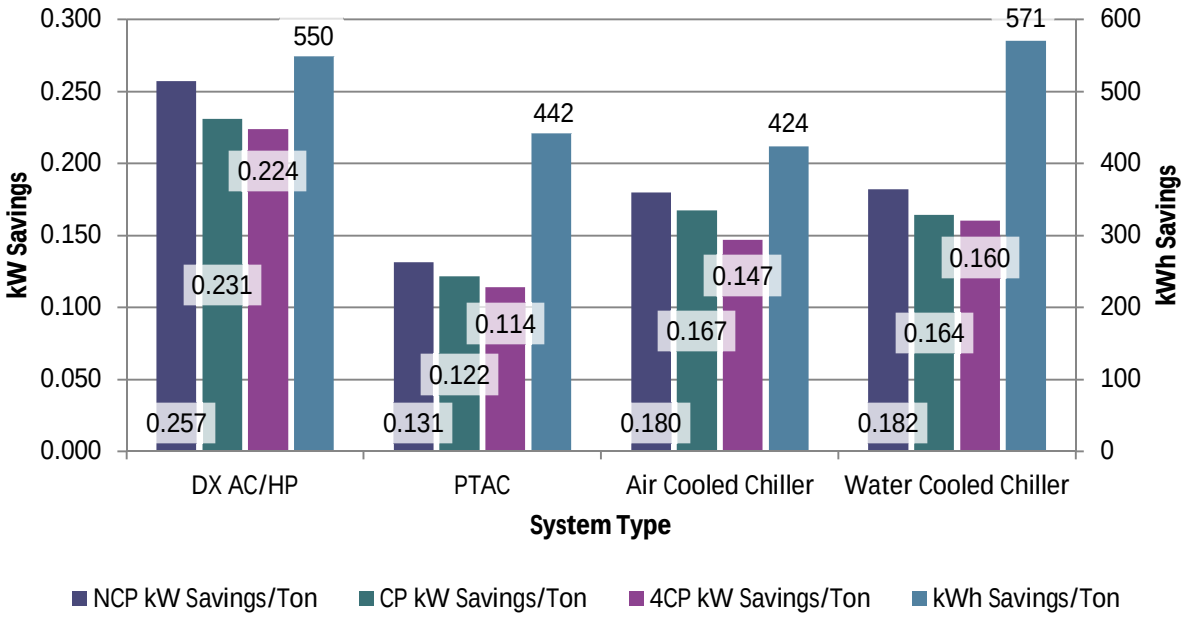


Figure 4.3-2: Commercial HVAC – Average Demand and Energy Savings per Ton by Equipment Type

4.3.2 Savings Calculation Method

Energy and demand savings were estimated using algorithms developed by Frontier for the Texas TRM v. 3.1. This method incorporates part-load efficiencies for the purposes of calculating energy savings, and includes the addition of heating energy savings to the methodology previously specified in Texas TRM v. 2.1.

In order to calculate energy savings for this measure, Frontier used weather specific assumptions for Texas TRM climate zone 3, which was the best match for the San Antonio climate zone based on a comparison of cooling degree days and heating degree days. Frontier plans to incorporate equivalent full-load hour assumptions developed using energy models that are being updated for incorporation into Texas TRM v. 4.0. These models will be adjusted to use the San Antonio weather file in order to develop a new climate zone that is regionally specific to the CPS service territory.

Baseline equipment efficiencies for new construction (NC) and replace-on-burnout (ROB) projects were assumed to be IECC 2009 for all system types in accordance with the current commercial energy code for the state of Texas.[28] Early retirement (ER) projects were allowed a dual-baseline weighted according to the estimated remaining useful life (RUL) of the existing equipment and EUL for the installed equipment.

Table 4.3-2: Commercial HVAC – Dual-Baseline for Early Retirement Projects

Baseline Period	Effective Baseline Code
RUL	Varies based on manufacture year of existing equipment
EUL - RUL	IECC 2009

4.3.2.1 Unitary AC Equipment

Savings algorithms from Texas TRM v. 3.1 were used to estimate energy savings using part-load system efficiency.

$$Cooling\ kWh\ Savings = \left(\frac{Cap_{C,pre}}{SEER/IEER_{baseline}} - \frac{Cap_{C,post}}{SEER/IEER_{installed}}\right) \times \frac{1\ kW}{1{,}000\ W} \times EFLH_C$$

$$Heating\ kWh\ Savings = \left(\frac{Cap_{H,pre}}{HSPF/COP_{baseline}} - \frac{Cap_{H,post}}{HSPF/COP_{installed}}\right) \times \frac{1\ kWh}{3{,}412\ Btu} \times EFLH_H$$

Where:

Cap_C = *Rated equipment cooling capacity of existing/installed equipment (Btuh)*

Cap_H = *Rated equipment heating capacity of existing/installed equipment (Btuh)*

[28] U.S. Department of Energy (DOE): Energy Codes by State. http://www.energycodes.gov/adoption/states.

$SEER/IEER_{baseline}$ = Deemed part-load cooling efficiency of existing equipment

$SEER/IEER_{installed}$ = Rated part-load cooling efficiency of installed equipment

$HSPF/COP_{baseline}$ = Deemed heating efficiency of existing equipment

$HSPF/COP_{installed}$ = Rated heating efficiency of installed equipment

$EFLH_C$ = Deemed equivalent full-load cooling hours

$EFLH_H$ = Deemed equivalent full-load cooling hours

Demand savings were estimated by applying the annual energy savings against a building-type specific load shape. From the resulting data, non-coincident peak (NCP) demand savings were determined by identifying the maximum demand reduction during the entire year. Coincident peak (CP) demand savings were calculated according to the procedure outlined in Section 2.2. ERCOT 4CP Transmission cost savings were calculated using the procedure outlined in Section 2.4.2.

4.3.2.2 Packaged Terminal Air Conditioners and Heat Pumps (PTAC/PTHPs)

Savings algorithms from the Texas TRM v. 3.1 were used to estimate energy savings using full-load system efficiency. Full-load efficiencies were used because PTACs do not have a part-load efficiency rating.

$$Cooling\ kWh\ Savings = \left(\frac{Cap_{C,pre}}{EER_{baseline}} - \frac{Cap_{C,post}}{EER_{installed}}\right) \times \frac{1\ kW}{1{,}000\ W} \times EFLH_C$$

$$Heating\ kWh\ Savings = \left(\frac{Cap_{H,pre}}{COP_{baseline}} - \frac{Cap_{H,post}}{COP_{installed}}\right) \times \frac{1\ kWh}{3{,}412\ Btu} \times EFLH_H$$

Where:

Cap_C = Rated equipment cooling capacity of existing/installed equipment (Btuh)

Cap_H = Rated equipment heating capacity of existing/installed equipment (Btuh)

$EER_{baseline}$ = Deemed full-load cooling efficiency of existing equipment

$EER_{installed}$ = Rated full-load cooling efficiency of installed equipment

$COP_{baseline}$ = Deemed heating efficiency of existing equipment

$COP_{installed}$ = Rated heating efficiency of installed equipment

$EFLH_C$ = Deemed equivalent full-load cooling hours

$EFLH_H$ = Deemed equivalent full-load cooling hours

Demand savings were estimated by applying the annual energy savings against a building-type specific load shape. From the resulting data, NCP demand savings were determined by identifying the maximum demand reduction during the entire year. CP demand savings were calculated according to the procedure outlined in Section 2.2. ERCOT 4CP demand savings were calculated using the procedure outlined in Section 2.4.2.

4.3.2.3 Air and Water Cooled Chillers

Savings algorithms from the Texas TRM v. 3.1 were adjusted to estimate energy savings using part-load system efficiency.

$$Cooling\ kWh\ Savings = Capacity \times \left(Cap_{C,pre} \times IPLV_{baseline} - Cap_{C,post} \times IPLV_{installed}\right) \times EFLH_C$$

Where:

Cap_C = Rated equipment cooling capacity of existing/installed equipment (tons)

$IPLV_{baseline}$ = Deemed part-load cooling efficiency of existing equipment (kW/ton)

$IPLV_{installed}$ = Rated part-load cooling efficiency of installed equipment (kW/ton)

$EFLH_C$ = Deemed equivalent full-load cooling hours

Any integrated part-load values (IPLV) rated in EER have been converted to kW/ton using the following conversion:

$$\frac{kW}{ton} = \frac{12}{EER}$$

Demand savings were estimated by applying the annual energy savings against a building-type specific load shape. From the resulting data, NCP demand savings were determined by identifying the maximum demand reduction during the entire year. CP demand savings were calculated according to the procedure outlined in Section 2.2. ERCOT 4CP demand savings were calculated using the procedure outlined in Section 2.4.2.

4.3.3 Equipment Verification

To verify the accuracy of the efficiency data listed in the program database, Frontier reviewed reported equipment information including building type, project type, system type, system count, system capacity, full/part-load cooling efficiency, and heating efficiency against project invoices, manufacturer specification sheets, and equipment information maintained by the Air Conditioning, Heating, and Refrigeration Institute (AHRI).[29]

For each split/unitary AC and HP installation, the reported cooling/heating capacity and full/part-load efficiencies were compared against available AHRI data. For each chiller installation, the reported capacity and full/part-load efficiencies were compared against manufacturer

[29] AHRI Certification Directory: https://www.ahridirectory.org/ahridirectory/pages/home.aspx.

specification sheets, referencing ratings at AHRI conditions whenever available. Reported system types, counts, capacities, and efficiencies were adjusted as necessary based on this review.

4.3.4 Results and Recommendations

Total verified energy and demand savings for the installation of split/unitary ACs and HPs, PTACs/PTHPs, and chillers are included in the following table.

Table 4.3-3: Commercial HVAC – Gross Energy and Demand Savings

Measure	Energy Savings (kWh)	Peak Demand Savings (kW)	Non-Coinc. Demand Savings (kW)	ERCOT 4CP Demand Savings (kW)
Commercial HVAC	10,351,490	3,330	3,672	3,180

The following are Frontier recommendations that CPS Energy may consider for implementation of the Commercial HVAC Program.

- In addition to the information that is already collected for all project types, Frontier will work with CPS Energy to ensure that the following information is collected for all Early Retirement projects:
    - Existing system type
    - Existing compressor type (for chillers)
    - Existing system count
    - Existing system capacity
- Adjust baseline for water cooled chillers with variable speed drives (VSDs) to use Path B option from IECC 2015. Path B is intended for applications where significant operating time is expected at part-load conditions. Path A is intended for applications where significant operating time is expected at full-load.
- Refer to the Commercial Custom Program regarding a recommendation to develop a commercial HVAC rebate offering for retrofitting rooftop HVAC units (RTUs) with advanced controls.
- Ensure that all calculators are updated to implement baseline efficiencies specified in IECC 2015, effective for the City of San Antonio as of July 1, 2015.
    - Update: Frontier has already incorporated the IECC 2015 baseline into the existing CPS savings calculator, but Frontier will need to work with CPS Energy to verify any new calculation tools.

- Review current incentive structure for water cooled chillers with VSDs to ensure cost-effectiveness relative to the baseline update for this system type.
    - Shifting the baseline for these units from the Path A to the Path B option will result in an increase in demand savings and a decrease in energy savings for all water cooled chillers with VSDs.
    - Update: Frontier is currently working with CPS Energy to review cost-effectiveness of existing incentive rates relative to increased baseline efficiencies and to recommend updated incentive rates as required.

4.4 SOLAR INITIATIVE – COMMERCIAL & SCHOOLS PROGRAM

4.4.1 Overview

CPS Energy offers rebates for commercial and school solar photovoltaic (PV) and solar thermal (hot water) systems; however, during the FY 2016 program year there were no solar thermal systems installed. Commercial solar PV rebates were offered at $1.60 per AC watt for the first 25 kWAC in capacity and $1.30 per AC watt for all remaining capacity greater than 25 kWAC, with a maximum rebate of $80,000 or 50% of the total installation price. Systems installed by non-local installers were rebated at $1.30 per AC watt, with a maximum rebate of $80,000 or 50% of the total installation price.

School solar PV rebates were offered at $2.00 per AC watt for the first 25 kWAC in capacity and $1.30 per AC watt for all remaining capacity greater than 25 kWAC, with a maximum rebate of $80,000. All systems were required to be installed by a CPS Energy certified contractor. Rebates were not available for leased equipment.

All systems are required to be interconnected to the CPS Energy distribution system on the customer's side of the meter in a net metering arrangement. Systems must be permitted, pass all required inspections, and comply with CPS Energy's requirements for interconnection.

In FY 2016, 49 commercial and school solar PV systems totaling 1,986 kWdc were installed, and $2.3 million in rebates distributed. The average solar PV system size was 40.5 kWdc. The figure below summarizes the commercial and school solar PV program history in terms of capacity installed, average system prices, and rebate levels annually.

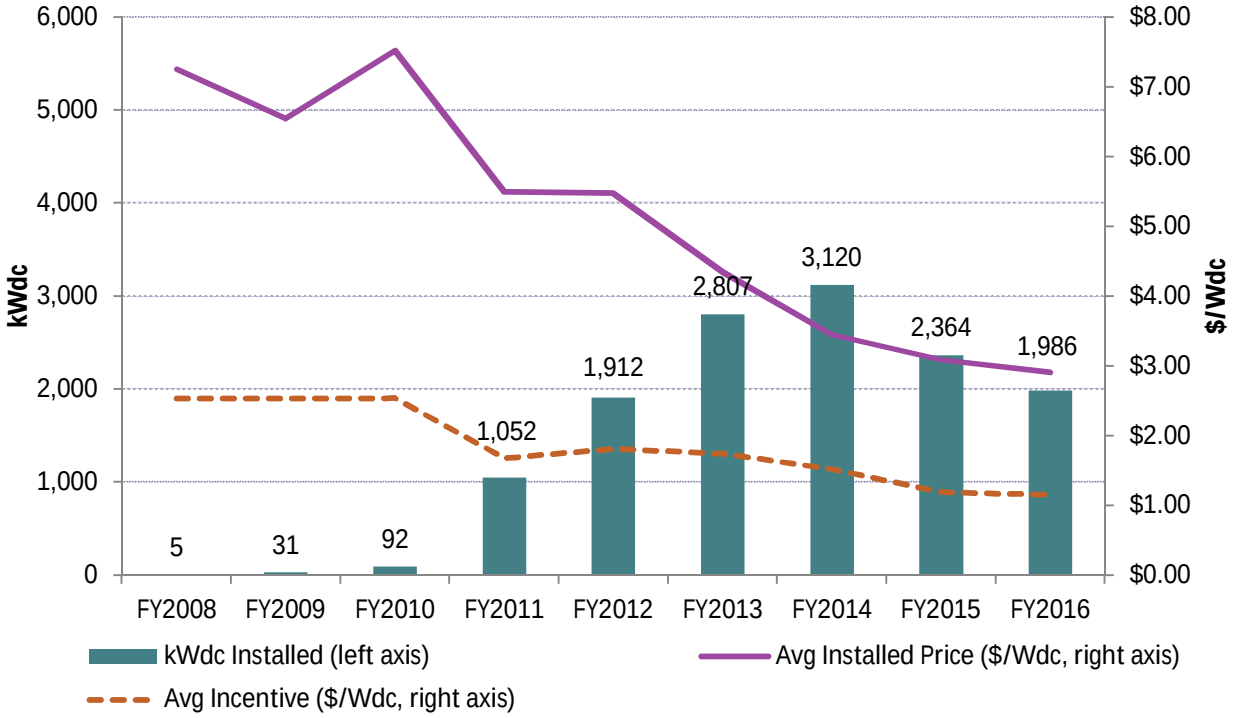


Figure 4.4-1: Solar Initiative – Commercial and Schools Program History: Annual Capacity Installed, Average System Price, and Average Rebate Levels

4.4.2 Savings Calculation Method

The savings calculation methods used for the Commercial and Schools Solar Initiative are identical to those used for the Residential Solar Initiative, with adjustments to account for tilt and orientation combinations more common in commercial installations. These methods are detailed in Section 3.5.2.

4.4.3 Results and Recommendations

The gross energy and demand savings for the Commercial and Schools Solar Initiative are presented below.

Table 4.4-1: Solar Initiative – Commercial & Schools Gross Energy and Demand Savings

Measure	Energy Savings (kWh)	Peak Demand Savings (kW)	Non-Coinc. Demand Savings (kW)	ERCOT 4CP Demand Savings (kW)
Commercial & Schools Solar PV	2,751,338	801	1,583	698

Frontier's recommendations for the Commercial and Schools Solar Initiative are equivalent to those offered for the Residential Solar Initiative, and are outlined in Section 3.5.3.

4.5 COMMERCIAL CUSTOM PROGRAM

4.5.1 Overview

In FY 2016, CPS Energy offered incentives for commercial custom measures at $0.08/kWh and $200/kW. There were a total of nine custom projects at sixteen project sites totaling $368,510 in incentives, as compared to nine projects in FY 2015 totaling $315,052 in incentives.

One commercial custom project was reviewed by the previous EM&V consultant upon application submittal, and the resulting documentation was reviewed for this report. The remaining eight projects were reviewed by Frontier both upon application submittal and again before rebate approval.

This program's internal review process, revised in FY 2013, was continued during the course of FY 2016. Customers were required to submit explanations for their projected savings, along with equipment information. Each project was reviewed individually, and an appropriate measurement and verification (M&V) plan was developed and provided to the customer. M&V was performed both before and after installation of new equipment, providing a high level of confidence in the calculation of actual energy savings achieved on each project.

4.5.2 Savings Calculation Method

Frontier completed an in-depth review of project documentation and savings estimates for each custom project to determine the reasonableness of savings estimates. A combination of measured data and manufacturer specifications was generally used, along with engineering estimations and assumptions where appropriate. Savings algorithms followed sound engineering principles and followed standard industry procedures for each given application.

The approximate M&V approach for each type of project is summarized in Table 4.5-1.

Table 4.5-1: Commercial Custom Program M&V Approach

Measure Type	Count of Projects	Approximate M&V Approach
Comprehensive HVAC improvements	1 project 1 site	Approximates IPMVP Option A – Retrofit Isolation
High Efficiency Elevator	2 projects 2 sites	Approximates IPMVP Option A – Retrofit Isolation
HVAC – Ammonia Cooling	1 project 1 site	Approximates IPMVP Option D – Calibrated Simulation
Retrocommissioning (RCx)	2 projects 2 sites	Spreadsheet based calculation using industry standard algorithms and trend data from building automation control system. Approximates IPMVP Options A and B – Retrofit Isolation
Variable Frequency	3 projects	Spot measurements taken to determine baseline conditions with

Measure Type	Count of Projects	Approximate M&V Approach
Drive (VFD)	10 sites	post-implementation site inspections to confirm operating conditions and control setpoints. Savings calculation completed using industry standard algorithms and a combination of field data and engineering estimations where appropriate.

Variable frequency drive projects were popular; roughly 65% of the project sites implemented VFDs. Savings for these projects relied heavily on manufacturer reported data and engineering assumptions. We noted slight variations in the savings algorithms across the VFD projects, but the variations are not significant to warrant revision of savings claims. Some VFD projects included motor replacements. On those projects, there is additional opportunity to capture peak demand savings if pre and post motor specifications are documented.

One of the elevator improvement projects was reviewed by the previous EM&V consultant upon application submittal. The report indicates that the applicant provided insufficient information to verify savings claims and outlined an acceptable M&V plan. No additional documentation was provided to confirm if the M&V plan was followed or if the measure was installed as proposed. For this reason, no savings are claimed for this project.

