EVALUATION, MEASUREMENT & VERIFICATION OF CPS ENERGY'S FY 2018 DSM PROGRAMS

May 1, 2018

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TABLES

1. EXECUTIVE SUMMARY

CPS Energy retained Frontier Energy ("Frontier") to conduct a comprehensive and independent evaluation, measurement, and verification (EM&V) of CPS Energy's Fiscal Year (FY) 2018 demand side management (DSM) programs. FY 2018 runs from February 1, 2017 through January 31, 2018. This report encompasses all DSM program activity accounted for by CPS Energy within this time. This report describes the EM&V methodology and process and presents the findings of the evaluation.

The evaluation focused primarily on verifying the energy and demand savings achieved by CPS Energy's FY 2018 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 CUMULATIVE PROGRESS TOWARD MEETING STEP GOALS

CPS Energy's Save for Tomorrow Energy Plan (STEP) is an initiative that aims to save 771 MW of electricity from 2009 to 2020. In FY 2018, CPSE delivered 97.68 MW towards the STEP goal. Annual STEP contributions are counted as the net avoided non-coincident peak (NCP) MW delivered by incremental program participants in FY 2018.

Energy Efficiency and Solar were strong contributors to the FY 2018 portfolio.

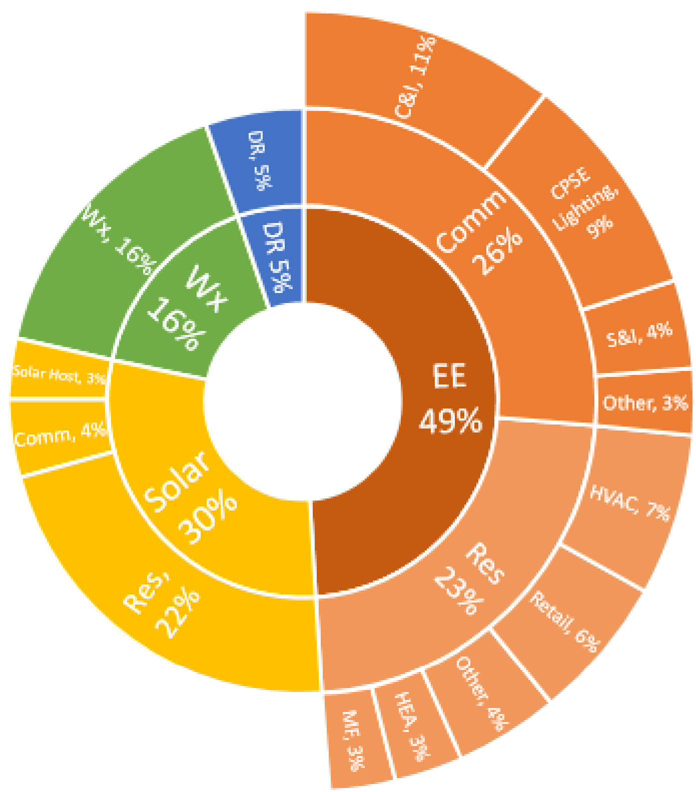

Figure 1-1: FY 2018 Contribution toward STEP Goal by Program

- Demand response programs' end-of-year NCP totaled 212.36 MW. However, their incremental savings as measured toward the STEP goal were 5.27 MW in FY 2018. FY 2017 incremental contributions were -25.08 MW. Negative incremental contributions mean that the current year did not deliver as much MW as the year prior.
- Residential solar was the largest individual program contributor delivering 22% due to relatively high participation and NCP impacts as compared to other programs.
- Residential weatherization contributed 16% primarily due to the high occurrence of envelope measures that deliver high NCP savings.

At the end of FY 2018, Frontier determined that CPS Energy had accomplished 620 MW of cumulative demand savings since STEP's inception. CPS Energy's cumulative progress toward meeting STEP goals is shown in Figure 1-2. Some decay is projected to start in 2019 when some measures installed in the early years of STEP reach the end of their useful lives. Further analysis will be done to estimate the magnitude of that decay.

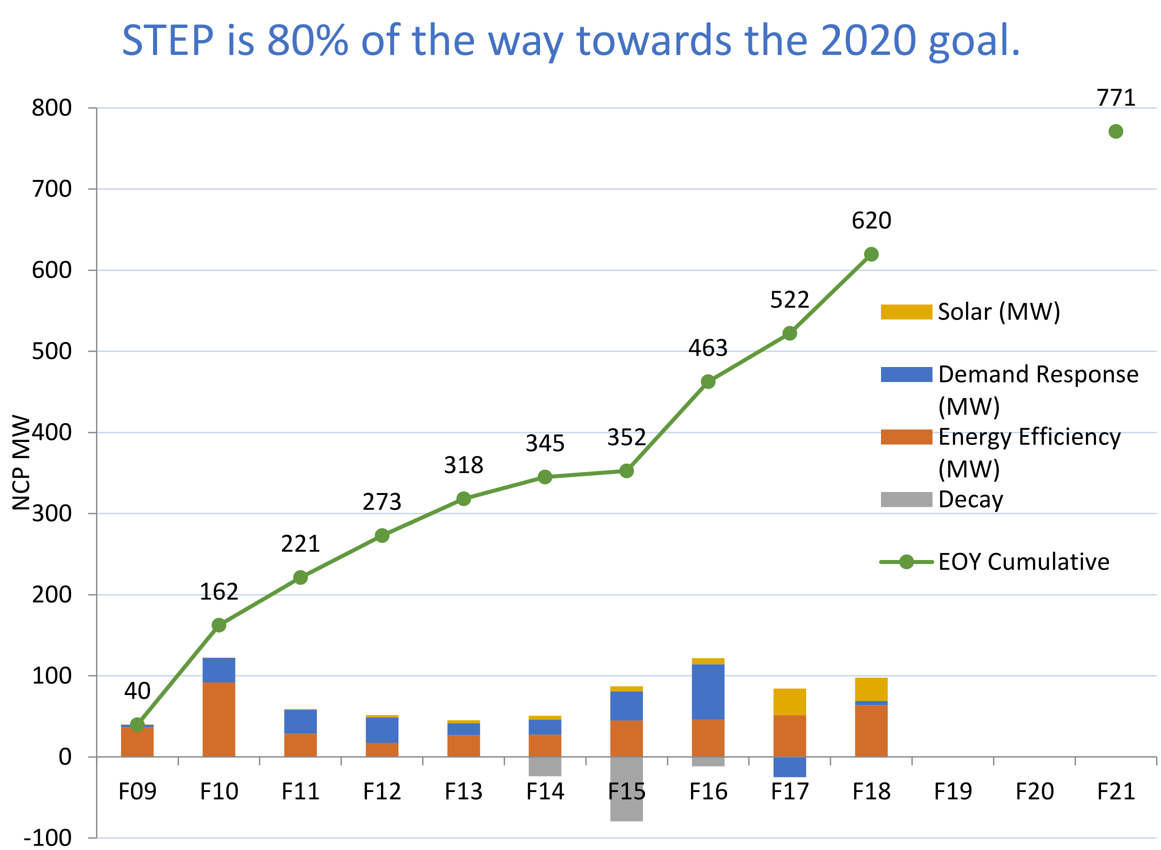

Figure 1-2: Cumulative Progress toward Meeting STEP Goal

1.2 PORTFOLIO ENERGY AND DEMAND IMPACTS AND COST-EFFECTIVENESS

The FY 2018 portfolio consists of energy efficiency programs contracted out to two implementers with solar and demand response programs implemented internally by CPS Energy. Legacy programs are carryover projects implemented by CPS Energy and were evaluated and reported separately. This year's report includes Frontier's evaluation of 30 different programs. Net energy and demand savings are listed in Table 1-1. The savings are represented on an annualized basis to simplify the reporting structure and for easy comparison from year to year.

Table 1-1: FY 2018 Portfolio Impacts and Cost-Effectiveness

Program	Net-to-Gross Ratio	Net Energy Savings (kWh)	Net CP Demand Savings (kW)	Net NCP Demand Savings (kW)	Net ERCOT 4CP Demand Savings (kW)	Rebate $	Admin and Marketing $	Total Program $	Program Administrator Benefit-Cost Ratio
Weatherization Program									
Weatherization	100%	15,261,975	6,552	15,775	6,201	$16,969,245	$1,546,895	$18,516,140	0.86
Energy Efficiency Programs									
CPSE Legacy Residential HVAC	99%	1,676	1	1	1	$1,140	$24	$1,164	1.72
Residential HVAC	95%	15,161,650	6,429	6,572	5,515	$4,259,686	$109,267	$4,368,954	3.76
Home Efficiency	93%	3,209,782	1,336	2,606	1,116	$1,362,019	$33,497	$1,395,516	2.78
CPSE Legacy New Homes	100%	114,067	66	101	80	$131,300	$2,836	$134,136	1.53
New Home Construction	100%	990,436	577	816	666	$1,326,225	$32,623	$1,358,848	1.30
Retail Channel Partnerships	77%	11,625,723	1,168	5,786	1,830	$3,063,740	$74,969	$3,138,709	2.38
AC/Duct Tune-Up	95%	151,493	54	69	51	$100,337	$2,417	$102,754	0.96
Energy Savings Through Schools	95%	1,734,151	106	608	128	$523,495	$12,954	$536,449	1.14
Home Energy Assessments	84%	6,510,930	604	2,825	884	$4,324,332	$105,732	$4,430,064	0.82
Multifamily	92%	7,392,774	784	2,638	1,000	$1,767,084	$42,949	$1,810,033	2.03
Cool Roof	100%	12,780	5	6	4	$8,458	$19,877	$28,335	0.44
Residential Subtotal		46,905,461	11,130	22,028	11,276	$16,867,815	$437,145	$17,304,961	2.18

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Program	Net-to-Gross Ratio	Net Energy Savings (kWh)	Net CP Demand Savings (kW)	Net NCP Demand Savings (kW)	Net ERCOT 4CP Demand Savings (kW)	Rebate $	Admin and Marketing $	Total Program $	Program Administrator Benefit-Cost Ratio
Energy Efficiency Programs (cont.)									
CPSE Legacy Lighting	96%	55,666,401	7,326	9,125	7,426	$8,835,129	$273,104	$9,108,233	3.30
CPSE Legacy Commercial HVAC	96%	184,406	35	39	38	$153,275	$7,540	$160,815	1.03
CPSE Legacy Commercial Custom	96%	20,881	74	70	63	$15,445	$1,676	$17,121	9.24
C&I Solutions	96%	39,267,943	7,235	10,368	6,657	$5,769,623	$179,495	$5,949,118	3.45
Schools & Institutions	96%	12,082,465	2,012	3,623	1,897	$2,468,233	$74,660	$2,542,893	2.21
Small Business Solutions	95%	8,773,980	1,400	2,137	1,401	$1,529,714	$47,099	$1,576,813	2.99
Whole Building Optimization	96%	3,008,363	414	400	435	$644,884	$19,174	$664,058	0.61
Commercial Subtotal		119,004,438	18,497	25,763	17,916	$19,416,303	$602,748	$20,019,051	3.08
Energy Efficiency Subtotal		165,909,899	29,627	47,791	29,192	$36,284,118	$1,039,893	$37,324,012	2.66
Demand Response Programs									
C&I DR	100%	3,143,263	71,574	89,823	54,394	$4,119,614	$130,101	$4,249,715	2.26
Auto DR	100%	272,075	7,881	9,703	7,207	$637,961	$19,493	$657,454	4.37
Smart Thermostat	100%	1,112,260	32,179	44,157	35,461	$2,565,728	$82,914	$2,648,642	3.11
Home Manager*	100%	453,946	20,682	24,539	21,851	$1,590,347	$160,817	$1,751,164	0.00
BYOT	100%	6,071,376	20,832	24,241	17,788	$1,465,579	$37,919	$1,503,498	5.09
Nest DI	100%	2,355,640	6,457	7,347	5,439	$2,723,900	$59,440	$2,783,340	2.89
Reduce My Use (Behavioral DR)	100%	25,111	12,555	12,555	3,139	$450,000	$11,825	$461,825	2.85
Demand Response** Subtotal		13,433,670	172,160	212,364	145,249	$13,553,129	$502,509	$14,055,638	3.08

Table continues on the next page.

Program	Net-to-Gross Ratio	Net Energy Savings (kWh)	Net CP Demand Savings (kW)	Net NCP Demand Savings (kW)	Net ERCOT 4CP Demand Savings (kW)	Rebate $	Admin and Marketing $	Total Program $	Program Administrator Benefit-Cost Ratio
Renewable Energy Programs									
Res. Solar Rebates	100%	36,054,456	10,365	21,367	9,328	$15,274,749	$557,176	$15,831,925	2.74
Comm. Solar Rebates	100%	7,010,621	2,108	4,169	1,836	$3,538,621	$128,349	$3,666,970	2.34
Solar Host SA***	100%	5,582,045	1,626	3,311	1,449	$0	$337,869	$337,869	0.93
Solar Energy Subtotal		48,647,123	14,099	28,848	12,614	$18,813,370	$1,023,394	$19,836,764	2.27
Grand Total		243,252,666	222,437	304,778	193,256	$85,619,861	$4,112,691	$89,732,554	2.25

* Home Manager did not have any incremental participation. Therefore, no PACT score is calculated. Savings and costs reported are for end-of-year participation.

**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. Demand response program net energy and demand savings (in lighter shade) represent end-of-year program capability, based on end-of-year enrollment.

*** In calculating the PACT for the SolarHostSA Pilot program, Frontier considered all energy purchases and bill credits paid to host site customers as part of the program costs. This differs from CPS Energy's accounting, which shows $0 in rebates paid to customers. Thus, the PACT for the SolarHostSA Pilot program cannot be directly calculated from the data presented in the table.

Additional table notes: Net savings = gross savings * Net to Gross ratio / (1 – line loss factor). Rows may not sum to total due to rounding

1.3 SUMMARY OF SAVINGS EVALUATION APPROACH

Frontier applied evaluation standards as published in the CPS Energy Technical Guidebook for Energy Efficiency and Demand Response Programs (Guidebook). The Guidebook provides a single common reference for estimating energy and peak demand savings resulting from the installation or implementation of energy efficiency and demand response measures provided through CPS Energy's programs. The methodologies described by and used in the Guidebook are based on the Public Utility Commission of Texas' (PUCT) Technical Reference Manual (TRM), with certain modifications required to accommodate CPS Energy's weather zone and STEP program goals and metrics. The Guidebook is intended to be updated annually to provide a common reference to Frontier's evaluation methodology.

1.4 SUMMARY OF ECONOMIC IMPACTS

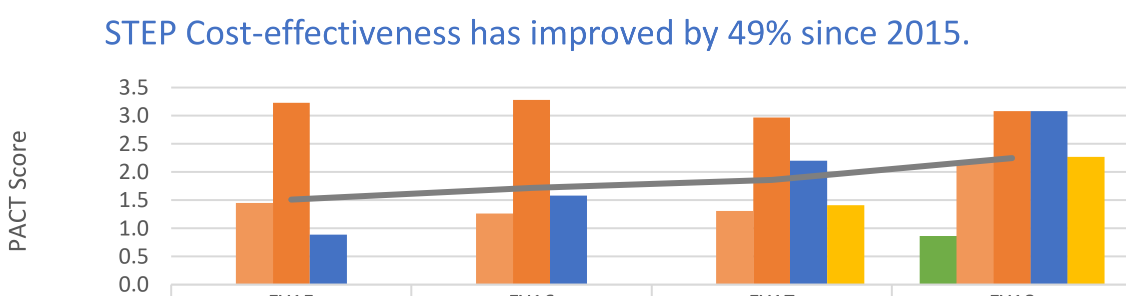
Frontier's evaluation included collecting administrative, management, and marketing costs as well as total incentives paid. The following economic impact metrics were calculated:

- Cost of Saved Energy (CSE), which represents the levelized program cost per annual kWh saved, was $0.0372.
- Net Reduction in Revenue Requirements (RRR), which represents the net reduction in utility costs due to the impact of the energy efficiency improvements, was $118,208,161.
- Benefit-Cost Ratio, representing the output of the program administrator cost test, was 2.25.
- For Demand Response (DR) programs, the summary table includes estimated savings from all active participants as of the end of FY 2018, including those who signed up in previous years, as this most accurately represents DR program capabilities in FY 2018 and beyond.

For DR program benefit-cost calculations, Frontier analyzed only the cohort of participants added in FY 2018. 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 2018 and other years, since significant differences in the composition of cohorts from year to year affect the outcome.

1.5 YEAR BY YEAR COST-EFFECTIVENESS COMPARISON

CPS Energy's STEP portfolio continues to deliver improved overall performance as measured by the program administrator cost test (PACT). In 2015 and 2016, solar programs were included in Residential and Commercial energy efficiency. In 2015 through 2017, Weatherization was included in Residential.



	FY15	FY16	FY17	FY18
Wx				0.86
Res EE	1.45	1.26	1.31	2.18
Comm EE	3.23	3.28	2.97	3.08
DR	0.89	1.58	2.20	3.08
Solar			1.41	2.27
Portfolio Total	1.51	1.72	1.86	2.25

Figure 1-3: Cumulative Progress toward Meeting STEP Goal

2. EVALUATION METHODS

2.1 ENERGY IMPACTS

Frontier's approach to this evaluation 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. Frontier has adapted the Texas TRM to be applicable to CPS Energy's service territory and provides 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. The adapted Texas TRM, along with other measures required for CPS Energy programs, can be found in the *CPS Energy Guidebook*. For this analysis, the *CPS Energy Guidebook* dated November 2017 was used except where noted.

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 Energy-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, used by all investor-owned electric utilities beginning in 2016.

Based on Frontier's analysis, the hours presented in Table 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

[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 Energy June 2014 Electricity Forecast, Sept. 2014, pp. 8-9.)

shown because some hours, such as those occurring on weekends or holidays, are eliminated for some measures. This analysis was completed in 2016 using weather and load data from 2010 to 2015.

Table 2-1: Top Hours in a TMY3 Weather File 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
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. Separate line loss factors relating to energy and demand are based on a 2016 energy system loss study provided by CPS Energy. The 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 avoided energy and capacity costs provided by CPS Energy, and CPS Energy's standard discount rate. For this year's analysis, CPS Energy provided avoided energy costs as the nominal $/MWh of the marginal variable cost of production using the load forecast without STEP programs being funded beyond February 1, 2018. For the purpose of calculating avoided energy benefits, annual kWh were allocated into the following seasonal blocks based on day of the week and hour of the day. Frontier developed or adopted appropriate 8760-hour load shapes for each STEP measure to assign annual kWh to corresponding cost periods.

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

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 and maintenance cost of a Reciprocating Internal Combustion Engine (RICE) brownfield plant with SCR & CO catalyst post combustion controls, annuitized over 35 years. Off-peak avoided capacity cost was defined as the blended cost of CPS Energy's forecasted capital and fixed operation and maintenance cost of a RICE and a natural gas combined cycle (NGCC GE Flex 1X1), with the blending ratio defined as the ratio of the added NGCC/RICE capacity in CPS Energy's 25-year expansion plan.

2.4.2 Avoided Transmission Cost of Service (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 2018 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 2018 4CP events.

For energy efficiency and renewable energy 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 impacts were then averaged to estimate the 4CP impact for each program. The total reduction to 4CP demand is then valued at the expected future TCOS provided by CPS Energy.

2.4.3 Avoided Price Spikes Savings (kWh)

Avoiding intervals of especially high energy prices in the ERCOT market is another benefit of demand response (DR) programs. In ERCOT energy prices may go up to $9,000/MWh ($9/kWh), which is over 300 times the average wholesale price of energy in 2017. By reducing demand during price spikes, CPS Energy benefits by avoiding high energy prices, or by selling energy from its own or contracted generation sources into the market. Avoided price spike savings are calculated for DR programs, which can sometimes be deployed in anticipation of price spike events.

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 Energy's load zone during 2011, but only 7 times in the combined six years that followed. [3] Price spikes are also harder to react to in a timely manner with some demand response resources. For example, a program that requires day-ahead notice to the program implementer would make rapid response to an unexpected price spike event impossible.

To estimate the value of energy (kWh) saved during FY 2018 price spike events, we compiled energy savings from all DR programs for every deployment interval, 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 (PACT) Ratio 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 (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.

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

Levelized program costs are calculated using a Capital Recovery Factor (CRF), which incorporates the estimated useful life (EUL)[4] of the savings (weighted by measure) and an annual discount rate.

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

Net Avoided Cost Benefit is 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.

[4] The Estimated Useful Life (EUL) values from the Texas TRM were utilized for all STEP measures, except where noted.

3. RESIDENTIAL PROGRAMS

3.1 SUMMARY OF RESIDENTIAL IMPACTS

CPS Energy's portfolio of residential programs addresses all markets and major residential end uses. Residential demand response programs are included in Section 5. CPS Energy offered the following energy efficiency programs for the residential sector in FY 2018:

Weatherization - assistance for families in need to reduce their monthly utility bills. Eligible participants may receive free upgrades designed to increase the energy efficiency of their homes.

CPS Legacy HVAC - incentives for eligible high efficiency central air conditioners (AC), heat pumps (HP) and room AC.

Residential HVAC - incentives for eligible high efficiency central AC, HP and room AC.

Home Efficiency - targets a wide range of energy efficiency measures that save cooling and heating energy in existing homes.

New Homes Construction - incentives for developers to build at least 15% more energy efficient than current CoSA building codes.

Residential Retail Partners - point of purchase incentives on ENERGY STAR® lighting and room air conditioners at participating retailers.

AC/Duct Tune-Up - performs diagnostic testing on HVAC systems and implements improvements such as duct sealing, coil cleaning, and refrigerant recharge.

Energy Savings Through Schools - reaches 6th grade classrooms by equipping teachers, students and parents with in-class curriculum and take home kits full of energy efficient products.

Home Energy Assessment - a free home assessment to identify energy saving opportunities, which may include directly installed LED lighting.

Multifamily Energy Efficiency - multiple direct install measures to help save energy through LED lights and other energy saving opportunities.

Cool Roof - rebates for self- or contractor-installed reflective roofing systems or coatings.

Most programs were implemented by Franklin Energy under contract to CPS Energy. However, there were some projects fully managed and implemented internally by CPS Energy. Those legacy projects are evaluated separately.

CPS Energy's 2018 fiscal calendar encompasses the second half of Program Year 1 (PY1) and first half of Program Year 2 (PY2) for contracted programs. Due to this break across program years, projects completed between February 1, 2017 and May 31, 2017 were evaluated against the October 2016 *CPS Energy Guidebook*. Projects completed between June 1, 2017 and January 31, 2018 were evaluated against the November 2017 *CPS Energy Guidebook*. For programs or measures where other methods were used, those are referenced in each section.

The contributions of each program to the residential portfolio's energy, peak demand, and non-coincident peak savings are shown in the following figures. Values in Figure 3-1 through Figure 3-3 represent energy and demand savings from new FY 2018 program participants as measured at the participant or end-user level and adjusted to account for net-to-gross ratios and line losses.[5] Program names are abbreviated in chart labels.[6]

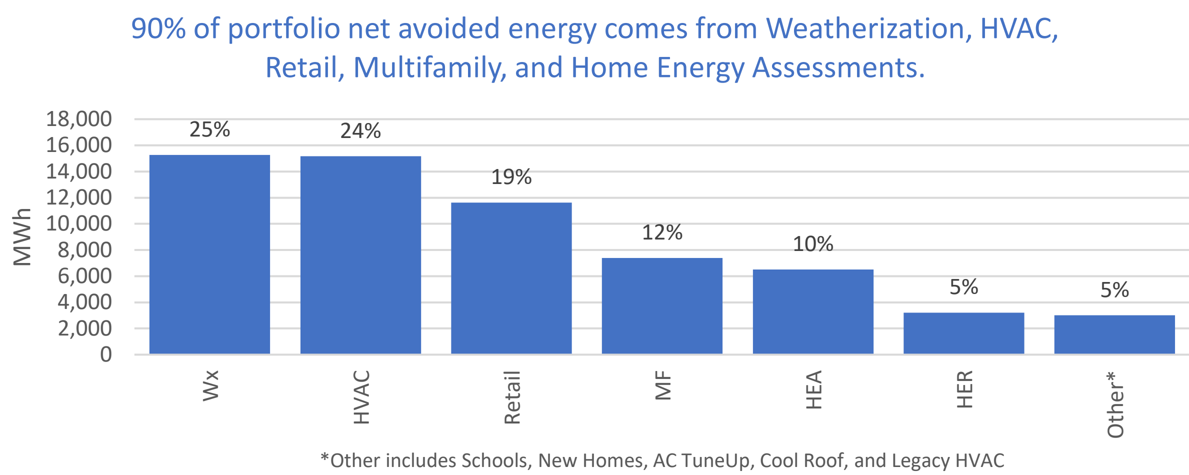


Figure 3-1: Summary of Residential Impacts – Net Avoided Energy by Program

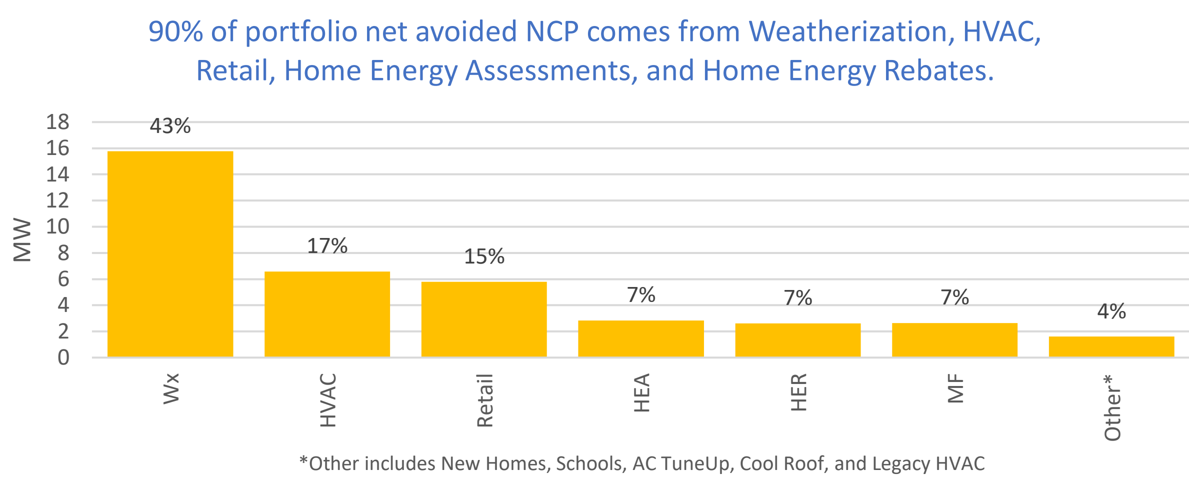


Figure 3-2: Summary of Residential Impacts – Net Avoided Non Coincident Peak by Program

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[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.

[6] HVAC = Heating Ventilation and Air Conditioning, Wx = Weatherization, HEA = Home Energy Assessments, MF = Multifamily, HER = Home Efficiency Rebates

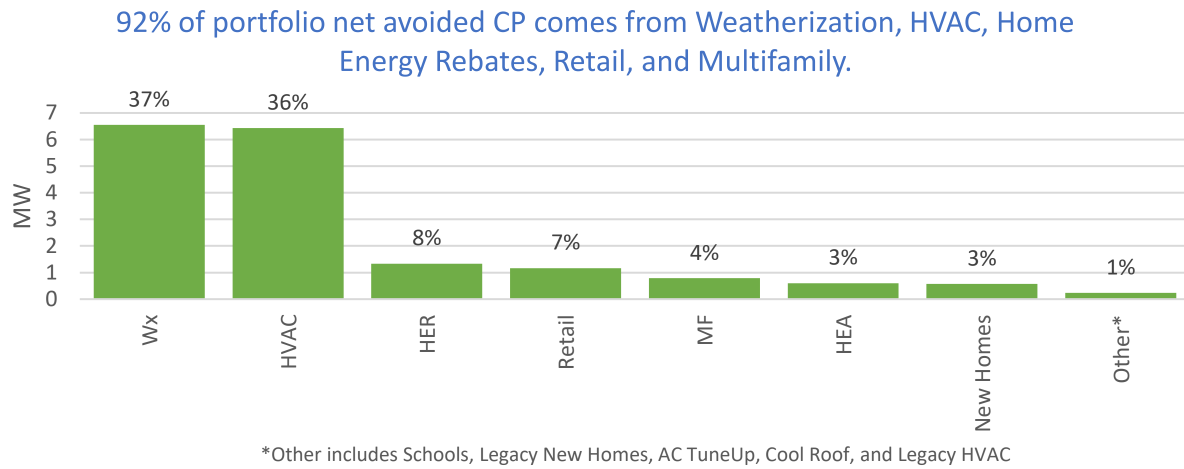

Figure 3-3: Summary of Residential Impacts – Net Avoided Coincident Peak by Program

3.2 WEATHERIZATION PROGRAM

3.2.1 Overview

CPS Energy's residential weatherization program provides comprehensive retrofits for income-eligible customers. In FY 2018, the program provided a range of services to 3,623 customers, compared with 3,900 customers in FY 2017. Installed measures included repair, health & safety, and energy-saving measures. The energy-saving measures may be categorized as follows:

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

The measure mix is diverse, but envelope measures (including wall insulation, attic insulation, floor insulation, solar screens, air infiltration) are by far the largest contributors to total program impacts for both energy and demand savings.

- Attic insulation is the largest single measure contributing more than 30% of savings
- Air infiltration is the 2nd highest non-coincident peak contributor with 24% of NCP kW impacts
- Lighting is the 2nd highest energy savings contributor with 15% of kWh impacts
- Domestic Hot Water Measures offered almost negligible program impacts, delivering only 1.5% of energy impacts and less than 0.25% of demand impacts.

Percent contribution to gross program-level energy and demand impacts are shown in Figure 3-4.

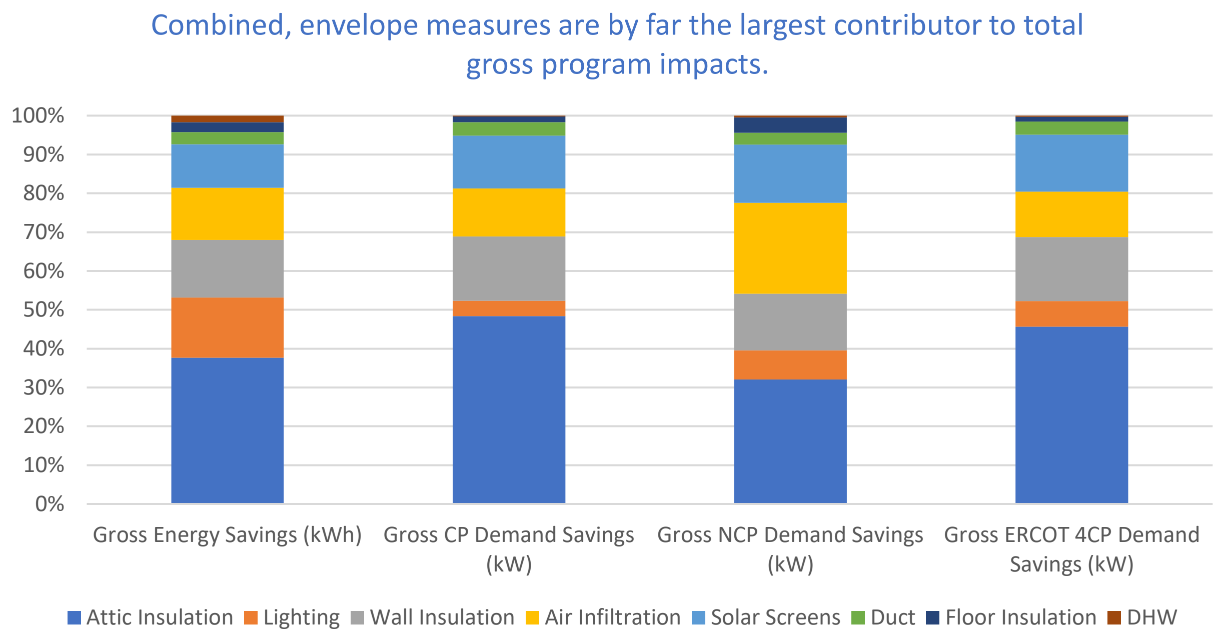

Figure 3-4: Weatherization – Gross Energy and Demand Impact Percentages by Measure

3.2.2 Savings Calculation Method

Frontier conducted a desk review for a sample of projects designed to deliver 90% confidence and 10% precision. Evaluators also made site visits to verify post-inspection procedures on selected projects. During the site visits, Frontier observed a thorough post-inspection process where inspectors adjust project details as necessary based on observed field conditions. Frontier's desk review of sampled projects indicated that project documentation supported the reported project data and no adjustments were made to project-level input assumptions.