4.5.3 Results and Recommendations

The gross energy and demand savings calculated for the Commercial Custom Program are listed in Table 4.5-2 and depicted in Figure 4.5-1 and Figure 4.5-2.

Table 4.5-2: Commercial Custom Program Gross Energy and Demand Savings

Measure	Energy Savings (kWh)	Peak Demand Savings (kW)	Non-Coinc. Demand Savings (kW)	ERCOT 4CP Demand Savings (kW)
Commercial Custom	4,088,751	86	661	106

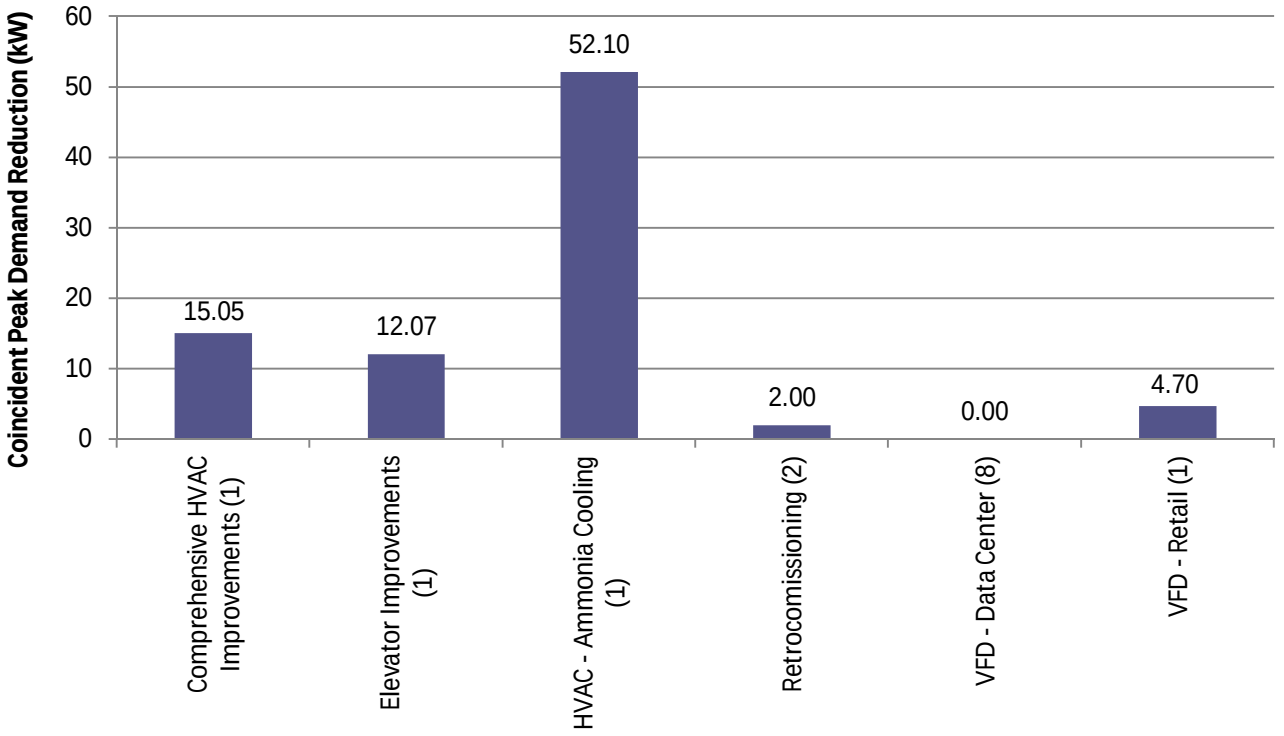


Figure 4.5-1: Commercial Custom – Coincident Peak Demand Reduction (kW) by Project Type

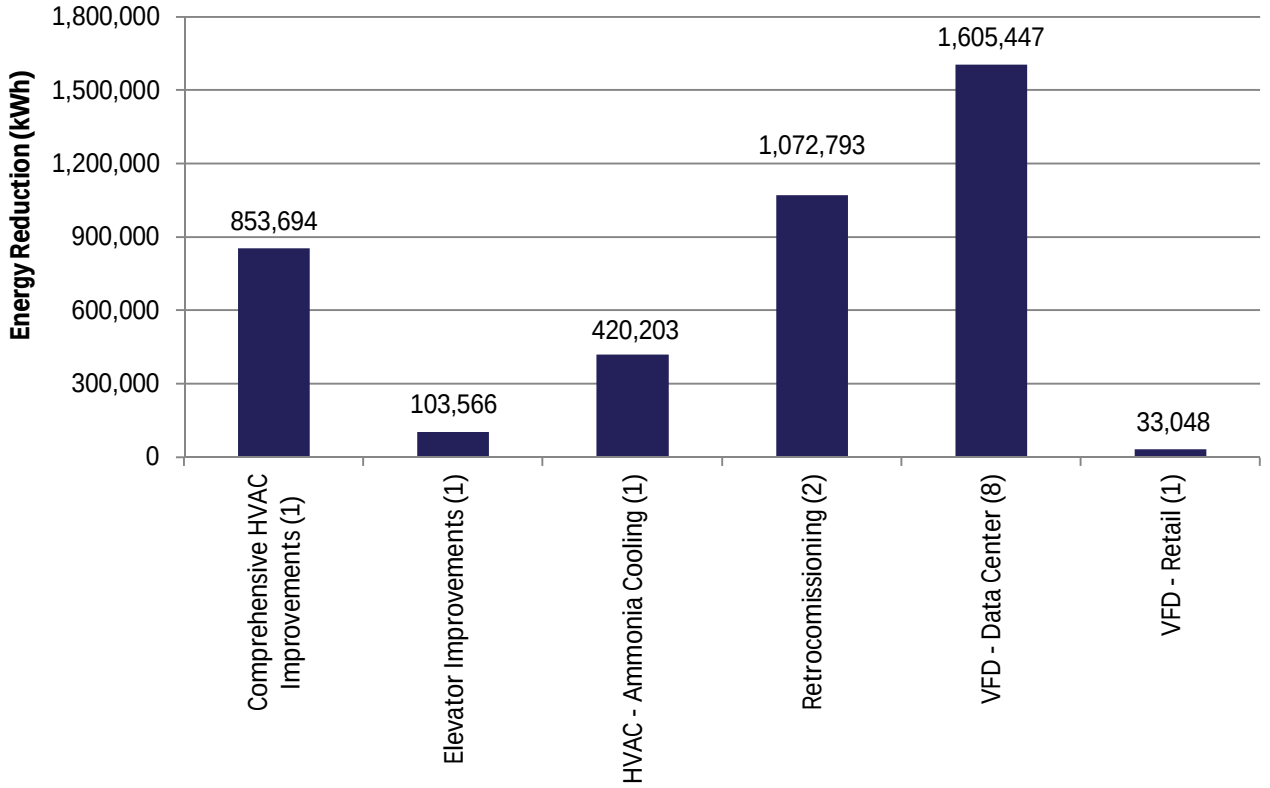


Figure 4.5-2: Commercial Custom – Energy Reduction (kWh) by Project Type

The following are program findings and recommendations CPS Energy may consider for this program in the future:

- Standardize accepted M&V methodologies. None of the projects specified a formal M&V approach which created a challenge when identifying the baseline conditions, independent variables, savings algorithms, and other key components of savings determination for each project.
- Although custom programs naturally incorporate a variety of technologies and applications, we recommend streamlining project verification through standardized M&V protocols.
    - Defining specific M&V guidelines or adopting an established industry protocol (e.g. IPMVP) can help facilitate compliance across custom applications, and reduce costs associated with the project review process.
    - We anticipate a low barrier to adoption based on our review of FY 2016 projects which generally closely approximated some version of IPMVP.
- Program participants should submit a qualifying M&V plan prior to beginning work. We recommend that as part of the Custom Program, a standardized M&V Plan template is made available for customers. This will reduce the burden on the customer as well as on the CPS project review team. Example M&V plan contents may include the following sections, as suggested by the IPMVP.[30]
    - Energy Conservation Measure (ECM) Intent:
        - Description of measure and goals for implementation.
    - Measurement Boundary:
        - Declares what systems will be measured (e.g. whole building, lighting only, all HVAC components, one motor, etc.).
    - Baseline & Reporting Period, Energy and Conditions:
        - Includes items relevant to evaluating savings (e.g. operating hours, occupancy rates, temperature setpoints, and equipment operating profiles).
    - Basis for Adjustment.
    - Analysis Procedures.
    - Energy Prices.
    - Meter Specifications.
    - Monitoring Responsibilities.
    - Expected Accuracy.

[30] International Performance Measurement & Verification Protocol (IPMVP). Available at: http://evo-world.org/en/

  - Justification of Estimates.
  - Quality Assurance.

- Define a standard savings algorithm and reference of default assumptions for VFD projects. We noted slight variation in the savings estimation methodology across the VFD projects. It is reasonable to find variations in field measurements and engineering assumptions as appropriate for each specific application. However, we recommend defining an acceptable algorithm so that savings estimates are consistently derived for this technology. Along with a standard algorithm, providing a reference of default assumptions for common applications will facilitate participation and streamline project savings verification.

- Consider capturing sufficient data to calculate coincident peak demand savings where appropriate on VFD projects that include motor replacements. It may be reasonable to anticipate no coincident peak demand savings for VFD installations where there is no upper limit and it is possible for maximum speed to occur during peak periods. However, there may be applications where peak demand savings are reasonable. For example, projects that also incorporated a motor replacement with a higher efficiency or smaller horsepower rating should be allowed to claim peak demand savings as the kW difference between the old and new motor at 100% load, incorporating diversity factors when appropriate.

4.6 COMMERCIAL NEW CONSTRUCTION PROGRAM

4.6.1 Overview

In FY 2016, CPS Energy paid incentives totaling $390,573 for five commercial new construction projects at the following rates:

- $0.08/kWh and $125/kW for savings 15-25% above code (Tier 1)
- $0.12/kWh and $150/kW for savings 25-35% above code (Tier 2)
- $0.20/kWh and $200/kW for savings more than 35% above code (Tier 3)

In comparison, for FY 2015, four commercial new construction projects were awarded rebates totaling $1,799,501.

All five commercial new construction projects (100%) were for retail sites. They were reviewed by the previous EM&V consultant upon application submittal, and the resulting documentation was reviewed for this report. During the course of FY 2016, the internal review process for this program, revised in FY 2013, was continued. Customers were required to submit whole building energy models in approved software and complete sets of design documents. Each project was reviewed by the EM&V consultant, with energy models first compared to design documents to confirm accurate modeling, and then compared to ASHRAE baselines to confirm calculations of savings relative to code.

4.6.2 Savings Calculation Method

Savings calculations were based on confirmed energy models. The models provide savings between the new building design and a corresponding reference design meeting minimum code requirements.

4.6.3 Results and Recommendations

The gross energy and demand savings calculated for the Commercial New Construction program are listed in Table 4.6-1.

Table 4.6-1: Commercial New Construction Gross Energy and Demand Savings

Measure	Energy Savings (kWh)	Peak Demand Savings (kW)	Non-Coinc. Demand Savings (kW)	ERCOT 4CP Demand Savings (kW)
Commercial New Construction	3,426,439	1,259	1,328	1,231

The following are findings and recommendations that CPS Energy may consider for future implementation of this program:

- Because of the relatively small number of projects, continue requiring submittal and EM&V review of simulation models and design documents for each project. Consider methods to streamline this review.
- Continue requiring customers to submit whole building energy models and complete sets of design documents for each project. Confirm (or add) the following submittals required for EM&V review (each project) prior to rebate disbursement:
    - Approved contractor product submittals for HVAC and lighting equipment, or product sheets from operations and maintenance (O&M) manual.
    - Simulation summary reports.
    - Hourly energy output files.
    - Demand and energy savings calculation file (spreadsheet).
    - Commissioning Report and HVAC TAB (test, adjust & balance) Report. Review of these reports will confirm initial building control settings are in accordance with design.
- We also recommend a visual site inspection be conducted post construction and before occupancy to confirm that as-built conditions match design documents.
- To have a better confidence in the persistence of the savings from new construction projects, we recommend a follow-up one year after occupancy. The follow-up can take a non-invasive approach by using meter data for the facility to measure against as-built

energy models. The empirical data will help assess the reasonableness of modeled energy savings estimates, and the results may be useful in guiding new construction program design for future years. In order to implement this recommendation, it is necessary to ensure that whole building energy models are obtained and retained at the time of application submittal.

5. DEMAND RESPONSE PROGRAMS

5.1 SUMMARY OF DEMAND RESPONSE IMPACTS

CPS Energy offered the following demand response programs in FY 2016:

- Commercial Demand Response
  - C&I Demand Response Options 1-3
  - Automated Demand Response (ADR)
  - Emergency Demand Response (EDR)
- Residential Demand Response
  - Smart Thermostat
  - Home Manager
  - Bring Your Own Thermostat (BYOT)
  - ThinkEco Room Air Conditioner

The contribution of each demand response program to energy, peak demand and non-coincident peak savings are shown in Figure 5.1-1, Figure 5.1-2, and Figure 5.1-3. In these figures and in Tables 1.2-1 and 7.1-1, we report estimated savings from all active participants to most accurately represent the programs' actual capability at the end of FY 2016. These savings are adjusted to account for net-to-gross ratios and distribution line losses.[31]

For benefit-cost calculations, our approach focuses on the incremental impacts of only new participants added in FY 2016, consistent with the approach used in all energy efficiency program benefit-cost calculations.

[31] Net-to-gross (NTG) ratios are estimated at the level of individual programs, and account for the net effects of free ridership and spillover. Free riders are defined as customers who would have delivered energy or demand savings without any program incentives but who received a financial incentive or rebate anyway. Spillover effects derive from customers who delivered energy or demand savings because of the program, but did not participate in the program or receive a financial incentive or rebate. Distribution line losses account for the fact that utilities must generate or import a greater amount of energy or demand than is required at the customer or end-user level because some energy is lost on the distribution system.

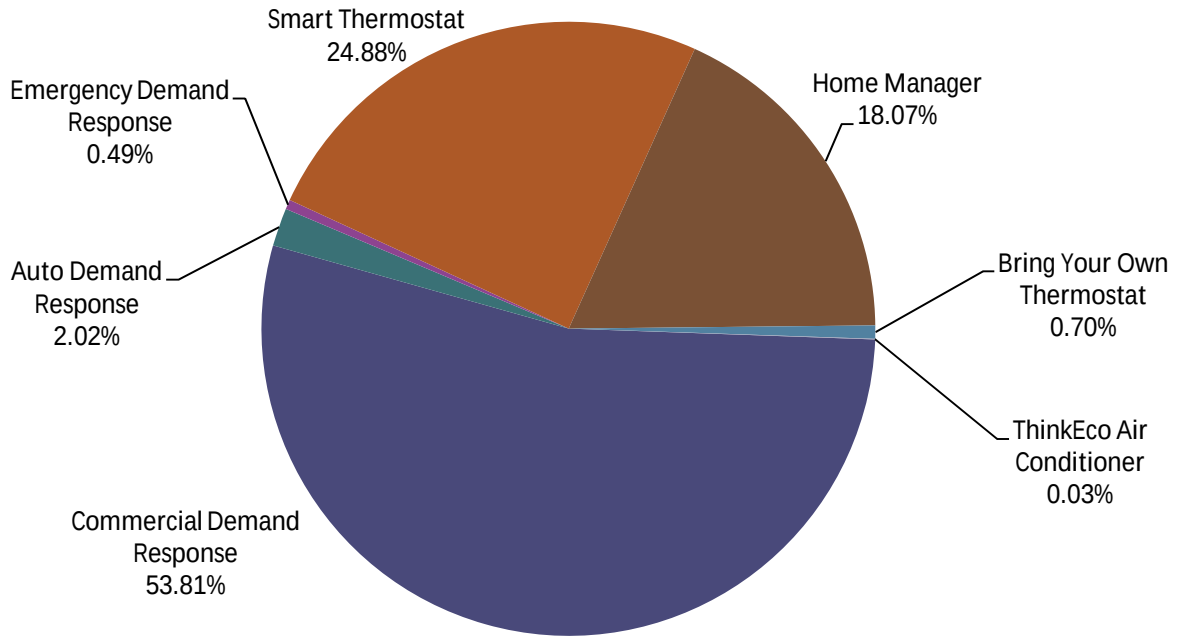


Figure 5.1-1: Summary of Demand Response Impacts – Energy (kWh) by Program

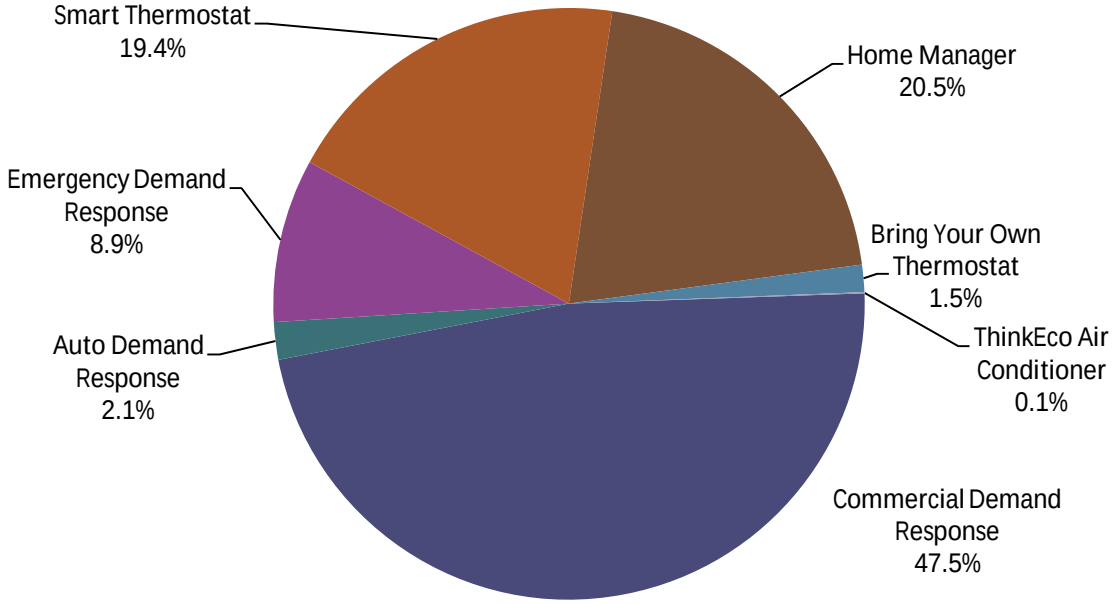


Figure 5.1-2: Summary of Demand Response Impacts – Peak Demand (kW) by Program

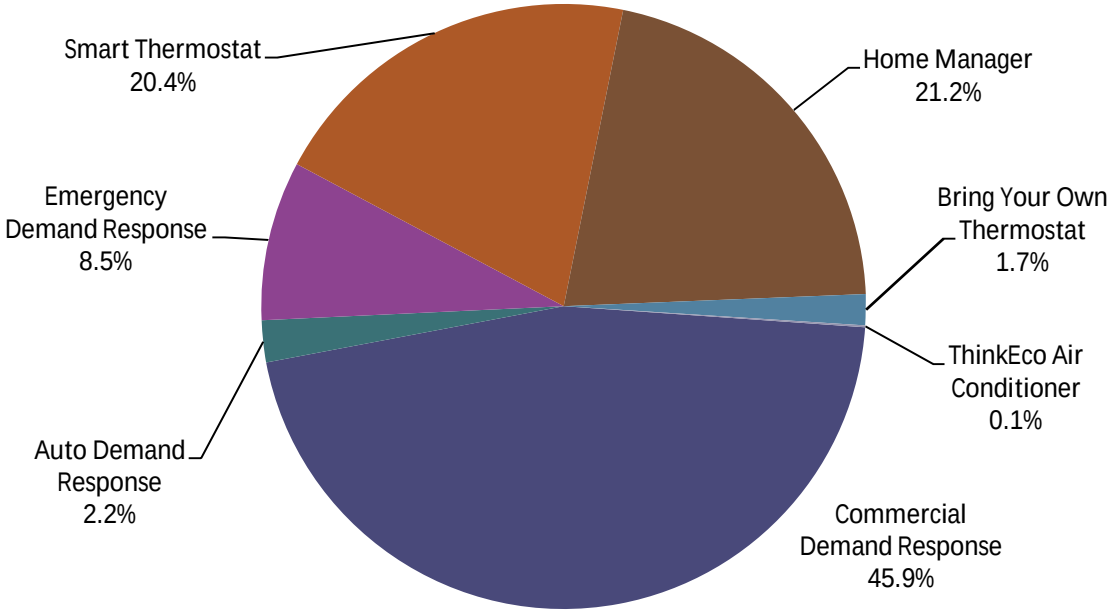


Figure 5.1-3: Summary of Demand Response Impacts – Non-Coincident Peak Demand (kW) by Program

5.2 COMMERCIAL DEMAND RESPONSE PROGRAMS

5.2.1 Overview

CPS Energy's Commercial Demand Response (DR) programs are voluntary load curtailment programs for its commercial and industrial customers. The programs are designed to reduce CPS Energy's peak load growth by incentivizing customers to shed electric loads on peak summer days. The Commercial Demand Response programs run from June 1 through September 30. Participating customers commit to be available between 1 p.m. and 7 p.m.; typically, events occur on weekdays between 3 p.m. and 6:30 p.m.