For each of the measures, Frontier determined energy savings using methodology from the *CPS Energy Guidebook*. Projects completed between February 1, 2017 and May 31, 2017 (PY1) were evaluated against the October 2016 *CPS Energy Guidebook*. Projects completed between June 1, 2017 and January 31, 2018 (PY2) were evaluated against the November 2017 *CPS Energy Guidebook*. For programs or measures where other methods were used, those are referenced in each section.

3.2.2.1 Envelope Measures

Energy savings for this measure are determined using calibrated simulation models developed using NREL's BEopt 2.6 software running EnergyPlus 8.4 as the underlying simulation engine. Coincident, non-coincident,[7] and 4CP peak demand savings were determined using building energy simulation models

[7] It should be noted that for some envelope measures installed in homes with electric heating, the non-coincident peak occurs during the non-summer months.

developed by subtracting the whole house energy use in each hour of the post-retrofit models from the energy use in the pre-retrofit models. Additional detail on savings determination is presented in the *CPS Energy Guidebook*.

Simulation models for envelope measures assumed homes had central air conditioning. For homes with room or window air conditioners, adjustment factors were applied. See the *CPS Energy Guidebook* for detail on those adjustment factors.

The following figures show frequency of installation and relative energy and demand impacts by envelope measure.

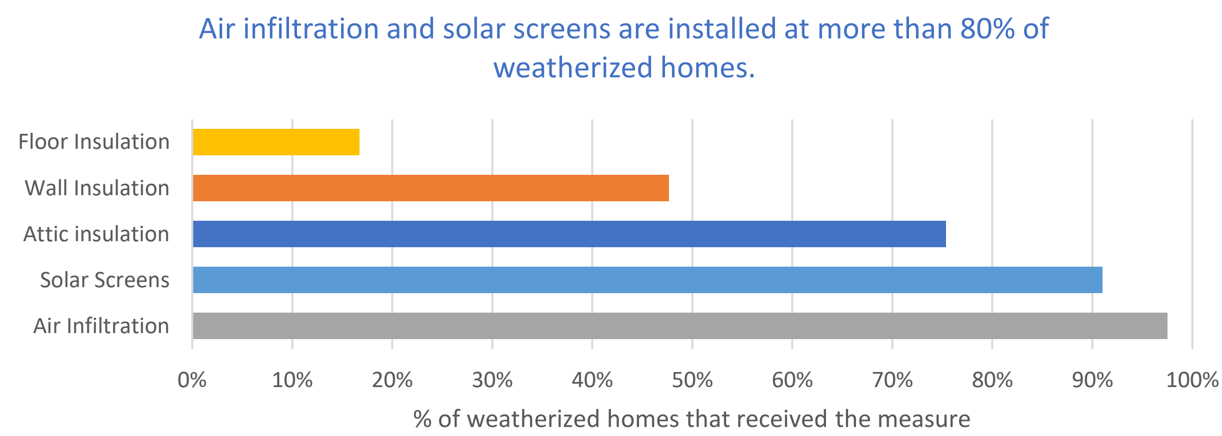

Figure 3-5: Weatherization – Frequency of Installation by Envelope Measure

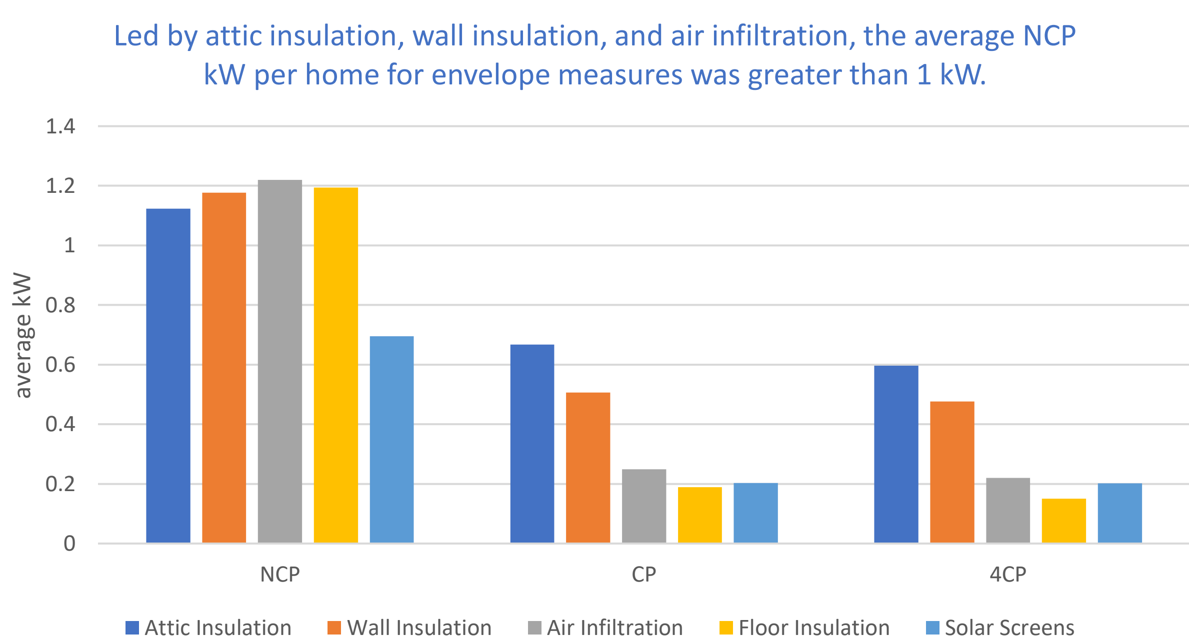

Figure 3-6: Weatherization – Average per Home NCP kW by Envelope Measure

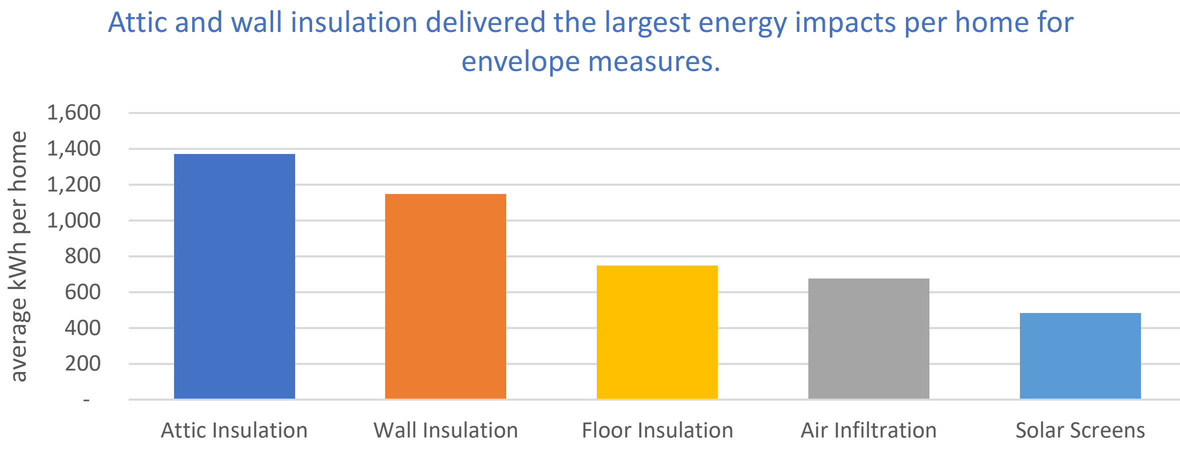

Figure 3-7: Weatherization – Average per Home kWh by Envelope Measure

Attic Insulation

As part of the weatherization program, Franklin Energy installed attic insulation in 2,730 homes in FY 2018. Average gross impacts per home for attic insulation are 1,370 kWh, 0.67 CP kW, 1.12 NCP kW, and 0.60 4CP kW.

Savings are determined per square foot of attic insulation installed and vary by heating and cooling system type and pre- and post-insulation levels. Adjustments to claimed savings were made as necessary to apply the appropriate savings factors for each project site.

Wall Insulation

Franklin Energy installed wall insulation in 1,727 homes in FY 2018. Energy and demand savings assume that an under-insulated wall cavity is insulated to R-13, typically by blowing in cellulose insulation. Average gross impacts per home for wall insulation are 1,147 kWh, 0.51 CP kW, 1.18 NCP kW, and 0.48 4CP kW.

Savings are determined per square foot of wall insulation installed and vary by heating and cooling system type. Adjustments to claimed savings were made as necessary to apply the appropriate savings factors for each project site.

Air Infiltration Reduction

As part of the Weatherization program, Franklin Energy installed air infiltration control measures in 3,532 homes in FY 2018. Average gross impacts per home for air infiltration are 676 kWh, 0.25 CP kW, 1.22 NCP kW, and 0.22 4CP kW.

Deemed savings are presented as a function of the CFM_{50} reduction achieved, as demonstrated by blower door testing. The *CPS Energy Guidebook* restricts base and post CFM_{50} readings to reasonable values that do not exceed building tightness limits. Where necessary to meet those requirements, pre- and post-CFM_{50} limits were applied to the documented CFM_{50} at each project site.

Floor Insulation

As part of the Weatherization program, Franklin Energy installed floor insulation in 605 homes during FY 2018. Average gross impacts per home for floor insulation are 749 kWh, 0.19 CP kW, 1.19 NCP kW, and 0.15 4CP kW.

The baseline is assumed to be a site-built house with pier and beam construction and no floor insulation against the floor of the conditioned area. Savings are determined per square foot of floor insulation installed and vary by heating and cooling. Adjustments to claimed savings were made as necessary to apply the appropriate savings factors for each project site.

Solar Screens

As part of the Weatherization program, Franklin Energy installed solar screens on 3,298 homes during FY 2018. Average gross impacts per home for solar screens are 482 kWh, 0.20 CP kW, 0.70 NCP kW, and 0.20 4CP kW.

The baseline is a single pane, clear glass, unshaded, east-, west-, or south-facing window with a solar heat gain coefficient of 0.75. Savings vary by window orientation and HVAC system type. Note that for this measure, the Guidebook applies a heating penalty to account for the reduction in solar heat gain during the heating season.

During the first half of the year, installed quantity was provided in united inches (window width plus height, in inches). This is the typical pricing unit for contractors. *CPS Energy Guidebook* 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. The total square feet of solar screens installed per home was reported during the second half of the year and so the *CPS Energy Guidebook* savings were applied directly.

3.2.2.2 LED Light Bulbs

The *CPS Energy Guidebook* includes separate calculation methodologies for omni-directional EISA-compliant and specialty EISA-exempt LED lighting. EISA-affected bulbs had savings that were determined using a two-tiered weighting approach due to the baseline change that is scheduled to occur in 2020. The savings for EISA-exempt bulbs were determined over the entire lifetime of the bulb using the equivalent wattages. The Guidebook also incorporates an interactive effects factor to account for the impacts on cooling and heating loads. Savings are discounted by a rate of 3% to account for an assumed 97% installation rate.

For projects evaluated against the November 2017 *CPS Energy Guidebook*, the first-tier savings period incremented down by a year and the second-tier savings period incremented up by a year. This change was made based on the calendar year change leading up to the EISA 2020 backstop. There were no other major changes to the savings calculation methodology compared to the approach used in the FY 2017 evaluation.

3.2.2.1 Duct System Improvement

Savings for all projects were validated using the savings methodologies outlined in the *CPS Energy Guidebook*. The primary change for this measure in the November 2017 update was the inclusion of demand and energy adjustment factors. These factors are single year transitional factors used to slowly move from the existing algorithm approach to a new modeled approach. Savings were significantly reduced in this update and are further reduced with the new modeled approach.

In place of site-specific leakage testing results for each project, Frontier worked with Franklin to deem CFM reduction values for minor, medium, and major reduction ranges. These ranges are determined by the contractor based on several factors, including a visual inspection, the amount of treated duct, and the severity of repaired leaks.

3.2.2.2 Domestic Hot Water

As part of the Weatherization program, Franklin Energy installed domestic hot water (DHW) measures in 894 homes during FY 2018, which is about 25% of all weatherized homes.

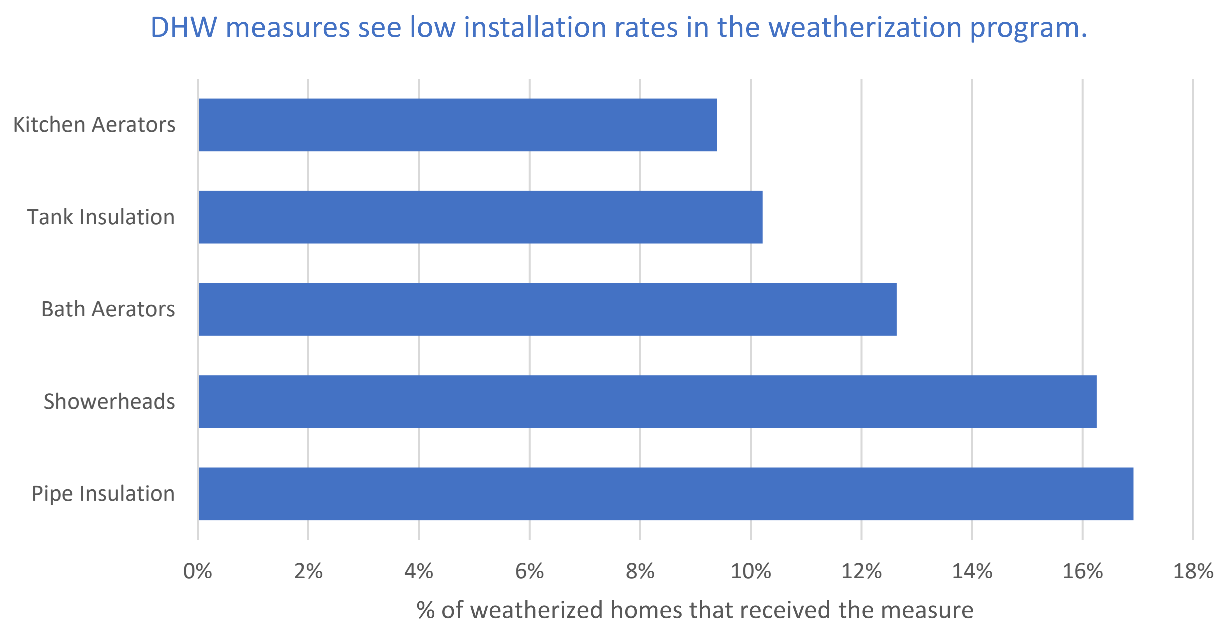

Figure 3-8: Weatherization – Frequency of Installation by DHW Measure

The energy and demand savings are determined using the algorithms in the *CPS Energy Guidebook*. Showerhead and aerator coincident, non-coincident, and 4CP peak demand factors were calculated using a DHW load profile developed from the Building America Analysis spreadsheet for existing homes. Pipe and water heater insulation coincident, non-coincident, and 4CP peak demand factors were calculated using an assumption that the load shape for this measure is evenly distributed across all hours of the year.

Domestic Hot Water (DHW) measures saw a change in methodology between the first and second half of the fiscal year. The change resulted in generally lower impacts for faucet aerator measures during the second half of the year.

Water Heater Pipe Insulation

As part of the Weatherization program, CPS Energy and Franklin Energy installed water heater pipe insulation in 613 homes during FY 2018. The savings are based on an assumed baseline of a typical electric water heater without insulation on the water heater pipes. Savings for water heater pipe insulation are based on a maximum allowable insulation length of 6 feet of piping per installation, as per the *CPS Energy Guidebook*. For any installation of water heater pipe insulation over six feet, the savings were capped at this maximum. Savings vary based on the location of the water heater, in conditioned or unconditioned space. Savings inputs based on the location of the water heater were applied based on project-specific documentation. If not provided, the more conservative inputs assumptions were used to estimate impacts.

Water Heater Insulation

As part of the Weatherization program, CPS Energy and Franklin Energy installed water heater insulation on 370 water heaters during FY 2018. Savings are determined using an assumption of a 30 gallon water heater of standard height and diameter, providing a tank surface area of 17.45 as per the *CPS Energy Guidebook*. The R-value of the installed insulation is reported by Franklin at R-4. Savings vary based on the location of the water heater, in conditioned or unconditioned space. Savings inputs based on the location of the water heater were applied based on project-specific documentation. If not provided, the more conservative inputs assumptions were used to estimate impacts. The *CPS Energy Guidebook* requires water heaters to be manufactured after 1991 to be eligible for this measure. Claimed savings were adjusted accordingly based on project documentation.

Low-Flow Showerheads

As part of the Weatherization program, CPS Energy and Franklin Energy installed 589 low-flow showerheads during FY 2018. Savings for this measure are determined using a baseline assumption of a 2.5 gallon per minute (GPM) flowrate for the existing showerhead and a 1.5 GPM flowrate for the replacement showerhead.

Faucet Aerators

Franklin Energy installed 798 faucet aerators, one for a kitchen faucet and one for a bathroom faucet. Savings for this measure are determined using a baseline assumption of a 2.2 gallon per minute (GPM) flowrate for the existing faucets. The savings for aerators are based on an assumed 1.5 GPM flowrate for the post-retrofit kitchen faucet and an assumed 1.0 GPM flowrate for the post-retrofit bathroom faucet.

3.2.3 Results and Recommendations

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

Table 3-1: Weatherization Gross Energy and Demand Savings

Measure	Gross Energy Savings (kWh)	Gross CP Demand Savings (kW)	Gross NCP Demand Savings (kW)	Gross ERCOT 4CP Demand Savings (kW)
Attic Insulation	5,460,448	2,911	4,806	2,599
Lighting	2,242,394	240	1,115	377
Wall Insulation	2,144,993	996	2,185	937
Air Infiltration	1,947,427	744	3,506	669
Solar Screens	1,621,361	816	2,242	833
Duct	452,411	209	457	195
Floor Insulation	367,871	86	596	72
DHW	249,761	14	67	14
Total[8]	14,486,666	6,018	14,974	5,696

Rows may not sum to total due to rounding.

The following summarizes recommendations for the Weatherization program:

Envelope Measures

- Solar Screens and Air Infiltration – These measures were installed more than 80% of the time despite their average per home energy and coincident peak impacts being among the lower of all envelope measures. This indicates a high incidence of need for these measures in homes served by the weatherization programs. Air infiltration does offer significant per home non-coincident peak impacts, however coincident peak is what drives cost-effectiveness results. Frontier recognizes that air infiltration and solar screens may offer occupant comfort benefits and interactive effects that are not measured in this evaluation. Investigation into these measure-level characteristics may be worthwhile for CPS Energy to consider during program planning and goal setting for the next iteration of STEP.

LED Light Bulbs

- Update savings calculation to calculate the first-tier savings period as 2021 minus installation year. The second-tier savings period should be calculated as the EUL minus the first-tier savings period.

- Note that in future years, EUL will no longer be deemed at 20 years for all LED lamps. Instead, EUL will vary between 15 and 20 years depending on the rated life of the LED lamp. This will

[8] The sum of the individual measures may not match the total due to the individual measure savings having been rounded to the nearest whole number.

affect the first- and second-tier savings period calculation. Additionally, Franklin will need to start collecting and reporting the lamp rated life to the evaluation team.

- Because of the two-tiered baseline and corresponding net present value weighting approach specified by the *CPS Energy Guidebook*, savings for lighting projects are reliant on assumed escalation rates, discount rates, avoided capacity costs, and avoided energy costs. Typically, CPS Energy provides these values after the program evaluation process has started. However, this makes it difficult for Franklin to produce reliable savings estimates. Frontier will work with CPS Energy and Franklin to specify deemed coefficients in an updated *CPS Energy Guidebook*. The goal will be to provide the values prior to the beginning of the program year so that the implementer can use those values for the entire program year.

- When reporting the cooling type, Franklin should distinguish between central air conditioner and central heat pump. Currently, cooling type is only reported as either “central system” or “window.” This does not provide enough information for the evaluation team to determine the appropriate HVAC interactive effects. Frontier assumed central air conditioner in these cases based on the expected heating type for the customer class in this program, but more clarity would be helpful for future evaluations.

- When reporting the heating type, Franklin should distinguish between electric resistance and heat pump. Currently, heating type is only reported as either “gas” or “electric.” This does not provide enough information for the evaluation team to determine the appropriate HVAC interactive effects. Frontier assumed electric resistance heat in these cases based on the expected heating type for the customer class in this program, but more clarity would be helpful for future evaluations.

Duct Sealing

- No cooling savings should be claimed for projects without central cooling. Similarly, no heating savings should be claimed for projects without central heat. In several cases, cooling savings were claimed for homes with window units reported as the primary cooling type, and heating savings were claimed for homes with space heaters reported as the primary heating type.

- When reporting the heating type and heating fuel type, Franklin should distinguish between electric resistance and heat pump. Currently, several projects are reported as having “central heat” for the heating type and “electric” for the heating fuel type. This does not provide enough information for the evaluation team to determine the appropriate heating type. Frontier assumed electric resistance heat in these cases based on the expected heating type for the customer class in this program, but more clarity would be helpful for future evaluations.

- Similarly, heating fuel type is often classified as mixed. That classification is not appropriate for this measure. While a residence may have multiple fuel types, the duct sealing measure is only concerned with the heating type corresponding to the ducted heating system. In the majority of cases, the heating type should be represented by a single heating fuel type.

Domestic Hot Water

- Water Heater insulation savings were claimed for 370 units, but savings were awarded for only 5. The low realization rate is primarily driven by violations of the manufacture date eligibility requirement for this measure. Going forward, water heater build date should be confirmed prior to implementation of this measure.

3.3 HOME EFFICIENCY PROGRAM

3.3.1 Overview

CPS Energy's Home Efficiency program offers incentives for attic insulation and variable-speed pool pumps. Through the home efficiency program, Franklin Energy served 1,876 homes in FY 2018. The proportion of total program energy and peak impacts derived from each measure type is presented in Figure 3-9.

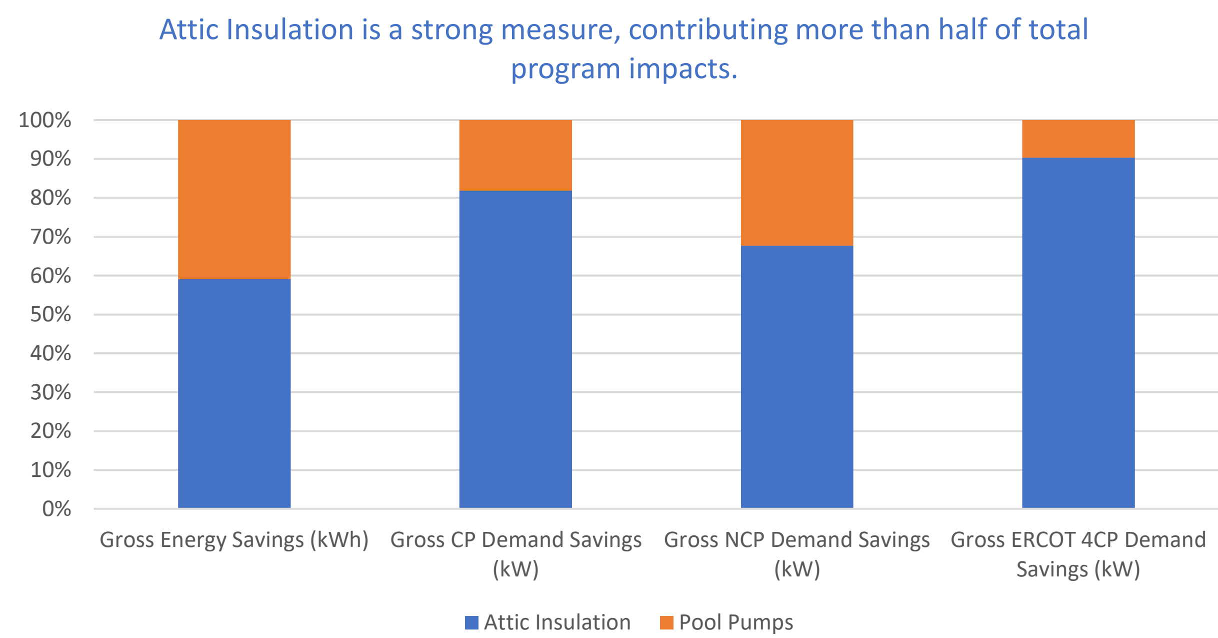

Figure 3-9: Home Efficiency – Gross Energy and Demand Impact Percentages by Measure

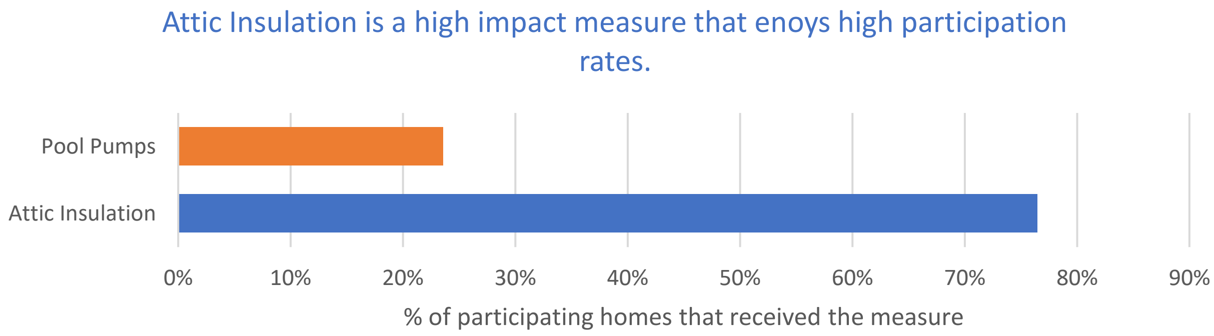

Figure 3-10: Home Efficiency – Frequency of Installation by Measure

3.3.2 Savings Calculation Method

Frontier conducted a desk review for a sample of projects designed to deliver 90% confidence and 10% precision. Additionally, we made site visits to verify inspection procedures on selected projects. During the site visits, Frontier observed a thorough inspection process where inspectors adjust project details as necessary based on observed field conditions. Frontier's desk review of sampled projects indicated that project documentation supported the reported project data and no adjustments were made to project-level input assumptions.

For each of the measures, Frontier determined energy savings using methodology from the *CPS Energy Guidebook*. Projects completed between February 1, 2017 and May 31, 2017 (PY1) were evaluated against the October 2016 *CPS Energy Guidebook*. Projects completed between June 1, 2017 and January 31, 2018 (PY2) were evaluated against the November 2017 *CPS Energy Guidebook*. For programs or measures where other methods were used, those are referenced in each section.

3.3.2.1 Attic Insulation

CPS Energy incentivized 1,434 attic insulation installations in FY 2018, compared with 1,065 attic insulation installations in FY 2017. Average gross impacts per home for attic insulation are 1,343 kWh, 0.75 CP kW, 1.22 NCP kW, and 0.69 4CP kW.

Savings are determined per square foot of attic insulation installed and vary by heating and cooling system type and pre- and post-insulation levels. Adjustments to claimed savings were made as necessary to apply the appropriate savings factors for each project site.

3.3.2.2 Variable-Speed Pool Pumps

Through the Home Efficiency program, CPS Energy provided incentives for the installation of 442 variable-speed pool pumps in FY 2018, compared to the 318 pool pumps installed in FY 2017.

The deemed energy and demand savings tables in the *CPS Energy Guidebook* includes savings for seven pool pump horsepower sizes, ranging from 0.5 to 3.0 horsepower. For pool pumps with a horsepower not included within the deemed energy and demand savings tables, the savings were applied for the closest appropriate horsepower.

3.3.3 Results and Recommendations

Program-level realization rates improved from PY1 to PY2 during FY 2018. The primary driver for this is that Franklin reconciled their project tracking system to the *CPS Energy Guidebook* mid-year.

Table 3-2: Home Efficiency Gross Energy and Demand Savings

Measure	Gross Energy Savings (kWh)	Gross CP Demand Savings (kW)	Gross NCP Demand Savings (kW)	Gross ERCOT 4CP Demand Savings (kW)
Attic Insulation	1,935,215	1,080	1,753	996
Pool Pumps	1,340,834	240	906	107
Total[9]	3,276,049	1,320	2,660	1,103

Rows may not sum to total due to rounding.

3.4 CPSE LEGACY RESIDENTIAL HVAC PROGRAM

3.4.1 Overview

This program promotes the installation of energy efficient Heating, Ventilation, and Air Conditioning (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). In FY 2018, a total of 8 legacy HVAC projects were incentivized through the CPS Residential HVAC program, including 1 AC, 0 HPs, 7 WACs, and 0 GSHPs. FY 2018 performance has not been compared to FY 2017 because this program only accounts for legacy projects that were in queue during earlier program years. All new projects are being implemented by a CPS implementation contractor under alternate programs.

3.4.1 Savings Calculation Method

Because of the small project population, a desk review was performed for all legacy projects incentivized in this program. All projects were completed between June 1, 2017 and January 31, 2018 and were evaluated against the November 2017 update to the *CPS Energy Guidebook*. Savings for all projects were validated using the savings methodologies outlined in the *CPS Energy Guidebook*. There were no major changes to the savings calculation methodology compared to the approach used in the FY 2017 evaluation.

[9] The sum of the individual measures may not match the total due to the individual measure savings having been rounded to the nearest whole number.

AC and HP savings were estimated using performance curves developed by the National Renewable Energy Laboratory.[10] These performance curves provide the capacity and efficiency of the heat pump operating in cooling mode across a wide range of outside air temperatures. Unit loading was estimated as a function of outside air temperature, and hours of cooling mode operation under different loadings were estimated using bin weather data for each weather zone. The model uses a set of normalized performance curves to scale the rated performance values as a function of outdoor dry-bulb temperature ranging from 65 to 115 degrees Fahrenheit. The total capacity and Energy Input Ratio (EIR = 1/COP) curves are a function of entering wet-bulb temperature (EWB) and outdoor dry-bulb temperature (ODB) with quadratic curve fittings.

In heating mode, predicted HVAC operation was limited to meeting 77% of load, using a factor applied in Manual J to correlate design load hours to equivalent full load hours under actual operating conditions, taking into account that heating systems are not always operated even when outdoor conditions indicate they should. It was assumed that typical HVAC systems are sized to 115% of their design cooling load (oversized by 15%). Heating mode capacity was related to rated cooling capacity using rated capacity in cooling and heating mode according to data exported from the Air-Conditioning, Heating, and Refrigeration (AHRI) Directory.[11]

Similarly, energy and demand savings for WACs and GSHPs were generally estimated by multiplying the installed capacity by the change in system efficiency. The typical format of the savings formula for this measure is as follows:

$$kW_{Savings} = \frac{Capacity}{1{,}000} \times \left(\frac{1}{Efficiency_{Baseline}} - \frac{1}{Efficiency_{Installed}}\right) \times Demand\ Factor$$

$$kWh_{Savings} = \frac{Capacity}{1{,}000} \times \left(\frac{1}{Efficiency_{Baseline}} - \frac{1}{Efficiency_{Installed}}\right) \times Hours$$

Non-coincident peak (NCP), coincident peak (CP), and four coincidental peaks (4CP) demand savings were derived using an approach adapted from the method outlined in Section 2.3 of the *CPS Energy Guidebook*.

3.4.2 Equipment Verification

To verify the accuracy of the reported equipment specifications, reported system capacities and efficiencies were validated against the AHRI Directory for the single AC project and against the ENERGY STAR certified product listing[12] for the WAC projects. No discrepancies were identified for the AC project, but several WACs were not ENERGY STAR listed. For those systems, reported system efficiencies did not meet the minimum ENERGY STAR room air conditioner efficiency requirement.

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[10] D. Cutler et al., Improved Modeling of Residential Air Conditioners and Heat Pumps for Energy Calculations. National Renewable Energy Laboratory. NREL/TP-5500-56354. January 2013. Tables 12 and 13. http://www.nrel.gov/docs/fy13osti/56354.pdf.
[11] AHRI Certification Directory: https://www.ahridirectory.org/ahridirectory/pages/home.aspx.
[12] ENERGY STAR Certified Room Air Conditioners: https://www.energystar.gov/productfinder/product/certified-room-air-conditioners/.

3.4.3 Results and Recommendations

Overall, the CPS Legacy Residential HVAC program achieved realization rates of 55% for NCP kW demand savings and 44% for kWh energy savings. Savings for the WAC projects were lower than for the AC project because zero savings were awarded to the projects that did not meet the minimum ENERGY STAR minimum efficiency requirement.

While the recommendations for residential HVAC measures in previous evaluations focused heavily on data collection and the application of appropriate savings baselines, that direction is no longer necessary because this program is no longer implemented by CPS Energy. For relevant recommendations, please refer to the section covering the Residential HVAC program implemented by Franklin.

Table 3-3: CPSE Legacy Residential HVAC Gross Energy and Demand Savings

Measure	Gross Energy Savings (kWh)	Gross CP Demand Savings (kW)	Gross NCP Demand Savings (kW)	Gross ERCOT 4CP Demand Savings (kW)
Central Air Conditioners	1,293	0.64	0.66	0.53
Window Air Conditioners	313	0.21	0.23	0.20
Total[13]	1,606	0.85	0.89	0.73

3.5 RESIDENTIAL HVAC PROGRAM

3.5.1 Overview

This program promotes the installation of energy efficient Heating, Ventilation, and Air Conditioning (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). In FY 2018, a total of 7,153 HVAC projects were incentivized through the CPS Residential HVAC program. No comparison has been made to FY 2017 participation because the program kicked off during the middle of FY 2017. A more complete analysis of program participation trends will be available after comparing the program’s FY 2018 and FY 2019 performance.

This evaluation includes both previously evaluated projects from the CPS PY1 evaluation and new PY2 projects completed during the CPS FY 2018 evaluation period. The figure below presents a percentage breakdown of kWh energy savings. Savings are presented by system type for all newly evaluated HVAC projects completed through this program.

[13] The sum of the individual measures may not match the total due to the individual measure savings having been rounded to the nearest whole number.

Almost two-thirds of energy savings come from air conditioners.

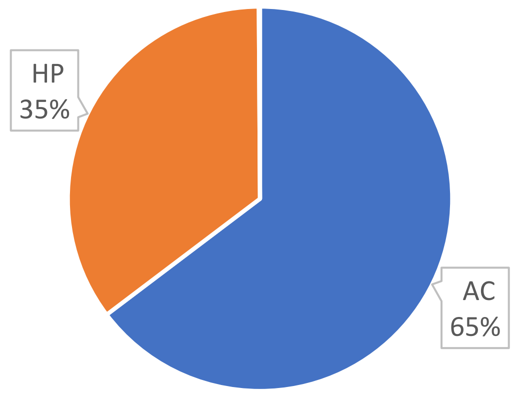

Figure 3-11: Residential HVAC – Percent of kWh Savings by System Type for Newly Evaluated HVAC Projects

3.5.2 Savings Calculation Method

A desk review was performed for a sample of projects incentivized in this program. Frontier selected a sample size to achieve a 90/10% confidence and precision interval. The results of the savings analysis for the sample were applied to the full program population.

Projects completed between February 1, 2017 and May 31, 2017 (PY1) were evaluated against the October 2016 update to the *CPS Energy Guidebook*. Projects completed between June 1, 2017 and January 31, 2018 (PY2) were evaluated against the November 2017 update to the *CPS Energy Guidebook*. Savings for all projects were validated using the savings methodologies outlined in the *CPS Energy Guidebook*. There were no major changes to the savings calculation methodology compared to the approach used in the FY 2017 evaluation.

AC and HP savings were estimated using performance curves developed by the National Renewable Energy Laboratory.[14] These performance curves provide the capacity and efficiency of the heat pump operating in cooling mode across a wide range of outside air temperatures. Unit loading was estimated as a function of outside air temperature, and hours of cooling mode operation under different loadings were estimated using bin weather data for each weather zone. The model uses a set of normalized performance curves to scale the rated performance values as a function of outdoor dry-bulb temperature ranging from 65 to 115 degrees Fahrenheit. The total capacity and Energy Input Ratio (EIR = 1/COP) curves are a function of entering wet-bulb temperature (EWB) and outdoor dry-bulb temperature (ODB) with quadratic curve fittings.

[14] D. Cutler et al., Improved Modeling of Residential Air Conditioners and Heat Pumps for Energy Calculations. National Renewable Energy Laboratory. NREL/TP-5500-56354. January 2013. Tables 12 and 13. http://www.nrel.gov/docs/fy13osti/56354.pdf.

In heating mode, predicted HVAC operation was limited to meeting 77% of load, using a factor applied in Manual J to correlate design load hours to equivalent full load hours under actual operating conditions, taking into account that heating systems are not always operated even when outdoor conditions indicate they should be in operation. It was assumed that typical HVAC systems are sized to 115% of their design cooling load (oversized by 15%). Heating mode capacity was related to rated cooling capacity using rated capacity in cooling and heating mode according to data exported from the AHRI Directory.[15]

Similarly, energy and demand savings for WACs and GSHPs were generally estimated by multiplying the installed capacity by the change in system efficiency. The typical format of the savings formula for this measure is as follows:

$$kW_{Savings} = \frac{Capacity}{1{,}000} \times \left(\frac{1}{Efficiency_{Baseline}} - \frac{1}{Efficiency_{Installed}}\right) \times Demand\ Factor$$

$$kWh_{Savings} = \frac{Capacity}{1{,}000} \times \left(\frac{1}{Efficiency_{Baseline}} - \frac{1}{Efficiency_{Installed}}\right) \times Hours$$

Non-coincident peak (NCP), coincident peak (CP), and four coincidental peaks (4CP) demand savings were derived using an approach adapted from the method outlined in Section 2.3 of the *CPS Energy Guidebook*.

3.5.3 Equipment Verification

To verify the accuracy of the reported equipment specifications, reported system capacities and efficiencies were validated against the AHRI Directory for the single AC project and against the ENERGY STAR certified product listing[16] for the WAC projects. Minimal discrepancies were identified for the AC and HP projects, but several could not be confirmed because neither model numbers nor AHRI certification number were reported in supplemental project documentation. WACs were not ENERGY STAR listed. For those systems, reported system efficiencies did not meet the minimum ENERGY STAR room air conditioner efficiency requirement.

3.5.4 Results and Recommendations

Overall, the Franklin Residential HVAC program achieved realization rates of 98% for NCP kW demand savings and 103% for kWh energy savings.

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

Table 3-4: Residential HVAC Gross Energy and Demand Savings

Measure	Gross Energy Savings (kWh)	Gross CP Demand Savings (kW)	Gross NCP Demand Savings (kW)	Gross ERCOT 4CP Demand Savings (kW)
Central Air Conditioners	9,809,745	4,392	4,569	3,709
Central Heat Pumps	5,323,521	1,813	1,986	1,613
Window Air Conditioners	15,617	11	12	10
Total[17]	15,148,882	6,216	6,566	5,332

Rows may not sum to total due to rounding.

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

- Check all reported AHRI certification numbers against reported equipment model numbers. For a small subset of sampled projects, the reported AHRI number did not match the equipment model numbers from the application, invoice, or other supplemental project documentation. If a new AHRI number is identified, savings should be calculated using the efficiency and capacity ratings from the revised AHRI certificate. If no AHRI match is found, that project should not be eligible to receive an incentive.
- Model numbers should be provided to the evaluation team for all system components, including the condenser, coils, and furnace, so that they can be verified against the AHRI certificate. This data should be available in supplemental project documentation requested for desk review of sample projects. In several cases, supporting documentation was incomplete or missing from the project entry on Salesforce.
- The system type should be verified when comparing to the reported AHRI number. Specifically, all HPs should be reported as HPs, even when a customer or contractor mistakenly submits an application for an AC. This issue does not appear to be as predominant as in past evaluations, but 2 of the 46 sampled AC projects were HPs that were mistakenly identified as ACs. In these cases, reporting the systems as ACs results in underclaimed savings that do not account for potential heating savings.
- Frontier understands that to simplify implementation, Franklin Energy has opted to utilize a savings estimation strategy to create deemed savings values for various tiers of products. There is a counteractive relationship between savings precision and ease of implementation. Many of Frontier's previous suggestions related to this topic seem to have been implemented for ACs and HPs. However, savings claims would benefit from the creation of additional savings tiers for WACs.

[17] The sum of the individual measures may not match the total due to the individual measure savings having been rounded to the nearest whole number.

  - For WACs, Frontier recommends that Franklin Energy adjust the existing tier specified for less than or equal to 8,000 btu/hr capacity category to less than 8,000 btu/hr, and, similarly, change the greater than 8,000 btu/hr capacity category to greater than or equal to 8,000 btu/hr. This is consistent with the implementation of the current federal standard for room air conditions. The endpoint capacity is typically included with the larger size category. This change will help to improve the baseline used for systems where the installed capacity matches the endpoint of one of the baseline capacity ranges.
  - Additionally for WACs, Frontier recommends that Franklin Energy add a new tier for capacities greater than or equal to 20,000 btu/hr. For units of this size, the baseline efficiency drops from 10.7 EER to 9.4 EER. It drops again to 9.0 EER for units greater than or equal to 25,000 btu/hr, but it could be reasonable to combine these size categories in the name of ease of implementation.
- Ensure that program minimum efficiency requirements are enforced for all measures. For ACs and HPs, minimum efficiency values of 14.5 SEER, 12.0 EER, 8.5 HSPF seem to have been enforced appropriately. For WACs, the installed efficiency should meet or exceed the October 30, 2015 ENERGY STAR minimum efficiency requirement for the corresponding capacity range. For 5 of the 12 sampled projects, no savings were awarded because the installed WAC failed to exceed the minimum efficiency requirement.
- When claiming an early retirement baseline, ensure that the project entry in Salesforce has appropriate documentation to validate that claim. At a minimum, that documentation should include an application with the reported baseline and the age of the existing system. Several projects were missing documentation, and other project applications documented baselines that did not match those reported to Frontier.
- Savings for early retirement projects are reliant on assumed escalation rates, discount rates, avoided capacity costs, and avoided energy costs. Typically, CPS does not provide these values to Frontier until after a program evaluation has already started. However, this makes it difficult for Franklin to produce reliable savings estimates. Frontier will work with CPS Energy and Franklin to specify deemed coefficients in an updated *CPS Energy Guidebook*. The goal will be to provide the values prior to the beginning of the program year so that the implementer can use those values for the entire program year.

3.6 NEW HOMES CONSTRUCTION PROGRAM

3.6.1 Overview

CPS Energy's FY 2018 new residential construction program provided incentives for 708 new homes completed in FY 2018 Of those 708 homes, 101 were legacy projects implemented by CPS Energy and

607 were implemented through contract to Franklin Energy. Nine builders participated in the program, maintaining the same level of builder participation as the previous program year.

CPS Energy used a two-tiered incentive structure in FY 2018, and paid incentives based on whether a certification could be obtained to confirm the construction of a home was expected to consume at least 15% less total source energy (electricity and gas) than a home built to the requirements of IECC 2015.

Participants could qualify for higher incentives by obtaining certification through the Build San Antonio Green (BSAG) program. The BSAG single family new construction program incorporates other elements in addition to energy consumption to achieve its certification including water, site, and health requirements. BSAG also requires a HERS rating and meeting of all the requirements of the Energy Star New Homes program.

Table 3-5: New Residential Construction –FY 2018 Incentive Levels

Incentive Amount ($)	Requirement	Participating Homes Franklin	Participating Homes CPS Energy
$1,100	15% better than IECC 2015 – no Certification	156	0
$1,300	15% better than IECC 2015 – with BSAG Certification	451	101
Total		607	101

3.6.1 Participation Trends

Of the total 708 homes participating in the FY 2018 program, 552 were certified by BSAG. These homes were built by five builders, with most of the homes coming from three main builders. Five participating builders submitted homes directly to CPS Energy while an additional six builders participated only in the Franklin implemented program. Three builders participated in both the CPS Energy and Franklin implemented programs. Two builders were responsible for 476 of the homes.

3.6.2 Savings Calculation Methods

Homes are accepted to the program based on ratings developed using the Energy Systems Lab's (ESL) International Code Compliance Calculator (IC3) and Architectural Energy Corporation's REM/Rate, the software used to establish Energy Star program compliance. Both tools provide site and source energy savings estimates based on a comparison of the predicted energy use in the as-built home to the energy use the models predict for a reference model, which incorporates the features of a home built to the reference code (IECC 2015) and equipped to relevant standards (e.g. federal equipment efficiency standards for HVAC units, water heaters, etc.). Source energy savings estimates are the basic requirement for establishing whether program guidelines have been met and the incentive tier for a given project. However, neither tool provides the coincident peak (CP), ERCOT 4 CP (4CP) or non-coincident peak (NCP) demand savings needed for benefit-cost analysis of the residential new construction program.

Frontier employed BEopt residential building energy use simulation software to develop models representative of the general suites of measures being incorporated into participating homes by the different builders to verify the energy savings estimates from the rating tools and to estimate CP, 4CP and NCP demand savings. The base Frontier model is a simple single-story square home with unfinished attic, built on a slab. The reference model is populated in accordance with the requirements for creating a standard reference model in Section R405 of the IECC 2015.

Builders are using a wide array of measures to meet program requirements: some have gone to 2x6 walls with R-19 insulation, while others are also adding continuous rigid insulation around the exterior of the homes. A majority of homes have 16 SEER air conditioners (or 16 SEER/8.5 and higher HSPF heat pumps), and some have tankless water heaters. Many are bringing the attics inside the envelope, insulating at the roof deck and completely sealing the attic; almost all are installing radiant barriers.

Perhaps the most important feature in determining by how much participating homes beat code is in reducing air infiltration. Code requires homes not allow more than 5 air changes per hour during blower door testing (pressurized to 50 pascals): reported air infiltration rates from post-construction blower door tests were between 2 and 5 ACH_{50}.

After reviewing the data from the IC3 reports and supplemental information requested (as listed in the *CPS Energy Guidebook* section for this program), Frontier developed simulation models reflecting the basic packages implemented by each of the builders, and ran simulations on variations of these models reflecting important differences such as the size (conditioned floor area) and achieved air infiltration rate.

3.6.2.1 Energy Savings (kWh)

While some variance is observed between homes, overall the energy savings from homes participating directly and submitting homes modeled in IC3 are producing savings in line with those estimated by the rating software.

Table 3-6: New Residential Construction - Site Electric Energy Savings Estimates

Participation Path	Est. Percent Improvement over Code	IC3 Ave. Site Energy Savings (kWh/100 ft2)	BEopt Site Energy Savings (kWh/100 ft2)	Percent Difference
Direct	16-32	46	46	0%

Homes entering the program through BSAG certification are estimated to achieve even higher normalized savings: Frontier's modeling indicates these homes are delivering about 85 kWh/100 ft^2 annually. In aggregate, Frontier estimates that participating homes completed during FY 2018 will deliver approximately 759,000 kWh of annual energy savings.

3.6.2.2 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 participating homes. In all, Frontier estimates that the FY 2018 participating new homes will provide 427 kW of CP demand savings.

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

Frontier extracted the maximum hourly value from the delta load shapes from its model runs to estimate the NCP demand savings for participating homes. In all, Frontier estimates that the FY 2018 participating new homes will provide 653 kW of NCP demand savings.

3.6.2.4 ERCOT 4CP Demand Savings (kW)

Frontier used the delta load shapes from its model runs to extract energy use in likely ERCOT 4CP hours. In all, Frontier estimates that the FY 2018 participating new homes will provide 514 kW of demand savings during the ERCOT 4CP.

3.6.3 Results and Recommendations

Coincident, non-coincident, and 4CP peak demand factors were calculated using an assumption that the load shape for this measure is evenly distributed across all hours of the year.

The estimated energy savings and coincident peak, non-coincident peak, and ERCOT 4CP demand savings for the FY 2018 residential new construction program are presented in Table 3-7.

Table 3-7: New Residential Construction Gross Energy and Demand Savings

Participant Type	Participant Count	Gross Energy Savings (kWh)	Gross CP Demand Savings (kW)	Gross NCP Demand Savings (kW)	Gross ERCOT 4CP Demand Savings (kW)
Direct	156	167,232	94	144	113
Build San Antonio Green	552	591,744	333	509	401
Total[18]	708	758,976	427	653	514

3.7 HOME ENERGY ASSESSMENT

3.7.1 Overview

The Home Energy Assessment (HEA) Program provides energy-saving products to CPS Energy customers by means of an in-person home energy assessment or through home energy assessment direct installation kits. The HEA Program provided 18,931 installations and kits in FY 2018.

[18] The sum of the individual measures may not match the total due to the individual measure savings having been rounded to the nearest whole number.

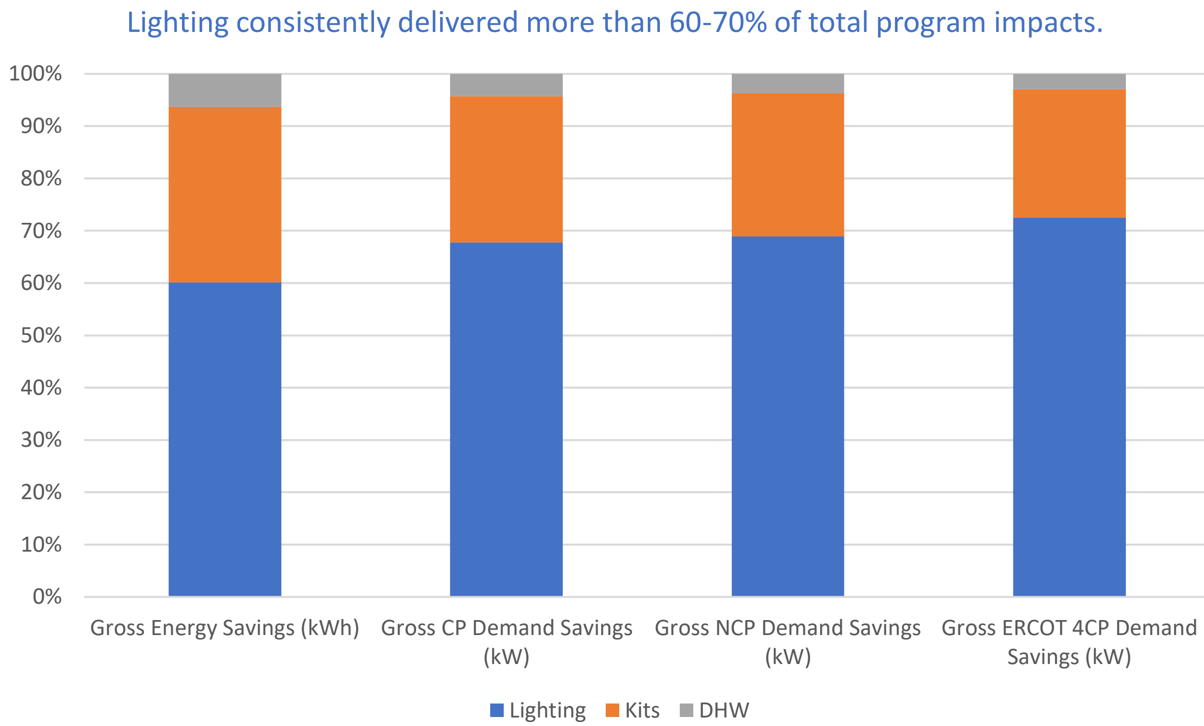


Figure 3-12: Home Energy Assessment Program – Gross Energy and Demand Impact Percentages by Measure

3.7.2 Savings Calculation Method

The energy and demand savings for the HEA Program were determined using the methodologies outlined in the *CPS Energy Guidebook*. Projects completed between February 1, 2017 and May 31, 2017 were evaluated against the October 2016 *CPS Energy Guidebook*. Projects completed between June 1, 2017 and January 31, 2018 were evaluated against the November 2017 *CPS Energy Guidebook*. For programs or measures where other methods were used, those are referenced in each section.

The sections below include the savings methodologies for in-person installations for LED light bulbs, low-flow showerheads, faucet aerators, and water heater pipe insulation. The following sections also include the savings methodologies for the two HEA kits, one for electric water heater customers and one for gas water heater customers.

A desk review was performed for a sample of projects incentivized in this program. Frontier selected a sample size to achieve a 90/10% confidence and precision interval. The results of the savings analysis for the sample were applied to the full program population.

3.7.2.1 LED Light Bulbs

The *CPS Energy Guidebook* includes separate calculation methodologies for omni-directional EISA-compliant and specialty EISA-exempt LED lighting. EISA-affected bulbs had savings that were determined using a two-tiered weighting approach due to the baseline change that is scheduled to occur in 2020. The savings for EISA-exempt bulbs were determined over the entire lifetime of the bulb using the equivalent wattages. The Guidebook also incorporates an interactive effects factor to account for the impacts on cooling and heating loads. Savings are discounted by a rate of 3% to account for an assumed 97% installation rate.

For projects evaluated against the November 2017 *CPS Energy Guidebook*, the first-tier savings period incremented down by a year and the second-tier savings period incremented up by a year. This change was made based on the calendar year change leading up to the EISA 2020 backstop. There were no other major changes to the savings calculation methodology compared to the approach used in the FY 2017 evaluation.

3.7.2.2 Domestic Hot Water

The HEA program installed domestic hot water measures in 1,046 homes in FY 2018. This includes low flow showerheads, kitchen and bath faucet aerators, and pipe insulation.

The energy and demand savings are determined using the algorithms in the *CPS Energy Guidebook.* Showerhead and aerator coincident, non-coincident, and 4CP peak demand factors were calculated using a DHW load profile developed from the Building America Analysis spreadsheet for existing homes. Pipe insulation coincident, non-coincident, and 4CP peak demand factors were calculated using an assumption that the load shape for this measure is evenly distributed across all hours of the year.

Domestic Hot Water (DHW) measures saw a change in methodology between the first and second half of the fiscal year. The change resulted in generally lower impacts for faucet aerator measures during the second half of the year.

Low-Flow Showerheads

The HEA program installed 793 low-flow showerheads in FY 2018. Savings for this measure are determined using a baseline assumption of a 2.5 gallon per minute (GPM) flowrate for the existing showerhead and a 1.5 GPM flowrate for the replacement showerhead.

Faucet Aerators

The Home Energy Assessment program includes the installation of two types of faucet aerators, one for a kitchen faucet and one for a bathroom faucet. Through this program, Franklin installed 338 kitchen aerators and 801 bathroom aerators for a total of 1,139 faucet aerators. Savings for this measure are determined using a baseline assumption of a 2.2 gallon per minute (GPM) flowrate for the existing faucets. The savings for aerators are based on an assumed 1.5 GPM flowrate for the post-retrofit kitchen faucet and an assumed 1.0 GPM flowrate for the post-retrofit bathroom faucet.

Water Heater Pipe Insulation

The Home Energy Assessment program includes installations of water heater pipe insulation in 198 homes. Savings for water heater pipe insulation are based on a maximum allowable insulation length of

6 feet of piping per installation, as per the *CPS Energy Guidebook*. For any installation of water heater pipe insulation over six feet, the savings were capped at this maximum. Savings vary based on the location of the water heater, in conditioned or unconditioned space. Water heater location was not tracked in project documentation and so the more conservative inputs assumptions were used to estimate impacts.

3.7.2.3 HEA Kits

Kits for Customers with Electric Water Heaters

Through the Home Energy Assessment program, Franklin Energy also offered the option of direct installation kits for customers. The electric water heater kit consists of five 9-Watt LED lightbulbs, one low-flow showerhead, one kitchen faucet aerator, one bathroom faucet aerator, and six feet of pipe insulation.

The savings methodology for each of these measures is described above. An installation rate is applied to the savings for each of these measures. These installation rates were provided by the contractor through a data analysis installation document. The installation rates for LEDs are 95% for the first LED, 90% for the second LED, 85% for the third LED, 80% for the fourth LED, and 75% for the fifth LED. The low-flow showerheads were evaluated using an installation rate of 65%. The savings for kitchen faucet aerators were determined using a 72% installation rate and savings for bathroom aerators were determined using a 71% installation rate. The savings for pipe insulation were determined using a 50% installation rate.

Kits for Customers with Gas Water Heaters

Through the Home Energy Assessment program, Franklin Energy also offered the option of direct installation kits for customers. The gas water heater kit consists of five 9-Watt LED lightbulbs.

The savings methodology for the LED lamp measure is described. An installation rate is applied to the savings for each of the light bulbs in the kit. These installation rates were provided by the contractor through a data analysis installation document. The installation rates for LEDs are 95% for the first LED, 90% for the second LED, 85% for the third LED, 80% for the fourth LED, and 75% for the fifth LED.

3.7.3 Results and Recommendations

For future iterations of the Home Energy Assessment program, Frontier recommends conducting customer surveys for the electric water heater kits and gas water heater kits. Using survey data, more accurate installation rates can be applied.

The following are the gross energy and demand savings for the Home Energy Assessment program.

Table 3-8: Home Energy Assessment Gross Energy and Demand Saving

Measure	Gross Energy Savings (kWh)	Gross CP Demand Savings (kW)	Gross NCP Demand Savings (kW)	Gross ERCOT 4CP Demand Savings (kW)
Lighting	4,449,121	450	2,213	705
Kits	2,484,437	186	878	239
DHW	467,849	28	121	28
Total[19]	7,401,406	664	3,212	972

Rows may not sum to total due to rounding.

Frontier's recommendations for future implementation of the Home Energy Assessment program are as follows:

LED Light Bulbs

- Update savings calculation to calculate the first-tier savings period as 2021 minus the installation year. The second-tier savings period should be calculated as the EUL minus the first-tier savings period.
- Note that in future years, EUL will no longer be deemed at 20 years for all LED lamps. Instead, EUL will vary between 15 and 20 years depending on the rated life of the LED lamp. This will affect the first- and second-tier savings period calculation. Additionally, Franklin will need to start collecting and reporting the lamp rated life to the evaluation team.
- Because of the two-tiered baseline and corresponding net present value weighting approach specified by the *CPS Energy Guidebook*, savings for lighting projects are reliant on assumed escalation rates, discount rates, avoided capacity costs, and avoided energy costs. Typically, CPS does not provide these values to Frontier until after a program evaluation has already started. However, this makes it difficult for Franklin to produce reliable savings estimates. Frontier will work with CPS Energy and Franklin to specify deemed coefficients in an updated *CPS Energy Guidebook*. The goal will be to provide the values prior to the beginning of the program year so that the implementer can use those values for the entire program year.

HEA Kits

- To ensure the validity of claimed savings, update savings calculations to coincide with the updated *CPS Energy Guidebook*. First and second tier savings periods need to be incremented for lighting, and there was a complete overhaul to the calculation methodology for the hot water measures.

[19] The sum of the individual measures may not match the total due to the individual measure savings having been rounded to the nearest whole number.

- Conduct additional student surveys to reinforce or improve existing installation rate assumptions.
- Consider adding a second low-flow showerhead to the kit to help offset the decreasing lighting and faucet aerator savings.

Domestic Hot Water

- Water heater location is not currently being tracked for DHW measures. Some measures, like pipe insulation, have variable savings based on whether the water heater is installed in conditioned or unconditioned space. While savings improvements for this measure may be small, we recommend documenting water heater location to maximize savings for this measure as well as provide a large data set for future program planning.

3.8 MULTIFAMILY ENERGY EFFICIENCY

3.8.1 Overview

The Multifamily Energy Efficiency program provides energy efficient measures to multifamily property with more than five units. The Multifamily program includes installation of LED bulbs, high-efficiency showerheads, kitchen and bathroom faucet aerators, water heater pipe insulation, and power strips. The Multifamily program served 12,306 individual apartments in FY 2018.

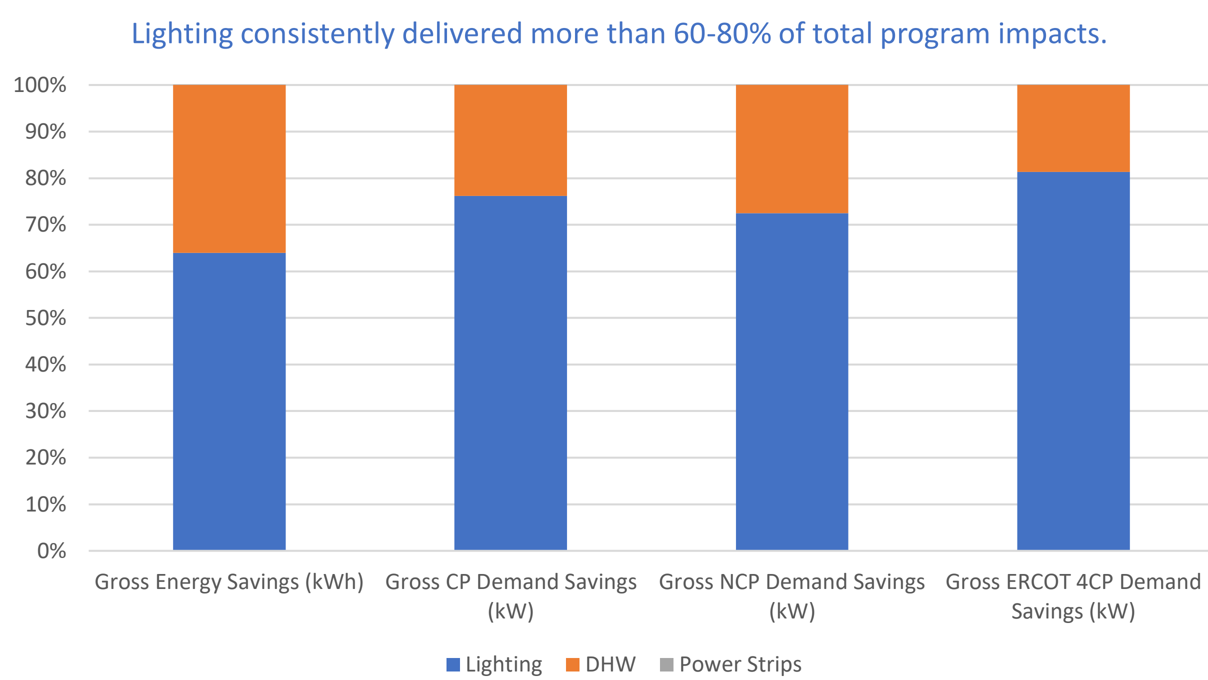


Figure 3-13: Multifamily Program – Gross Energy and Demand Impacts by Measure

3.8.2 Savings Calculation Method

Frontier conducted a desk review for a sample of projects designed to deliver 90% confidence and 10% precision. Frontier's desk review of sampled projects indicated that project documentation supported the reported project data and no adjustments were made to project-level input assumptions.

For each of the measures, Frontier determined energy savings using methodology from the *CPS Energy Guidebook*. Projects completed between February 1, 2017 and May 31, 2017 were evaluated against the October 2016 *CPS Energy Guidebook*. Projects completed between June 1, 2017 and January 31, 2018 were evaluated against the November 2017 *CPS Energy Guidebook*. For programs or measures where other methods were used, those are referenced in each section.

3.8.2.1 LED Light Bulbs

The *CPS Energy Guidebook* includes separate calculation methodologies for omni-directional EISA-compliant and specialty EISA-exempt LED lighting. EISA-affected bulbs had savings that were determined using a two-tiered weighting approach due to the baseline change that is scheduled to occur in 2020. The savings for EISA-exempt bulbs were determined over the entire lifetime of the bulb using the equivalent wattages. The Guidebook also incorporates an interactive effects factor to account for the impacts on cooling and heating loads. Savings are discounted by a rate of 3% to account for an assumed 97% installation rate.

For projects evaluated against the November 2017 *CPS Energy Guidebook*, the first-tier savings period incremented down by a year and the second-tier savings period incremented up by a year. This change was made based on the calendar year change leading up to the EISA 2020 backstop. There were no other major changes to the savings calculation methodology compared to the approach used in the FY 2017 evaluation.

3.8.2.2 Domestic Hot Water

The energy and demand savings are determined using the algorithms in the *CPS Energy Guidebook*. Showerhead and aerator coincident, non-coincident, and 4CP peak demand factors were calculated using a DHW load profile developed from the Building America Analysis spreadsheet for existing homes. Pipe insulation coincident, non-coincident, and 4CP peak demand factors were calculated using an assumption that the load shape for this measure is evenly distributed across all hours of the year.