The Commercial DR programs consist of:

- Commercial Demand Response (Options 1, 2, and 3)
- Automated Demand Response (ADR)
- Emergency Demand Response (EDR)

CPS Energy uses these programs differently because they have different purposes, capabilities, and contractual stipulations. Table 5.2-1 summarizes these differences.

Table 5.2-1: Commercial DR Program Characteristics

Measure	Performance Period	Time Period	Event Days	Events	Total Hours Avail.	Advance Notice (hrs)
Option 1	Jul 1 - Aug 31	1300 - 1900	Weekdays	18	55	2
Option 2	Jun 1 – Sep 30	1300 - 1900	Weekdays	25	75	2
Option 3	Jun 1 – Sep 30	1300 - 1900	Weekdays	6	25	1
ADR *	Jun 1 – Sep 30	24/7	All Days	N/A	50	0
EDR	Jun 1 – Sep 30	1300 - 2000	Weekdays	5	20	0.5
* There is also a non-summer ADR program offering that runs for the other 8 months of the year, but its impacts are not evaluated herein.						

Programs vary in the length of the performance period for which customers agree to make load available (Option 1 is not available in June or September), the days and hours in which participants commit to make their capacity available, as well as the number of events and total number of hours participants can be called upon to deliver. They also require different degrees of advance notice: ADR is the most responsive, with load being taken offline immediately upon call, while the other programs offer customers from 30 minutes (EDR) to 2 hours (Options 1 and 2) of advance notice. For programs with longer lead times, forecasting activities must predict high-value time periods and deployments must be set in motion in advance for load reduction to be realized during those periods.

5.2.2 Participation Trends

As can be seen in Figure 5.2-1 overall participation (by number of sponsors and sites) and by kW under contract in CPS Energy's Commercial DR programs increased in FY 2016 relative to FY 2015.

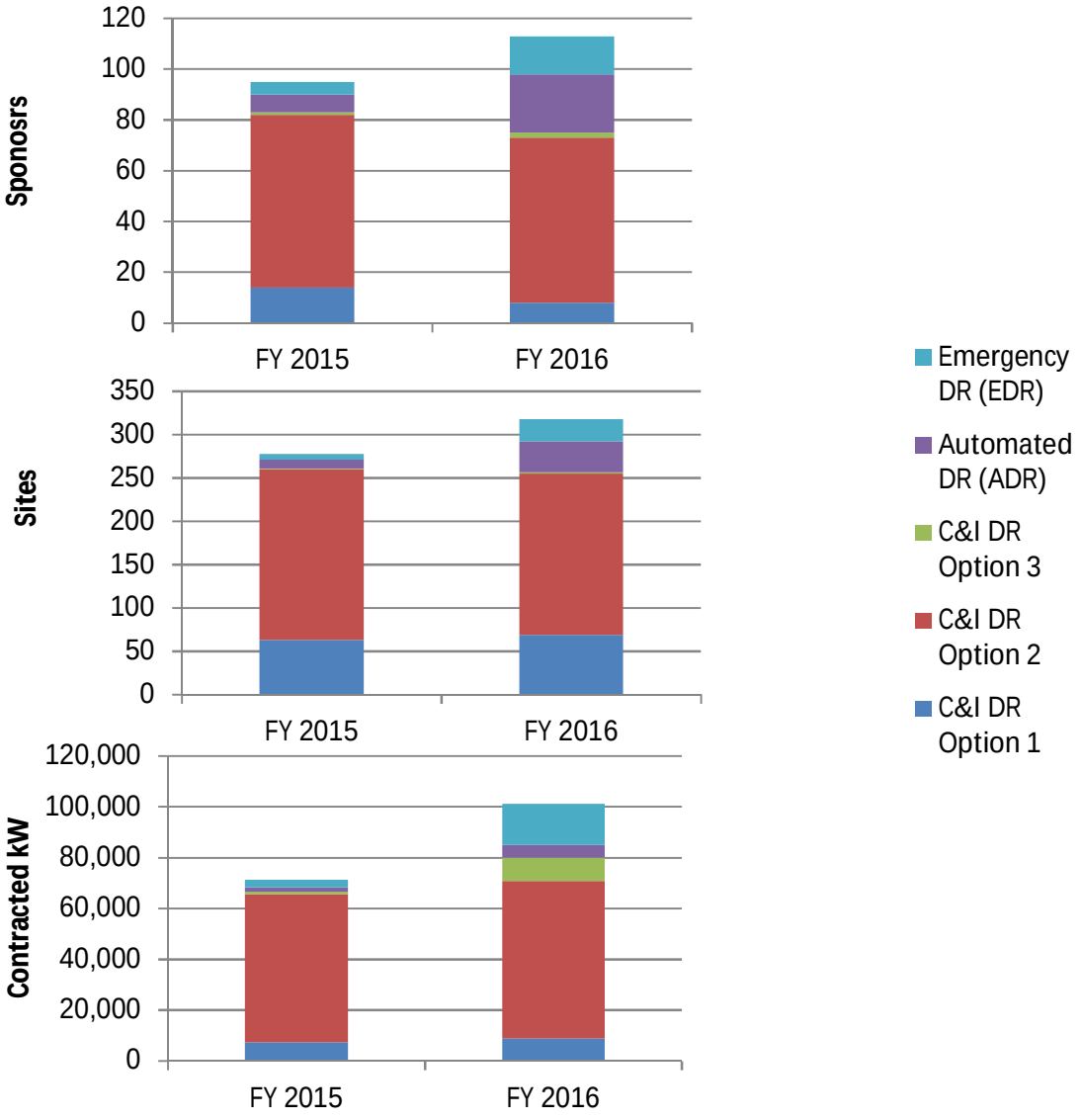


Figure 5.2-1: Commercial DR - Participation and Contracted kW, FY 2015 – FY 2016

Despite losing participants in the Option 1 and Option 2 programs, all programs brought more kW under contract in FY 2016 relative to the previous year. Most growth was concentrated in the Option 3, ADR, and EDR programs. The Option 3 program added just one customer but over 8 MW of contracted load. The ADR program grew from 8 to 23 participants and added 3.2 MW, and the EDR program added 10 participants and almost 13.5 MW.

CPS Energy utilizes its Commercial DR program offerings differently, given their different characteristics. These differences imply varying levels of availability of each program's capacity for achieving key objectives, such as demand reduction during CP, ERCOT 4CP, or high energy price periods. The event on July 30 was the only occasion in FY 2016 on which all five programs were simultaneously deployed.

CPS Energy deployed its Commercial DR programs on 17 occasions in FY 2016. As can be seen in Table 5.2-2, Option 2 and the ADR programs were most frequently included in these events (13), while the EDR program was invoked only once. On average, events lasted 1.8 hours.

Table 5.2-2: Commercial DR Events and Average Duration by Program Offering

C&I DR Program/ Option	Jun				Jul								Aug				Sep	Total Events (#)	Avg. Duration (Hrs)
	9	10	25	26	13	14	20	23	27	28	29	30	6	10	11	12	8		
Option 1					X		X	X	X		X	X	X	X	X	X		10	2.0
Option 2	X			X	X		X	X	X		X	X	X	X	X	X	X	13	1.9
Option 3									X			X	X	X	X		X	6	1.8
ADR		X	X		X	X	X		X	X	X	X	X	X	X		X	13	1.5
EDR												X						1	1.0
Total	1	1	1	1	3	1	3	2	4	1	3	5	4	4	4	2	3	17	1.8

5.2.3 Savings Calculation Methods

CPS Energy generally estimates delivered demand savings according to a High 3 of 10 baseline estimation method. In certain cases in which the High 3 of 10 baseline is not deemed to provide a reasonable baseline for a given participant for a given event, a single proxy day (like-day) may be used.

To verify CPS Energy's estimated savings, Frontier has employed panel regressions and a rigid application of CPS Energy's High 3 of 10 baseline methodology. These analyses produced results that generally supported CPS Energy's estimated savings. Frontier accepts CPS Energy's savings estimates, but recommends further study of alternative calculation methods.

5.2.3.1 Energy Savings (kWh)

Energy savings achieved from the Commercial DR programs are estimated by multiplying the demand savings estimated for each participant for each event by that event's duration and summing these energy reductions across all events for all the programs. The calculation assumes there is no load shifting (e.g. rescheduling of industrial processes) or pre-cooling or snapback associated with temperature-dependent loads.

5.2.3.2 Coincident Peak (CP) Demand Savings (kW)

Coincident peak (CP) demand savings have two components: (1) the extent to which program events coincide with CP intervals; and (2) how customers actually perform during those intervals when a DR event is called. Frontier has evaluated the CP demand savings from the Commercial DR programs according to actual performance during actual summer 2015 CPS system peaks

and by applying judgment to assessing the likelihood of CPS Energy deploying the individual program options during the CP in future years (projected CP contributions) given the unique characteristics of the various program options and how CPS Energy deploys their respective capacities.

5.2.3.3 Non-Coincident Peak (NCP) Demand Savings (kW)

Non-coincident peak demand savings for the Commercial DR programs represent the maximum event demand savings among all events for each program (or program option). The delivered NCP savings reported for each program (or program option) may have occurred on different event dates. End of year and incremental estimates of NCP savings were estimated as the maximum event demand savings from those customers comprising the end of year or incremental enrollees. For the Commercial DR program as a whole, we sum the maximum event demand savings from each program option.

5.2.3.4 ERCOT 4CP Demand Savings (kW)

ERCOT 4CP demand savings obtained from the Commercial DR programs are directly estimated by evaluating the load reductions delivered when each month's 4CP event occurred.

5.2.4 Impact Analysis Results

For demand response programs, we present impacts in three ways:

1) Estimated program impacts during summer 2015 DR events.
2) End of year program capability based on program enrollment at the end of FY 2016; this information is useful for planning purposes.
3) End of year program capability based on incremental enrollment during FY 2016; this information is used for program benefit-cost analysis, consistent with the methods used for energy efficiency programs.

For Options 1-3 and Emergency DR, there is no distinction between total participation (no. 2 above) and incremental enrollment (no. 3 above): all participants are treated as new participants each program year. As such, the analysis of incremental impacts of these programs is no different than the analysis of total impacts.

5.2.4.1 Estimated Impacts During Summer 2015 DR Events

Seventeen demand response events were called during the summer of 2015 for Commercial DR program participants. Demand savings estimates for these events are shown in Figure 5.2-2.

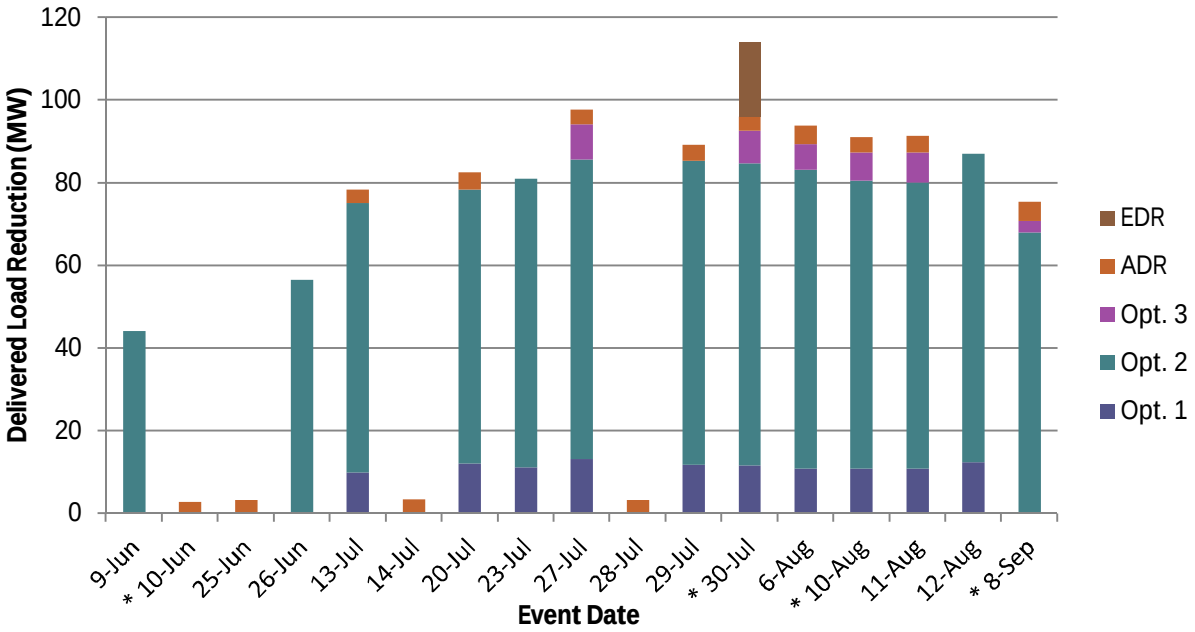


Figure 5.2-2: Commercial DR - Delivered Demand Savings, Summer 2015

Note: Events coinciding with ERCOT 4CP intervals are designated with a *.

For those events in which only the ADR capability was deployed, delivered demand savings was limited to about 3.3 MW. Maximum demand savings was achieved on the July 30 event (approximately 114 MW); the average event saw 64.4 MW of demand savings. Given the differences in how the individual Commercial DR programs are used, Frontier estimates the demand savings delivered by each program individually; total demand savings are presented as the sum of the demand savings delivered by each of the respective programs.

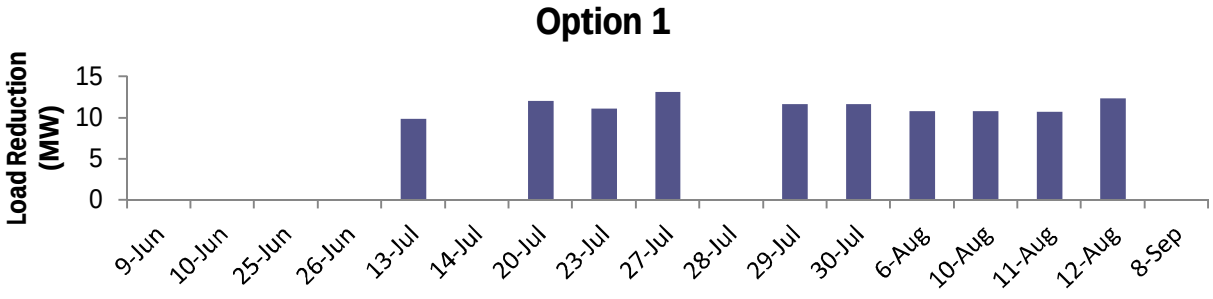


Figure 5.2-3: Commercial DR Option 1 Demand Savings by Event

Average demand savings delivered by program participants in Option 1 was 11.4 MW.

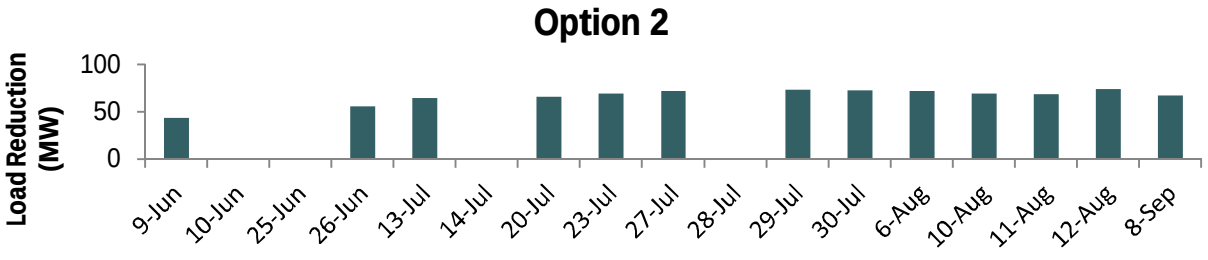


Figure 5.2-4: Commercial DR Option 2 Demand Savings by Event

Average demand savings delivered by program participants in Option 2 was 67.3 MW.

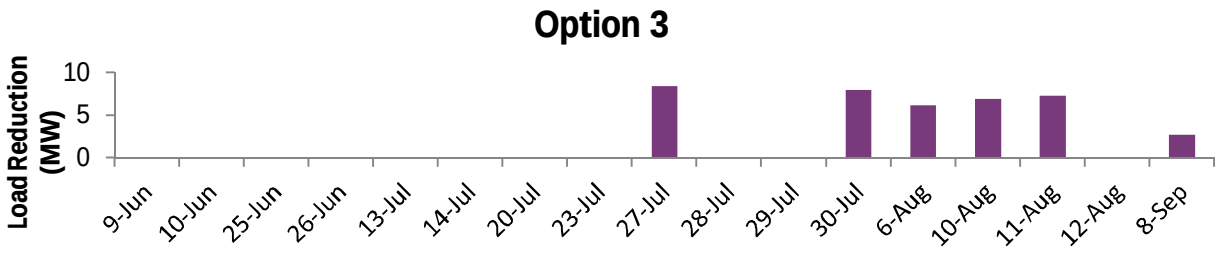


Figure 5.2-5: Commercial DR Option 3 Demand Savings by Event

Average demand savings delivered by program participants in Option 3 was 6.6 MW.