Domestic Hot Water (DHW) measures saw a change in methodology between the first and second half of the fiscal year, resulting in generally lower impacts for faucet aerator measures during the second half of the year.

Low Flow Showerheads

The Multifamily Energy Efficiency program includes the installation of 6,355 low-flow showerheads. Savings for this measure are determined using a baseline assumption of a 2.5 gallon per minute (GPM) flowrate for the existing showerhead and a 1.5 GPM flowrate for the replacement showerhead.

Faucet Aerators

The Multifamily Energy Efficiency program includes the installation of two types of faucet aerators, one for a kitchen faucet and one for a bathroom faucet. Through this program, CPS Energy installed 4,516 kitchen aerators and 4,419 bathroom aerators for a total of 8,935 faucet aerators.

Savings for this measure are determined using a baseline assumption of a 2.2 gallon per minute (GPM) flowrate for the existing faucets. The savings for aerators are based on an assumed 1.5 GPM flowrate for the post-retrofit kitchen faucet and an assumed 1.0 GPM flowrate for the post-retrofit bathroom faucet.

Water Heater Pipe Insulation

The Multifamily Energy Efficiency program included 32 installations of water heater pipe insulation. Savings for water heater pipe insulation are based on a maximum allowable insulation length of 6 feet of piping per installation, as per the *CPS Energy Guidebook*. For any installation of water heater pipe insulation over six feet, the savings were capped at this maximum.

Water heater pipe insulation savings vary based on the location of the water heater, in conditioned or unconditioned space. Water heater location was not tracked in project documentation and so the more conservative inputs assumptions were used to estimate impacts.

3.8.2.3 Power Strips

There were 3 tier 1 power strips installed in FY 2018. For FY 2018 projects, we assumed the power strips were installed in a home office to control a desktop computer.

3.8.3 Results and Recommendations

The following are the gross energy and demand savings for the Multifamily Energy Efficiency program.

Table 3-9: Multifamily Gross Energy and Demand Saving

Measure	Gross Energy Savings (kWh)	Gross CP Demand Savings (kW)	Gross NCP Demand Savings (kW)	Gross ERCOT 4CP Demand Savings (kW)
Lighting	4,879,359	597	1,973	812
DHW	2,747,943	187	749	187
Power Strips	113	0	0	0
Total[20]	7,627,414	783	2,721	999

Rows may not sum to total due to rounding.

20 The sum of the individual measures may not match the total due to the individual measure savings having been rounded to the nearest whole number.

Frontier's recommendations for future implementation of the Multifamily Energy Efficiency program are as follows:

LED Light Bulbs

- Update savings calculation to calculate the first-tier savings period as 2021 minus the installation year. The second-tier savings period should be calculated as the EUL minus the first-tier savings period.
- Note that in future years, EUL will no longer be deemed at 20 years for all LED lamps. Instead, EUL will vary between 15 and 20 years depending on the rated life of the LED lamp. This will affect the first- and second-tier savings period calculation. Additionally, Franklin will need to start collecting and reporting the lamp rated life to the evaluation team.
- Savings for LED lamps installed in commercially-metered common areas should be calculated using the commercial savings methodologies outlined in the *CPS Energy Guidebook*. Primarily, this includes referencing different values for operating hours, coincidence factors, and HVAC interactive effects factors.
- Because of the two-tiered baseline and corresponding net present value weighting approach specified by the *CPS Energy Guidebook*, savings for lighting projects are reliant on assumed escalation rates, discount rates, avoided capacity costs, and avoided energy costs. Typically, CPS does not provide these values to Frontier until after a program evaluation has already started. However, this makes it difficult for Franklin to produce reliable savings estimates. Frontier will work with CPS Energy and Franklin to specify deemed coefficients in an updated *CPS Energy Guidebook*. The goal will be to provide the values prior to the beginning of the program year so that the implementer can use those values for the entire program year.

3.9 ENERGY SAVINGS THROUGH SCHOOLS

3.9.1 Overview

The Energy Savings Through Schools Program provides students with energy efficiency kits. The kits are comprised of three 9-Watt LED light bulbs, a high-efficiency showerhead, a kitchen faucet aerator, and a bathroom faucet aerator. 14,294 kits were distributed at 85 schools in FY 2018. No comparison has been made to FY 2017 participation because the program kicked off during the middle of FY 2017. A more complete analysis of program participation trends will be available after comparing the program's FY 2018 and FY 2019 performance.

This evaluation includes both previously evaluated projects from the CPS PY1 evaluation and new PY2 projects completed during the CPS FY 2018 evaluation period. The figure below presents a percentage breakdown of kWh energy savings. Savings are presented by kit measure type for all newly evaluated kits projects completed through this program.

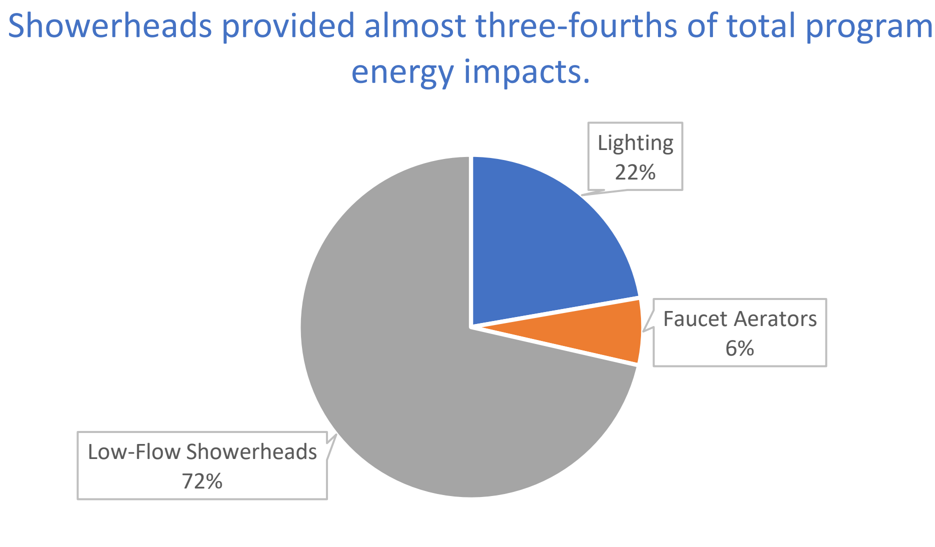


Figure 3-14: Energy Savings Through Schools – Percent of kWh by Kit Measure for Newly Evaluated Kits

3.9.2 Savings Calculation Method

A desk review was performed for a sample of projects incentivized in this program. Frontier selected a sample size to achieve a 90/10% confidence and precision interval. The results of the savings analysis for the sample were applied to the full program population.

Projects completed between February 1, 2017 and May 31, 2017 were evaluated against the October 2016 update to the *CPS Energy Guidebook*. Projects completed between June 1, 2017 and January 31, 2018 were evaluated against the November 2017 update to the *CPS Energy Guidebook*.

Installation rates for the kits were derived from student survey data for the program.

3.9.2.1 LED Light Bulbs

The *CPS Energy Guidebook* includes separate calculation methodologies for omni-directional EISA-compliant and specialty EISA-exempt LED lighting. EISA-affected bulbs had savings that were determined using a two-tiered weighting approach due to the baseline change that is scheduled to occur in 2020. The savings for EISA-exempt bulbs were determined over the entire lifetime of the bulb using the equivalent wattages. The Guidebook also incorporates an interactive effects factor to account for the impacts on cooling and heating loads. Savings are discounted by a rate of 3% to account for an assumed 97% installation rate.

For projects evaluated against the November 2017 *CPS Energy Guidebook*, the first-tier savings period incremented down by a year and the second-tier savings period incremented up by a year. This change was made based on the calendar year change leading up to the EISA 2020 backstop. There were no other major changes to the savings calculation methodology compared to the approach used in the FY 2017 evaluation.

Installation rates were derived from the student survey data, which indicated that 66% of families installed the first LED light bulb, 56% of families installed the second LED light bulb, and 49% of families installed the third LED light bulb.

3.9.2.2 Low-Flow Showerheads

Savings for this measure are determined using a baseline assumption of a 2.5 gallon per minute (GPM) flowrate for the existing showerhead and a 1.5 GPM flowrate for the replacement showerhead. Savings values for projects evaluated against the November 2017 *CPS Energy Guidebook* increased based on a change in the way that hot water volume is calculated in the *CPS Energy Guidebook*.

Installation rates were derived from the student survey data, which indicated that 51% of families installed the high-efficiency showerhead.

3.9.2.3 Faucet Aerators

Savings for this measure are determined using a baseline assumption of a 2.2 gallon per minute (GPM) flowrate for the existing faucets. The savings for aerators are based on an assumed 1.5 GPM flowrate for the post-retrofit kitchen faucet and an assumed 1.0 GPM flowrate for the post-retrofit bathroom faucet. Savings values for projects evaluated against the November 2017 *CPS Energy Guidebook* decreased based on a change in the way that hot water volume is calculated in the *CPS Energy Guidebook*.

Installation rates were derived from the student survey data, which indicated that 39% of families installed the new kitchen faucet aerator and 38% of families installed the new bathroom aerator.

3.9.3 Results and Recommendations

Overall, the Energy Savings Through Schools kit program achieved realization rates of 97% for NCP kW demand savings and 103% for kWh energy savings.

Table 3-10: Energy Savings Through Schools Gross Energy and Demand Savings

Measure	Gross Energy Savings (kWh)	Gross CP Demand Savings (kW)	Gross NCP Demand Savings (kW)	Gross ERCOT 4CP Demand Savings (kW)
School Kits	1,732,691	102	607	124

Frontier's recommendations for future implementation of the Energy Savings Through Schools kit program are as follows:

- To ensure the validity of claimed savings, update savings calculations to coincide with the updated *CPS Energy Guidebook*. First and second tier savings periods need to be incremented for lighting, and there was a complete overhaul to the calculation methodology for the hot water measures.

  - Update savings calculation to calculate the first-tier savings period as 2021 minus the installation year. The second-tier savings period should be calculated as the EUL minus the first-tier savings period.
  - Note that in future years, EUL will no longer be deemed at 20 years for all LED lamps. Instead, EUL will vary between 15 and 20 years depending on the rated life of the LED lamp. This will affect the first- and second-tier savings period calculation. Additionally, Franklin will need to start collecting and reporting the lamp rated life to the evaluation team.
- Conduct additional student surveys to reinforce or improve existing installation rate assumptions.
- Consider adding a second low-flow showerhead to the kit to help offset the decreasing lighting and faucet aerator savings.
- Because of the two-tiered baseline and corresponding net present value weighting approach specified by the *CPS Energy Guidebook*, savings for lighting projects are reliant on assumed escalation rates, discount rates, avoided capacity costs, and avoided energy costs. Typically, CPS does not provide these values to Frontier until after a program evaluation has already started. However, this makes it difficult for Franklin to produce reliable savings estimates. Frontier will work with CPS Energy and Franklin to specify deemed coefficients in an updated *CPS Energy Guidebook*. The goal will be to provide the values prior to the beginning of the program year so that the implementer can use those values for the entire program year.

3.10 RESIDENTIAL RETAIL PARTNERS

3.10.1 Overview

The Residential Retail Partners program offers in-store rebates for ENERGY STAR certified lighting. There are 73 participating retailers in this program and rebates were offered for 144 different lighting products.

3.10.2 Savings Calculation Method

A desk review was performed for a sample of projects incentivized in this program. Frontier selected a sample size to achieve a 90/10% confidence and precision interval. The results of the savings analysis for the sample were applied to the full program population.

Projects completed between February 1, 2017 and May 31, 2017 were evaluated against the October 2016 update to the *CPS Energy Guidebook*. Projects completed between June 1, 2017 and January 31, 2018 were evaluated against the November 2017 update to the *CPS Energy Guidebook*.

The *CPS Energy Guidebook* includes separate calculation methodologies for omni-directional EISA-compliant and specialty EISA-exempt LED lighting. EISA-affected bulbs had savings that were determined using a two-tiered weighting approach due to the baseline change that is scheduled to occur in 2020. The savings for EISA-exempt bulbs were determined over the entire lifetime of the bulb using the equivalent wattages. The Guidebook also incorporates an interactive effects factor to account for the impacts on cooling and heating loads. Savings are discounted by a rate of 3% to account for an assumed 97% installation rate.

For projects evaluated against the November 2017 *CPS Energy Guidebook*, the first-tier savings period incremented down by a year and the second-tier savings period incremented up by a year. This change was made based on the calendar year change leading up to the EISA 2020 backstop. There were no other major changes to the savings calculation methodology compared to the approach used in the FY 2017 evaluation.

3.10.3 Results and Recommendations

Overall, the Residential Retail Partners program achieved realization rates of 94% for NCP kW demand savings and 94% for kWh energy savings. However, this program is lighting only, and lighting realization rates have dropped over the second half of FY 2018. Savings calculations will need to be updated to maintain a high realization rate for this program.

Table 3-11: Residential Retail Partners Gross Energy and Demand Saving

Measure	Gross Energy Savings (kWh)	Gross CP Demand Savings (kW)	Gross NCP Demand Savings (kW)	Gross ERCOT 4CP Demand Savings (kW)
LED	14,368,667	1,397	7,151	2,189

Frontier's recommendations for future implementation of the Residential Retail Partners program are as follows:

- Update savings calculation to calculate the first-tier savings period as 2021 minus the installation year. The second-tier savings period should be calculated as the EUL minus the first-tier savings period.
- Note that in future years, EUL will no longer be deemed at 20 years for all LED lamps. Instead, EUL will vary between 15 and 20 years depending on the rated life of the LED lamp. This will affect the first- and second-tier savings period calculation. Additionally, Franklin will need to start collecting and reporting the lamp rated life to the evaluation team.
- Include manufacturer and ENERGY STAR model number in initial evaluation data report. This will prevent the evaluation team from needing to request supplemental data during future evaluations.

- Because of the two-tiered baseline and corresponding net present value weighting approach specified by the *CPS Energy Guidebook*, savings for lighting projects are reliant on assumed escalation rates, discount rates, avoided capacity costs, and avoided energy costs. Typically, CPS does not provide these values to Frontier until after a program evaluation has already started. However, this makes it difficult for Franklin to produce reliable savings estimates. Frontier will work with CPS Energy and Franklin to specify deemed coefficients in an updated *CPS Energy Guidebook*. The goal will be to provide the values prior to the beginning of the program year so that the implementer can use those values for the entire program year.

3.11 AC DUCT TUNE-UP

3.11.1 Overview

The AC Duct Tune-Up program consists of technicians performing diagnostic testing on HVAC systems and implementing improvements such as duct sealing, coil cleaning, and refrigerant recharge to improve overall HVAC system performance. Franklin served 572 homes with duct sealing and AC tune-up measures in FY 2018.

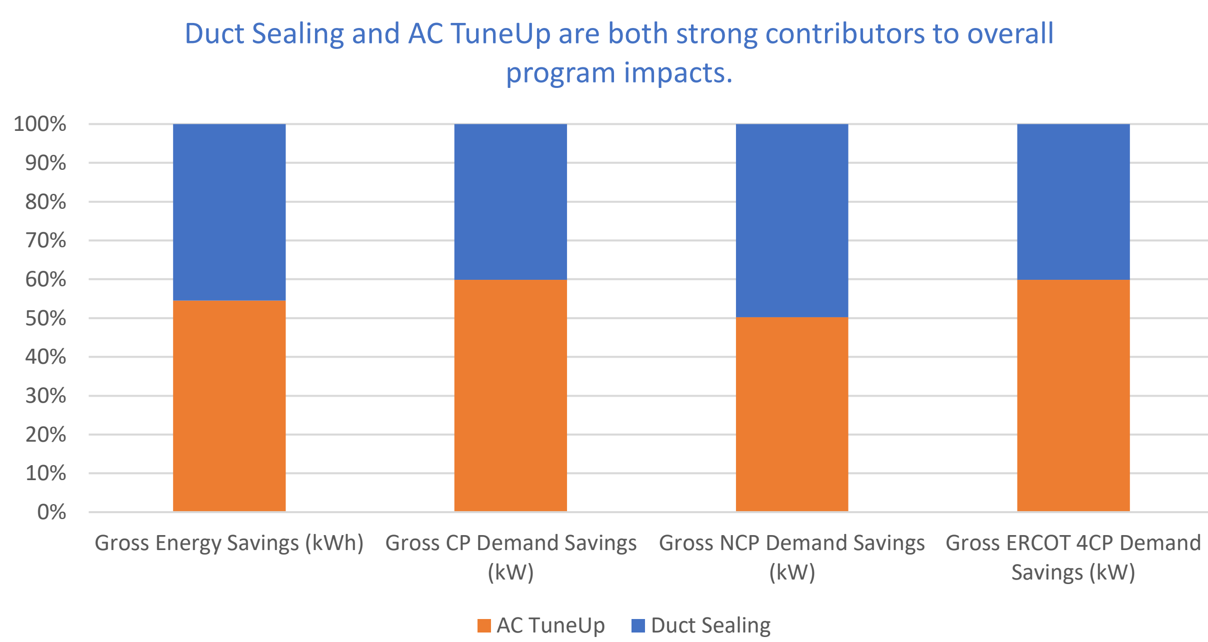


Figure 3-15: AC/Duct Tune-Up – Gross Energy and Demand Impact Percentages by Measure

3.11.2 Savings Calculation Method

A desk review was performed for a sample of projects incentivized in this program. Frontier selected a sample size to achieve a 90/10% confidence and precision interval. The results of the savings analysis for the sample were applied to the full program population.

Projects completed between February 1, 2017 and May 31, 2017 were evaluated against the October 2016 update to the *CPS Energy Guidebook*. Projects completed between June 1, 2017 and January 31, 2018 were evaluated against the November 2017 update to the *CPS Energy Guidebook*.

3.11.2.1 Duct Sealing

Savings for all projects were validated using the savings methodologies outlined in the *CPS Energy Guidebook*. The primary change for this measure in the November 2017 update was the inclusion of demand and energy adjustment factors. These factors are single year transitional factors used to slowly move from the existing algorithm approach to a new modeled approach. Savings were significantly reduced in this update and are further reduced with the new modeled approach.

3.11.2.2 AC Tune-Up

The *CPS Energy Guidebook* provides savings methodologies based on HVAC system type and tonnage. For the first half of the program, that information was provided with project documentation. For the second half of the fiscal year, system type and tonnage information was not provided. To calculate savings for the second half of the year, Frontier calculated the distribution by system type and average tonnage for the first half of the year and applied it to projects from the second half of the program year.

3.11.3 Results and Recommendations

Table 3-12: AC Duct Tune-Up Gross Energy and Demand Saving

Measure	Gross Energy Savings (kWh)	Gross CP Demand Savings (kW)	Gross NCP Demand Savings (kW)	Gross ERCOT 4CP Demand Savings (kW)
Duct Sealing	68,465	21	34	20
AC Tune-Up	82,172	31	34	29
Total[21]	150,637	52	69	49

Rows may not sum to total due to rounding.

CPS Energy has phased out this program and will not be implementing it in future years. However, should the program be reinstated at some time in the future, Frontier's recommendations are as follows:

Duct Sealing

Only one project was reported in the second half of FY 2018, making it appear that this measure is being eliminated from the AC Duct Tune-Up program. However, should this program continue, Frontier recommends recording cooling type, heating type, cooling capacity, pre-improvement duct leakage, and post-improvement duct leakage in Salesforce for each installation. The evaluation team will need to access this information for any projects included in future evaluation desk review sample sets.

[21] The sum of the individual measures may not match the total due to the individual measure savings having been rounded to the nearest whole number.

AC Tune-Up

To ensure a high level of confidence in savings results, it is important to track all required inputs as listed in the *CPS Energy Guidebook*. When input assumptions must be made, conservative values are generally applied which may result in underestimated savings.

3.12 COOL ROOF

3.12.1 Overview

The Cool Roof program is a new program for FY 2018. The installation of a highly reflective roof decreases the roofing heat transfer coefficient and reduces the solar heat transmitted to the home. During hours when cooling is required in the home, this measure decreases the cooling energy use. During hours when heating is required in the building, this measure may increase or decrease the heating energy use depending on characteristics of the site. Qualifying projects receive an incentive for using Energy Star-rated cool roofing materials. The rebate is calculated per square foot of roofing area located above conditioned space.

3.12.2 Savings Calculation Method

Energy savings for this measure are determined using calibrated simulation models developed using NREL's BEopt 2.6 software running EnergyPlus 8.4 as the underlying simulation engine. The simulation models used for other *CPS Energy Guidebook* envelope models were adapted to estimate impacts for Cool Roof. Savings impacts for this program are not yet incorporated into the *CPS Energy Guidebook*, but coincident, non-coincident,[22] and 4CP peak demand savings were determined using building energy simulation models developed by subtracting the whole house energy use in each hour of the post-retrofit models from the energy use in the pre-retrofit models.

Projects completed in FY 2018 were evaluated based on a desk review of project documentation including site photos, invoices, and confirmation of roofing system reflectivity. Savings vary by heating type and solar reflectance value of the installed roof. The program requires a solar reflectance of greater than 40%. Projects that did not meet the minimum value were not awarded savings. There were 24 eligible projects with verified savings in FY 2018. The average installed solar reflectance was 69% and the average roof area was 1,820 square feet.

[22] For some envelope measures installed at homes with electric heating, the non-coincident peak occurs during the non-summer months.

3.12.3 Results and Recommendations

Table 3-13: Residential Cool Roof Gross Energy and Demand Savings

Measure	Gross Energy Savings (kWh)	Gross CP Demand Savings (kW)	Gross NCP Demand Savings (kW)	Gross ERCOT 4CP Demand Savings (kW)
Cool Roof	12,131	5	6	4

The Cool Roof program had unusually high administrative costs relative to delivered savings and achieved a PACT score of 0.44. This is in part due to this being the program's first year with program start-up costs that should not be expected in subsequent years of the program. Now that typical project savings impacts are available, we recommend that CPS Energy review their implementation procedures for this program to align with anticipated participation and savings levels.

4. COMMERCIAL PROGRAMS

4.1 SUMMARY OF COMMERCIAL IMPACTS

CPS Energy's portfolio of commercial programs addresses most markets and major commercial end uses. In mid FY 2017, CLEAResult began implementing the majority of commercial programs. Legacy programs are those (now closed) CPSE-administered programs with project that carried over into FY 2018. Commercial demand response programs are included in Section 5. CPS Energy offered the following programs for the Commercial sector in FY 2018:

CPS Legacy Lighting – incentives for the installation of efficient lighting for both retrofit and new construction projects.

CPS Legacy HVAC - incentives for the installation of high efficiency unitary AC equipment, heat pumps and chillers.

CPS Legacy Custom - cost–effective efficiency measures not addressed by the other commercial rebate offerings.

C&I Solutions - energy assessments to identify opportunities and rebates for measures including lighting, HVAC, and refrigeration.

Schools & Institutions - helps schools and government agencies reduce energy use through benchmarking, technical assistance, energy master planning, and rebate offerings.

Small Business Solutions – contractor-led incentive program for small business customers with less than 100 kW demand.

Whole Building Optimization - offers contractor-led incentives for building optimization, including tools and strategies to enhance a facility's operational efficiency

Due to the fiscal year break across program years, projects completed between February 1, 2017 and May 31, 2017 were evaluated against the October 2016 *CPS Energy Guidebook*. Projects completed between June 1, 2017 and January 31, 2018 were evaluated against the November 2017 Guidebook. For measures where other methods were used, those are referenced in each section. Except as noted, CP values were calculated using the 20-hour probability method, as outlined in Section 2.2.

Values in Figure 4-3 through Figure 4-1 represent energy and demand savings from new FY 2018 program participants as measured at the participant or end-user level and adjusted to account for net-to-gross ratios and line losses.[23] Program names are abbreviated in chart labels.[24]

[23] 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.

[24] CPS Lighting = CPS Legacy Lighting, C&I = Commercial and Industrial, S&I = Schools and Institutions, SBS = Small Business Solutions

These figures show program contributions to the commercial portfolio's energy and demand savings.

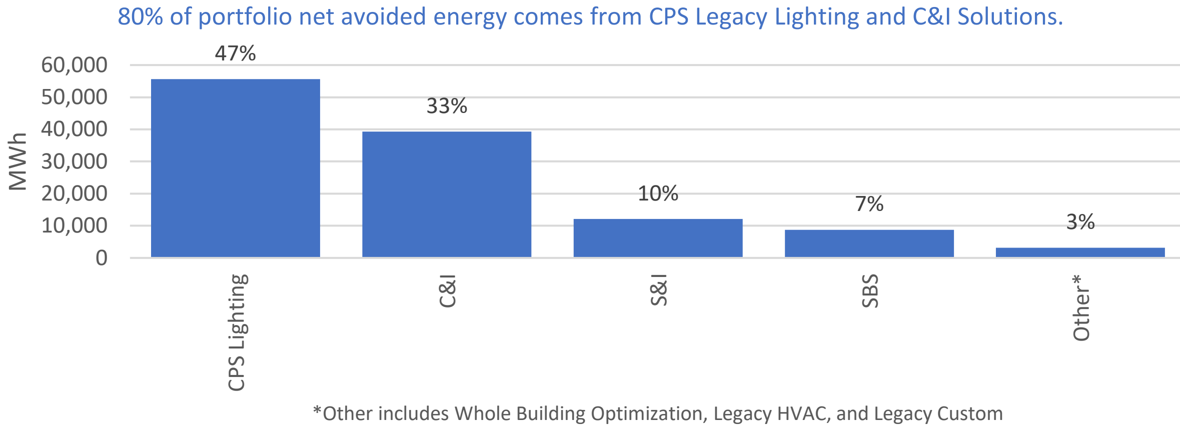


Figure 4-1: Summary of Commercial Impacts – Net Avoided Energy by Program

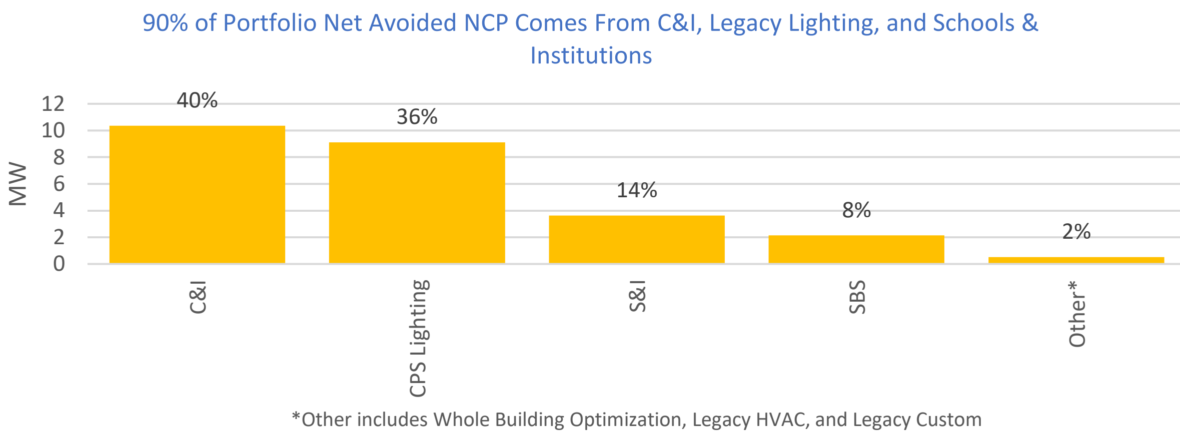


Figure 4-2: Summary of Commercial Impacts – Net Avoided NCP by Program

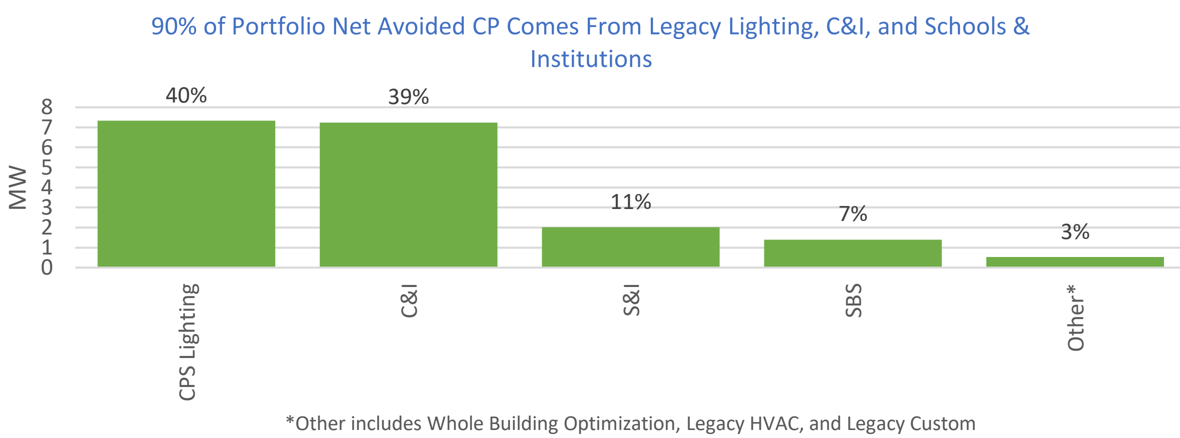


Figure 4-3: Summary of Commercial Impacts – Net Avoided CP by Program

4.2 COMMERCIAL LIGHTING CPSE LEGACY PROGRAM

4.2.1 Overview

This program includes legacy projects that were in queue during earlier program years for the installation of energy-efficient lighting and lighting controls. In FY 2018, a total of 49 lighting and/or lighting controls projects were incentivized through the CPS Energy Commercial Lighting Legacy Program, including one FY 2017 project incentive adjustment with no additional savings claimed.[25] FY 2018 performance has not been compared to FY 2017 because this is a legacy program and all new projects are being implemented by CLEAResult under alternate programs.

The figures below present percentage breakdowns of kWh energy savings by savings measure type and building type for sampled lighting projects completed through this program.

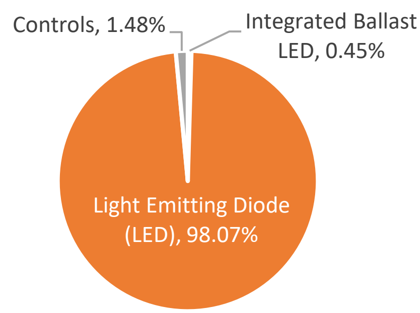
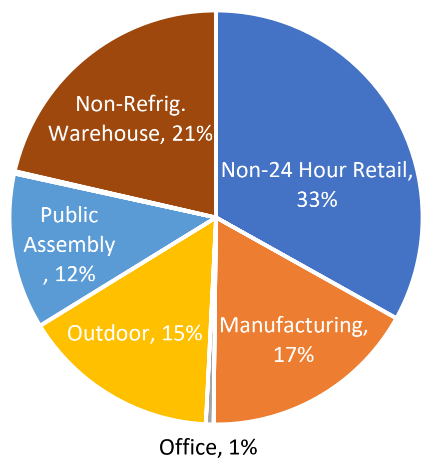


Figure 4-4: Commercial CPSE Lighting Legacy – Percent of kWh Savings by Savings Measure Type for Sampled Projects



Percentages may not sum to 100 due to rounding.

Figure 4-5: Commercial CPSE Lighting Legacy - Percent of kWh Savings by Building Type for Sampled Projects

[25] The FY 2017 project incentive adjustment included final and full payment for a project that was only partially paid in the FY 17 program year.

4.2.2 Savings Calculation Method

A desk review was performed for a sample of projects incentivized in this program. Frontier selected a sample size to achieve a 90/10% confidence and precision interval. The results of the savings analysis for the sample were applied to the full program population.

Frontier randomly selected a sample of 29 lighting projects for desk review. Savings for all sampled projects were validated using the savings methodologies outlined in the *CPS Energy Guidebook*. There were no major changes to the savings calculation methodology compared to the approach used in the FY 2017 evaluation.

In addition to validating the savings calculations against the *CPS Energy Guidebook*, claimed pre/post fixture counts and wattages were verified against project documentation. Hours of operation and demand factors were also verified against the reported building type. For lighting installed in a conditioned space, Frontier awarded additional savings to account for HVAC/refrigeration interactive effects of the projects. A reduced lighting load reduces the internal heat gain to the building, which reduces the cooling load but increases the heating load.

Frontier selected 4 sites for inspection, representing 15% of the sample population. For inspected sites, savings were also adjusted to match any site observations that contrasted with reported data.

The non-coincident peak (NCP), coincident peak (CP), and four coincidental peaks (4CP) demand factors used to estimate demand savings for this measure were derived using an approach adapted from the method outlined in Section 2.3 of the *CPS Energy Guidebook*. First, lighting schedules were extracted from BEopt energy simulation models developed for the commercial HVAC measures based on Department of Energy (DOE) commercial reference buildings.[26] Next, hourly percentages of lighting in operation were extracted from the lighting schedules. The resulting lighting factors were weighted using the probabilities assigned to each of the top 20 peak hours and 4CP hours. NCP factors match the maximum lighting factor from the lighting schedule for each building type.

After the inclusion of HVAC interactive effects, the CP or 4CP verified savings would occasionally exceed the verified NCP savings despite the higher NCP demand factor. In these instances, the CP or 4CP (higher of the two) was substituted as the verified NCP demand savings for that project.

4.2.3 Results and Recommendations

A weighted average realization rate (weighted by claimed NCP kW and kWh savings) was calculated for the projects sampled for a desk review. The weighted average realization rates were applied to the entire project population (both sampled and un-sampled).

[26] DOE Commercial Reference Buildings: http://energy.gov/eere/buildings/commercial-reference-buildings.

The weighted average realization rate for the lighting and lighting controls projects were 99.2% for NCP kW demand savings and 96.7% for kWh energy savings. The weighted average estimated useful life (EUL) applied to the verified savings was 14.9 years.

While the recommendations for commercial lighting measures in previous evaluations focused heavily on data collection, that direction is no longer necessary because this measure is no longer implemented directly by CPS Energy. For relevant recommendations, please refer to the sections for the CLEAResult C&I Solutions, Schools and Institutions, and Small Business Solutions programs.

Table 4-1: Commercial Lighting Legacy Gross Energy and Demand Savings

Measure	Gross Energy Savings (kWh)	Gross CP Demand Savings (kW)	Gross NCP Demand Savings (kW)	Gross ERCOT 4CP Demand Savings (kW)
Commercial Lighting Legacy	55,040,154	7,009	9,022	7,105

4.3 COMMERCIAL HVAC CPSE LEGACY PROGRAM

4.3.1 Overview

CPS Energy's Commercial Heating, Ventilation, and Air Conditioning (HVAC) Legacy 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 Commercial HVAC Legacy program had 2 unique project sites in FY 2018 while the majority of HVAC projects were implemented under CLEAResult programs. Both projects in the Commercial HVAC Legacy program were submitted for a desk review as part of the FY 2018 evaluation.

4.3.2 Savings Calculation Method

Energy and demand savings were estimated using algorithms developed by Frontier for the *CPS Energy Guidebook*. This method incorporates part-load efficiencies for the purposes of calculating energy savings as well as heating energy savings derived from the methodology previously specified in Texas TRM v. 4.0 but adapted for CPS Energy. To calculate energy savings for this measure in the *CPS Energy Guidebook*, Frontier used weather-specific assumptions for San Antonio instead of a regional climate zone. Frontier used equivalent full-load hour assumptions developed using energy models that have been updated for incorporation into Texas TRM v. 4.0. These models were adjusted to use the San Antonio weather file to develop a new climate zone that is regionally specific to the CPS Energy service territory.

Baseline equipment efficiencies for new construction (NC) and replace-on-burnout (ROB) projects were assumed to be IECC 2015 for all system types in accordance with the current commercial energy code for the city of San Antonio.[27] This is a change from previous program years that used IECC 2009 as the baseline for equipment efficiencies.

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

Savings algorithms from the *CPS Energy Guidebook* 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.

4.3.2.2 Air and Water-Cooled Chillers

Savings algorithms from the *CPS Energy Guidebook* were adjusted to estimate energy savings using part-load system efficiency.

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

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

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).[28]

For reviewed split/unitary AC and HP installation, the reported cooling/heating capacity and full/part-load efficiencies were compared against available AHRI data. For reviewed chiller installation, the reported capacity and full/part-load efficiencies were compared against manufacturer 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 PTACs/PTHPs, and chillers are included in the following table.

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

Table 4-2: Commercial HVAC – Gross Energy and Demand Savings

Measure	Gross Energy Savings (kWh)	Gross CP Demand Savings (kW)	Gross NCP Demand Savings (kW)	Gross ERCOT 4CP Demand Savings (kW)
Commercial HVAC	182,331	34	39	36

- While the recommendations for commercial HVAC measures in previous evaluations have focused on data collection, that direction is no longer necessary because this measure is no longer implemented directly by CPS Energy. For relevant recommendations, please refer to the sections for the CLEAResult C&I Solutions, Schools and Institutions, and Small Business Solutions programs.

4.4 COMMERCIAL CUSTOM CPSE LEGACY PROGRAM

4.4.1 Overview

In FY 2018, CPS Energy processed the remaining custom legacy projects while new custom projects fell under the scope of the CLEAResult implemented programs. The two custom projects totaled $15,445 in incentives. Both custom projects were reviewed by Frontier 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 2018. 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.

4.4.2 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 data collected from site visits, engineering estimations and assumptions where appropriate. Savings algorithms followed sound engineering principles and followed standard industry procedures for each given application.

4.4.3 Results and Recommendations

The gross energy and demand savings calculated for the Commercial Custom Program are listed in Table 4-3.

Table 4-3: Commercial Custom Program Gross Energy and Demand Savings

Measure	Gross Energy Savings (kWh)	Gross CP Demand Savings (kW)	Gross NCP Demand Savings (kW)	Gross ERCOT 4CP Demand Savings (kW)
Commercial Custom	20,646	71	69	61

Recommendations for commercial custom measures in previous evaluations have focused on continuing to seek pre-approval of M&V procedures. That direction is no longer necessary because this measure is no longer implemented directly by CPS Energy. For relevant recommendations, please refer to the sections for the CLEAResult C&I Solutions, Schools and Institutions, and Small Business Solutions programs.

4.5 C&I SOLUTIONS

4.5.1 Overview

This program includes the installation of the following commercial energy-efficiency measures: lighting, lighting controls, HVAC, HVAC tune-up, VFD, and custom. In FY 2018, a total of 458 projects were incentivized through the C&I Solutions program. No comparison has been made to FY 2017 participation because the C&I Solutions program kicked off during the middle of FY 2017. A more complete analysis of program participation trends will be available after comparing the program's FY 2018 and FY 2019 performance.

This evaluation includes both previously evaluated projects from the CPS PY1 evaluation and new PY2 projects completed during the CPS FY 2018 evaluation period. The figures below present percentage breakdowns of kWh energy savings. For lighting measures, savings are presented by savings measure type for all newly evaluated lighting projects and by building type for newly sampled lighting projects completed through this program.

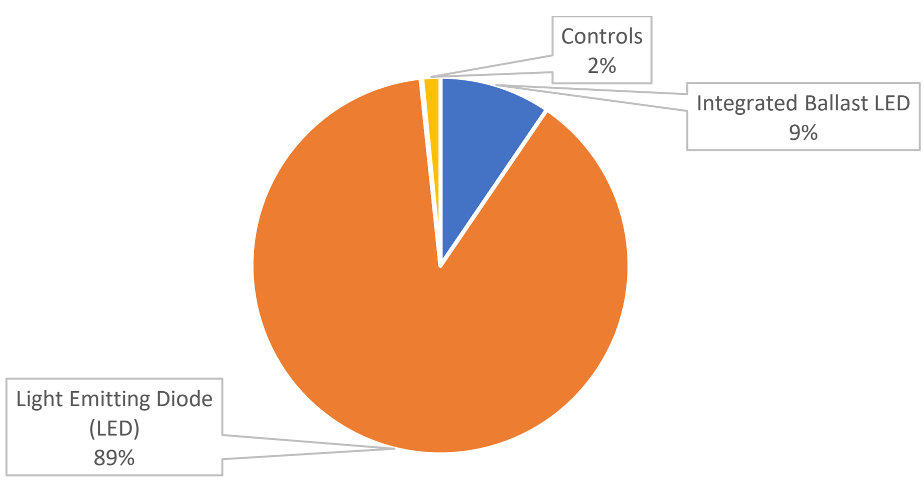

Figure 4-6: C&I Solutions – Percent of kWh Savings by Savings Measure Type for Newly Evaluated Lighting Projects

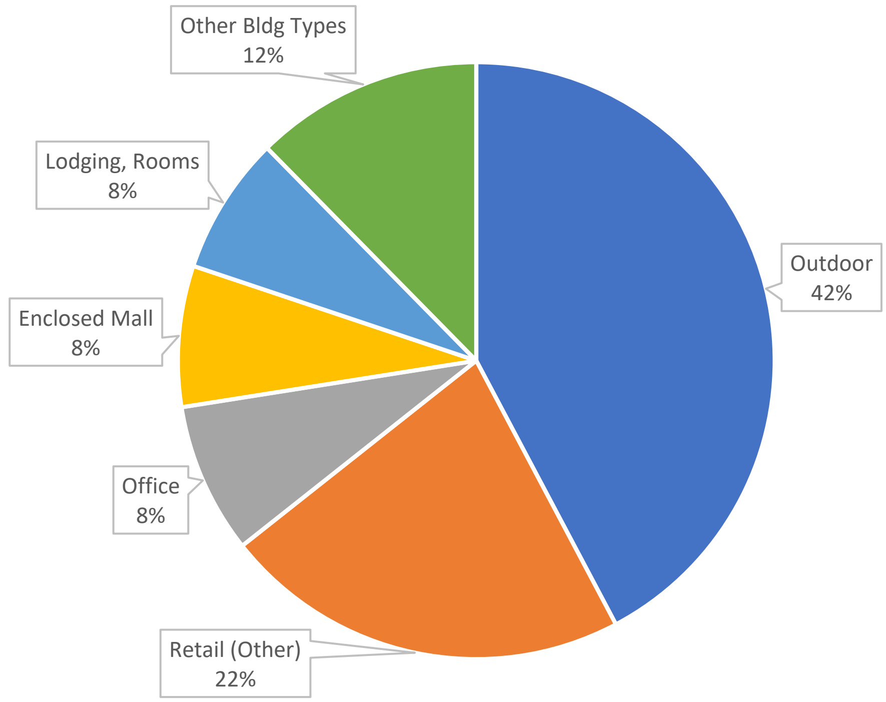

Figure 4-7: C&I Solutions - Percent of kWh Savings by Building Type for Newly Sampled Lighting Projects

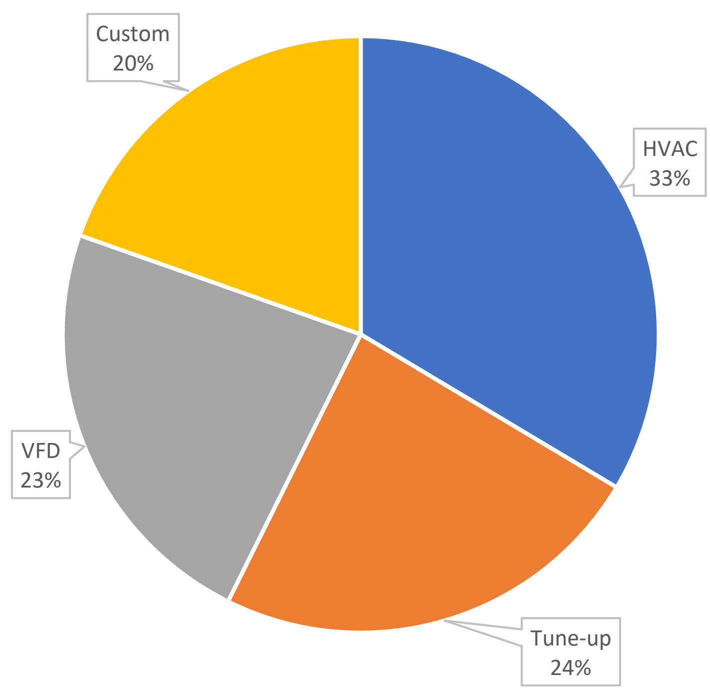

Figure 4-8: C&I Solutions - Percent of kWh Savings by Measure Type for non-Lighting Projects

4.5.2 Savings Calculation Method

A desk review was performed for a sample of projects incentivized in this program. Frontier selected a sample size to achieve a 90/10% confidence and precision interval. The results of the savings analysis for the sample were applied to the full program population.

Projects completed between February 1, 2017 and May 31, 2017 were evaluated against the October 2016 update to the *CPS Energy Guidebook*. Projects completed between June 1, 2017 and January 31, 2018 were evaluated against the November 2017 update to the *CPS Energy Guidebook*.

4.5.2.1 Lighting and Lighting Controls

Projects previously evaluated under the CPS PY1 evaluation were not adjusted for the FY 2018 evaluation. For the new PY2 projects completed during the CPS FY 2018 evaluation period, Frontier randomly selected a sample of 29 lighting projects for desk review. Savings for all sampled projects were validated using the savings methodologies outlined in the *CPS Energy Guidebook*. There were no major changes to the savings calculation methodology compared to the approach used in the FY 2017 evaluation.

In addition to validating the savings calculation against the *CPS Energy Guidebook*, claimed pre/post fixture counts and wattages were verified against project documentation. Hours of operation and demand factors were also verified against the reported building type. For lighting installed in a conditioned space, Frontier awarded additional savings to account for HVAC/refrigeration interactive effects of the projects. A reduced lighting load reduces the internal heat gain to the building, which reduces the cooling load but increases the heating load.

Frontier selected 4 sites for inspection, representing 15% of the sample population. For inspected sites, savings were also adjusted to match any site observations that contrasted with reported data.

The non-coincident peak (NCP), coincident peak (CP), and four coincidental peaks (4CP) demand factors used to estimate demand savings for this measure were derived using an approach adapted from the method outlined in Section 2.3 of the *CPS Energy Guidebook*. First, lighting schedules were extracted from BEopt energy simulation models developed for the commercial HVAC measures based on Department of Energy (DOE) commercial reference buildings.[29] Next, hourly percentages of lighting in operation were extracted from the lighting schedules. The resulting lighting factors were weighted using the probabilities assigned to each of the top 20 peak hours and 4CP hours. NCP factors match the maximum lighting factor from the lighting schedule for each building type.

After the inclusion of HVAC interactive effects, the CP or 4CP verified savings would occasionally exceed the verified NCP savings despite the higher NCP demand factor. In these instances, the CP or 4CP (higher of the two) was substituted as the verified NCP demand savings for that project.

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[29] DOE Commercial Reference Buildings: http://energy.gov/eere/buildings/commercial-reference-buildings.

4.5.2.2 HVAC and HVAC Tune-up

Frontier examined 13 HVAC projects for the desk review along with several site inspections. Frontier selected 26 HVAC tune-up projects for the desk review. No tune-up projects were selected for a site inspection for the PY2 evaluation period. Savings for all sampled projects were validated using the savings methodologies outlined in the *CPS Energy Guidebook*. General savings algorithms are specified below.

$$Energy\ (Cooling)\ \left[kWh_{Savings,C}\right] = Capacity \times \left(\frac{1}{EER_{pre}} - \frac{1}{EER_{post}}\right) \times \frac{EFLH_C}{1{,}000}$$

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.

4.5.2.3 VFD

VFD projects for FY 2018 were allowed to use a new baseline condition of no existing fan control as defined in the 2017-2018 *CPS Energy Guidebook*. This was a recent addition for the current program year as agreed upon between Frontier and CLEAResult based on the type of projects that were to be installed. Percent power was set to 100% for each hour of operation during all baseline conditions when determining initial kW calculations. This differs from the other options available in the measure that follow specific power curves for each control type (Outlet Damper, Inlet Damper, Inlet Guide Vane).

4.5.2.4 Custom

Custom projects were validated by reviewing submitted M&V plans and confirming procedures aligned with claimed savings as described in the calculation methodology. All procedures were confirmed to have been followed as planned.

4.5.3 Results and Recommendations

A weighted average realization rate (weighted by claimed NCP kW and kWh savings) was calculated for the projects sampled for a desk review. The weighted average realization rates were applied to the entire project population (both sampled and un-sampled). Sampled projects from the C&I Solutions and Schools & Institutions programs were evaluated together because of their similar program design. Similarly, a weighted average estimated useful life (EUL) from the sample review was applied to the verified savings. This EUL was based on a weighted average across the C&I Solutions, Schools & Institutions, and Small Business Solutions programs.

Overall, the Small Business Solutions program achieved realization rates of 97% for NCP kW demand savings, 96% for CP kW demand savings, and 95% for kWh energy savings.

Table 4-4: C&I Solutions Gross Energy and Demand Savings

Measure	Gross Energy Savings (kWh)	Gross CP Demand Savings (kW)	Gross NCP Demand Savings (kW)	Gross ERCOT 4CP Demand Savings (kW)
Lighting	29,592,255	4,386	6,838	4,329
AC Tune Up	2,381,978	1,460	1,510	997
HVAC	3,363,535	721	767	671
VFD	2,309,168	72	620	145
Custom	1,964,215	241	377	206
Envelope	271,425	209	367	189
Total[30]	39,882,576	7,089	10,478	6,537

Rows may not sum to total due to rounding.

Lighting and Lighting Controls

The data available in the CLEAResult lighting calculator aligns closely with the inputs used by the evaluation team to validate program savings claims, including pre and post fixture types, fixture counts, wattages, and control types. Additionally, burn hours and demand factors are determined based on the identified building type. Frontier makes the following recommendations to enhance data reporting structure and help refine the precision of verified savings for future program years.

- CLEAResult currently reports the fixture type in their “Measure Description.” In most cases, this matched one of the EUL categories from the CPS Energy Guidebook. However, in some cases, there is no direct match. For example, in some cases, the fixture was identified as “Interior LED” or “Exterior LED.” In other cases, a description of the fixture was provided. In addition to reporting the fixture type/EUL category, Frontier requests that CLEAResult also report the claimed EUL to help determine the fixture type in those cases where the claimed EUL is unclear.
- After the inclusion of HVAC interactive effects, the CP or 4CP verified savings would occasionally exceed the verified NCP savings despite the higher NCP demand factor. In these instances, the CP or 4CP (higher of the two) was substituted as the verified NCP demand savings for that project. This typically results in NCP demand realization rates that exceeded 100%. CLEAResult could incorporate this approach into their lighting calculator to bring claimed NCP demand savings more in line with verified savings.
- All projects completed at commercially classified sites can be claimed under commercial programs. However, for residential applications, such as the installation of lighting in the residential units of an apartment complex, savings should be calculated using the residential

30 The sum of the individual measures may not match the total due to the individual measure savings having been rounded to the nearest whole number.

methodologies specified in the CPS Energy Guidebook. This issue was identified only in the C&I Solutions program.

- For integrated-ballast LED lamps and LED tubes, Frontier will allow savings to be calculated using lamp wattages rounded to the nearest half-watt. However, this recommendation is optional. Frontier will evaluate savings by rounding savings to the nearest half- or full-watt, matching the format reported by CLEAResult.

Non-Lighting Measures (HVAC, Tune-up, VFD, Custom)

- The data available in the CLEAResult HVAC calculator aligns closely with the inputs used by the evaluation team to validate program savings claims, including pre and post efficiency, tonnage, building type, and replaced equipment.
- CLEAResult currently uses a predetermined avoided cost and escalation rate from the beginning of the program year. However, these often change once updated numbers are available and provided by CPS Energy at the end of the program year. This can impact the realization rate if several early retirement projects are selected as part of the desk review. The impact will vary depending on the remaining useful life of previously installed equipment and can mean up to a 4% deviation from claimed savings.
- Site inspections for VFD projects revealed different motor sizes than what was documented in savings calculations. Frontier recommends that procedures should be reviewed for VFD post inspection to make sure that documented information is correct and can be verified.

4.6 SCHOOLS & INSTITUTIONS

4.6.1 Overview

This program includes the installation of the following commercial energy-efficiency measures: lighting, lighting controls, HVAC, HVAC tune-up, VFD, and custom. In FY 2018, a total of 122 projects were incentivized through the Schools & Institutions program. No comparison has been made to FY 2017 participation because the Schools & Institutions program kicked off during the middle of FY 2017. A more complete analysis of program participation trends will be available after comparing the program's FY 2018 and FY 2019 performance.

This evaluation includes both previously evaluated projects from the CPS PY1 evaluation and new PY2 projects completed during the CPS FY 2018 evaluation period. The figures below present percentage breakdowns of kWh energy savings. For lighting measures, savings are presented by savings measure type for all newly evaluated lighting projects and by building type for newly sampled lighting projects completed through this program.

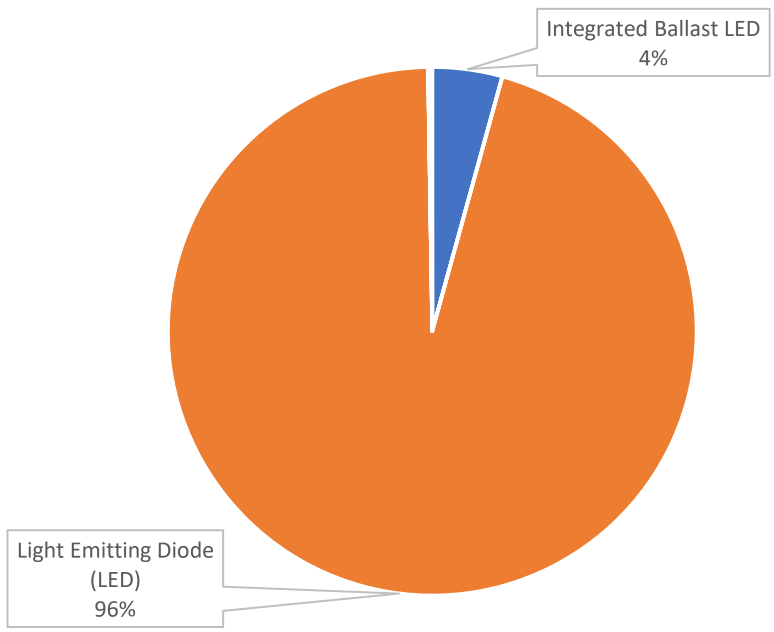

Figure 4-9: Schools & Institutions – Percent of kWh Savings by Savings Measure Type for Newly Evaluated Lighting Projects

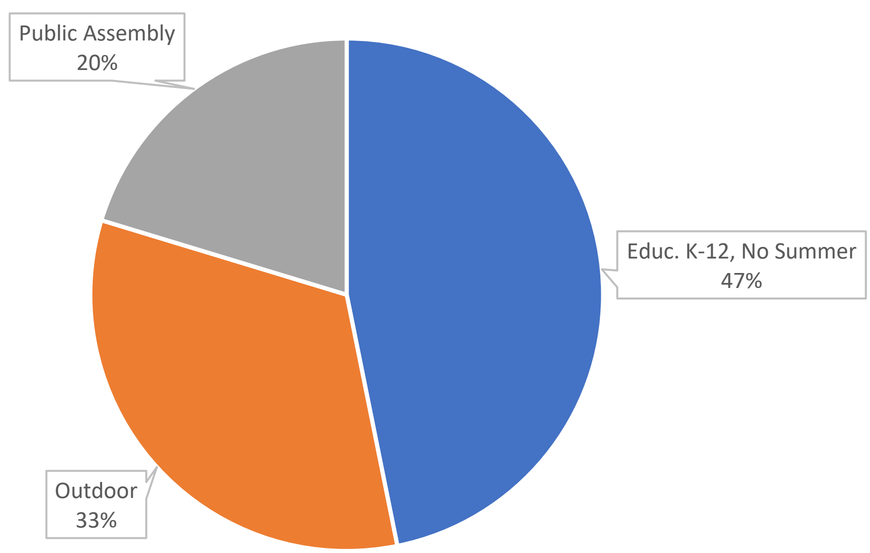

Figure 4-10: Schools & Institutions - Percent of kWh Savings by Building Type for Newly Sampled Lighting Projects

For other projects that are not lighting or lighting controls, Figure 4-11 presents percentage breakdowns of kWh energy savings.

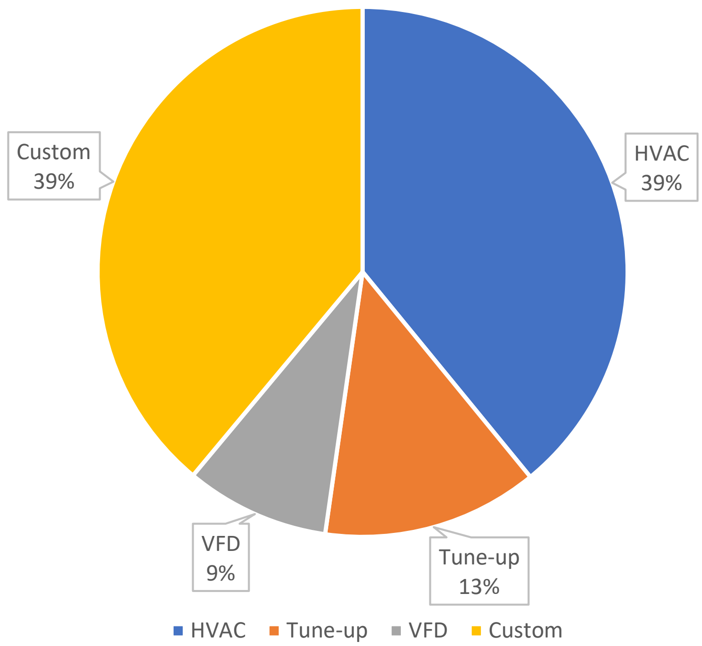

Figure 4-11: Schools & Institutions - Percent of kWh Savings by Measure Type for non-Lighting Projects

4.6.2 Savings Calculation Method

A desk review was performed for a sample of projects incentivized in this program. Frontier selected a sample size to achieve a 90/10% confidence and precision interval. The results of the savings analysis for the sample were applied to the full program population.

Projects completed between February 1, 2017 and May 31, 2017 were evaluated against the October 2016 update to the *CPS Energy Guidebook*. Projects completed between June 1, 2017 and January 31, 2018 were evaluated against the November 2017 update to the *CPS Energy Guidebook*.

4.6.2.1 Lighting and Lighting Controls

Projects previously evaluated under the CPS PY1 evaluation were not adjusted for the FY 2018 evaluation. For the new PY2 projects completed during the CPS FY 2018 evaluation period, Frontier randomly selected a sample of 29 lighting projects for desk review. Savings for all sampled projects were validated using the savings methodologies outlined in the *CPS Energy Guidebook*. There were no major changes to the savings calculation methodology compared to the approach used in the FY 2017 evaluation.

In addition to validating the savings calculation against the *CPS Energy Guidebook*, claimed pre/post fixture counts and wattages were verified against project documentation. Hours of operation and demand factors were also verified against the reported building type. For lighting installed in a conditioned space, Frontier awarded additional savings to account for HVAC/refrigeration interactive effects of the projects. A reduced lighting load reduces the internal heat gain to the building, which reduces the cooling load but increases the heating load.

Frontier selected 4 sites for inspection, representing 15% of the sample population. For inspected sites, savings were also adjusted to match any site observations that contrasted with reported data.

The non-coincident peak (NCP), coincident peak (CP), and four coincidental peaks (4CP) demand factors used to estimate demand savings for this measure were derived using an approach adapted from the method outlined in Section 2.3 of the *CPS Energy Guidebook*. First, lighting schedules were extracted from BEopt energy simulation models developed for the commercial HVAC measures based on Department of Energy (DOE) commercial reference buildings.[31] Next, hourly percentages of lighting in operation were extracted from the lighting schedules. The resulting lighting factors were weighted using the probabilities assigned to each of the top 20 peak hours and 4CP hours. NCP factors match the maximum lighting factor from the lighting schedule for each building type.

After the inclusion of HVAC interactive effects, the CP or 4CP verified savings would occasionally exceed the verified NCP savings despite the higher NCP demand factor. In these instances, the CP or 4CP (higher of the two) was substituted as the verified NCP demand savings for that project.

4.6.2.2 HVAC and HVAC Tune-up

Frontier reviewed 111 HVAC projects for the desk review along with several site inspections. Frontier reviewed 18 HVAC tune-up projects for the desk review. No projects were selected for a site inspection for PY2 evaluation period. Savings for all sampled projects were validated using the savings methodologies outlined in the *CPS Energy Guidebook*. General savings algorithms are specified below.

$$Energy\ (Cooling)\ \left[kWh_{Savings,C}\right] = Capacity \times \left(\frac{1}{EER_{pre}} - \frac{1}{EER_{post}}\right) \times \frac{EFLH_C}{1{,}000}$$

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.

4.6.2.3 VFD

VFD projects for FY 2018 were allowed to use a new baseline condition of no existing fan control as defined in the 2017-2018 *CPS Energy Guidebook*. This was a recent addition for the current program year as agreed upon between Frontier and CLEAResult based on the type of projects that were to be installed. Percent power was set to 100% for each hour of operation during all baseline conditions when

[31] DOE Commercial Reference Buildings: http://energy.gov/eere/buildings/commercial-reference-buildings.

determining initial kW calculations. This differs from the other options available in the measure that follow specific power curves for each control type (Outlet Damper, Inlet Damper, Inlet Guide Vane).

4.6.2.4 Custom

Custom projects were validated by reviewing submitted M&V plans and confirming procedures aligned with claimed savings as described in the calculation methodology. All procedures were confirmed to have been followed as planned.

4.6.3 Results and Recommendations

A weighted average realization rate (weighted by claimed NCP kW and kWh savings) was calculated for the projects sampled for a desk review. The weighted average realization rates were applied to the entire project population (both sampled and un-sampled).

Sampled projects from the C&I Solutions and Schools & Institutions programs were evaluated together because of their similar program design. Similarly, a weighted average estimated useful life (EUL) from the sample review was applied to the verified savings. This EUL was based on a weighted average across the C&I Solutions, Schools & Institutions, and Small Business Solutions programs.

Overall, the Small Business Solutions program achieved realization rates of 99% for NCP kW demand savings, 97% for CP kW demand savings, and 98% for kWh energy savings.

Table 4-5: Schools & Institutions Gross Energy and Demand Savings

Measure	Gross Energy Savings (kWh)	Gross CP Demand Savings (kW)	Gross NCP Demand Savings (kW)	Gross ERCOT 4CP Demand Savings (kW)
Commercial Lighting	9,129,224	902	2,498	884
HVAC Tune-up	392,240	240	249	199
HVAC	1,163,453	470	506	413
VFD	261,831	35	58	41
Custom	1,159,228	290	290	290
Total[32]	12,105,978	1,937	3,600	1,827

Rows may not sum to total due to rounding.

Lighting and Lighting Controls

The data available in the CLEAResult lighting calculator aligns closely with the inputs used by the evaluation team to validate program savings claims, including pre and post fixture types, fixture counts, wattages, and control types. Additionally, burn hours and demand factors are determined based on the

[32] The sum of the individual measures may not match the total due to the individual measure savings having been rounded to the nearest whole number.

identified building type. Frontier makes the following recommendations to enhance data reporting structure and help refine the precision of verified savings for future program years.

- CLEAResult currently reports the fixture type in their "Measure Description." In most cases, this matched one of the EUL categories from the CPS Energy Guidebook. However, in some cases, there is no direct match. For example, in some cases, the fixture was identified as "Interior LED" or "Exterior LED." In other cases, a description of the fixture was provided. In addition to reporting the fixture type/EUL category, Frontier requests that CLEAResult also report the claimed EUL to help determine the fixture type in those cases where the claimed EUL is unclear.
- After the inclusion of HVAC interactive effects, the CP or 4CP verified savings would occasionally exceed the verified NCP savings despite the higher NCP demand factor. In these instances, the CP or 4CP (higher of the two) was substituted as the verified NCP demand savings for that project. This typically results in NCP demand realization rates that exceeded 100%. CLEAResult could incorporate this approach into their lighting calculator to bring claimed NCP demand savings more in line with verified savings.
- For integrated-ballast LED lamps and LED tubes, Frontier will allow savings to be calculated using lamp wattages rounded to the nearest half-watt. However, this recommendation is optional. Frontier will evaluate savings by rounding savings to the nearest half- or full-watt, matching the format reported by CLEAResult.

Non-Lighting Measures (HVAC, Tune-up, Custom)

The data available in the CLEAResult HVAC calculator aligns closely with the inputs used by the evaluation team to validate program savings claims, including pre and post efficiency, tonnage, building type, and replaced equipment.