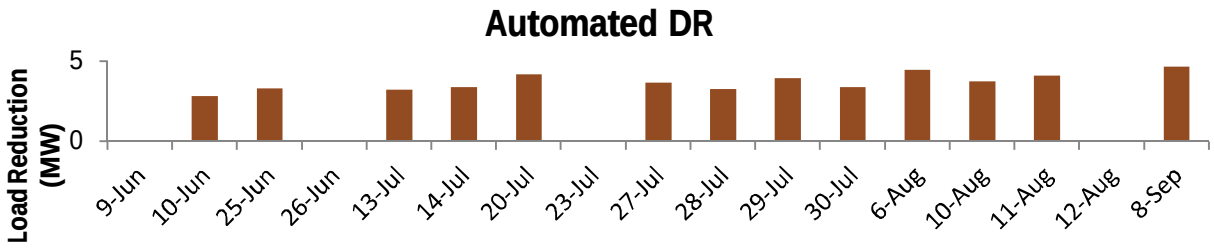


Figure 5.2-6: Commercial DR Automated DR Demand Savings by Event

Average demand savings delivered by participants in the Automated DR program was 3.7 MW.

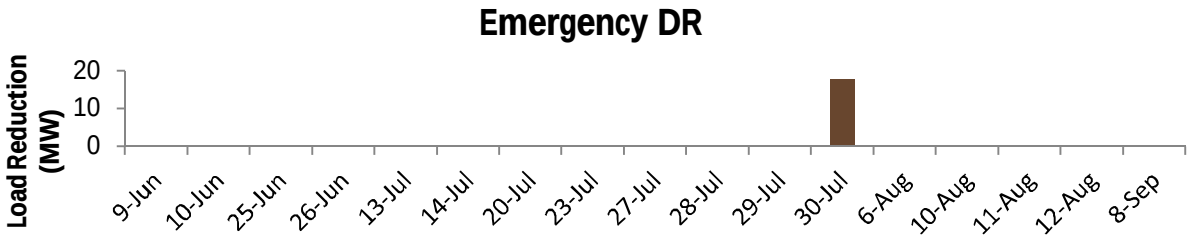


Figure 5.2-7: Commercial DR Emergency DR Demand Savings by Event

Participants in the Emergency DR program delivered 17.9 MW of demand savings in the one event for which they were called upon to reduce load.

Coincident Peak Savings

Frontier analyzed summer 2015 system peak load (with all load estimated to have been removed via Demand Response added back into the system load shape) to evaluate the extent to which CPS Energy deployed its Commercial DR capacity during CP hours. The only program CPS Energy did not deploy during the top four CP intervals was the EDR program. In the CP intervals in which the programs' capacity was deployed, the average demand savings was approximately 91 MW.

In the FY 2015 M&V report on the Commercial DR program, Frontier estimated the CP demand savings for each program option as the average savings across all events. This year's approach looks at demand savings during the specific intervals in which CPS Energy's system was most stressed, or would have been absent DR deployment. For most of the Commercial DR programs, the difference between the average event savings and Frontier's assessment of the FY 2016 delivered CP demand savings is small. However, there is a large difference in the total savings across the programs, which is almost entirely explained by the non-deployment of the EDR program during the top CP events.

Table 5.2-3: Commercial DR Demand Savings – FY 2016 Delivered

Measure	Average Event Savings by Program (kW)	Coincident Peak Demand Savings (kW)
Option 1	11,441	10,790
Option 2	67,317	69,452
Option 3	6,609	7,116
Automated DR	3,707	3,665
Emergency DR	17,903	0
Total	106,977	91,023

Non-Coincident Peak Savings

NCP demand savings represent the maximum event demand savings within each program option. NCP demand savings are estimated to be approximately 119 MW.

ERCOT 4CP Savings

CPS Energy deployed the Commercial DR programs during each of the 4CP events used by ERCOT to allocate transmission costs to load-serving entities in the summer of 2015. For the June 10 4CP event, only the ADR program was called, resulting in a relatively low total demand savings (2.8 MW) for that month; in contrast, all five programs were engaged for the July 30 4CP event, delivering just under 114 MW.

Table 5.2-4: Commercial DR FY 2016 ERCOT 4CP Event Performance

Measure	6/10 16:45	7/30 16:45	8/10 17:00	9/8 16:30
Option 1	n/a	11,668	10,833	0
Option 2	0	72,998	69,641	68,011
Option 3	0	8,009	6,915	2,739
Automated DR	2,818	3,378	3,744	4,669
Emergency DR	0	17,903	0	0
Total	2,818	113,955	91,133	75,419
Average Demand Savings during FY 2016 4CP Events				70,831

Overall, CPS Energy obtained 70.8 MW of demand savings from the Commercial DR programs during FY 2016 4CP events.

FY 2016 Delivered Savings

Table 5.2-5 presents the different estimates of savings delivered by the Commercial DR programs for FY 2016.

Table 5.2-5: Commercial DR Gross Energy and Demand Savings – FY 2016 Delivered

Measure	Energy Savings (kWh)	Average Demand Savings (kW)	Coinc. Peak Demand Savings (kW)	Non-Coinc. Demand Savings (kW)	ERCOT 4CP Demand Savings (kW)
Option 1	223,447	11,441	10,790	13,149	5,625
Option 2	1,663,832	67,317	69,452	74,640	52,663
Option 3	70,611	6,609	7,116	8,474	4,416
Automated DR	73,345	3,707	3,665	4,669	3,652
Emergency DR	17,903	17,903	0	17,903	4,476
Total	2,049,137	106,977	**91,023**	**118,835**	**70,831**

5.2.4.2 End of Year Program Capability

Savings estimates based on end of year program capability are useful for planning and forecasting. In residential DR programs, end of year capability estimates tend to differ from

estimates of savings actually delivered during the DR season because of the continuous enrollment of new customers into the programs throughout the year – before, during, and after the DR season.

End of year savings capability estimates tend to differ less from estimates of savings actually delivered for commercial DR programs. Because CPS Energy's commercial DR participants are contracted for short periods (outside of ADR, most Commercial DR participants are on one year contracts and there is no installed equipment to amortize) within the Commercial DR program no distinction is made between customers who participated in previous years, those who signed up and participated during the current DR season, and those who signed up for subsequent program years after the summer DR season ended.

In addition, Commercial DR customers tend to be heterogeneous relative to residential customers, such that it may not be accurate to assume that program capability at the end of a program year (or into the next program year) is tightly correlated to demand savings produced by current participants.

Instead of basing end of year capability projections primarily on enrollment trends, for the Commercial DR programs it is reasonable to take other factors into account, such as the relationship between delivered load reduction and ambient temperature, when projecting the program capabilities at year end.

Coincident Peak Savings

Frontier evaluated participant performance during the FY 2016 curtailment events for each Commercial DR program. Given that some share of participating loads are temperature dependent, estimated event performance was regressed against the average of hourly ambient temperature readings from Kelly AFB during the events. The results are presented in Figure 5.2-8.

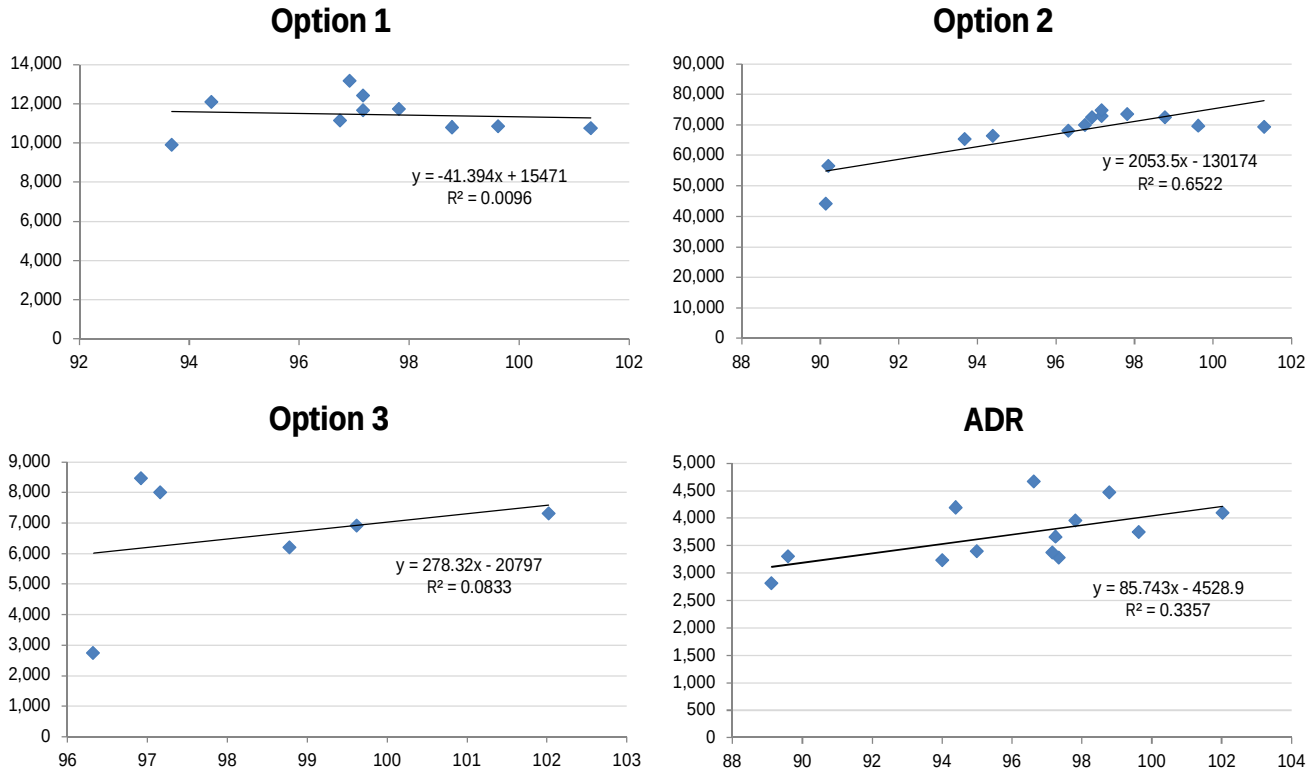


Figure 5.2-8: Commercial DR FY 2016 Event kW Savings (y-axis) by Temperature (°F, x-axis)

Given there was only one event called for the EDR program, no regression was performed on that program's data. For Options 1 and 3, temperature seems to have only a small effect on kW savings (R^2 values of 0.0096 and 0.0833, respectively). As such, future demand savings for these two program options - assuming the same set of future participants - is projected as the simple average of load shed delivered across the events.

For Option 2 and the ADR programs, the simple regressions explain 65 percent and 34 percent of the variance in program performance, respectively, and these relationships can be used to project the end of year CP capability of these programs. The remainder of the variance is likely explained by other factors, such as increasing or decreasing participation, differences in individual participant response on an event-by-event basis, or other factors. Frontier's evaluation of coincident peak conditions indicates an average temperature of about 101 degrees. Incorporating this value into the regression equations for the two programs, we

estimate CP capabilities of 77,230 kW for Option 2 and 4,131 kW for the ADR program.

Table 5.2-6: Commercial DR Coincident Peak Demand Savings (kW) – End of Year

Option 1	Option 2	Option 3	Automated DR	Emergency DR	Total
11,441	77,230	6,609	4,131	17,903	117,314

Realization of this level of CP demand reduction in future years would require that CPS Energy deploy the capabilities of these programs during coincident peak events. As observed above, CPS Energy deployed all but the EDR program during the top FY 2016 CP intervals. In both FY 2015 and FY 2016, CPS Energy deployed its EDR capacity just one time. While this usage pattern implies significant continued risk of missing the CP with the EDR program, its capacity is included in the end of year CP demand savings capability estimate.[32]

Non-Coincident Peak Savings

End of year NCP demand reduction capability is estimated to be the same as the NCP demand reductions actually delivered in FY 2016. While the NCP analysis indicates that the greatest demand reductions are likely to be achieved at highest temperatures, the large difference between the delivered CP demand reductions and the NCP demand reductions in FY 2016 demonstrates some variability in when individual customers deliver their greatest demand reductions. As such, the delivered NCP demand reductions from the past program year provide a reasonable guide to NCP demand reduction capabilities at the end of the program year.

ERCOT 4CP Savings

Estimating end of year ERCOT 4CP demand savings capability requires anticipating that CPS Energy will have a certain success rate at identifying ERCOT 4CP events and calling Commercial DR program events to coincide with them. Table 5.2-7 presents CPS Energy's recent success rates at calling Commercial DR events coinciding with 4CP events by program over the last two fiscal years.

[32] The EDR program has been discontinued and will not operate in FY 2017.

Table 5.2-7: Commercial DR – ERCOT 4CP Demand Savings – End of Year

Measure	FY 2015 Success Rate	FY 2016 Success Rate	Average Success Rate	Average Savings when Deployed, FY 2016 4CP Events	ERCOT 4CP Demand Savings (kW)
Option 1	25%	50%	37.5%	11,250	4,219
Option 2	75%	75%	75%	70,217	52,663
Option 3	50%	75%	62.5%	5,887	3,680
Automated DR	75%	100%	87.5%	3,652	3,196
Emergency DR	25%	25%	25%	17,903	4,476
Total					68,232

Option 1 participants are not available in June or September, meaning at least two 4CP events will always be missed with that program option. Option 3 and EDR program participants are available for a maximum of six and five events, respectively (see Table 5.2-1), limiting CPS's ability to use these program options for 4CP avoidance. Given these issues, it is reasonable to expect a continued lower success rate for avoiding 4CP with these three programs than with the Option 2 and ADR programs.

Totals are provided in Table 5.2-8; energy savings projections are taken directly from the FY 2016 program results, as they are predominantly a function of how the programs are used. Our best guide to how CPS Energy will use the program in future years is how they used the program in recent years: given similar usage of this capacity in future years (number and duration of events), CPS Energy can expect current participants to continue delivering this level of energy savings. Coincident peak demand savings of 117 MW compare with almost 143 MW of NCP savings and 68 MW of demand reduction achieved during ERCOT 4CP events.

Table 5.2-8: Commercial DR Gross Energy and Demand Savings – End of Year Capability

Measure	Energy Savings (kWh)	Coinc. Peak Demand Savings (kW)	Non-Coinc. Demand Savings (kW)	ERCOT 4CP Demand Savings (kW)
Option 1	223,447	11,441	13,149	4,219
Option 2	1,663,832	77,230	74,640	52,663
Option 3	70,611	6,609	8,474	3,680
Automated DR	73,345	4,131	4,669	3,196
Emergency DR	17,903	17,903	17,903	4,476
Total	2,049,137	117,314	**118,835**	68,232

5.2.4.3 Incremental Impacts

For Options 1-3 and EDR, there is no distinction between total participation and incremental participation: all participants are treated as new each program year. As such, the analysis of incremental impacts of these programs is no different from the analysis of total impacts.

The ADR program is a vendor-implemented program involving installation of hardware and for which customers sign longer-term contracts. Frontier has assigned the ADR program a 10-year measure life. For this program, incremental impacts differ from the total impacts. In FY 2016 the program added 18 new sites and 6 sites that had participated in different Commercial DR program options in FY 2015 for a total of 24 new sites. Table 5.2-9 presents estimated incremental savings for the new additions to the ADR program in FY 2016. The same approaches used for projecting the total capabilities of the Commercial DR program (above) have been applied to estimating the incremental capabilities of the ADR program. The same 87.5% success rate is projected for ERCOT 4CP avoidance as was used for all ADR participants.

Table 5.2-9: ADR Gross Energy and Demand Savings – Incremental Impacts

Measure	Energy Savings (kWh)	Coinc. Peak Demand Savings (kW)	Non-Coinc. Demand Savings (kW)	ERCOT 4CP Demand Savings (kW)
Automated DR	37,415	2,174	2,237	1,664

5.2.5 Recommendations

Frontier makes the following recommendations for the Commercial DR programs.

- Some modifications to current deployment strategy may be warranted. For instance, missing the June 4CP with the Option 2 and Option 3 programs resulted in significant reductions in 4CP avoidance. Given the limited number of events available under Option 3, it probably makes sense to continue to not chase the June 4CP with this program; however, it may make sense to pursue the June 4CP more aggressively with Option 2 than was done in FY 2016.
- CPS Energy's current procedure for assessing baseline energy use for each participant for each event maximizes flexibility, but makes it impossible to verify by uniformly applying a methodology such as the high 3 of 10 baseline. Frontier recommends further study of these differences to reconcile the different impact estimates.
- CPS Energy typically uses the hour from 1 p.m. to 2 p.m. as its day-of baseline adjustment period, independent of the time at which program events start and the number of hours of prior notification customers receive for an event. Many events start at 3:30 p.m., and participants in Commercial DR Options 1 and 2 receive two hours advance notification. This means that half of the baseline adjustment period is occurring after customers have been notified of the event. If participants are aware of the adjustment period methodology, they could use this information to game the program (by ramping up usage in this half hour). Conversely, participants who begin to shed load upon notification will have their

baseline and, as a result, their demand savings estimate, reduced. The day-of baseline adjustment period should be revised to avoid this possibility; typically, the period used is the hour (or two hours) immediately prior to notification.[33]

- Regarding day-of baseline adjustments, in Frontier's experience some industrial participants in DR programs shut down production well in advance of notification (either in anticipation of the program event or for their own reasons). For these customers, a day-of adjustment does not work, and some other approach should be used. CPS Energy may already implement similar procedures, but these instances should be more clearly documented.
- As the Commercial DR programs shift toward having savings estimated automatically via algorithms in near real time, CPS Energy will benefit from a clearer understanding of the differences in savings estimates that would result from application of its current methods and other standardized methods. Frontier recommends conducting further research into such additional baseline/adjustment and panel data regression approaches, and will undertake such research in coordination with CPS Energy in the coming months.

5.3 SMART THERMOSTAT PROGRAM

5.3.1 Overview

The Smart Thermostat direct load control program has been available to residential sector participants in single-family homes since 2003. It was expanded to include multifamily and small commercial customers in 2010. Through the program, CPS Energy installs a programmable, controllable thermostat (PCT) at participants' home or place of business at no cost to the customer. In return, CPS Energy is permitted to remotely control their central air conditioning systems during demand response events. Once an event is called, CPS Energy can cycle the air conditioner compressor on and off for short periods of time on event days. Each air conditioning unit is given a randomized start time which ensures that all units will not be cycling off and back on at exactly the same time. Cycling events occur during the summer months of May through September, between the hours of 3 p.m. and 7 p.m. on weekdays.

Single-family and multifamily residential customers participate at either a 33% cycling rate (during which units are cycled off for 10 minutes during each half hour) or a 50% cycling rate (during which units are cycled off for 15 minutes during each half hour).

Most multifamily and small business customers participate at a 33% cycling rate. However, a small but increasing number of these customers are now participating at a 50% cycling rate, due in part to the growing prevalence of Wi-Fi-enabled thermostats. Participants with Wi-Fi-enabled thermostats are required to participate at the 50% cycling rate.

Beginning in FY 2016, CPS Energy has moved to enable customers who purchase and install their own qualifying thermostat to participate in a more broadly defined Bring Your Own Thermostat (BYOT) program. Some thermostats purchased and installed under BYOT participate and respond to DR events in a manner equivalent to those installed under the Smart

[33] To maintain flexibility, CPS Energy does consider a final adjustment factor, if warranted, to improve accuracy.

Thermostat program, but are reported separately.

5.3.2 Participation Trends

Figure 5.3-1 below shows overall participation in the Smart Thermostat program at the beginning and end of FY 2016 and at the time of DR events during June through September 2015. Overall participation increased by 9% in FY 2016.

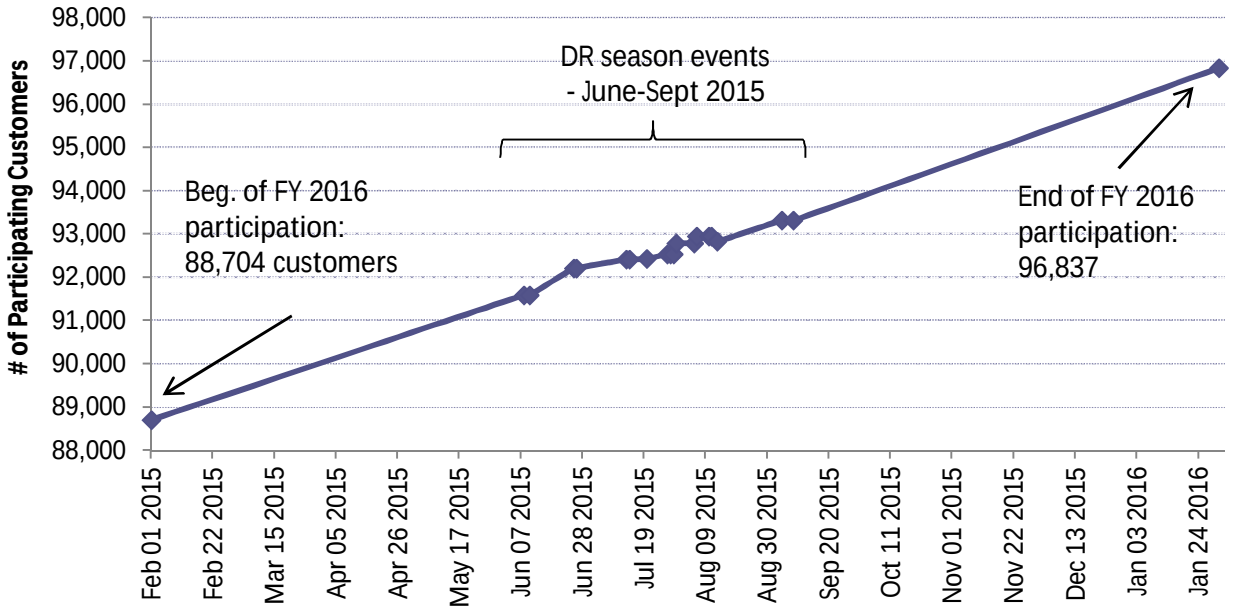


Figure 5.3-1: Smart Thermostat – Participation Trend (FY 2016) – Total Customer Count

Note: One additional DR event was called on August 13 but is not shown here. This event was a last minute call due to a rise in ERCOT market prices, and participation was much lower than for other events because only customers with Wi-Fi-connected thermostats were called. The event is included in all savings calculations.

Figure 5.3-2 shows participation trends by customer segment over the past three years. Participation in Residential (50% Cycling) increased by 35% in FY 2016, while participation in Multifamily and Commercial each increased by 16%. Participation decreased by 4% in FY 2016 in Residential (33% Cycling). About two thirds of all new customers who enrolled in the program in FY 2016 were from the Multifamily segment.

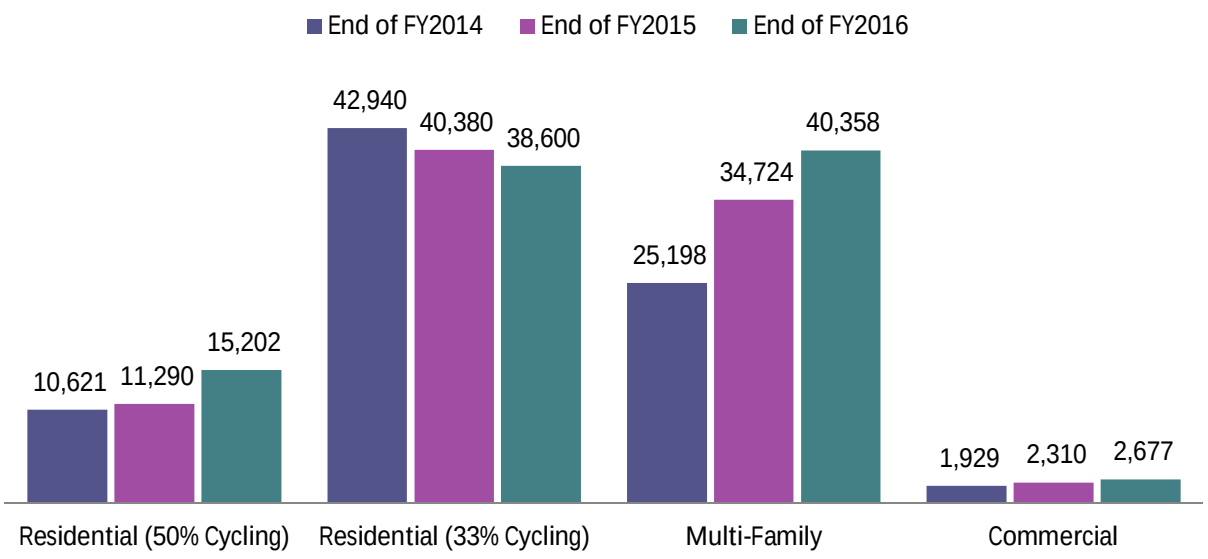


Figure 5.3-2: Smart Thermostat – Participation Trends (FY 2014-FY 2016) – By Segment

As a consequence of these trends, the residential share of total participation in the Smart Thermostat program has declined, from 66% at the end of FY 2014 to 56% at the end of FY 2016, while the multifamily share of total participation has increased, from 31% at the end of FY 2014 to 42% at the end of FY 2016, as shown in Figure 5.3-3.

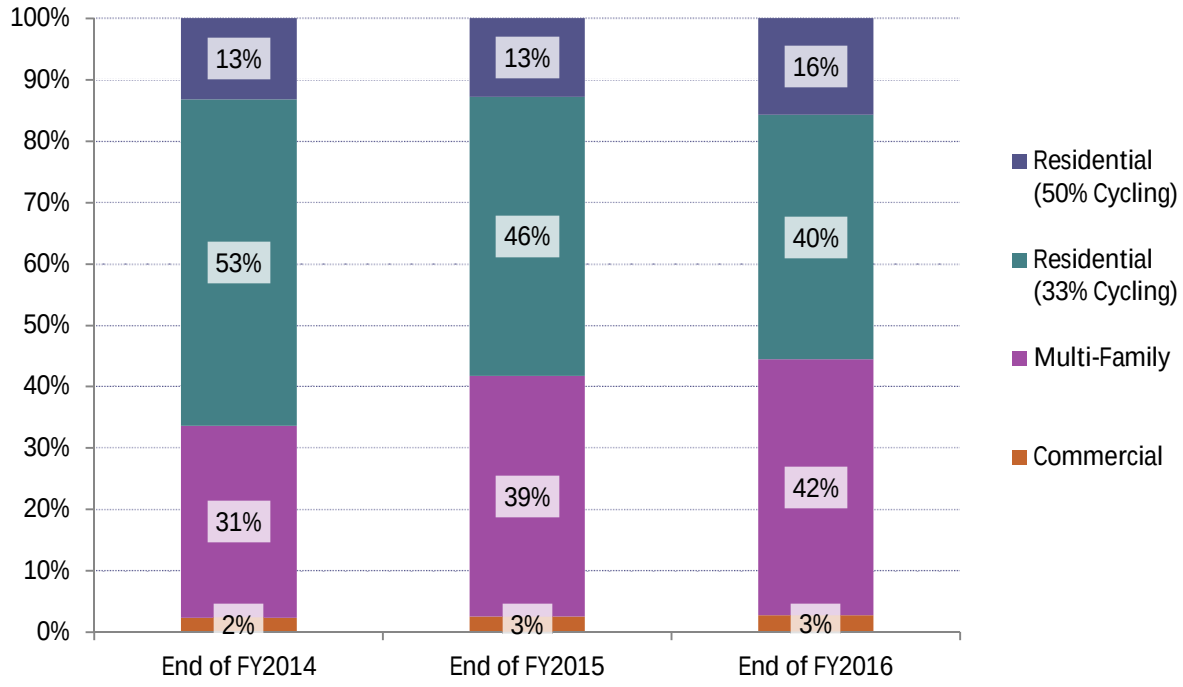


Figure 5.3-3: Smart Thermostat – Participation Share (FY 2014-FY 2016) – By Segment

Overall, the share of customers using the 50% cycling strategy is increasing in all segments (from about 13% in FY 2014 to 18% in FY 2016), due primarily to new residential participants coming on at the 50% cycling level and to a new requirement that all participants with Wi-Fi-enabled thermostats participate at the 50% cycling level. Significantly, 19% of all commercial participants were participating at the 50% cycling level by the end of FY 2016. Table 5.3-1 summarizes end of FY 2016 participation levels by customer segment and cycling strategy.

Table 5.3-1: Smart Thermostat – Program Participation by Group, End of FY 2016

Cycling Strategy	Single-family	Multifamily	Commercial	Total
33% Cycling	38,600	38,552	2,172	**79,324**
50% Cycling	15,202	1,806	505	**17,513**
Total	**53,802**	**40,358**	**2,677**	**96,837**
Percent on 50% Cycling	28%	4%	19%	18%

5.3.3 Savings Calculation Methods

A previous study conducted by Nexant examined the relationship between the timing of a DR event, outside temperature, and measured load reduction per installed thermostat. Frontier reviewed Nexant's study and concluded that the methods employed and the findings reported were reasonable. However, some aspects of Nexant's findings posed challenges in their application to FY 2016 events. These challenges are described below, along with Frontier's approach toward accounting for them in the FY 2016 analysis.

- Nexant's per-customer impact estimates were based on events being called from either 3-6 p.m. or 4-7 p.m., but the FY 2016 event schedule was more varied, and includes different start times ranging from 3:15 p.m. to 4:15 p.m.. In addition, Nexant's impacts were calculated based on 3 hour duration events, but in FY 2016 event durations ranged from 1 to 2 hours, with an average duration of 1.6 hours. To account for variation in start times, Frontier adjusted Nexant's impacts based on the weighted average of event intervals in each of Nexant's two start time bins. Frontier also examined Nexant's estimates of savings by hour over DR events and concluded that adjusting for shorter durations was unnecessary.
- Nexant included different impact assessments for residential customers at the 33% and 50% cycling strategies, but not for multifamily or commercial customers, presumably all of whom were on a 33% cycling strategy in FY 2014. By the end of FY 2016, however, 19% of commercial participants and 4% of multifamily participants were at 50% cycling. Frontier adjusted the impacts for multifamily and commercial customers participating at the 50% cycling strategy by 149%, equivalent to the average increase found by Nexant for single-family residential customers participating 50% rather than 33% cycling. This approach is consistent with the assumption that a change from 33% to 50% cycling strategy would increase average demand savings over an hourly period by about 150%

(0.5/0.33=1.50).

5.3.3.1 Energy Savings (kWh)

To compute net energy savings, Frontier employed Nexant's time-temperature matrix (Nexant TTM) to estimate gross per participant demand savings achieved during each called DR event, multiplied the result by the event duration in hours to obtain gross kWh savings, and then subtracted estimated snapback effects. Frontier adjusted Nexant's snapback impacts for multifamily and commercial customers participating at the 50% cycling strategy by 131%, equivalent to the average increase in snapback energy found by Nexant for single-family residential customers participating at 50%, rather than 33%, cycling. This approach only considers energy savings in the hours immediately before, during, and after called DR events, and does not consider more general conservation effects which may also be associated with the installation and use of a programmable thermostat.

5.3.3.2 Coincident Peak (CP) Demand Savings (kW)

To compute coincident peak demand savings, we estimated per customer demand savings using the Nexant TTM during the top 20 hours identified as most likely to coincide with CPS Energy system peaks. The probability-weighted average of demand savings during these hours was then calculated, and the result was scaled to the number of installed devices at the end of FY 2016.

5.3.3.3 Non-Coincident Peak (NCP) Demand Savings (kW)

Delivered non-coincident peak savings represent selected the maximum event demand savings among FY 2016 events. End of year and incremental estimates of NCP savings were obtained by scaling the delivered NCP to the number of installed devices at the end of FY 2016.

5.3.3.4 ERCOT 4CP Demand Savings (kW)

For ERCOT 4CP demand savings, we used the Nexant TTM to estimate per-device demand savings during each of 20 4CP intervals from 2011 to 2015, averaged those estimates, and scaled the result to the number of installed devices at the end of FY 2016. Finally, we adjusted the result by 87.5 percent, the rate at which the Smart Thermostat program has been successfully deployed during ERCOT 4CP event intervals over the past two years (the program coincided with 3 of 4 ERCOT 4CP events in FY 2015, and 4 of 4 intervals in FY 2016).

5.3.4 Impact Analysis Results

For demand response programs, we present impacts in three ways:

1) Estimated program impacts during summer 2015 DR events.

2) End of year program capability based on program enrollment at the end of FY 2016; this information is useful for planning purposes.

3) End- of-year program capability based on incremental enrollment during FY 2016; this information is used for program benefit-cost analysis, consistent with the methods

used for energy efficiency programs.

5.3.4.1 Estimated Impacts During Summer 2015 DR Events

Nineteen demand response events were called during the summer of 2015 for Smart Thermostat participants. Frontier applied the adjusted per-customer savings estimates to the demand response events called by CPS Energy for this program during the summer of 2015 to obtain estimates of the demand reduction attributable to events called during FY 2016.[34] Four of the events called by CPS Energy during the summer of 2015 coincided with the four coincident peak intervals (4CPs) used by ERCOT to allocate transmission costs to load-serving entities. The average demand reduction during FY 2016 4CP intervals was 33,564 kW. These demand reduction estimates are shown in Figure 5.3-4.

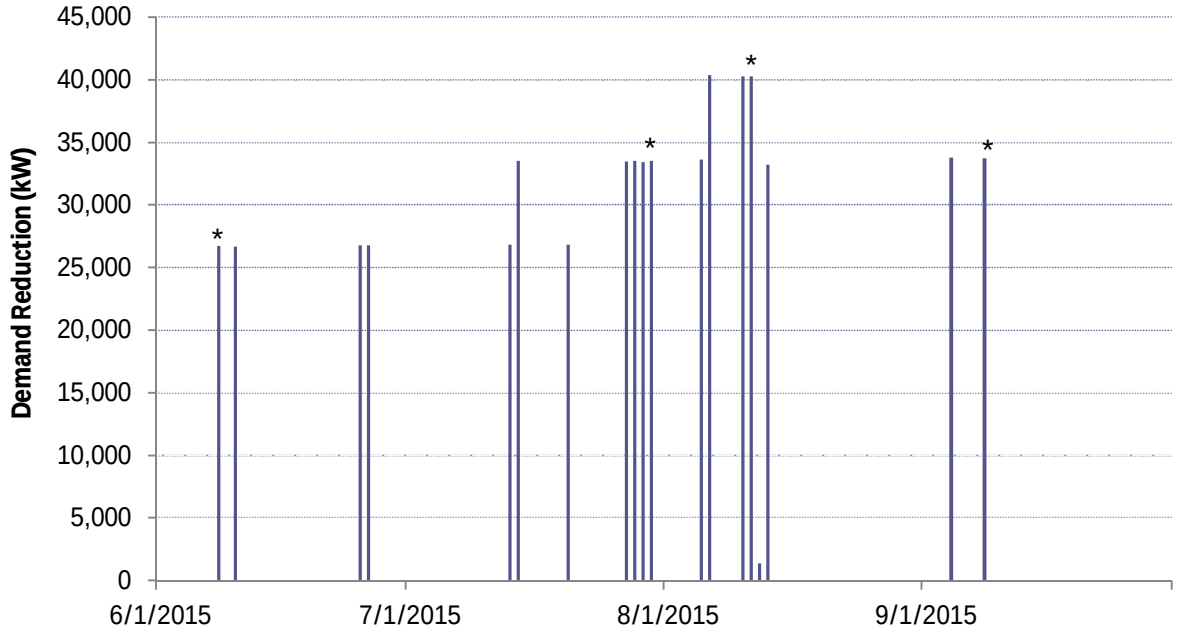


Figure 5.3-4: Smart Thermostat – Achieved Demand Reduction during Summer 2015 Called Events

Note: Called events coinciding with ERCOT 4CP intervals are designated with a *.

The table below shows estimated energy, peak demand, non-coincident peak demand, and ERCOT 4CP demand savings actually delivered by the program in FY 2016. Peak demand savings are the average estimated savings during CPS Energy's top five system peak intervals; ERCOT 4CP savings are the average estimated savings during ERCOT 4CP events. Non-coincident peak savings are the highest savings achieved during any event.

[34] The impact of the August 13 event was estimated at 1,372 kW and is shown on the graph. This event was a last minute call due to a rise in ERCOT market prices, and participation was much lower than for other events because only customers with Wi-Fi-connected thermostats were called. The event is included in all savings calculations.

Table 5.3-2: Smart Thermostat Gross Energy and Demand Savings – FY 2016 Delivered

Measure	Energy Savings (kWh)	Peak Demand Savings (kW)	Non-Coinc. Demand Savings (kW)	ERCOT 4CP Demand Savings (kW)
Single-Family Dwellings, 33% Cycling	396,571	19,958	19,939	16,652
Single-Family Dwellings, 50% Cycling	158,473	8,296	8,301	6,920
Multifamily (33% and 50% Cycling)	241,111	10,547	10,635	8,766
Commercial (33% and 50% Cycling)	29,443	1,488	1,508	1,225
Total	**825,597**	**40,288**	**40,383**	**33,564**

5.3.4.2 End of Year Program Capability

End of year program capability is based on end of year enrollment; both are shown below.

Table 5.3-3: Smart Thermostat Gross Energy and Demand Savings – End of Year Capability

Measure	End of Year Enrollment	Energy Savings (kWh)	Peak Demand Savings (kW)	Non-Coinc. Demand Savings (kW)	ERCOT 4CP Demand Savings (kW)
Single-Family Dwellings, 33% Cycling	38,600	373,390	16,604	18,889	14,449
Single-Family Dwellings, 50% Cycling	15,202	223,812	9,962	11,121	8,670
Multifamily (33% and 50% Cycling)	40,358	275,100	10,850	11,198	9,442
Commercial (33% and 50% Cycling)	2,677	32,871	1,493	1,459	1,300
Total	**96,837**	**905,173**	**38,909**	**42,667**	**33,862**

5.3.4.3 Incremental Impacts

Incremental impacts used for cost-effectiveness analysis are based on gross incremental enrollment; both are shown below.

Table 5.3-4: Smart Thermostat Gross Energy and Demand Savings – Incremental Impacts

Measure	Gross Incremental Enrollment	Energy Savings (kWh)	Peak Demand Savings (kW)	Non-Coinc. Demand Savings (kW)	ERCOT 4CP Demand Savings (kW)
Single-Family, 33% Cycling	0	0	0	0	0
Single-Family, 50% Cycling	2,273	33,464	1,490	1,663	1,296
Multifamily (33% and 50% Cycling)	5,536	37,736	1,488	1,536	1,295
Commercial (33% and 50% Cycling)	356	4,371	199	194	173
Total	**8,165**	**76,321**	**3,281**	**3,598**	**2,855**

5.3.5 Recommendations

Frontier makes the following recommendations for the Smart Thermostat program.