- CLEAResult currently uses a predetermined avoided cost and escalation rate from the beginning of the program year. However, these often change once updated numbers are available and provided by CPS at the end of the program year. This can impact the realization rate if several early retirement projects are selected as part of the desk review. The impact will vary depending on the remaining useful life of previously installed equipment and can mean up to a 4% deviation from claimed savings.
- The Resource Management Service provided by CLEAResult to schools that fell under the custom track operated as expected. The EUL for this behavioral program was not defined and was created after discussion with CLEAResult. The EUL should be formally defined for the next program year if the measure is to continue to be used.

4.7 SMALL BUSINESS SOLUTIONS

4.7.1 Overview

This program includes the installation of the following commercial energy-efficiency measures: lighting, lighting controls, Envelope, HVAC, HVAC tune-up, and custom. In FY 2018, a total of 223 projects were incentivized through the Small Business Solutions program. No comparison has been made to FY 2017 participation because the Small Business Solutions program kicked off during the middle of FY 2017. A more complete analysis of program participation trends will be available after comparing the program's FY 2018 and FY 2019 performance.

This evaluation includes both previously evaluated projects from the CPS PY1 evaluation and new PY2 projects completed during the CPS FY 2018 evaluation period. The figures below present percentage breakdowns of kWh energy savings. For lighting measures, savings are presented by savings measure type for all newly evaluated lighting projects and by building type for newly sampled lighting projects completed through this program.

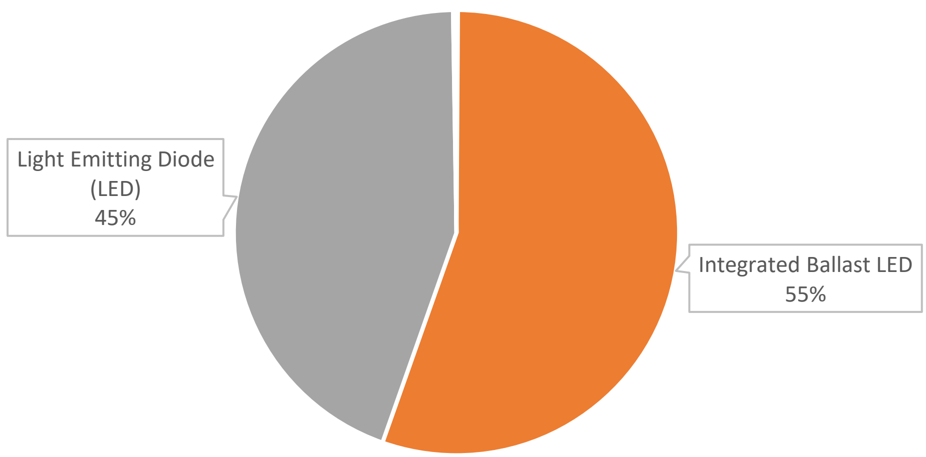

Figure 4-12: Small Business Solutions – Percent of kWh Savings by Savings Measure Type for Newly Evaluated Lighting Projects

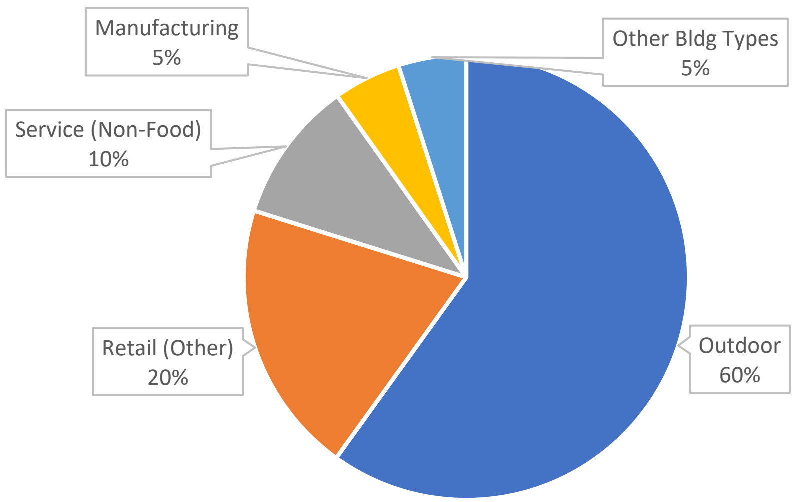

Figure 4-13: Small Business Solutions - Percent of kWh Savings by Building Type for Newly Sampled Lighting Projects

For other projects that are not lighting or lighting control, Figure 4-14 presents percentage breakdowns of kWh energy savings.

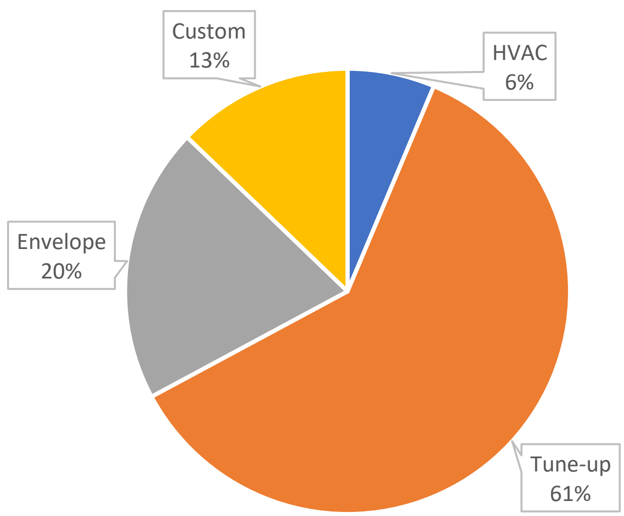

Figure 4-14: Small Business Solutions - Percent of kWh Savings by Measure Type for non-Lighting Projects

4.7.2 Savings Calculation Method

A desk review was performed for a sample of projects incentivized in this program. Frontier selected a sample size to achieve a 90/10% confidence and precision interval. The results of the savings analysis for the sample were applied to the full program population.

Projects completed between February 1, 2017 and May 31, 2017 were evaluated against the October 2016 update to the *CPS Energy Guidebook*. Projects completed between June 1, 2017 and January 31, 2018 were evaluated against the November 2017 update to the *CPS Energy Guidebook*.

4.7.2.1 Lighting and Lighting Controls

Projects previously evaluated under the CPS PY1 evaluation were not adjusted for the FY 2018 evaluation. For the new PY2 projects completed during the CPS FY 2018 evaluation period, Frontier randomly selected a sample of 29 lighting projects for desk review. Savings for all sampled projects were validated using the savings methodologies outlined in the *CPS Energy Guidebook*. There were no major changes to the savings calculation methodology compared to the approach used in the FY 2017 evaluation.

In addition to validating the savings calculations against the *CPS Energy Guidebook*, claimed pre/post fixture counts and wattages were verified against project documentation. Hours of operation and demand factors were also verified against the reported building type. For lighting installed in a conditioned space, Frontier awarded additional savings to account for HVAC/refrigeration interactive effects of the projects. A reduced lighting load reduces the internal heat gain to the building, which reduces the cooling load but increases the heating load.

Frontier selected 4 sites for inspection, representing 15% of the sample population. For inspected sites, savings were also adjusted to match any site observations that contrasted with reported data.

The non-coincident peak (NCP), coincident peak (CP), and four coincidental peaks (4CP) demand factors used to estimate demand savings for this measure were derived using an approach adapted from the method outlined in Section 2.3 of the *CPS Energy Guidebook*. First, lighting schedules were extracted from BEopt energy simulation models developed for the commercial HVAC measures based on Department of Energy (DOE) commercial reference buildings.[33] Next, hourly percentages of lighting in operation were extracted from the lighting schedules. The resulting lighting factors were weighted using the probabilities assigned to each of the top 20 peak hours and 4CP hours. NCP factors match the maximum lighting factor from the lighting schedule for each building type.

After the inclusion of HVAC interactive effects, the CP or 4CP verified savings would occasionally exceed the verified NCP savings despite the higher NCP demand factor. In these instances, the CP or 4CP (higher of the two) was substituted as the verified NCP demand savings for that project.

4.7.2.2 HVAC and HVAC Tune-up

Frontier conducted a desk review of all HVAC projects along with several site inspections. Frontier also selected HVAC tune-up projects for the desk review. No tune-up projects were selected for a site inspection for the PY2 evaluation period. Savings for all sampled projects were validated using the

[33] DOE Commercial Reference Buildings: http://energy.gov/eere/buildings/commercial-reference-buildings.

savings methodologies outlined in the *CPS Energy Guidebook*. General savings algorithms are specified below.

$$Energy\ (Cooling)\ [kWh_{Savings,C}] = Capacity \times \left(\frac{1}{EER_{pre}} - \frac{1}{EER_{post}}\right) \times \frac{EFLH_C}{1{,}000}$$

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.

4.7.2.3 Custom

Custom projects were validated by reviewing submitted M&V plans and confirming procedures aligned with claimed savings as described in the calculation methodology. All procedures were confirmed to have been followed as planned.

4.7.3 Results and Recommendations

A weighted average realization rate (weighted by claimed NCP kW and kWh savings) was calculated for the projects sampled for a desk review. The weighted average realization rates were applied to the entire project population (both sampled and un-sampled). Similarly, a weighted average estimated useful life (EUL) from the sample review was applied to the verified savings. This EUL was based on a weighted average across the C&I Solutions, Schools & Institutions, and Small Business Solutions programs. Overall, the Small Business Solutions program achieved realization rates of 105% for NCP kW demand savings, 108% for CP kW demand savings, and 98% for kWh energy savings.

Table 4-6: Small Business Solutions Gross Energy and Demand Savings

Measure	Gross Energy Savings (kWh)	Gross CP Demand Savings (kW)	Gross NCP Demand Savings (kW)	Gross ERCOT 4CP Demand Savings (kW)
Lighting	8,864,884	1,338	2,131	1,339
HVAC	2,476	3	3	3
AC Tune Up	23,741	23	24	24
Custom	5,006	2	3	2
Envelope	7,815	3	5	3
Total[34]	8,903,922	1,370	2,168	1,371

Rows may not sum to total due to rounding.

[34] The sum of the individual measures may not match the total due to the individual measure savings having been rounded to the nearest whole number.

Lighting and Lighting Controls

The data available in the CLEAResult lighting calculator aligns closely with the inputs used by the evaluation team to validate program savings claims, including pre and post fixture types, fixture counts, wattages, and control types. Additionally, burn hours and demand factors are determined based on the identified building type. Frontier makes the following recommendations to enhance data reporting structure and help refine the precision of verified savings for future program years.

- CLEAResult currently reports the fixture type in their "Measure Description." In most cases, this matched one of the EUL categories from the *CPS Energy Guidebook*. However, in some cases, there is no direct match. For example, in some cases, the fixture was identified as "Interior LED" or "Exterior LED." In other cases, a description of the fixture was provided. In addition to reporting the fixture type/EUL category, Frontier requests that CLEAResult also report the claimed EUL to help determine the fixture type in those cases where the claimed EUL is unclear. This issue was especially evident for midstream lighting projects incentivized through the Small Business Solutions program.

- After the inclusion of HVAC interactive effects, the CP or 4CP verified savings would occasionally exceed the verified NCP savings despite the higher NCP demand factor. In these instances, the CP or 4CP (higher of the two) was substituted as the verified NCP demand savings for that project. This typically results in NCP demand realization rates that exceeded 100%. CLEAResult could incorporate this approach into their lighting calculator to bring claimed NCP demand savings more in line with verified savings.

- For integrated-ballast LED lamps and LED tubes, Frontier will allow savings to be calculated using lamp wattages rounded to the nearest half-watt. However, this recommendation is optional. Frontier will evaluate savings by rounding savings to the nearest half- or full-watt, matching the format reported by CLEAResult.

- It appears that LED tubes are being reported as integrated-ballast LEDs when they should be reported as Light Emitting Diode (LED) because savings are calculated at the fixture level rather than at the lamp level.

- Report lamp or fixture model number on the Small Business final proposal in addition to the fixture description for comparison against the DLC screenshots provided in the project documentation. Additional steps should be put in place to ensure that DLC wattage is used to calculate claimed savings. In many cases, reported wattages were used to calculate claimed savings despite the inclusion of a DLC screenshot specifying a different lamp or fixture wattage.

- For sampled projects dealing with ineligible controls savings scenarios, it appeared that the claimed savings were not accounting for the control contribution to kWh energy savings. Similarly, the NCP and CP demand calculations do not seem to be discounting the pre and post coincidence factor to account for the controls adjustment factor when calculating savings for ineligible controls savings scenarios. For eligible controls savings scenarios where no existing controls are in place, the total fixture savings should first be calculated by adjusting the post annual operating hours and coincidence factor using the specified adjustment factor for the installed control. Next, the control savings should be calculated using the controls methodology specified in the *CPS Energy Guidebook*. The resulting savings should be claimed as controls savings against the controls EUL. Last, the difference of the total fixture and controls savings should return the fixture savings to be claimed against the fixture EUL. However, in an ineligible controls savings scenario where there are existing controls, the total fixture savings should still be calculated by adjusting both the pre and post annual operating hours and coincidence factors. Even though the resulting savings value has a control component, those savings are ineligible to be claimed as control savings because the control was already in place. Still, the controls affect the performance of the installed fixture, and the resulting savings should be claimed entirely as fixture savings against the fixture EUL.

- During inspections, CLEAResult staff indicated that inspections for the Small Business Solutions program were performed for the first 5 projects done by a participating contractor. Subsequent projects were not typically subject to CLEAResult inspection. Frontier proposes that CLEAResult randomize the small business inspection process and consider increasing the amount of inspections completed. In comparison to the C&I Solutions and Schools & Institutions programs, inspection findings for the Small Business Solutions showed the most variation compared to claimed savings. Even in cases where the total verified savings did not differ substantially from claimed savings, individual lamp or fixture counts often varied significantly compared to claimed counts.

- For midstream lighting projects, report the lamp or fixture cost to be used as the incremental cost of the measure.

4.7.3.1 Non-Lighting Measures (HVAC, Tune-up, Envelope, Custom)

The data available in the CLEAResult HVAC calculator aligns closely with the inputs used by the evaluation team to validate program savings claims, including pre and post efficiency, tonnage, building type, and replaced equipment.

- CLEAResult currently uses a predetermined avoided cost and escalation rate from the beginning of the program year. However, these often change once updated numbers are available and provided at the end of the program year by CPS. This can impact the realization rate if several early retirement projects are selected as part of the desk review. The impact will vary depending on the remaining useful life of previously installed equipment and can mean up to a 4% deviation from claimed savings.

4.8 WHOLE BUILDING OPTIMIZATION

4.8.1 Overview

The Whole Building Optimization program is a new program implemented by CLEAResult for FY 2018. The program consists of a toolbox of measures related to optimizing settings and conditions for the building's HVAC equipment. These can range from changing setpoints, schedules, and static pressures in a Building Automation System (BAS) to physical changes such as coil cleaning and valve repair. A third-party company evaluated buildings to identify opportunities for optimization among the eligible options specified in CLEAResult's Express Building Tune-up Methodology. Frontier reviewed and approved the methodology prior to the beginning of the program year allowing for the opportunity to discuss changes if any issues were observed during initial implementation.

4.8.2 Participation Trends

Of the 16 buildings that participated in the FY 2018 program, four were for municipal government buildings, nine were commercial, and three were for religious worship facilities. There were four different third-party market actors that participated in the program and implemented the optimization measures for each site.

4.8.3 Savings Calculation Methods

Savings claims are based on the calculations and assumptions described in CLEAResult's Express Building Tune Up (EBTU) Methodology. All variables related to building equipment and characteristics were collected by the market actors and were added as inputs into a pre-built calculator that modeled total savings based on the methodology. While many measures were available, not all were implemented for each project. Frontier reviewed all assumptions, equipment, and accompanying EBTU savings calculator for each sampled project.

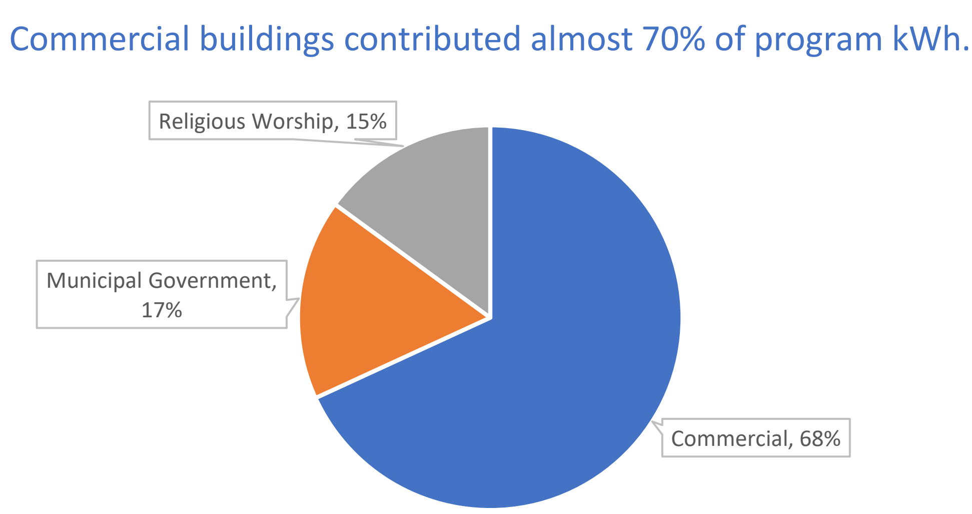

Figure 4-15: Whole Building Optimization – Percent of kWh Savings by Building Type

4.8.4 Results and Recommendations

Five sites were sampled for a desk review, and one of those sites was inspected by CPS and Frontier staff. A weighted average realization rate (weighted by claimed NCP kW and kWh savings) was calculated for the entire sample based on validating inputs used for the EBTU calculator. The weighted average realization rates were applied to the entire program population.

The weighted average realization rate for the whole building optimization projects were 100.9% for NCP kW demand savings and 100.5% for kWh energy savings. In aggregate, Frontier estimates that participating buildings completed during FY 2018 will deliver approximately 2,975,000 kWh of annual energy savings.

The estimated energy savings and coincident peak, non-coincident peak, and ERCOT 4CP demand savings for the FY 2018 Whole Building Optimization program are presented in Table 3-7.

Table 4-7: Whole Building Optimization Gross Energy and Demand Savings

Participant Count	Gross Energy Savings (kWh)	Gross CP Demand Savings (kW)	Gross NCP Demand Savings (kW)	Gross ERCOT 4CP Demand Savings (kW)
16	2,974,519	396	396	416

Frontier recommends that research be conducted to determine an appropriate EUL for the program. Determining a single EUL for the entire program is difficult due to measure diversity and varying degrees of longevity by measure. For the current program year, Frontier and CLEAResult agreed to use 3 years as a conservative estimate until a more robust method can be determined.

5. DEMAND RESPONSE PROGRAMS

5.1 SUMMARY OF DEMAND RESPONSE IMPACTS

CPS Energy offered the following demand response programs in FY 2018:

Commercial Demand Response – Commercial and industrial customers are incentivized to curtail during times of peak summer demand. Demand response customers lower their energy demand for a 1 to 3 hour curtailment period. Incentives are tied to performance during this period. CPS Energy offers three different demand response participation options, Options 1-3, and an Automated Demand Response (ADR) option.

Residential Demand Response – The program encourages residential customers to reduce load during times of peak summer demand through the following programs:

Smart Thermostat – This program provides free installation of a free Honeywell thermostat in customers' homes, and uses the thermostat to cycle off the compressor of participating air conditioners during periods of peak summer demand.

Home Manager – Using a home energy management system designed by Landys+Gyr (formerly Consert, Inc.), load control devices are placed on a participant's AC, water heater and/or pool pump. A gateway, the brain of the Home Manager system, uses a wireless network to relay information between a CPS Energy data center and the installed system devices.

Bring Your Own Thermostat (BYOT) - CPS Energy has teamed up with Nest, Honeywell, Energy Hub, Emerson and WhiskerLabs to offer customers with smart thermostats an opportunity to participate in CPS Energy's load management events.

Nest Direct Install (DI) – CPS Energy is helping Home Manager customers migrate to the Nest DI program by offering customers free Nest(s) and installation to replace the older generation Home Manager Consert devices.

Reduce My Use (BDR) – CPS Energy partnered with Opower to implement a pilot behavioral demand response (BDR) program for residential customers. Implemented as an opt-out randomized controlled trial (RCT). Participants are all equipped with AMI meters, and do not participate in other CPS Energy DR programs.

For benefit-cost calculations, our approach focuses only on the incremental impacts of new participants added in FY 2018, consistent with the approach used in all energy efficiency program benefit-cost calculations. The contribution of each demand response program to energy, coincident peak demand, and non-coincident peak demand savings are shown in Figure 5-1 through Figure 5-3. In these figures and in Table 1-1 and Table 7-1, estimated savings are reported from all active participants to most accurately represent actual program capability at the end of FY 2018. These savings are adjusted to account for net-to-gross ratios and distribution line losses.[35]

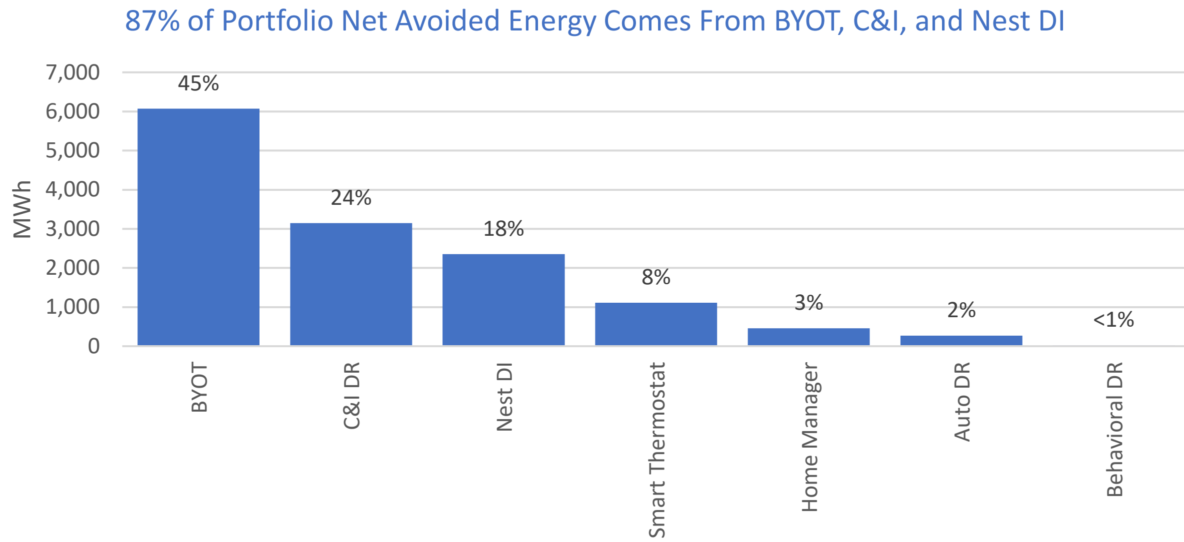

Figure 5-1: Summary of Demand Response Impacts – Energy (MWh) by Program

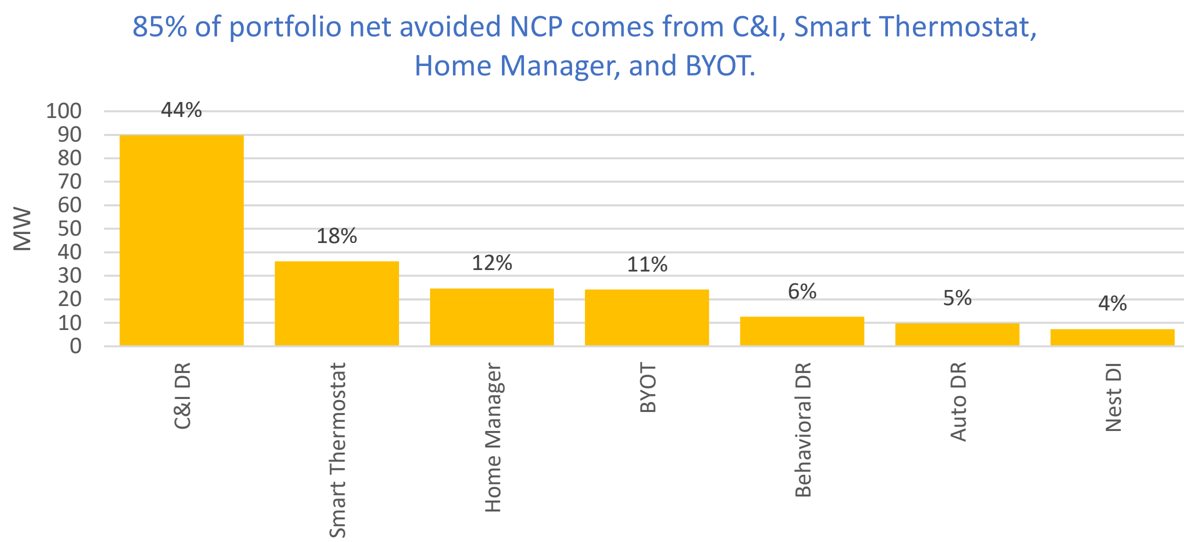

Figure 5-2: Summary of Demand Response Impacts – Non-Coincident Peak Demand (MW) by Program

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[35] 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.

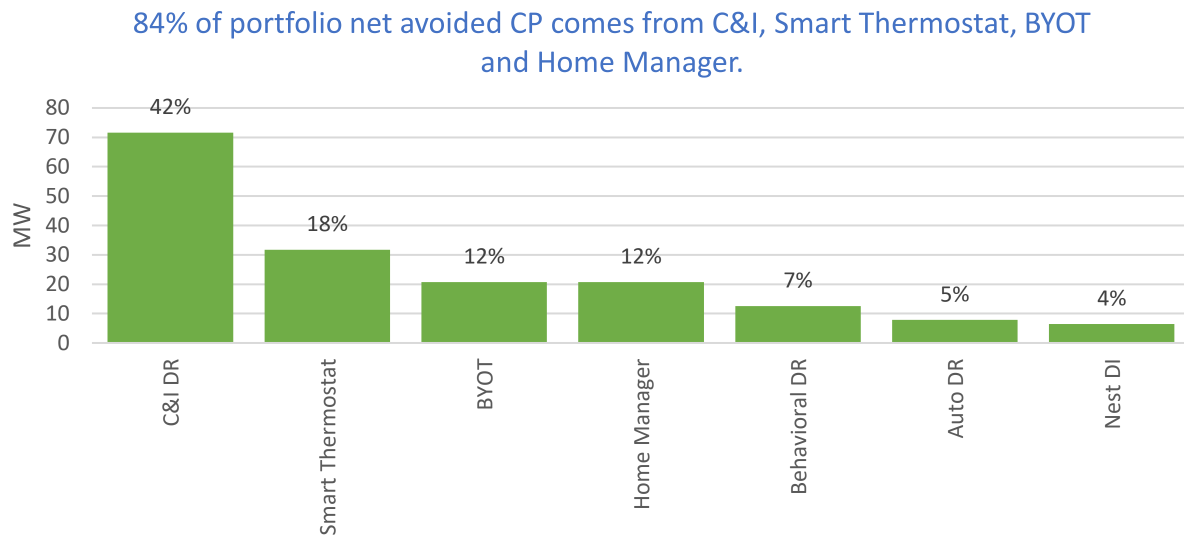

Figure 5-3: Summary of Demand Response Impacts – Coincident Peak Demand (MW) by Program

5.2 COMMERCIAL AND AUTO DEMAND RESPONSE PROGRAMS

5.2.1 Overview

CPS Energy's Commercial DR programs are voluntary load curtailment programs for commercial and industrial customers. They are designed to reduce peak load by incentivizing customers to shed electric loads on peak summer days. The programs run from June 1st through September 30th. Participating customers commit to be available to participate in events from 1 p.m. to 7 p.m., with events typically on weekdays till 5:30 p.m.

In FY 2018, the Commercial DR programs consisted of Options 1, 2, and 3, and ADR. CPS Energy uses these programs differently because they have different purposes, capabilities, and contractual stipulations. Table 5-1 summarizes these differences.

Table 5-1: Commercial DR Program Characteristics

Measure	Performance Period	Time Period	Event Days	Max 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[36]	Jun 1 – Sep 30	24/7	All Days	N/A	50	0

[36] There is also a non-summer ADR program offering that runs for the rest of the year, but its impacts are not evaluated herein.

Programs vary by performance period, events available, total hours available, and advance notice. Option 1 is not available in June and September, while other programs operate throughout the entire summer. ADR is the most responsive, with load being curtailed immediately after calling an event. Other programs have 1 to 2 hours of advance notice.

5.2.2 Participation Trends

As can be seen in Figure 5-4 through Figure 5-6, the total number of sponsors (i.e. participating entities) stayed the same in FY 2018 compared with the previous year. There has been an upward trend from FY 2015 to FY 2018 in the number of sites. The total contracted kW increased slightly in FY 2018 compared to FY 2017.

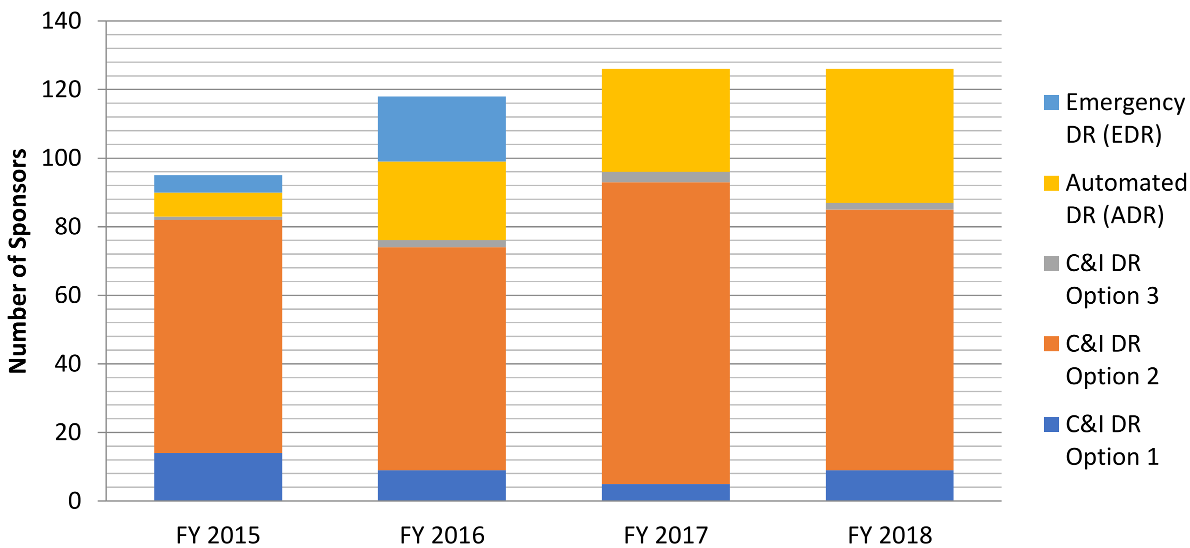

Figure 5-4: Commercial DR – Sponsor Counts, FY 2015 – FY 2018

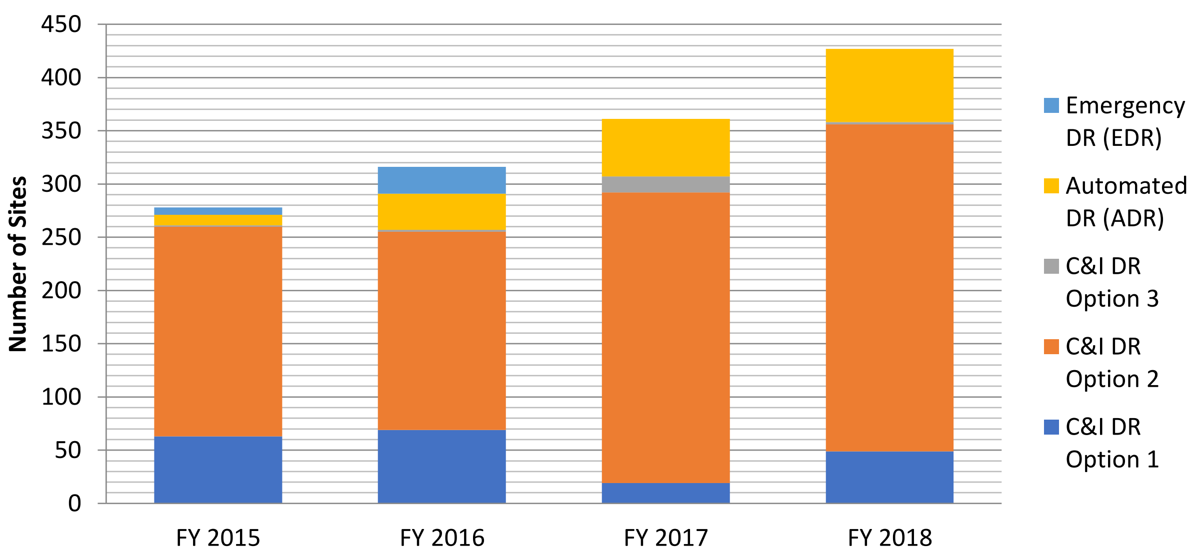

Figure 5-5: Commercial DR – Site Counts, FY 2015 – FY 2018

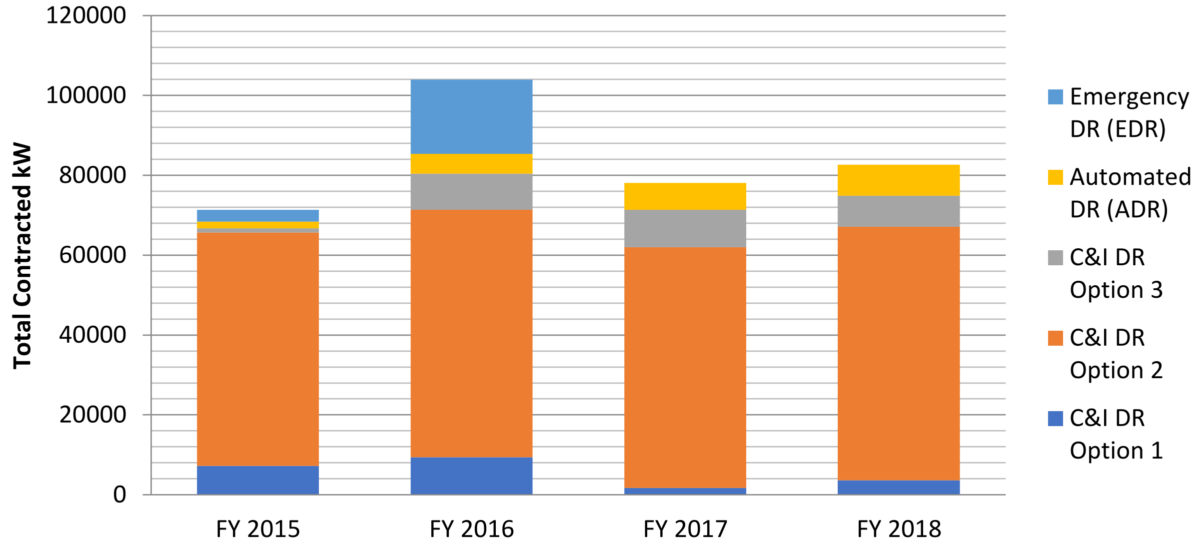

Figure 5-6: Commercial DR - Contracted kW, FY 2015 – FY 2018

Participation trends of note include:

Total contracted kW increased from 78.1MW to 82.6MW from FY 2017 to FY 2018. This increase is mainly driven by an increase in the kW contracted under Option 2 (from 60.3MW to 63.6MW).