- Highest growth in FY 2016 was in the multifamily sector, which presents CPS Energy with similar per-customer costs, but lower per-customer savings.
- To improve program cost effectiveness, concentrate marketing toward 50% cycling in all customer segments.
- Revisit savings estimates to update assumed savings, especially for the commercial and multifamily 50% cycling segments.

5.4 HOME MANAGER PROGRAM

5.4.1 Overview

Launched in 2012, Home Manager is a comprehensive electric load monitoring and direct load control program. Total participation stood at 22,211 on 01/31/2016.[35]

The Home Manager system controls three types of devices: HVAC units, electric water heaters, and pool pumps. When CPS Energy calls an event, all Home Manager thermostats are adjusted upward by three degrees from their pre-event setpoints. Water heaters and pool pumps are powered off for the duration of the event. Customers have the ability to reset their thermostat setpoints or drop completely out of the event at any time. In 2015, CPS Energy called 10 test events and 13 additional events, including one that fell on a federal holiday, ranging from 0.83 to 1.75 hours in duration.[36]

[35] 22,211 is the total number of active Consert Meter and Active Stand Alone Gateway combined.
[36] One event coincided with a federal holiday (9/07/2015) and thus was not included in the analysis of estimated savings. Another 2 events (on 8/18/2015 and 8/26/2015) were also dropped from the savings analysis because they were deployed in a manner that sought less than 100% load shed.

5.4.1 Participation Trends

The following figure shows the number of active premises during each event in summer 2015.

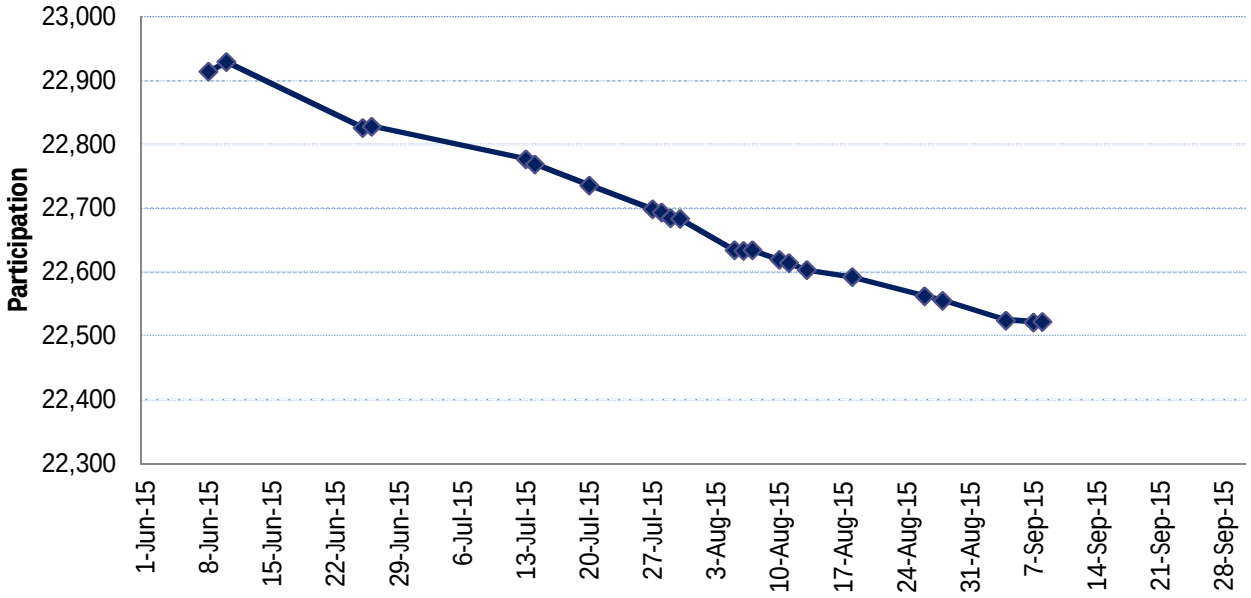


Figure 5.4-1: Home Manager – Participation Trend

Nearly 99 percent of program participation is from single family homes with no pool. All other premise types comprise slightly more than 1 percent of the total. The following table shows the estimated breakdown of Home Manager program participation by category as of 1/31/2016.[37]

Table 5.4-1: Home Manager - Estimated Participation by Category, as of 01/31/2016

	# of Premises	%
Single Family House – no pool	21,957	98.9%
Mobile Home	111	0.5%
Townhouse	47	0.2%
Apartments	36	0.2%
Single Family House – with pool	30	0.1%
All others (duplexes, businesses, US military, condominiums, official county agencies)	31	0.1%

[37] Breakdown of participating premises by category was available for 12/31/2015. The proportions on 12/31/2015 were applied to the total participation on 1/31/2016 to generate the estimates shown above.

5.4.2 Event kW and kWh Savings Methodology

CPS Energy provided Frontier with interval meter data from a sampling of Home Manager customer types. Frontier produced estimates of kW and kWh savings within each sample, and scaled the results to applicable participation levels during each event and at the end of the program year.

A top 3-of-10 baseline method was applied to estimate kW savings. For each customer during each event, the previous 10 non-event, non-holiday weekdays were ranked based on total kWh during the event period. The three days with the highest kWh during the curtailment period were selected and averaged as a calculated baseline. An adjustment factor of the average kWh during an event day from ten minutes before the event until five minutes before the event[38] divided by the average kWh during three selected baseline days may be applied to the calculated baseline to account for weather effects and customer operation levels on the event day.

Frontier also employed a fixed-effects panel data analysis regression model to quantify the kWh savings using 15-minute energy consumption data from a sample of Home Manager customers in each category, as a reference for baseline method calculation. Panel data regression analysis takes temperature and snapback usage into consideration. The model equation is stated as follows:

$$Consumption_{i,t} = \beta_{0i} + \beta_1 * cdh_t + \beta_2 * event_t + \beta_3 * snapback_t + \varepsilon_{i,t}$$

In the equation above:

Cdh:	cooling degree hours. Balance point is set at 65F. cdh = max(hourly temperature – 65F, 0)
event:	dummy variable, 1 if on an event period; 0 otherwise
snapback:	dummy variable, 1 if on a post event 1-hour period; 0 otherwise

$-\beta_2$ is the estimate for 15-minute kWh savings during event period. β_3 is the estimate for 15-minute kWh snapback during 1-hour post event period. So within each category, the average kWh savings for each customer is $-\beta_2 * 4 *$ event hours $- \beta_3 * 4 * 1$ (snap back hour).

5.4.2.1 Coincident Peak Demand Savings (kW)

To estimate coincident peak demand kW savings, we estimated per premise demand savings using the top 3-of-10 baseline analysis within each sample category for each event. An average kW savings of sixteen out of twenty high temperature[39] events in 2015 was then calculated. To estimate program capability based on end-of-year and incremental enrollment, we scaled the result to the number of active premises at the end of FY 2016 and to the number of new participants during FY 2016, respectively.

[38] CPS used the 5 minute interval immediately before the event start. Frontier found some participants appeared to have begun the curtailment a few minutes before the event start time, and thus moved the adjustment period 5 minutes earlier.
[39] Four low temperature events in June (when event temperature was below 95F) were excluded from the analysis.

5.4.2.2 Non-Coincident Peak (NCP) Demand Savings (kW)

To estimate delivered non-coincident peak savings, we estimated per-premise demand savings using the top 3-of-10 baseline analysis within each sample category for each event. We then selected the single event with the highest savings. For the year-end capability and incremental calculations, we scaled the result to the number of active premises at the end of FY 2016 and to the number of new participants during FY 2016, respectively.

5.4.2.3 ERCOT 4CP Demand Savings (kW)

During summer 2015, four of the twenty Home Manager events coincided with ERCOT 4CP events, including one non-test event and three test events, for a success rate of 100%. To estimate ERCOT 4CP demand savings, we estimated per-premise kW savings using top 3-of-10 baseline analysis, selected the four events which coincided with ERCOT 4CP, and multiplied the result by the ERCOT 4CP success rate. For the year-end capability and incremental calculations, we scaled the result to the number of active premises at the end of FY 2016 and to the number of new participants during FY 2016, respectively.

5.4.3 Impact Analysis Results

For demand response programs, we present impacts in three ways:

1) Estimated program impacts during 2015 called DR events.
2) End-of-year program capability based on program enrollment at the end of FY 2016; this information is useful for planning purposes.
3) End-of-year program capability based on incremental enrollment during FY 2016; this information is used for program benefit-cost analysis, consistent with the methods used for energy efficiency programs.

5.4.3.1 Estimated Impacts during 2015 DR Events

During summer 2015, the impacts of events ranged from 26,226 kW (6/10 event) to 49,344 kW (8/13 event). Four of the called events coincided with the four coincident peak intervals (4CPs) used by ERCOT to allocate transmission costs to load-serving entities. These demand reduction estimates are shown in the following figure.

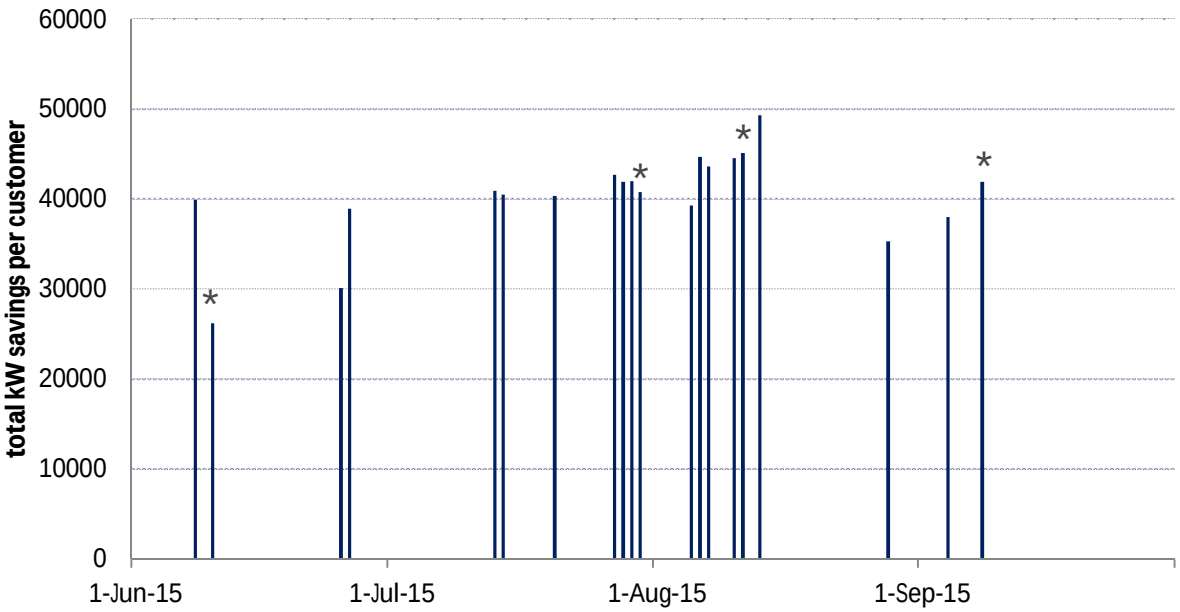


Figure 5.4-2: Home Manager – Achieved Demand Reduction during Summer 2015 Called Events

Note: Events coinciding with ERCOT 4CP intervals are designated with a *.

The per-participant energy savings achieved during events called by CPS Energy averaged 2.24 kWh per event[40] with later snapback of 0.76 kWh per event.[41] Thus overall energy savings through each event per customer was estimated at 1.48 kWh. Annual energy savings are estimated at 671,836 kWh,[42] reflecting the per-participant energy savings, the number and duration of events called, the snapback effect, and the number of participants during each event.

Using the top 3-of-10 methodology for preliminary calculation, the per-participant demand reduction achieved through this program during high-temperature events called by CPS Energy averaged 1.85 kW.[43] Multiplication of these per-participant savings values by the year-end numbers of participants yields an average demand reduction of 41,970 kW during high temperature events.[44] Non-coincident peak demand savings are estimated at 45,182 kW.[45] Four of the events called by CPS Energy for the Home Manager Program coincided with ERCOT's 4CP intervals in 2015, resulting in a reduction in CPS Energy's demand during ERCOT 4CP intervals of roughly 38,398 kW.[46]

[40] 2.24 kWh = ($\sum_{event}$ average kWh savings per event per customer within each category* estimated # of premises within each category on that event day)/(# of events/average total # of premises during 20 events.
[4141] 0.76 kWh = ($\sum_{event}$ average kWh snapback per event per customer within each category* estimated # of premises within each category on that event day)/# of events/average total # of premises during 20 events.
[42] 671,836kWh = ($\sum_{event}$ average kWh savings per event per customer within each category* estimated # of premises within each category) - ($\sum_{event}$ average kWh snapback per event per customer within each category* # of premises within each category).
[43] 1.85kW = ($\Sigma_{housing\ type}$ average kW savings per high-temperature-event per customer * estimated # of premises within each category on that event date)/# of high-temperature events/average total # of premises during high-temperature events.
[44] 41,970 kW = $\Sigma_{housing\ type}$ average kW savings per high-temperature-event per customer * estimated # of premises within each category on that event date)/# of high-temperature events.
[45] 45,182kW = max (total kW savings for each event).
[46] 38,398kW = ($\Sigma_{housing\ type}$ average kW savings on 4 events coinciding with ERCOT 4CP per customer * total # of premises within

Table 5.4-2: Home Manager Gross Energy and Demand Savings – FY 2016 Delivered

Measure	Energy Savings (kWh)	Peak Demand Savings (kW)	Non-Coinc. Demand Savings (kW)	ERCOT 4CP Demand Reduction (kW)
Total	671,836	41,970	45,182	38,398

5.4.3.2 End of Year Program Capability

Based on a total of 22,211 online devices at the end of FY 2016, the Home Manager program was capable of providing the energy and demand savings shown in the table below. End-of-year capability is less than delivered savings due to declining net enrollment in the program.

Table 5.4-3: Home Manager Gross Energy and Demand Savings – End of Year Capability

Measure	Energy Savings (kWh) [47]	Peak Demand Savings (kW) [48]	Non-Coinc. Demand Savings (kW) [49]	ERCOT 4CP Demand Reduction (kW) [50]
Total	657,515	41,157	44,375	37,633

5.4.3.3 Incremental Impacts

Incremental impacts used for cost-effectiveness analysis are based on gross incremental enrollment. 2,331 new customers joined in Home Manager program between 2/1/2015 and 1/31/2016. The results are shown below.

Table 5.4-4: Home Manager Gross Energy and Demand Savings – Incremental Impacts

Measure	Energy Savings (kWh) [51]	Peak Demand Savings (kW) [52]	Non-Coinc. Demand Savings (kW) [53]	ERCOT 4CP Demand Reduction (kW) [54]
Total	69,004	4,319	4,657	3,949

each category on that event date) * 100% (success rate).

[47] 657,515kWh = per-participant energy savings achieved during event * # of events called in 2015 * year-end customer counts – per-participant energy snapback 1 hour after event * # of events called in 2015 * year-end customer counts

[48] 41,157 kW = 1.85 * year-end customer counts

[49] 44,375 kW = 45,182 kW / # of participants on that event day * year-end customer counts

[50] 37,633 kW = average kW savings on 4 events coinciding with ERCOT 4CP per participant * year-end customer counts * 100% success rate

[51] 69,004 kWh = per-participant energy savings achieved during event * # of events called in 2015 * gross customer increase – per-participant energy snapback 1 hour after event * # of events called in 2015 * gross customer increase

[52] 4,319 kW = 1.85 kW * gross customer increase

[53] 4,657 kW = per-participant kW savings on NCP event day in 2015 * gross number increase

[54] 3,949 kW = average per-participant kW savings on 4CP days in 2015 * 100% success rate * gross number increase

5.5 BRING YOUR OWN THERMOSTAT (BYOT) PROGRAM

5.5.1 Overview

Beginning in FY 2015, CPS Energy partnered with Nest Labs to implement the Rush Hour Rewards (RHR) program for customers with Nest thermostats. Rush Hour Rewards uses a combination of pre-cooling in anticipation of a 'rush hour' – a demand response event initiated by CPS Energy – and air conditioner cycling during the events to achieve load reduction. Nest RHR events must be called a day in advance, and each event lasts for three hours. Because of Nest's 'learning' capabilities, reductions may vary based on whether the home is occupied at the time of the event, or other variables. More information on Nest's Rush Hour Rewards (RHR) program is available from the Nest Labs website.[55]

Starting in FY 2016, CPS Energy began incorporating existing Nest RHR customers into a more broadly defined Bring Your Own Thermostat (BYOT) program,[56] which offers similar incentives to customers who self-install any of several qualifying thermostats. These include Honeywell thermostats that operate in a manner similar to those installed under the existing Smart Thermostat program, and EnergyHub thermostats that operate in a manner similar to those installed under the existing Home Manager program. The key differentiator of BYOT, relative to Smart Thermostat and Home Manager, is that the customer purchases and installs the qualifying thermostat under BYOT, reducing direct install costs otherwise incurred by CPS Energy.

CPS Energy typically passes these savings on to the customer via a one-time credit of $85 upon enrollment in the program, plus a $30 bill credit at the end of each summer for participating in the program. This year, CPS Energy also offered a retail credit of $150 toward customers' purchase of qualifying thermostats from participating vendors, in a late November through January promotion.

Throughout the FY 2016 demand response season, only Nest thermostats participated in BYOT. However, some Honeywell and EnergyHub thermostats became active in the BYOT program in the late fall. Thus, our estimates of demand and energy savings achieved during the demand response season consider only the Nests that were available at the time of each demand response event. However, our estimates of year-end program capability and incremental capability resulting from new program additions during the year are built around all types of participating thermostats.

5.5.2 Participation Trends

Figure 5.5-1 shows the number of enrolled devices in the BYOT program at the beginning and end of FY 2016 and through all DR events. The number of enrolled Nests increased by 237% in FY 2016, while the total number of enrolled thermostats in BYOT increased by 286%.

[55] Nest Support. *What is Rush Hour Rewards?* Online. Available: https://nest.com/support/article/What-is-Rush-Hour-Rewards. Accessed March 8, 2016.
[56] CPS Energy markets this program as the My Thermostats Rewards program.

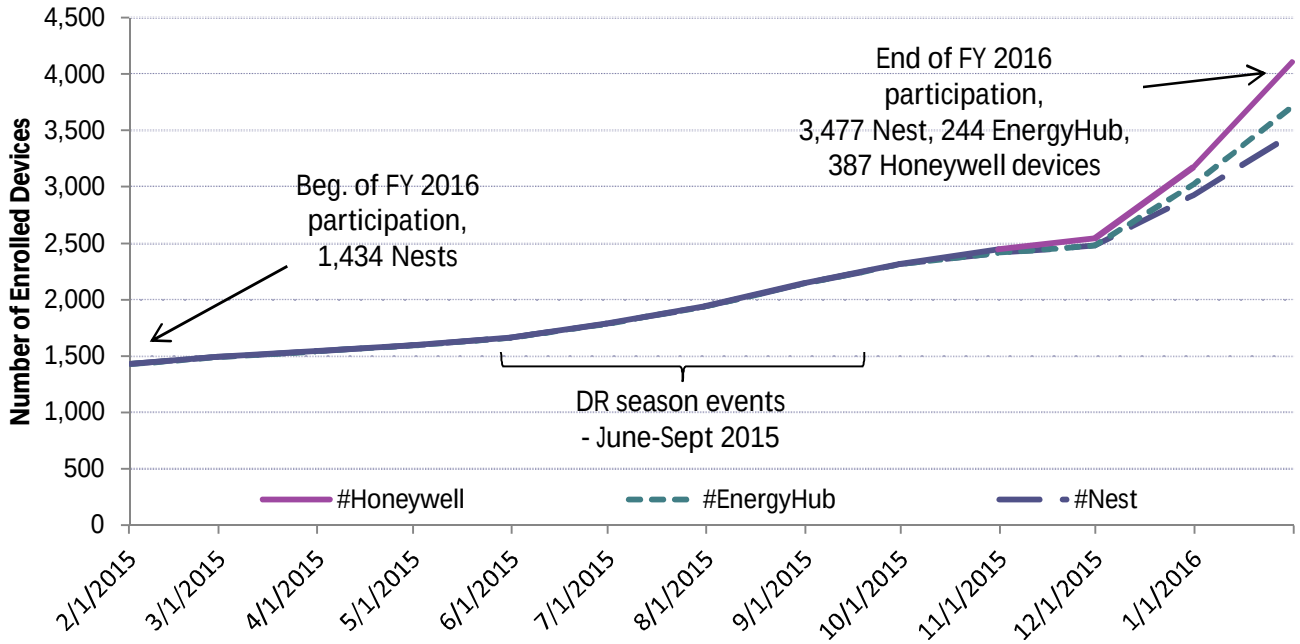


Figure 5.5-1: Bring Your Own Thermostat – Participation Trend (FY 2016)

Using CPS Energy-provided data on Nest RHR customers who enrolled over the past two years, we observed only minor changes in the number of Nests per enrollee, premise type, and premise size. These findings suggest that the per-device impacts previously estimated by Nexant[57] may continue to serve as a reasonable proxy for Nest impacts in FY 2016. For new participation by EnergyHub and Honeywell devices, we used savings factors derived from Frontier's analyses of the Home Manager and Smart Thermostat programs, respectively.

[57] CPS Energy Nest Pilot Evaluation FY 2015 – FINAL, Nexant, November 21, 2014.

The number of Nests per household declined slightly from 1.27 to 1.22 by the end of FY 2016.

Figure 5.5-2 below breaks down Nest RHR customers by premise type over the past two calendar years. About 72% of all enrollee premise types are single-family homes, about 9% are apartments, and about 17% are unknown. Participation by businesses, condominiums, duplexes and other premise types together comprise less than 2%.

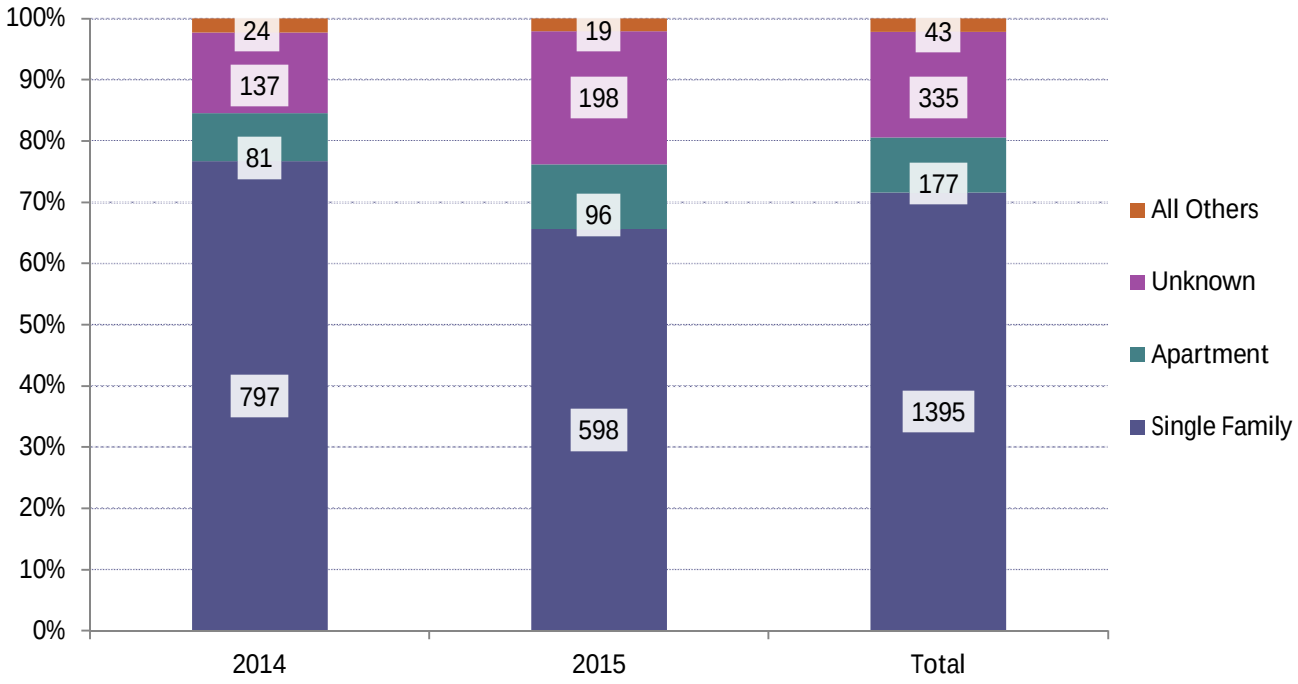


Figure 5.5-2: Bring Your Own Thermostat – Nest Participation Share by Premise Type

Note: The 2014 and 2015 columns show the participation share of new enrollees during calendar year 2014 and 2015, respectively. The Total column shows the combined participation share of all enrollees (2014 and 2015).

5.5.3 Savings Calculation Method

The following sections describe Frontier's methods for estimating savings attributable to Nest thermostats participating in the BYOT program. Methods for estimating savings from BYOT-enrolled EnergyHub and Honeywell thermostats are described in the Home Manager and Smart Thermostat sections of this report, respectively.

5.5.3.1 Energy Savings (kWh)

Frontier employed billing analysis using a fixed effects panel data analysis model to quantify the electricity and gas savings attributable to installation of a Nest thermostat and enrollment in the Nest RHR program. Monthly usage data were collected for about 900 consumers who acquired a Nest thermostat, as revealed by the Nest RHR program participation records. Electricity and natural gas usage data were collected for the period from January 2010 through the end of 2015 for customers who acquired Nests between June 2014 and the end of 2014. Thus the data

include many months of usage before and after utilization of the Nest thermostat. Usage data based on inconsistent meter read dates were “calendarized” to coincide with calendar months.

A panel data model was used to quantify the average monthly savings associated with installing a Nest after controlling for the weather (i.e., heating and cooling degree days) within a single model. Separate analyses were conducted for electricity and natural gas consumption; only electricity savings are presented here.

Frontier’s model found that the presence of a Nest thermostat reduced electricity consumption by 51 kWh per household per month. Since the average monthly electricity consumption of this group of customers is 1,565 kWh, this conservation effect is 3.2%.

5.5.3.2 Coincident Peak (CP) Demand Savings (kW)

A previous study conducted by Nexant examined the relationship between the timing of a called DR event, outside temperature, and measured load reduction per installed Nest thermostat. Frontier reviewed Nexant’s study and concluded that the methods employed and the findings reported were reasonable.

To compute coincident peak demand savings, we estimated per-device demand savings using the Nexant TTM during the top 20 hours identified as most likely to coincide with CPS Energy system peaks. We then calculated the probability-weighted average of demand savings during these hours, and scaled the result to the number of installed devices at the end of FY 2016.

5.5.3.3 Non-Coincident Peak (NCP) Demand Savings (kW)

Delivered non-coincident peak savings represent selected the maximum event demand savings among FY 2016 events. End of year and incremental estimates of NCP savings were obtained by scaling the delivered NCP to the number of installed devices at the end of FY 2016.

5.5.3.4 ERCOT 4CP Demand Savings (kW)

For ERCOT 4CP demand savings, we used the Nexant TTM to estimate per device demand savings during each of twenty 4CP intervals called from 2011 to 2015. Those estimates were averaged (about 0.69 kW per device), and the result was scaled to the number of installed devices at the end of FY 2016. Finally, we adjusted the result by fifty percent, the rate at which the Nest RHR program has been successfully deployed during ERCOT 4CP event intervals over the past two years (the BYOT program coincided with one of four ERCOT 4CP events in FY 2015, and three of four intervals in FY 2016).

5.5.4 Impact Analysis Results

For demand response programs, we present impacts in three ways:

1) Estimated program impacts during summer 2015 DR events.

2) End of year program capability based on program enrollment at the end of FY 2016; this information is useful for planning purposes.

3) End of year program capability based on incremental enrollment during FY 2016; this information is used for program benefit-cost analysis, consistent with the methods used for energy efficiency programs.

5.5.4.1 Estimated Impacts During 2015 DR Events

Ten demand response events were called during the summer of 2015 for BYOT participants. Frontier applied the per-device savings estimates to each event in order to obtain estimates of the demand reduction attributable to events called during FY 2016. The impacts of events ranged from 1,094 kW (6/24 event) to 1,519 kW (8/10 event). Three of the called events coincided with the four coincident peak intervals (4CPs) used by ERCOT to allocate transmission costs to load-serving entities. These demand reduction estimates are shown in Figure 5.5-3.

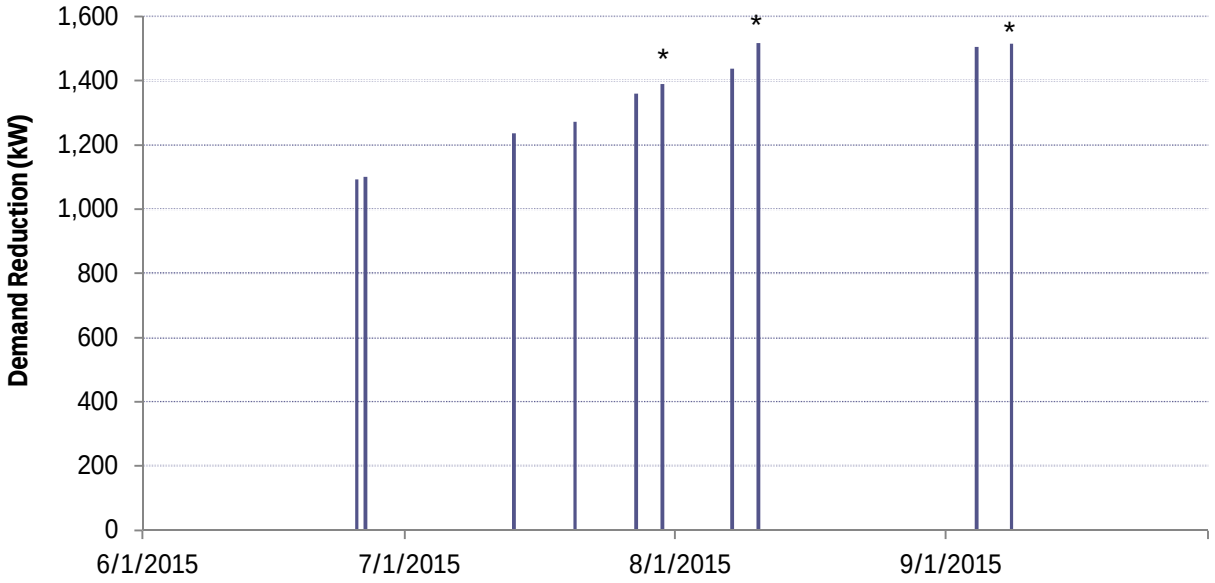


Figure 5.5-3: Bring Your Own Thermostat – Achieved Demand Reduction during Summer 2015 DR Events

Note: Events coinciding with ERCOT 4CP intervals are designated with an *.

The table below shows estimated energy, peak demand, non-coincident peak demand, and ERCOT 4CP demand savings actually delivered by the program in FY 2016. Peak demand savings are the average estimated savings achieved when the program was dispatched during CPS Energy's top five system peak intervals; ERCOT 4CP savings are the average estimated savings during ERCOT 4CP events (the program was dispatched during 3 of the 4 ERCOT 4CP events; thus the total represents approximately 75% of the savings during each event which overlapped with an ERCOT 4CP interval). Non-coincident peak savings are the highest savings achieved during any event. Because the BYOT program consisted only of Nest thermostats through the DR season, the delivered impacts do not consider the introduction of other thermostat types later in the program year.

Table 5.5-1: BYOT Gross Energy and Demand Savings – FY 2016 Delivered

Measure	Energy Savings (kWh)	Peak Demand Savings (kW)	Non-Coinc. Demand Savings (kW)	Demand Reduction during 4CPs
Nest	40,315	1,519	1,519	1,107
EnergyHub	0	0	0	0
Honeywell	0	0	0	0
Total	40,315	1,519	1,519	1,107

5.5.4.2 End of Year Program Capability

End of year program capability is based on end of year enrollment; both are shown in the table below.

Table 5.5-2: BYOT Gross Energy and Demand Savings – End of Year Capability

Measure	End of Year Enrollment	Energy Savings (kWh)	Peak Demand Savings (kW)	Non-Coinc. Demand Savings (kW)	ERCOT 4CP Demand Savings (kW)
Nest	3,477	15,084	2,735	2,735	2,003
EnergyHub	244	4,663	302	453	92
Honeywell	387	5,698	254	283	221
Total	4,108	25,444	3,291	3,471	2,316

5.5.4.3 Incremental Impacts

Incremental impacts used in benefit-cost analysis are based on gross incremental enrollment during the program year; both are shown in the table below.

Table 5.5-3: BYOT Gross Energy and Demand Savings – Incremental Impacts

Measure	Gross Incremental Enrollment	Energy Savings (kWh)	Peak Demand Savings (kW)	Non-Coinc. Demand Savings (kW)	ERCOT 4CP Demand Savings (kW)
Nest	2,043	8,863	1,607	1,607	1,177
EnergyHub	244	4,663	302	453	92
Honeywell	387	5,698	254	283	221
Total	2,674	19,223	2,163	2,343	1,490

5.5.5 Recommendations

Frontier provides the following recommendations for the BYOT program:

- Application of Nexant's TTM to FY 2016 events yielded demand reduction estimates that were an average of 11% lower than Nest's demand reduction estimates; however, when Nexant compared its TTM derived results to Nest's in FY 2014, those results were, on average, approximately equivalent. Differences in FY 2016 may be due to certain events being called earlier in the day, to changes made to Nest's algorithms since FY 2014, or to other unidentified factors. Changes in Nest RHR program enrollment, such as the number of Nests per enrollee, and enrollment by premise type and size, based on the data received by Frontier, do not appear to explain the difference. During the next program year, it may be appropriate to re-analyze Nest participants with interval meter data in order to re-estimate demand savings factors over a wider range of event start times.

- Transition of this program to BYOT involves the inclusion of additional thermostat types, which may incorporate different approaches to demand and energy savings within and outside DR events. The evaluation methodology will likely need to be updated to accommodate various device types, for example, by estimating savings based on interval meter data from samples of customers with each device type, similar to the analysis undertaken this year for the Home Manager program.

5.6 THINKECO ROOM AIR CONDITIONER PROGRAM

5.6.1 Overview

Through the ThinkEco Room Air Conditioner Pilot Program (ThinkEco Pilot), CPS Energy customers with one or more room air conditioners (RACs) are offered a free SmartAC kit from ThinkEco (valued at $139) and a participation incentive in the form of a $30 end-of-season bill credit. Each customer can receive up to 3 free SmartAC kits. In return, participants allow CPS Energy to adjust the RAC setpoints during peak summer day events. The SmartAC kit also allows consumers to remotely control the thermostat on their RAC. This remote displays a “DR” indicator during a demand response event, during which time the customer’s thermostat setpoint is raised. Customers are able to opt out of an event by adjusting their setpoints via the remote, web, or smartphone application. A “refresh” signal is sent halfway through the event, requiring customers to opt out a second time if they wish to again override the curtailment request.

Curtailment implementation combines RAC cycling with a setpoint adjustment, once at the start of an event and a second time at the event refresh. First, units are cycled off for 10 minutes at the start and refresh of each event. After the first 10 minutes, the SmartAC moderates RAC usage by revising the thermostat setpoint on controlled units. The exact timing at which individual units are started during an event is randomized across devices in an effort to smooth the load shed from the initiation of the events.

5.6.1 Participation Trends

The following figure shows the participation trend by the number of devices online on each curtailment event during summer 2015.

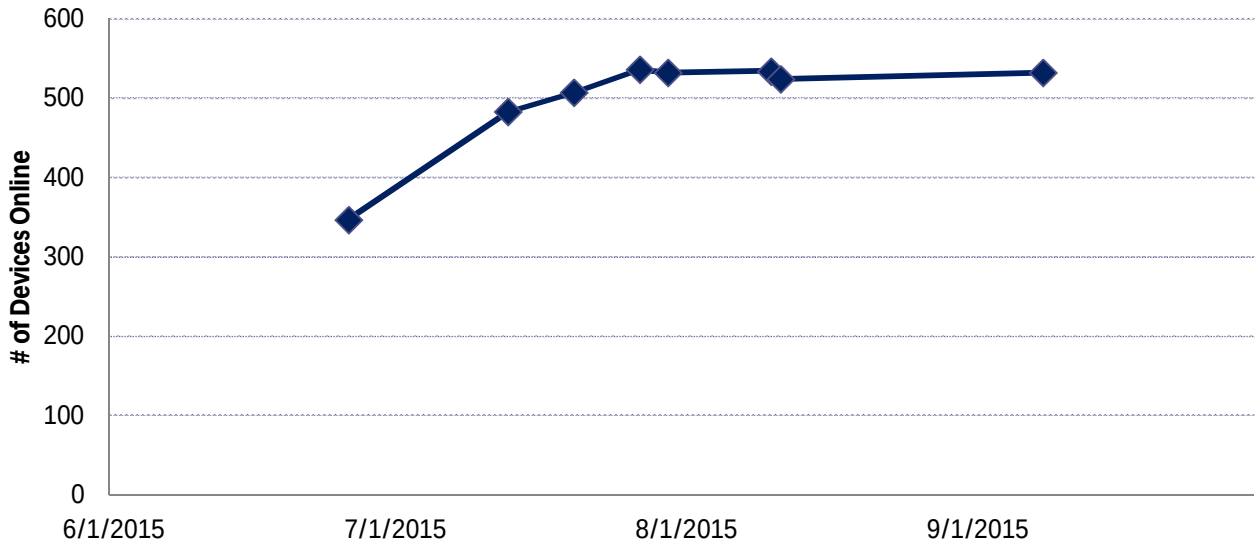


Figure 5.6-1: ThinkEco – Program Participation by Devices Installed, Summer 2015

Customers were signed up, approved, and units were installed throughout the program year, including during the curtailment season. This program year, particular emphasis was placed on improving the response rate of installed units. During FY 2016, ThinkEco reported 820 total installs resulting in 793 online devices, for an online rate of 97%. By year end, these plus 287 responsive devices installed in the prior year were reported as online and available, for a total of 1,080 online devices.