Number of Option 3 sites dropped from 15 to 2 from FY 2017 to FY 2018. This is because the remainder of the 13 sites moved to Option 2.

CPS Energy deployed its Commercial DR programs on 23 days in FY 2018. As can be seen in Table 5-2, Option 2 and the ADR programs were called most frequently, while Option 3 was only called 6 times due to a limit on the maximum number of events that could be called under that program.

The four days highlighted in orange are 4CP days in FY 2018. All 4 programs hit 4CP events in July, while 3 programs reduced demand during the 4CPs in June and September, due to Option 1 only being deployed in July and August. Only the ADR program hit the August 4CP event in FY 2018.

Table 5-2: Commercial DR Events and Average Duration by Program Offering

	June			July							August						September							
	15	16	23	14	19	20	21	26	27	28	4	11	16	17	18	22	1	5	14	15	18	19	20	Total
Option1				X	X	X	X	X	X	X	X	X		X	X	X								12
Option2	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	22
Option3			X			X				X						X	X						X	6
ADR	X	X	X	X	X	X	X		X	X	X	X	X	X		X	X		X		X	X	X	19
Total	2	2	3	3	3	4	3	2	3	4	3	3	1	3	2	4	3	1	2	1	2	2	3	23

As can be seen in Table 5-3, there was an increase in the total number of events called in FY 2018 compared to the previous two fiscal years:

Table 5-3: Commercial DR total Number of Events called: FY 2016 – FY 2018

C&I DR Program/ Option	FY 2018	FY 2017	FY 2016
Option 1	12	11	10
Option 2	22	19	13
Option 3	6	6	6
ADR	19	18	13
EDR	NA	NA	1
Total	23	21	17

Figure 5-7 compares the average event duration from FY 2016 to FY 2018. The average event duration was slightly longer for each of the 4 C&I DR programs in FY 2018:

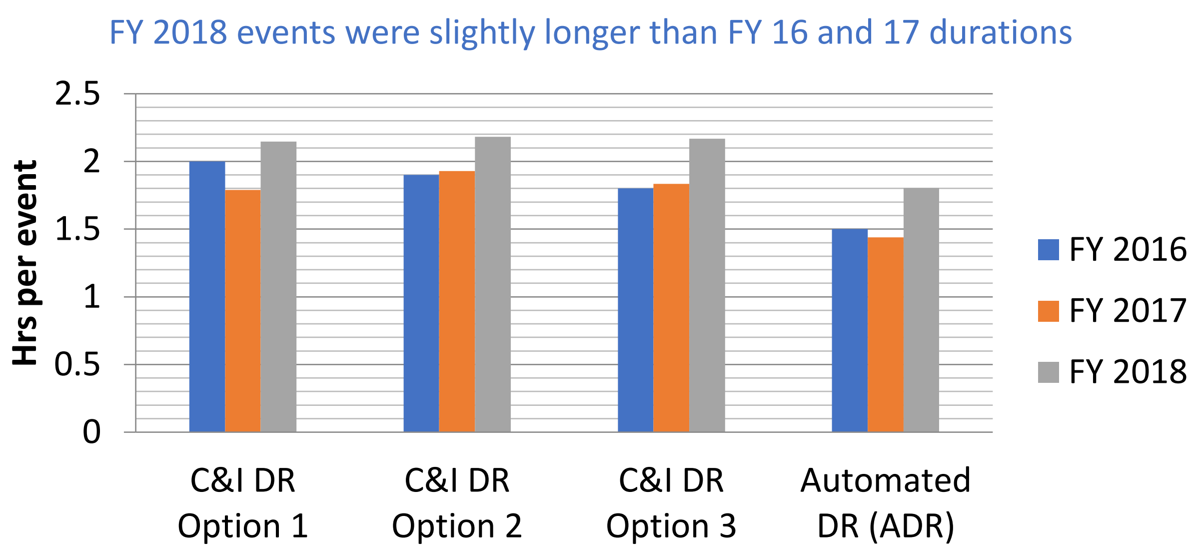

Figure 5-7: Commercial DR Average Event Duration, FY 2016 – FY 2018

5.2.3 Savings Calculation Methods

CPS Energy generally estimates delivered demand savings according to a high 3 of 10 baseline estimation method. In cases where the high 3 of 10 baseline is not deemed to provide a reasonable baseline for a given participant for a given event, other methods such as using a single proxy day (like-day) or applying further adjustments by evaluators may be used.

To verify CPS Energy's estimated savings, Frontier has employed a "multiple-baselining method." This approach calculates savings using 4 different methods and then selects the savings generated by the most appropriate method by evaluating some statistical criteria. Specifically, the general calculation process of "multiple-baselining method" is as follows:

Step 1: Data Selection. For each event each customer, the previous 10 eligible days and the event day are selected. These 11 days of data are used for the analysis as outlined in the following steps.

Step 2: Calculation. For each customer on each event, kW savings are calculated by using 4 different methods:

- Regression: Load is modeled as a function of *cdh* (cooling degree hours), *notify period* dummy variable indicating whether a time period is within the notification period, *event* dummy variable indicating whether a time period is within the event period, 10 day-dummy variables indicating date, and 3 *time-of-day* dummy variables indicating time of day – 0:00-6:00, 6:00-12:00, 12:00-18:00 or 18:00-24:00. The model equation can be expressed as follows:

  $$kW_t = \beta_0 + \beta_1 * cdh_t + \beta_2 * event_t + \beta_3 * notify\text{-}period_t + \sum_{i=4}^{6} \beta_i * time\text{-}of\text{-}day_t + \sum_{j=7}^{16} \beta_j * date_t$$

  $-\beta_2$ is the estimated load reduction for a certain customer during a certain event.

- CPS Energy's "high 3 of 10 baseline" analysis.

- Previous X hours: X = event duration + notifying period. For example, if an event duration is 2 hours, and CPS Energy notifies customers 2 hours in advance, then X = 4. If an event is from 3:30 to 5:30 p.m., then the baseline would be the average load within the period from 11:30 a.m. – 1:30 p.m.

- Average everything: this method calculates the average of all the load for the previous 10 eligible days to provide a baseline. This approach is designed for customers with rather amorphous and irregular load.

Step 3: Evaluation. For the testing data period,[37] three measures including accuracy (RMSE), bias (difference) and variability (standard deviation) are calculated. This step measures how fit the model results are compared with actual results for a similar time period.

Step 4: Final Selection. For the three measures described in Step 3, a pairwise comparison is conducted using ranking method[38]. The method with top ranking (lowest score) is selected.

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[37] Here "testing data period" refers to the same time period as event period on top 3 of the previous 10 eligible days, plus 09:00am – 1:00pm on event day.

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.

5.2.3.2 Coincident Peak (CP) Demand Savings (kW)

To estimate coincident peak demand kW savings, Frontier estimated per event demand savings using "multiple-baselining" analysis for each customer. For each option/program, an average kW savings of all events in summer 2017 was then calculated. This is the number used to report achieved CP savings.

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 option/program. The delivered NCP savings reported for each sub-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, Frontier sums 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 2017 DR events.
2) End-of-year (EOY) program capability based on program enrollment at the end of FY 2018; this information is useful for planning purposes.
3) End-of-year (EOY) program capability based on incremental enrollment during FY 2018; this information is used for program benefit-cost analysis, consistent with the methods used for energy efficiency programs.

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[38] General rule for "pairwise comparison using ranking": if the difference for a pair of baselines > 2% then the baseline with the higher one gets one point. Otherwise, both baselines get 0.5 point. In the end, for each method respectively, RMSE, Error and standard deviation score are added together.

For Options 1-3, there is no distinction between total EOY participation and incremental enrollment: 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 2017 DR Events

During summer 2017, C&I demand response events were called on 23 days. The aggregated kW savings estimate for these days are shown in Figure 5-8.

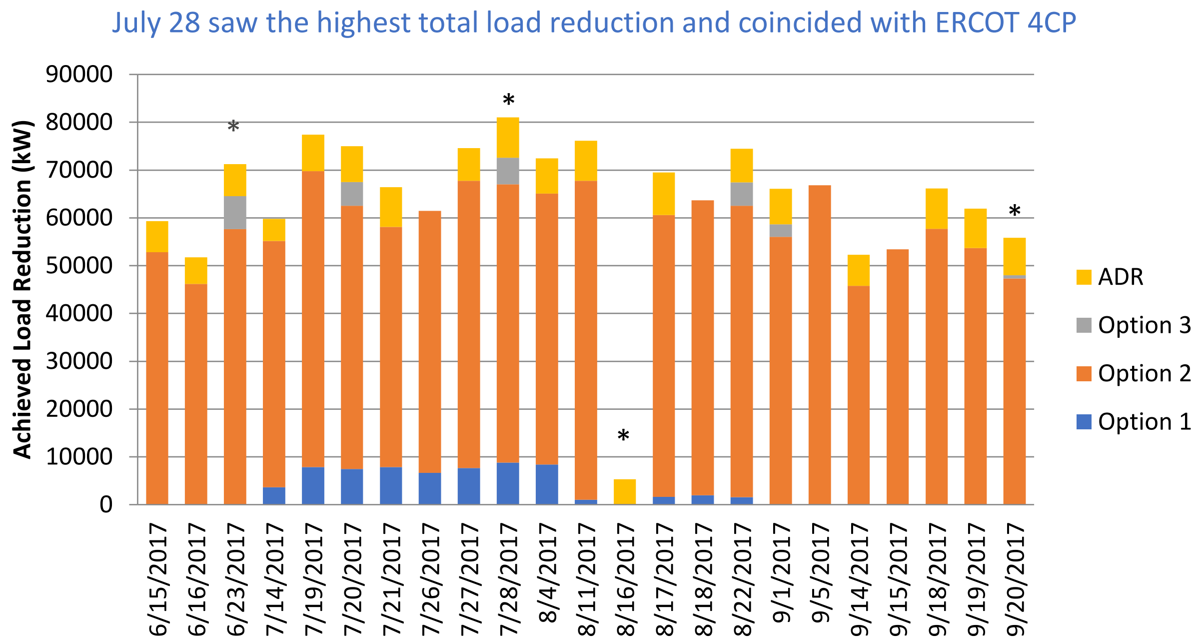


Figure 5-8: Commercial DR - Delivered Demand Savings, Summer 2017

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

Maximum total demand reductions were achieved on July 28th, which was also a 4CP day. The total demand reduction from the C&I DR programs was 81 MW on that day. Given the differences in how the individual C&I 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. The demand reduction and the number of customers participating for each option/program are shown in Figure 5-9 to Figure 5-12.

There was a sharp drop in Option 1 load reduction after the August 4th event due to the fact that 7 sites (most of them schools) chose not to participate in the latter events.

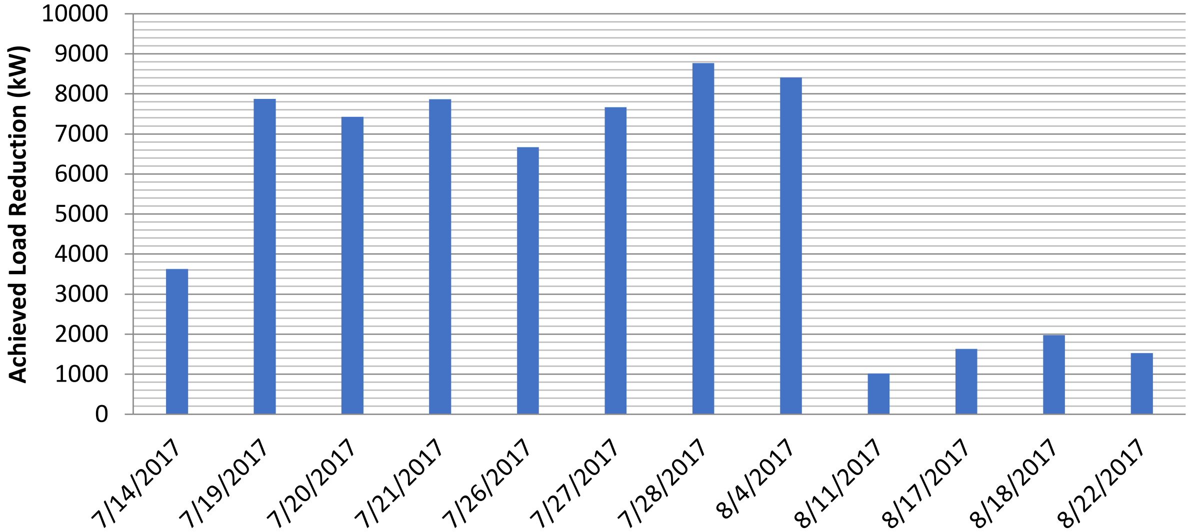


Figure 5-9: Commercial DR Option 1 Demand Savings by Event

Load reduction for option 2 remained relatively stable all summer, with an average load reduction of about 56 MW across all 22 events.

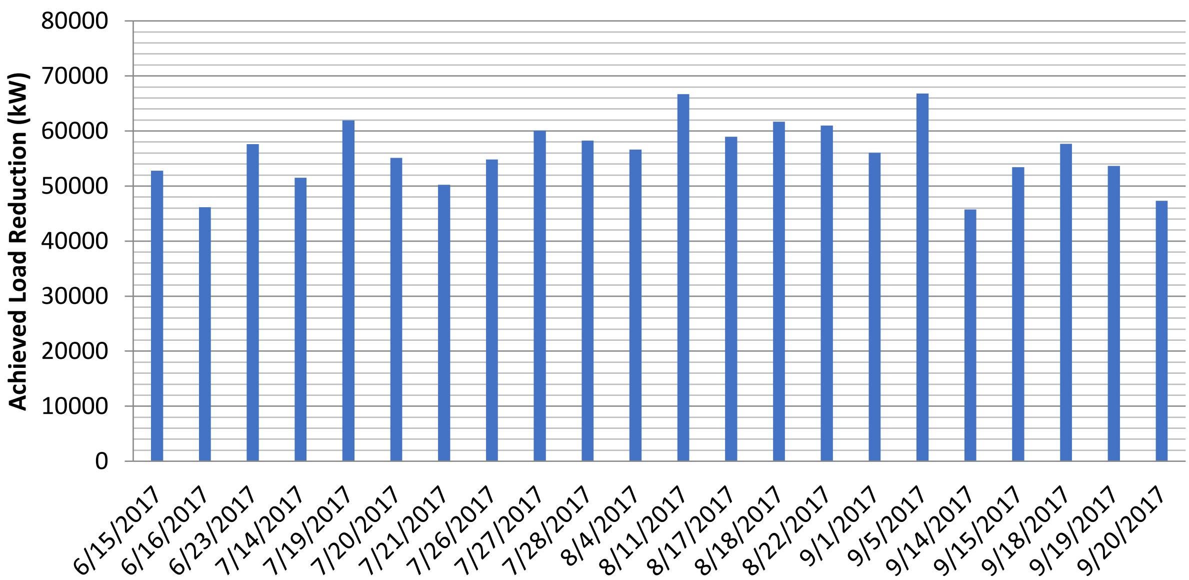


Figure 5-10: Commercial DR Option 2 Demand Savings by Event

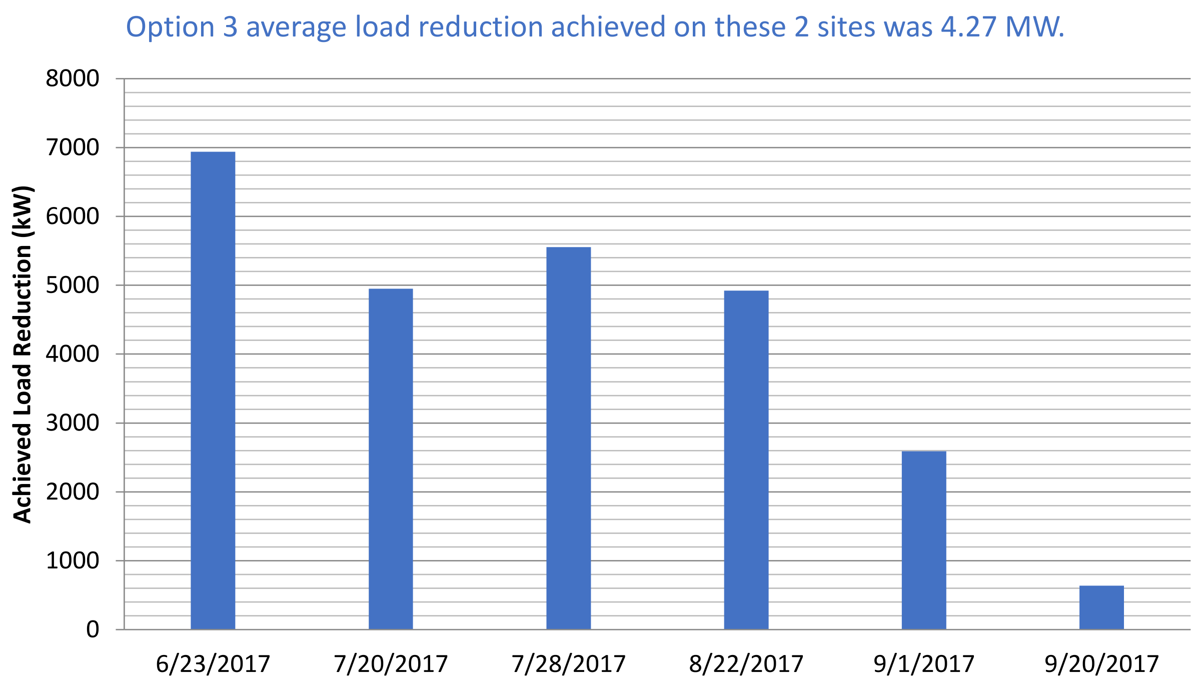


Figure 5-11: Commercial DR Option 3 Demand Savings by Event

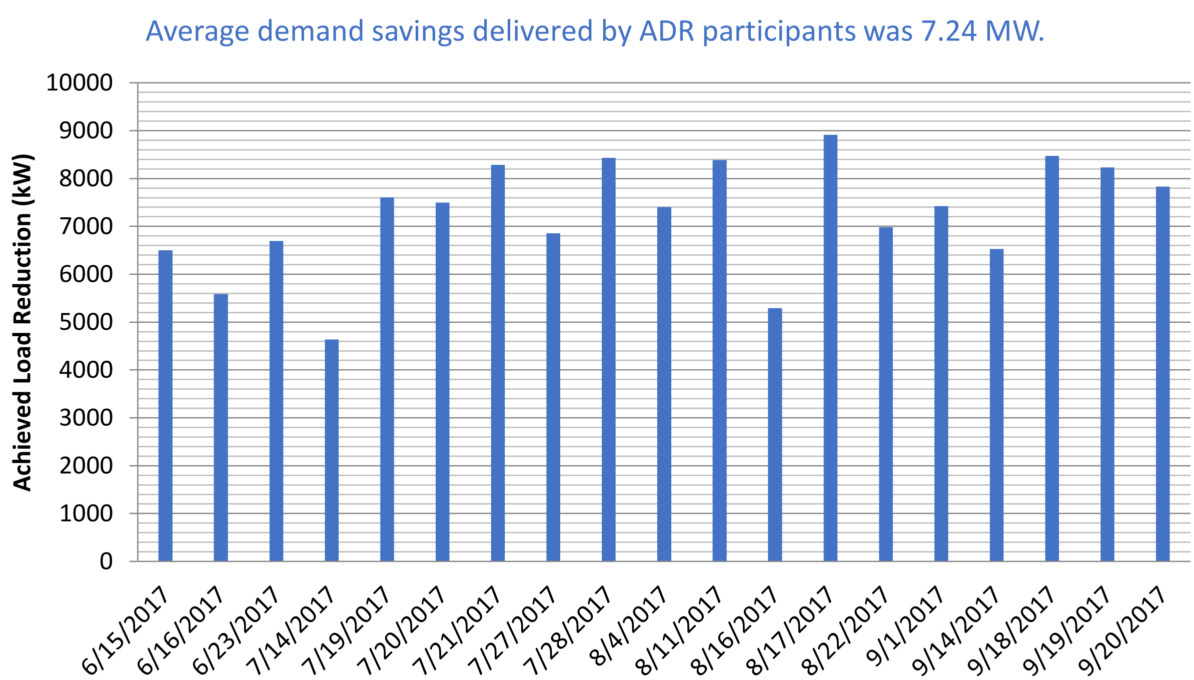


Figure 5-12: Commercial DR Automated DR Demand Savings by Event

A comparison of the estimated impacts from FY 2016 to FY 2018 is shown below:

Table 5-4: Estimated Achieved kW Impacts Comparison: FY 2016 to FY 2018

C&I DR Program/ Option	FY 2018 Average Savings (kW)	FY 2017 Average Savings (kW)	FY 2016 Average Savings (kW)
Option 1	5,373	994	11,441
Option 2	56,103	66,010	67,317
Option 3	4,265	7,860	6,609
ADR	7,239	5,684	3,707
EDR	NA	NA	17,903
Total	72,980	80,548	106,977

Rows may not sum to total due to rounding.

FY 2018 Delivered Savings

Table 5-5 presents the estimates of savings delivered by the Commercial DR programs for FY 2018.

Table 5-5: Commercial DR Gross Energy and Demand Savings – FY 2018 Delivered

Measure	Gross Energy Savings (kWh)	Gross CP Demand Savings (kW)	Gross NCP Demand Savings (kW)	Gross ERCOT 4CP Demand Savings (kW)
Option 1	142,840	5,373	8,768	2,192
Option 2	2,688,406	56,103	66,798	40,811
Option 3	55,841	4,265	6,936	3,283
Automated DR	249,901	7,239	8,912	7,061
Total	3,136,989	72,980	91,414	53,347

Rows may not sum to total due to rounding.

5.2.4.2 End-of-year Program Capability

Unlike residential DR programs which see annual recurring participation, most C&I DR programs are short and contract-based, lasting only 1-2 years, except for the ADR program. For energy savings (kWh), coincident peak savings (kW) and non-coincident peak savings (kW), Frontier uses the savings achieved in summer 2017 as an end-of-year result. As for ERCOT 4CP demand savings, since 4CP chasing has a certain success rate, Frontier considers it reasonable to use the average success rate of past 4 fiscal years to estimate end-of-year program capability.

Table 5-6: Commercial DR – ERCOT 4CP Demand Savings – End-of-year

Measure	FY 2015 Success Rate	FY 2016 Success Rate	FY 2017 Success Rate	FY 2018 Success Rate	Average Success Rate	Achieved FY 2018 ERCOT 4CP Demand Savings (kW)	EOY FY 2018 ERCOT 4CP Demand Savings (kW)
Option 1	25%	50%	50%	25%	38%	2,192	3,288
Option 2	75%	75%	100%	75%	81%	40,811	44,211
Option 3	50%	75%	25%	75%	56%	3,283	2,462
Automated DR	75%	100%	100%	100%	94%	7,061	6,620
						Total:	56,582

Rows may not sum to total due to rounding.

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 participants are available for a maximum of six events, limiting CPS Energy's ability to use these program options for 4CP avoidance. Therefore, the end-of-year program capability is summarized as follows:

Table 5-7: 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	142,840	5,373	8,768	3,288
Option 2	2,688,406	56,103	66,798	44,211
Option 3	55,841	4,265	6,936	2,462
Automated DR	249,901	7,239	8,912	6,620
Total	3,136,989	72,980	91,414	56,582

Rows may not sum to total due to rounding.

5.2.4.3 Incremental Impacts

For Options 1-3, 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 the installation of hardware. Moreover, 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 2018 the program added 17 new sites. Table 5-8 presents estimated incremental savings for the new additions to the ADR program in FY 2018. 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 94% success rate is projected for ERCOT 4CP avoidance as was used for all ADR participants.

Table 5-8: 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	28,807	827	1,577	868

5.2.5 Recommendations

Slightly shorter commercial DR events may boost savings in the future. However, one major purpose of calling DR events is to reduce 4CP costs. Therefore, DR events would be preferred if they are short enough while covering the possible 4CP periods at the same time. The table below summarizes the time periods when 4CP events occurred for the past 8 years:

Table 5-9 Time periods when 4CP events occurred for the past 8 years

15-minute interval	# of times happened in 2009-2016
15:45-16:00	3
16:00-16:15	2
16:15-16:30	6
16:30-16:45	9
16:45-17:00	12

As can be seen from the table above, for the past 8 years, all of the 4CPs happened between 3:45pm-5:00pm. Therefore, calling events that cover the 3:45pm-5:00pm period while keeping the event duration within 2 hours would be optimal in the future.

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, Honeywell installs a programmable, controllable thermostat (PCT) at a participant’s 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. 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, multifamily and small commercial 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). Customers can choose either a pager-style thermostat or a WiFi-enabled thermostat. Pager thermostats are available on either a 33% or 50% cycling rate, while WiFi Thermostats are only available for a 50% cycling rate. In FY 2018, a small portion[39] of single family WiFi-enabled thermostats were selected as a pilot trial for a new cycling strategy – a unique cycling pattern designed by Whisker Labs. Therefore, WiFi thermostats are either under traditional 50% cycling or Whisker Labs cycling in FY 2018.

Beginning in FY 2016, CPS Energy enabled 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 Thermostat program but are reported separately.

5.3.2 Participation Trends

Figure 5-13 shows overall participation in the Smart Thermostat program at the beginning and end of FY 2018 and at the time of DR events during June through September 2017.[40]

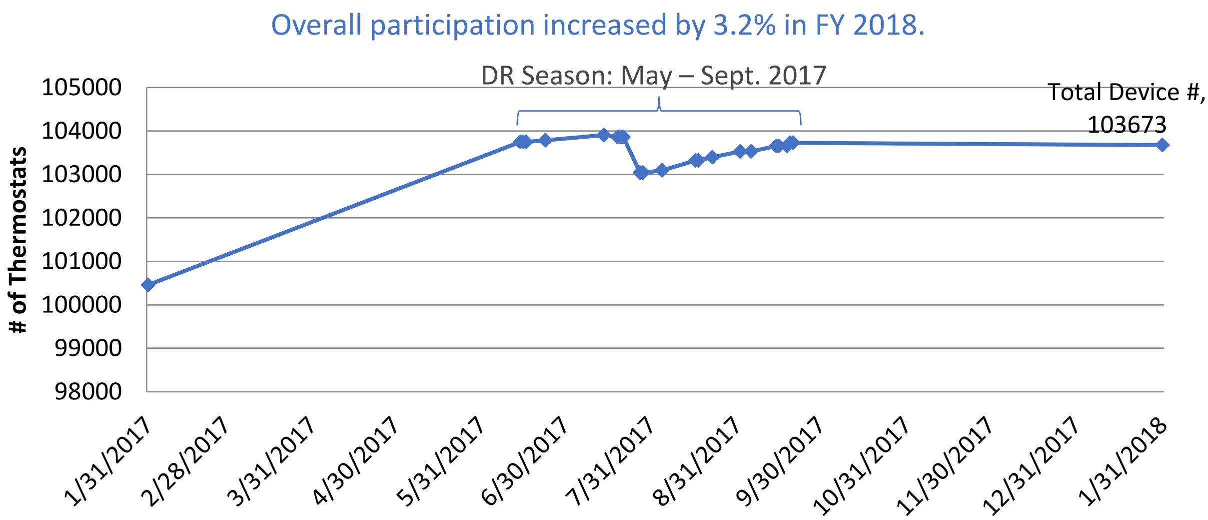


Figure 5-13: Smart Thermostat – Participation Trend (FY 2018) – Total Thermostats Count

Figure 5-14 shows participation trends by customer segment over the past five years. There have been consecutive increases in participation for the Residential (50% cycling) and Commercial segments of the program. Participation in Residential (33% cycling) dropped from 42,940 to 39,497 over the past 4 years

[39] A total of 917 AMI accounts customers were in this pilot Whisker Labs cycling group in summer 2017 when event was called. The device/AMI account ratio is 1.23. Therefore, a total of about 1128 devices participated in this pilot group. This AMI account number in this group dropped to 883 by the end of FY 2018, making the final EOY device count of 1086, after applying the device/AMI ratio.

[40] A slight drop in participation on 07/27/2017 in Figure 5-13 is due to the participation decrease in the Multifamily pager 33% cycling group.

due to CPS Energy gradually shifting customers to the 50% cycling group. The Multifamily group participation dropped slightly in FY 2018.