The dropout rate continues to challenge the program. The 287 responsive devices installed in the previous year represent just 35% of the total number installed. It is possible that devices are simply unplugged during the off season when RACs are not in use, and then not redeployed during the next DR season. Although the expected useful life of thermostats is typically 10 years, in this year's benefit-cost analysis we have reduced the EUL for SmartAC kits to 3 years, to better reflect the data on persistence.

5.6.2 Event kW and kWh Savings

A top 3-of-10 baseline method was applied to estimate kW savings. For each customer during each event, the previous 10 non-event, non-holiday weekdays were ranked based on total kWh during the event period. The three days with the highest kWh during the curtailment period were selected and averaged as a calculated baseline. An adjustment factor of the average kWh during an event day from 13:00 to 14:00 divided by the average kWh during 3 selected baseline days may be applied to the calculated baseline to factor in weather effects and customer operation levels on the event day.

5.6.2.1 Energy Savings (kWh)

Frontier employed a regression analysis model to quantify the kWh savings using 15-minute wattage data. Regression analysis takes temperature and later snapback time into consideration. A customer's electricity consumption is modeled as a function of temperature, event period and snapback period. The model equation is represented as below:

$$Consumption_t = \beta_0 + \beta_1 * cdh_t + \beta_2 * hdh_t + \beta_3 * event_t + \beta_4 * snapback_t + \varepsilon$$

In the equation above:

cdh:	cooling degree hours. Balance point is set at 65F. If hourly temperature > 65F, cdh = hourly temperature – 65; if hourly temperature <= 65F, cdh = 0.
hdh:	heating degree hours. Balance point is set at 65F. If hourly temperature < 65F, hdh = 65 – hourly temperature; if hourly temperature >= 65F, hdh = 0.
event:	dummy variable, 1 if on an event period; 0 otherwise.
snapback:	dummy variable, 1 if on a snapback period (snapback period: 1 hour right after the event); 0 otherwise.

In the equation above: $-\beta_3$ is the wattage savings estimate per device; β_4 is the wattage increase

estimate per device on 1-hour snapback period. So the average kWh savings per online device is ($-\beta_3$ * event duration - β_4 * 1) / 1000.

5.6.2.2 Coincident Peak Demand Savings (kW)

To estimate coincident peak demand kW savings, we estimated total kW savings using a top 3-of-10 baseline analysis for each event, and took the average kW savings of 7 out of 8 events in 2015 as the coincident peak. The first event in June was eliminated due to relatively low temperature.

5.6.2.3 Non-Coincident Peak (NCP) Demand Savings (kW)

To estimate delivered non-coincident peak savings, we estimated total demand savings using top 3-of-10 baseline analysis for each event. We then selected the single event with the highest per-device savings and multiplied by the appropriate number of devices deployed. These results were then scaled to obtain end of year and incremental impacts.

5.6.2.4 ERCOT 4CP Demand Savings (kW)

During the summer of 2015, 3 events coincided with ERCOT 4CP event intervals for a 75% success rate. To estimate ERCOT 4CP demand savings, we estimated total kW savings on the 3 events that coincided with ERCOT 4CP intervals using top 3-of-10 baseline analysis, and multiplied the result by the success rate.

5.6.3 Impact Analysis Results

For demand response programs, we present impacts in three ways:

1) Estimated program impacts during summer 2015 DR events.
2) End of year program capability based on program enrollment at the end of FY 2016; this information is useful for planning purposes.
3) End of year program capability based on incremental enrollment during FY 2016; this information is used for program benefit-cost analysis, consistent with the methods used for energy efficiency programs.

5.6.3.1 Estimated Impacts during 2015 DR Events

The following bar chart summarizes total kW savings by each curtailment event during the summer of 2015.

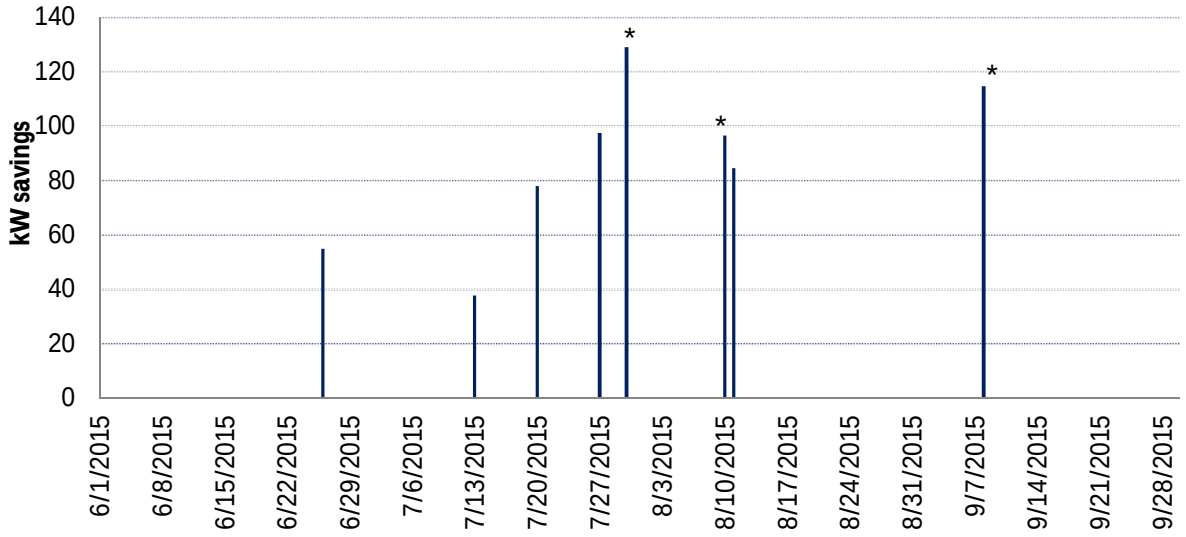


Figure 5.6-2: ThinkEco – Achieved kW Demand Reduction during Summer 2015 Called Events

Note: ERCOT 4CP events are marked with a *.

Estimated energy and demand savings for the ThinkEco program during summer 2015 events are shown in the table below.

Table 5.6-1: ThinkEco Gross Energy and Demand Savings – FY 2016 Delivered

Measure	Energy Savings (kWh) [58]	Peak Demand Savings (kW) [59]	Non-Coinc. Demand Savings (kW) [60]	ERCOT 4CP Demand Savings (kW) [61]
Total	483	91	129	85

5.6.3.2 End-of-Year Program Capability

Based on a total of 1,080 online devices at the end of FY 2016, the ThinkEco program was capable of providing the energy and demand savings shown in the table below. [62]

[58] 483 kWh = Σ_{event} (average kW savings estimate through regression * event duration – average kW snapback estimate through regression) * # of online devices during each event = 483 kWh

[59] 91 kW = Σ_{event} total kW savings per high-temperature-event/# of events = (37.93 + 78.03 + 97.57 + 129.14 + 96.6 + 84.68 + 114.84) / 7

[60] 129 kW = Non-coincident Peak Demand Savings (kW) = max(total kW savings per high-temperature-event)

[61] 85 kW = (total kW impact on July 4CP + total kW impact on August 4CP + total kW impact on September 4CP) / 4 = (129.14 + 96.6 + 114.84) /4

[62] The total number of devices online by 01/31/2016 was 1,080, the sum of 287 online devices installed in the previous year and 793 online devices installed in FY 2016.

Table 5.6-2: ThinkEco Gross Energy and Demand Savings – End of Year Capability

Measure	Energy Savings (kWh) [63]	Peak Demand Savings (kW) [64]	Non-Coinc. Demand Savings (kW) [65]	ERCOT 4CP Demand Savings (kW) [66]
Total	1040	184	231	170

5.6.3.3 Incremental Impacts

Incremental impacts used for cost-effectiveness analysis are based on gross incremental enrollment of 820 units, with 793 online, during FY 2016. The results, based on 793 online units, are shown below.

Table 5.6-3: ThinkEco Gross Energy and Demand Savings – Incremental Impacts

Measure	Energy Savings (kWh) [67]	Peak Demand Savings (kW) [68]	Non-Coinc. Demand Savings (kW) [69]	ERCOT 4CP Demand Savings (kW) [70]
Total	763	135	170	125

5.6.1 Recommendations

Maintaining working units in the field is a big challenge in this program, particularly over more than just a few years. This challenge stems from the fact that SmartAC devices are not permanently installed infrastructure and thus may easily be removed, and from the fact that RACs themselves tend to be used seasonally. A technology that permanently affixes to the RAC might improve the EUL.

[63] Energy Savings (kWh) = Σ_{event} (average kW savings estimate through regression * event duration – average kW snapback estimate through regression * 1 hour) * # of devices online by 01/31/2016 (1,080)
[64] Coincident Peak Demand Savings (kW) = average kW savings per device per high-temperature-event during 2015 * 1,080
[65] Non-coincident Peak Demand Savings (kW) = highest kW savings per device among 2015 events * 1,080
[66] 4CP Event Demand Reduction (kW) = average kW savings on 2015 4CP events * 75% hit rate * 1,080
[67] 763 kWh = Σ_{event} (average kW savings estimate through regression * event duration – average kW snapback estimate through regression * 1 hour) * (# of devices online by 01/31/2016 - # of devices online by 01/31/2015)
[68] 135 kW = average kW savings per device per high-temperature-event during 2015 * (1,080 – 287)
[69] 170 kW = highest kW savings per device among 2015 events * (1,080 – 287)
[70] 125 kW = average kW savings on 2015 4CP events * 75% hit rate * (1,080 – 287)

6. PROGRAMS IN DEVELOPMENT

In addition, CPS Energy is currently ramping up two new solar initiatives which incurred startup expenses in FY 2016 and are expected to begin generating energy and demand savings in FY 2017. The new Roofless Solar and SolarHostSA programs are designed to engage and enable CPS Energy customers to directly benefit from new PV capacity installed on the local distribution system, reducing the need for energy production from other, predominantly fossil, resources, while enabling customers to reduce their monthly electric bills.

Expenses associated with these programs are shown in the summary tables, and are incorporated into the portfolio-wide cost effectiveness analysis.

6.1 ROOFLESS SOLAR PHOTOVOLTAIC PROGRAM

The Roofless Solar program presents a means for some customers who cannot or do not wish to install solar on their own property to purchase a share in a solar installation elsewhere and see the benefits monthly on their electric bill.

6.2 SOLARHOSTSA PROGRAM

Under SolarHostSA, CPS Energy has contracted with a developer to install solar PV systems on residential and commercial rooftops within CPS Energy's service area and inject energy directly into the CPS Energy distribution system. CPS Energy pays the developer a contracted price for energy generated from the systems, and credits the host customers 3 cents/kWh generated for the use of their rooftops for this purpose.

7. TOTAL IMPACTS AND COST-EFFECTIVENESS

7.1 NET PROGRAM IMPACTS & COST-EFFECTIVENESS

Program impacts presented in the Residential Energy Efficiency, Commercial Energy Efficiency, and Demand Response sections of this report are gross program impacts (measured at the customer's meter), without any adjustments for distribution losses or Net-to-Gross (NTG) adjustments.

The net program energy savings values shown here and in the executive summary were derived by converting the program-level gross energy savings at the meter to savings at the source using a CPS Energy-provided energy loss factor equal to 6.08%. The net program capacity savings values were derived by converting the program-level gross capacity savings at the meter to savings at the source using a CPS Energy-provided capacity loss factor equal to 9.73%.

The gross energy and capacity savings were further adjusted using the NTG values seen in the below table. These values were provided by CPS Energy and based on previous evaluations, with the exception of the Weatherization program. Based on Frontier experience and industry standards used in Texas, a 100% NTG factor was used for this program.

Overall, CPS Energy's energy efficiency and demand response portfolio produced positive net benefits, resulting in a portfolio-wide benefit-cost ratio of 1.72.

Frontier also calculated the three following economic metrics, in-line with previous evaluations:

1. Cost of Saved Energy (includes DR) ($/kWh) = $0.0646
2. Reduction in Revenue Requirements (includes DR) = $57,087,620
3. Benefit-Cost Ratio = 1.72

The net program impacts and results of the benefit-cost tests are provided in the following table.

Table 7.1-1: FY 2016 Net Energy and Demand Savings

Program	Net-to-Gross Ratio	Net Energy Savings (kWh)	Net Coincident Peak Demand Savings (kW)	Net Non-Coincident Demand Savings (kW)	Net ERCOT 4CP Demand Savings (kW)	Net Present Value of Avoided Cost Benefits	Program and Rebate $	Admin and Marketing $	Total Program $	Program Admin. Benefit-Cost Ratio
Energy Efficiency Programs										
Home Efficiency	93%	1,931,079	505	930	466	$1,597,553	$878,975	$49,240	$928,215	1.72
Air Flow Performance	90%	889,053	386	399	362	$1,011,396	$789,090	$42,838	$831,927	1.22
Residential HVAC	95%	13,401,849	6,648	7,384	6,843	$17,162,717	$3,706,733	$154,975	$3,861,708	4.44
Solar Initiative - Residential	100%	10,000,580	2,893	5,735	2,513	$11,907,973	$9,315,955	$575,402	$9,891,358	1.20
New Homes Construction	100%	6,734,139	1,304	1,509	1,216	$6,114,769	$1,144,500	$54,124	$1,198,624	5.10
Refrigerator	63%	402,432	57	57	58	$133,556	$45,155	$76,704	$121,859	1.10
Weatherization	100%	13,758,521	3,843	13,337	3,615	$10,955,723	$18,881,535	$2,922,249	$21,803,784	0.50
Residential Lighting (LED)	85%	2,054,729	65	4,814	79	$1,027,866	$1,050,040	$67,736	$1,117,776	0.92
Residential Subtotal		**49,172,380**	**15,702**	**34,165**	**15,151**	**$49,911,552**	**$35,811,983**	**$3,943,267**	**$39,755,250**	**1.26**
Commercial Lighting	85%	47,723,649	7,194	11,901	6,933	$25,974,321	$7,438,476	$454,737	$7,893,213	3.29
Commercial HVAC	96%	10,580,739	3,541	3,753	3,382	$11,992,245	$2,851,072	$154,384	$3,005,455	3.99
Solar Initiative - Commercial & Schools	100%	2,929,448	887	1,685	773	$3,573,833	$2,330,041	$156,661	$2,486,702	1.44
Commercial Custom	92%	4,001,682	87	647	108	$1,383,230	$368,510	$31,090	$399,600	3.46
Commercial New Construction	92%	3,353,474	1,282	1,299	1,254	$3,596,493	$390,573	$18,246	$408,819	8.80
Commercial Subtotal		**68,588,992**	**12,993**	**19,286**	**12,449**	**$46,520,122**	**$13,378,671**	**$815,116**	**$14,193,788**	**3.28**
Energy Efficiency Subtotal		**117,761,373**	**28,695**	**53,450**	**27,601**	**$96,431,674**	**$49,190,654**	**$4,758,383**	**$53,949,037**	**1.79**

Table continues on next page.

Program	Net-to-Gross Ratio	Net Energy Savings (kWh)	Net Coincident Peak Demand Savings (kW)	Net Non-Coincident Demand Savings (kW)	Net ERCOT 4CP Demand Savings (kW)	Net Present Value of Avoided Cost Benefits	Program and Rebate $	Admin and Marketing $	Total Program $	Program Admin. Benefit-Cost Ratio
Demand Response Programs										
Commercial DR	100%	2,168,927	105,550	106,639	67,089	$14,614,793	$4,928,551	$273,336	$5,201,887	2.81*
Auto DR	100%	81,251	4,576	5,172	3,540	$2,755,081	$1,720,079	$95,320	$1,815,399	0.46*
Emergency DR	100%	19,833	19,833	19,833	4,958	$2,311,420	$456,084	$25,274	$481,358	4.80*
Smart Thermostat	100%	1,002,740	43,103	47,266	37,512	$4,337,902	$4,903,769	$231,488	$5,135,257	1.14*
Home Manager	100%	728,387	45,593	49,158	41,689	$5,765,200	$3,150,298	$378,080	$3,528,379	1.74*
Bring Your Own Thermostat	100%	28,187	3,268	3,845	2,566	$2,466,263	$441,454	$190,136	$631,590	1.92*
ThinkEco Air Conditioner	100%	1,152	204	256	188	$63,755	$301,831	$21,548	$323,379	0.16*
Demand Response Subtotal		**4,030,475**	**222,127**	**232,169**	**157,543**	**$32,314,414**	**$15,902,067**	**$1,215,183**	**$17,117,250**	**1.58***
Programs in Development										
SolarHostSA Pilot	100%	0	0	0	0	$0	$222,489	$186,974	$409,463	0.00
Roofless Solar Pilot	100%	0	0	0	0	$0	$0	$182,719	$182,719	0.00
In Dev. Subtotal		**0**	**0**	**0**	**0**	**$0**	**$222,489**	**$369,693**	**$592,182**	**0.00**
Grand Total		**121,791,848**	**250,821**	**285,619**	**185,144**	**$128,746,088**	**$65,315,210**	**$6,343,259**	**$71,658,469**	**1.72***

* The PACT for Demand Response Programs is calculated based on the net present value of avoided cost benefits divided by the net present value of program costs *attributable to new, incremental participants during the program year*. Because total program costs in the table represent the costs attributable to *all* participants, the PACT for Demand Response Programs cannot be directly calculated from data presented in the table.

Table notes:

- Net savings = gross savings * Net to Gross ratio / (1 – line loss factor).
- DR program net energy and demand savings (in lighter shade) represent end of year program capability, based on end of year enrollment.
- For the Residential Lighting (LED) program, we display maximum program capability in place of non-coincident peak demand savings to maintain consistency with past evaluation practice.

7.2 EMISSIONS REDUCTION

Emission reductions are based on annual energy savings, those attributable to the gross number of new participants in each program in the current year.

Table 7.2-1: Emissions Reduction Impacts by Program (lbs.)

Program	CO_2	NO_x	SO_2	TSP
Home Efficiency	1,853,836	792	1,526	73
Air Flow Performance	853,491	365	702	34
Residential HVAC	12,865,775	5,495	10,587	509
Solar Initiative - Residential	9,600,556	4,100	7,900	380
New Homes Construction	6,464,773	2,761	5,320	256
Refrigerator	386,334	165	318	15
Weatherization	13,208,180	5,641	10,869	523
Residential Lighting (LED)	1,972,540	842	1,623	78
Residential Subtotal	**47,205,485**	**20,161**	**38,846**	**1,869**
Commercial Lighting	45,814,703	19,567	37,702	1,813
Commercial HVAC	10,157,510	4,338	8,359	402
Solar Initiative - Commercial & Schools	2,812,270	1,201	2,314	111
Commercial Custom	3,841,615	1,641	3,161	152
Commercial New Construction	3,219,335	1,375	2,649	127
Commercial Subtotal	**65,845,432**	**28,121**	**54,185**	**2,606**
Commercial Demand Response	2,082,169	889	1,713	82
Auto Demand Response	39,790	17	33	2
Emergency Demand Response	19,039	8	16	1
Smart Thermostat	81,166	35	67	3
Home Manager	73,384	31	60	3
Bring Your Own Thermostat	20,443	9	17	1
ThinkEco Air Conditioner	811	0	1	0
Demand Response Subtotal	**2,316,804**	**989**	**1,907**	**92**
SolarHostSA Pilot	0	0	0	0
Roofless Solar Pilot	0	0	0	0
In Development Subtotal	**0**	**0**	**0**	**0**
Grand Total	**115,367,722**	**49,272**	**94,938**	**4,567**

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