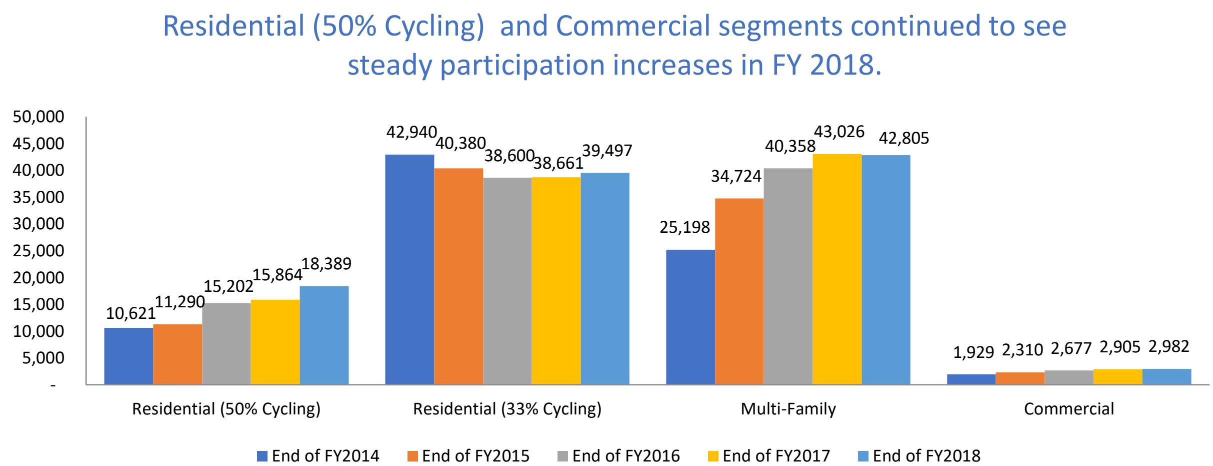


Figure 5-14: Smart Thermostat – Participation Trends (FY 2014-FY 2018) – By Segment

Figure 5-15 shows the participation share by segment from FY 2014 to FY 2018. Residential (33% Cycling) is the only segment that has a declining share for the past 4 years, since customers gradually shifted to the 50% cycling group. The Residential (50% Cycling) segment share increased from 13% to 18% due to rapid growth in WiFi customers. The Multifamily share increased from 31% to 43% in FY 2017 then dropped slightly to 41% in FY 2018. The share associated with the commercial customers has remained relatively stable over these years.

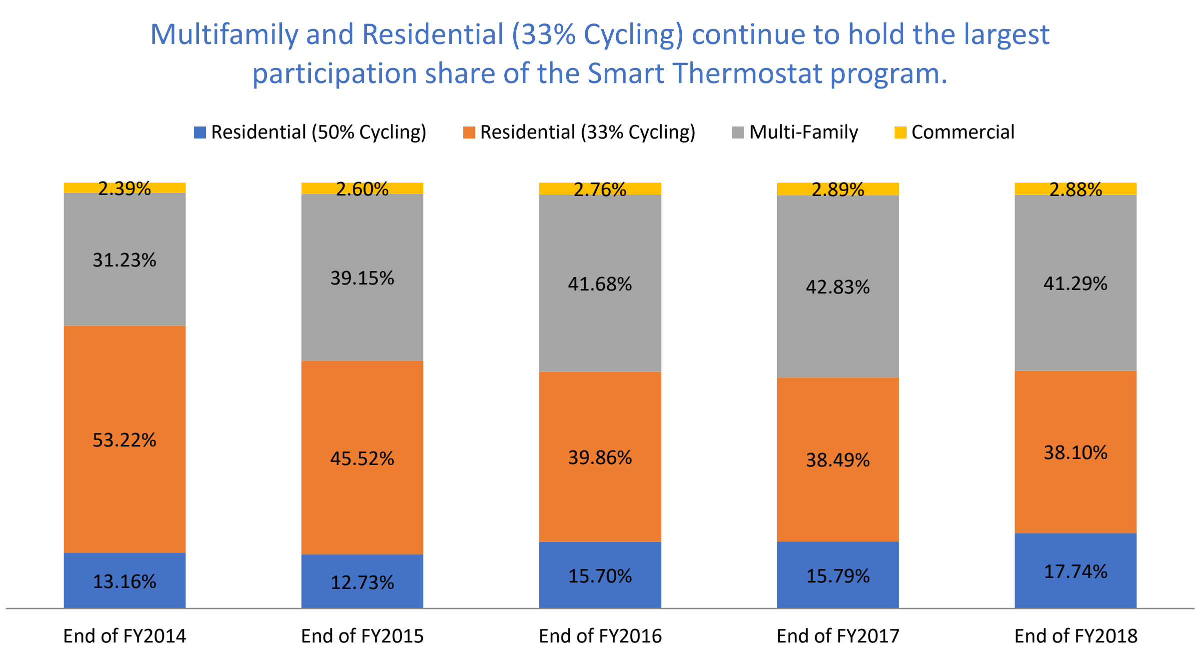


Figure 5-15: Smart Thermostat – Participation Share (FY 2014-FY 2018) – By Segment

Figure 5-16 shows the participation share by thermostat type (pager or WiFi) from FY 2017 to FY 2018.

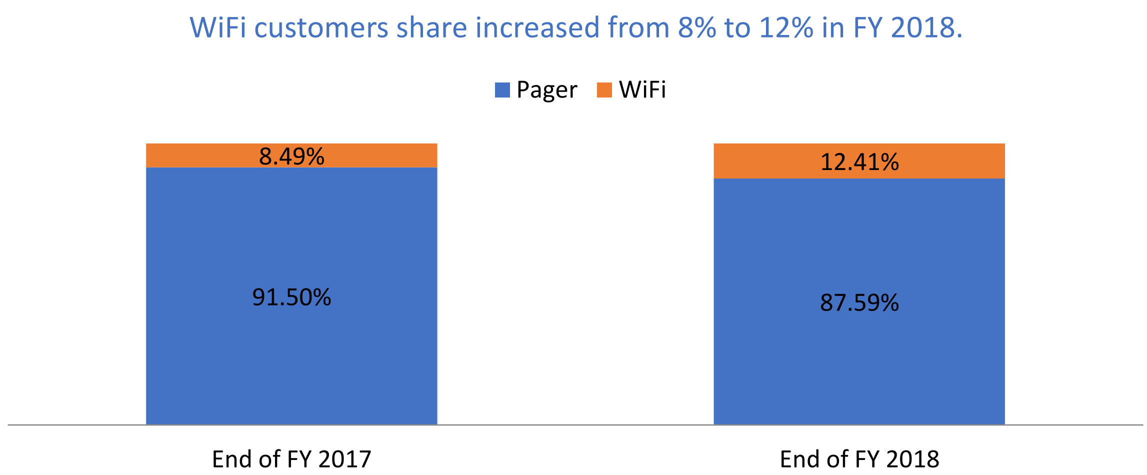


Figure 5-16 Smart Thermostat – Participation Share (FY 2017 and FY 2018) – By Thermostat Type

Similar to FY 2017, WiFi customers contributed most of the new customer growth in FY 2018. Figure 5-17 shows the breakdown of thermostat types (pager or WiFi) of all newly installed devices in FY 2018.

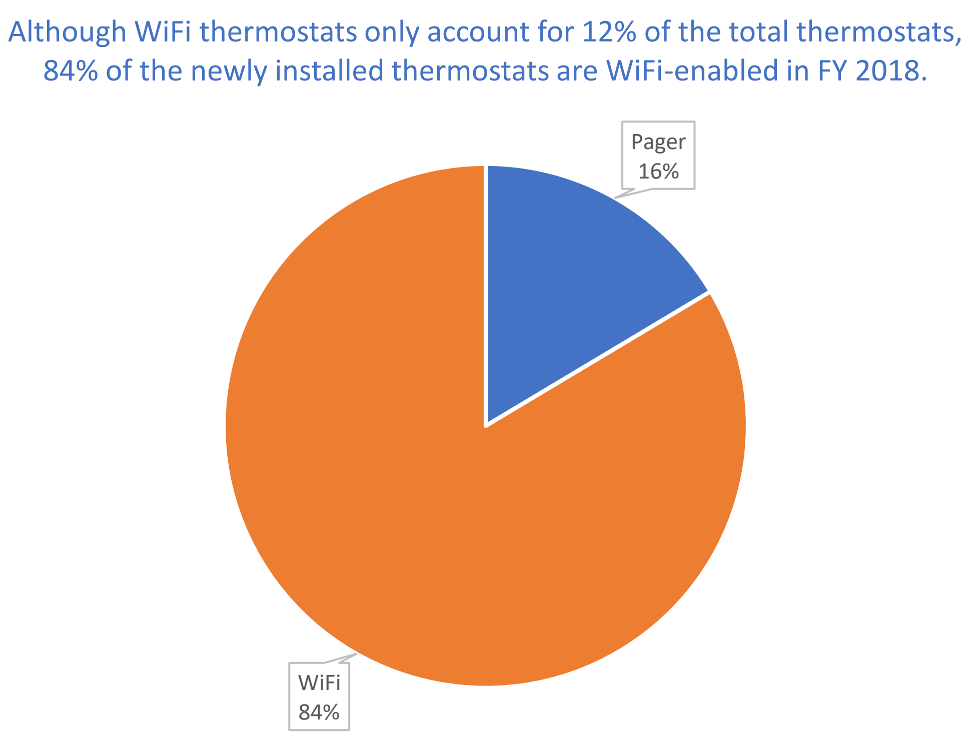


Figure 5-17: Smart Thermostat – Breakdown by Thermostat Type – FY 2018 New Installs

Table 5-10 summarizes end of FY 2018 participation levels by customer segment and cycling strategy.

Table 5-10: Smart Thermostat – Program Participation by Group, End of FY 2018

Thermostat Type	Dwelling Type	Cycling Strategy	Device Count Number
Pager	Single Family	33%	39,497
		50%	10,173
	Multi Family	33%	39,009
	Commercial	33%	2,133
WiFi	Single Family	50%	7,130
		Whisker Labs	1,086
	Multi Family	50%	3,796
	Commercial	50%	849
		Total:	103,673

5.3.3 Savings Calculation Methods

5.3.3.1 Per Device kW and kWh Savings

Frontier adopted different approaches for estimating savings for non-Whisker Labs cycling thermostats and Whisker Labs cycling thermostats respectively.

Traditional cycling (Non-Whisker Labs cycling) thermostats:

In FY 2017, Frontier conducted a full EM&V analysis for Smart Thermostat program by using sample customers' raw 15-minute interval AMI data throughout the summer of 2016. In FY 2018, we considered these results still valid and therefore did not collect raw AMI data to perform full EM&V analysis.

Events were called on every rounded integer temperature point from 91°F to 100°F in FY 2017. For per device per event kW savings estimate in FY 2018, we looked up the savings per device with the same temperature in FY 2017 events, and average the savings if multiple events had the same temperature. However, temperatures during 3 events in FY 2018 were above 100°F, which is beyond the highest temperature among all FY 2017 events. Therefore, we adopted average per device savings from 91°F to 100°F for these 3 events, for conservative estimation purpose.

To calculate net kWh savings per device per event, 1-hour post event snapback is also taken into consideration and is based on the following equation:

$$Net\ kWh\ savings\ =\ estimated\ kW\ savings\ *\ event\ duration - 1\ hour\ snapback\ kWh$$

In FY 2017, a regression method was applied on each category and net kWh savings were generated from regression model results. No regression analyses were performed in FY 2018. Therefore, 1-hour snapback results of FY 2017 were also applied in FY 2018's kWh savings estimates. The table below summarizes the per device 1-hour snapback estimates:

Table 5-11 Smart Thermostat – Estimated 1-hour Snapback kWh Savings per Device

Category	Estimated 1-hour snapback per device (kWh)
Single family pager 33% cycling	0.17
Single family pager 50% cycling	0.16
Single family WiFi 50% cycling	0.33
Multifamily pager 33% cycling	0.12
Multifamily WiFi 50% cycling	0.01
Commercial pager 33% cycling	0
Commercial WiFi 50% cycling	0

Whisker Labs cycling thermostats:

In FY 2018, 917 single family households (about 1128 WiFi devices) participated in the Whisker Labs cycling pilot. CPS Energy provided Frontier with all the available 15-minute interval AMI meter level data from June 1st, 2017 to September 30th, 2017. The sample size used for analysis is 856, which represents most participants.

There are two methodologies used in Whisker Labs cycling savings estimation. The first is top 3-of-10 baseline method, which is used to estimate kW savings. This methodology can be expressed in the following equation:

$$kW\ savings = original\ baseline\ kW * adjustment\ factor - event\ kW$$

In the equation above:

> *Original baseline kW*: For each event, the previous 10 non-event, non-holiday weekdays were ranked based on kW during the event period. The three days with the highest load during the curtailment period were selected and averaged as the original baseline.
>
> *Adjustment factor*: The ratio of event day kW versus average 3 baseline days kW during the 15-minute interval starting one hour and fifteen minutes prior to the event to avoid possible pre-cool. This ratio was applied to the original baseline kW, intending to make up for variations caused by weather effects and customer operation levels to some extent.
>
> *Event kW*: Event day kW during event time period.

The second methodology is fixed-effects panel data analysis regression, which is used for kWh savings estimate and building "temperature bin" for Whisker Labs cycling thermostats. This model takes temperature, precool, and snapback effect into consideration. The data used is 13:00-19:00, all summer afternoon. The model equation is stated as follows:

$$\text{15-minute kWh Consumption}_{i,t} = \beta_{0i} + \beta_1 * cdh_t + \beta_2 * cdhevent_t + \beta_3 * precool_t + \beta_4 * snapback_t + \sum_{k=5}^{7} \beta k * month_t + \sum_{m=8}^{13} \beta m * \text{day-of-week}_t + \varepsilon_{i,t}$$

In the equation above:

cdh:	cooling degree hours. Balance point is set at 65F, i.e., max(hourly temperature – 65F, 0)
cdhevent:	cooling degree hour and event dummy variable interaction
precool:	dummy variable, 1 if on a 1-hour pre event period; 0 otherwise
snapback:	dummy variable, 1 if on a post event 1-hour period; 0 otherwise
month:	3 dummy variables indicating month
day-of-week:	6 dummy variable indicating day of week (this set of variables are only applied on commercial types)

For example, for a certain event with temperature at 95F, the average gross kWh savings for each household during event period is $-\beta_2$ * (95-65) * event duration * 4. Since β_3 and β_4 are the estimates for 1-hour precool and 1-hour snapback respectively, net kWh savings for each household would be: $-\beta_2$ * 30 * event duration * 4 - β_3*4 – β_4*4. The device/household ratio in Whisker Labs cycling group is 1.23, so the net kWh savings per device is ($-\beta_2$ * 30 * event duration * 4 - β_3*4 – β_4*4)/1.23.

5.3.3.2 Coincident Peak (CP) Demand Savings (kW)

To estimate coincident peak demand kW savings, we estimated total demand savings using the per device kW savings multiplied by the total number of devices by category for each event. Average kW savings across all events in summer 2017 was then calculated. To estimate program capability based on end-of-year and incremental enrollment, we scaled the result to the number of Smart Thermostats at the end of FY 2018 and to the number of new thermostats during FY 2018, respectively.

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 2018 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 2018.

5.3.3.4 ERCOT 4CP Demand Savings (kW)

During summer 2017, 4 of the 22 Smart Thermostat events coincided with ERCOT 4CP events, with a success hitting rate of 100%. To estimate ERCOT 4CP demand savings, we estimated total demand savings for each event, selected the four events which coincided with ERCOT 4CP, and multiplied the result by the ERCOT 4CP success rate, which is 100%. For the year-end capability and incremental calculations, we scaled the result to the number of thermostats at the end of FY 2018 and to the number of newly installed thermostats during FY 2018.

5.3.4 Impact Analysis Results

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

1) Estimated per device kW and kWh savings during summer 2017 DR events.
2) Estimated program impacts during summer 2017 DR events.
3) End-of-year program capability based on program enrollment at the end of FY 2018; this information is useful for planning purposes.
4) End-of-year program capability based on incremental enrollment during FY 2018; this information is used for program benefit-cost analysis, consistent with the methods used for energy efficiency programs.
5) Temperature Bins for Whisker Labs Cycling.

5.3.4.1 Estimated per device kW and kWh savings during summer 2017 DR events

The table below summarizes average per device kW and kWh savings for each category across all summer 2017 DR events:

Table 5-12 Estimated per Device kW and Net kWh Savings during Summer 2017 DR Events

Category	Average kW savings per device	Average Net kWh savings per device per event
Single family pager 33% cycling	0.24	0.30
Single family pager 50% cycling	0.35	0.55
Single family WiFi 50% cycling	0.76	1.41
Multifamily pager 33% cycling	0.19	0.31
Multifamily WiFi 50% cycling	0.08	0.13
Commercial pager 33% cycling	0.28	0.57
Commercial WiFi 50% cycling	1.96	3.96
Single Family WiFi Whisker Labs cycling	1.20	2.44

5.3.4.2 Estimated Impacts During Summer 2017 DR Events

Twenty-two demand response events were called during the summer of 2017 for Smart Thermostat traditional non-Whisker Labs cycling participants. For Whisker Labs cycling participants, 19 events were called. For both categories, four of the events called by CPS Energy during the summer of 2017 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 5-18. Total summer 2017 kW reduction ranged from 8,257 kW (08/22/2017) to 39,409 kW (07/19/2017). WiFi thermostats were not called on 08/11/2017.

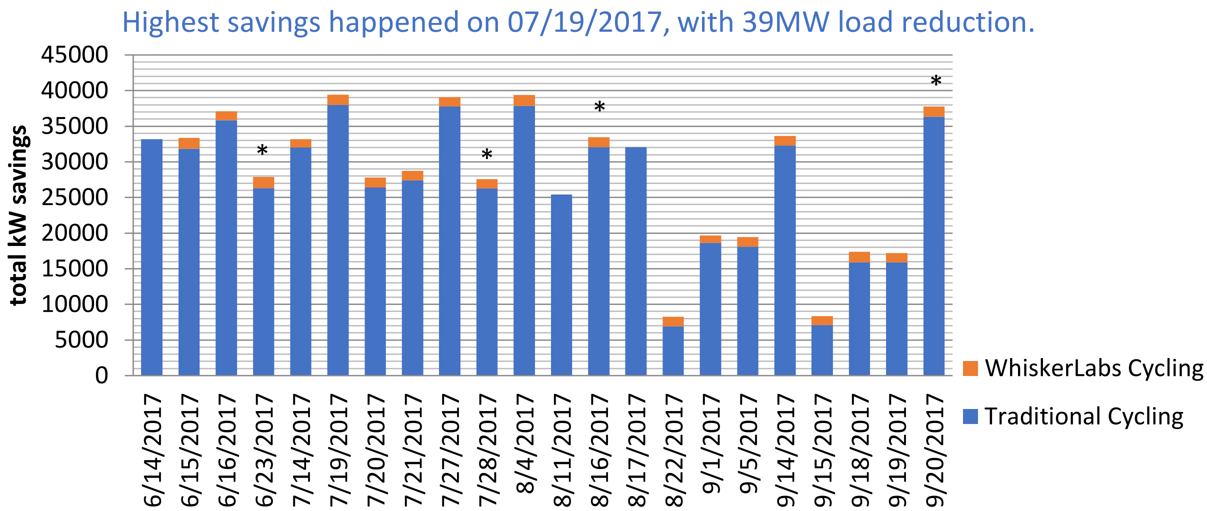


Figure 5-18: Smart Thermostat – Achieved Demand Reduction during Summer 2017 Events

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

Table 5-11 shows estimated energy, peak demand, non-coincident peak demand, and ERCOT 4CP demand savings delivered by the program in FY 2018. Peak demand savings are the average estimated savings across events. ERCOT 4CP savings are the average estimated savings during ERCOT 4CP events. Non-coincident peak savings are the highest savings achieved during any event.

Table 5-13: Smart Thermostat Gross Energy and Demand Savings – FY 2018 Delivered

Measure	Gross Energy Savings (kWh)	Gross CP Demand Savings (kW)	Gross NCP Demand Savings (kW)	Gross ERCOT 4CP Demand Savings (kW)
Traditional Cycling	945,185	26,979	37,985	30,241
Whisker Labs Cycling	42,550	1,354	1,574	1,416
Total	987,735	28,333	39,559	31,657

5.3.4.3 End-of-year Program Capability

End-of-year program capability is based on end-of-year enrollment. Table 5-14 shows the end of FY 2018 program capability values.

Table 5-14: Smart Thermostat Gross Energy and Demand Savings – End-of-year Capability

Measure	Device Count	Gross Energy Savings (kWh)	Gross CP Demand Savings (kW)	Gross NCP Demand Savings (kW)	Gross ERCOT 4CP Demand Savings (kW)
Traditional Cycling	102,587	980,639	28,252	39,042	31,179
Whisker Labs Cycling	1,086	40,972	1,304	1,516	1,364
Total	103,673	1,021,611	29,556	40,558	32,543

5.3.4.4 Incremental Impacts

For traditional cycling thermostats, incremental impacts used for cost-effectiveness analysis are based on gross incremental enrollment. For Whisker Labs cycling thermostats, incremental impacts are calculated by the additional savings caused by Whisker Labs cycling compared with what would have achieved if continuing using traditional 50% cycling. Both are shown Table 5-15.

Table 5-15: Smart Thermostat Gross Energy and Demand Savings – Incremental Impacts

Measure	Gross Energy Savings (kWh)	Gross CP Demand Savings (kW)	Gross NCP Demand Savings (kW)	Gross ERCOT 4CP Demand Savings (kW)
Traditional Cycling	96,194	2,379	2,850	2,497
Whisker Labs Cycling	19,172	533	721	536
Total	115,366	2,912	3,571	3,033

5.3.4.5 Temperature Bins for Whisker Labs Cycling

Temperature bins may serve as an expedited method for estimating savings in future years. Based on this year's panel data regression, Frontier generated temperature bins for the per device savings of single family WiFi Whisker Labs cycling appearing in Table 5-16.

Table 5-16: Temperature Bin Savings per Device for Single Family WiFi Whisker Labs Cycling Thermostats

Temperature(°F)	kW savings/device
90	0.84
91	0.88
92	0.91
93	0.95
94	0.98
95	1.01
96	1.05
97	1.08
98	1.11
99	1.15

Temperature(°F)	kW savings/device
100	1.18
101	1.22
102	1.25
103	1.28
104	1.32
105	1.35
106	1.38
107	1.42
108	1.45
109	1.49
110	1.52

Pre and Post Event Over-consumption for kWh savings Calculation (unit: kW)	
1-hour precool:	-0.01
1-hour snapback:	0.17

For example, for a 2-hour 95°F event, the kW savings estimate for a single family WiFi Whisker Labs cycling thermostat would be 1.01 kW. Net kWh savings estimate per device on this event would be 1.01kW * 2 Hrs - (-0.01kW * 1 Hr) – (0.17kW * 1Hr) = 1.86kWh. Other categories can be estimated in similar manner.

5.3.5 Recommendations

Frontier provides the following recommendations for the Smart Thermostat program:

- Per device savings of WiFi thermostats is higher than that of pager thermostats. To improve program cost effectiveness, consider replacing old pagers with WiFi ones.
- Based on summer 2017 data, per device savings of WiFi thermostats with dynamic cycling is higher than traditional 50% cycling. To improve program cost effectiveness, consider applying dynamic cycling to more WiFi thermostats.
- For more accurate estimates, a full EM&V analysis will be performed on Smart Thermostat program next year.

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. This 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 set points. Water heaters and pool pumps are powered off for the duration of the event. Customers can reset their thermostat set points or drop completely out of the event at any time. In summer 2017, CPS Energy successfully called 11 test events and 11 additional events, ranging from 1 to 2.25 hours in duration. By January 31, 2018, total participation in Home Manager program was 13,041. The Home Manager population is shrinking as customers are being transitioned to the Nest Direct Installation (DI) program. The transition provides customers a newer technology and mobile app while also enabling CPS Energy to replace the Home Manager meter gateway with an AMI meter.

5.4.2 Participation Trends

The following figure shows the number of participants during each event in the summer of 2017.

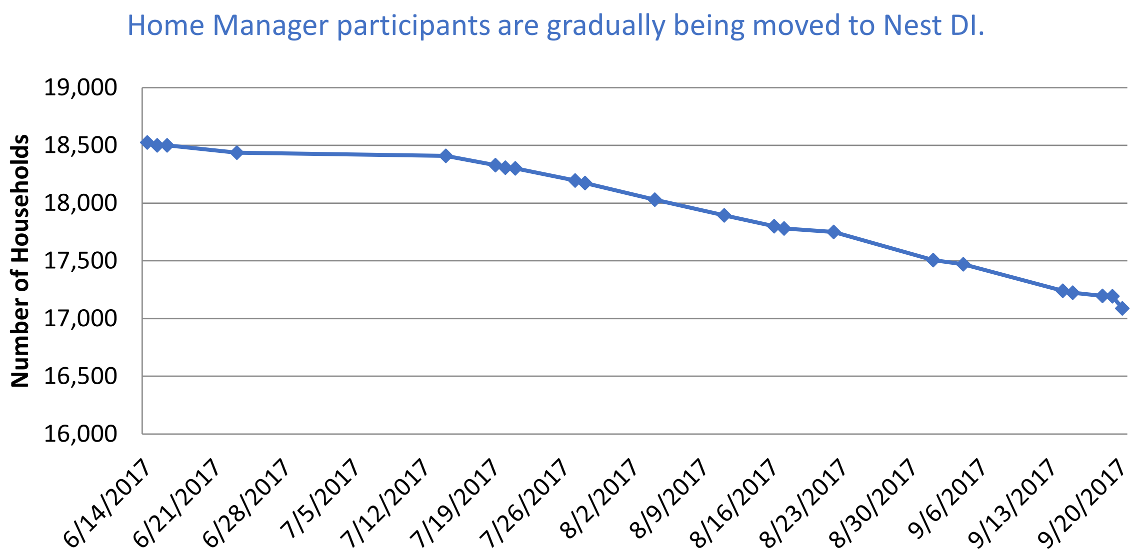


Figure 5-19: Home Manager – Participation Trend

5.4.3 Event kW and kWh Savings Methodology

CPS Energy provided Frontier with overall aggregated interval meter data for the Home Manager program. Frontier produced estimates of total kW and kWh savings and scaled the results to the end of the fiscal year participation numbers and new installment numbers to generate EOY program capability and incremental savings.

A top 3-of-10 baseline method was applied to estimate kW savings. The equation is stated as follows:

$$kW\ savings = original\ baseline\ kW * adjustment\ factor - event\ kW$$

In the equation above:

Original baseline kW: For each event, the previous 10 non-event, non-holiday weekdays were ranked based on kW during the event period. The three days with the highest load during the curtailment period were selected and averaged as the original baseline.

Adjustment factor: The ratio of event day kW versus average 3 baseline days kW during the 20 minutes before the event until 15 minutes before the event period.[41] This ratio was applied to the original baseline kW, intending to make up for variations caused by weather effects and customer operation levels to some extent.

Event kW: Event day kW during event time period.

[41] A slight load drop which happens 10-15 minutes before the event start time was observed for most of the events in summer 2017. Therefore, we skip the 15 minutes before the event start time when calculating adjustment factor.

Frontier also employed a linear regression model to quantify the kWh savings using 5-minute aggregated energy consumption data from the Home Manager program. This model takes temperature and any snapback effect into consideration. Whole summer aggregated 5-minute interval kW data was fed into the model. The model equation is stated as follows:

$$\text{5-minute-}kW_t = \beta_0 + \beta_1 * cdh_t + \sum_{k=2}^{23} \beta_k * event_t + \sum_{l=24}^{45} \beta_l * snapback_t + \beta_{46} * weekday + \sum_{m=47}^{69} \beta_m * hour_t + \sum_{n=70}^{72} \beta_n * month_t + \varepsilon_{i,t}$$

In the equation above:

cdh:	cooling degree hours. Balance point is set at 65°F, i.e., cdh = max(hourly temperature – 65°F, 0)
event:	a set of 22 dummy variables, 1 if within an event period; 0 otherwise
snapback:	a set of 22 dummy variables, 1 if within a 1-hour post event period; 0 otherwise
weekday:	dummy variable, 1 if within a weekday; 0 if on a weekend
hour:	a set of 23 dummy variables indicating the hour of the day
month:	a set of 3 dummy variables indicating the month

Take the first event (06/14/2017, 16:15 - 17:15) as an example. -β_2 is the estimate for kW savings during the event period (16:15 -17:15). β_{24} is the estimate for kW snapback during the 1-hour post event period (17:15 – 18:15). Thus the net kWh savings for this event is -β_2 * 1 (event duration) – β_{24} * 1 (snapback duration).

5.4.3.1 Coincident Peak Demand Savings (kW)

To estimate coincident peak demand kW savings, we estimated program-level total demand savings using the top 3-of-10 baseline analysis for each event. An average kW savings of 18 out of 22 high temperature[42] events in 2017 was then calculated. To estimate program capability based on end-of-year enrollment, we scaled the result to the number of active premises at the end of FY 2018. Since Home Manager customers are gradually migrating to the Nest DI program, there is no new enrollment this year. Therefore, incremental impacts are set to zero.

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

To estimate delivered non-coincident peak savings, Frontier estimated program-level total demand savings using the top 3-of-10 baseline analysis for each event. We then selected the single event with the highest savings. For the year-end capability calculations, we scaled the result to the number of active premises at the end of FY 2018.

[42] High temperature threshold is set at 95°F.

5.4.3.3 ERCOT 4CP Demand Savings (kW)

During the summer of 2017, 4 of the 22 Home Manager events coincided with ERCOT 4CP events, with a success rate of 100%. To estimate ERCOT 4CP demand savings, we estimated program-level per-event kW savings using a top 3-of-10 baseline analysis, selected the four events which coincided with the ERCOT 4CPs, and multiplied the result by the ERCOT 4CP success rate. For the year-end capability calculations, we scaled the result to the number of active premises at the end of FY 2018.

5.4.4 Impact Analysis Results

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

1) Estimated Achieved program impacts during DR events called during the summer of 2017.

2) End-of-year program capability based on program enrollment at the end of FY 2018; this information is useful for planning purposes.

The incremental impact is set to zero since no new Home Manager customers were added to the program in FY 2018.

5.4.4.1 Estimated Impacts during Summer 2017 DR Events

Using the top 3-of-10 methodology, the per-participant demand reduction achieved through this program during high-temperature events called by CPS Energy averaged 1.44 kW in the summer of 2017. The total impacts of events ranged from 21,341 kW (the event on 9/1) to 31,864 kW (the event on 6/23). Four 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 5-20.

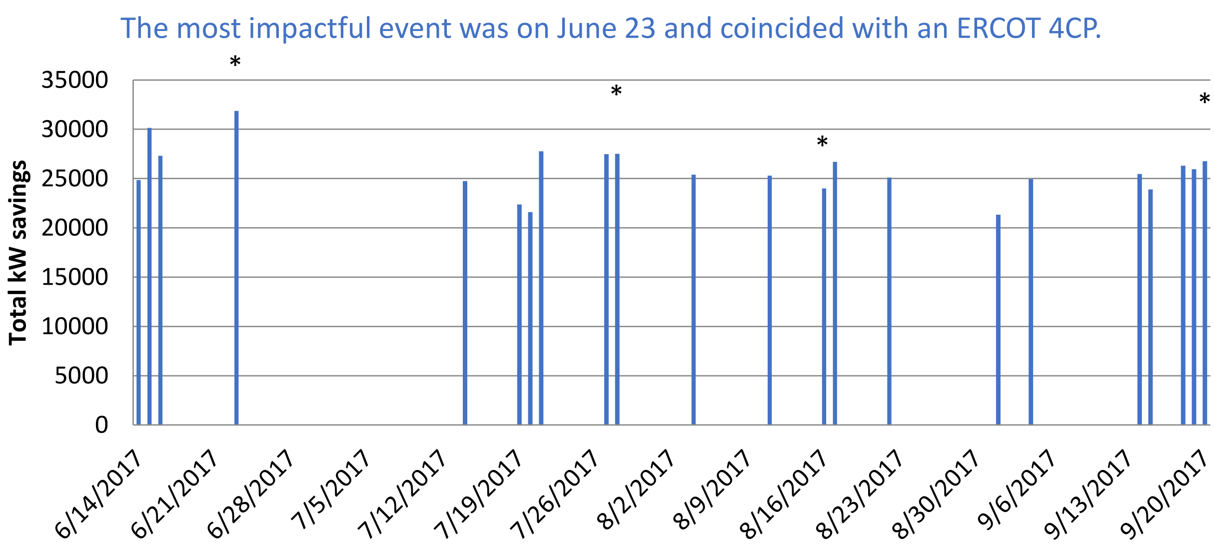


Figure 5-20: Home Manager – Achieved Demand Reduction during Summer 2017 Called Events

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

The per-participant per-event energy savings averaged 1.94 kWh with later snapback of 0.49 kWh. Therefore, net energy savings per-participant per event is 1.45 kWh. Annual achieved total net energy savings for the Home Manager program is estimated at 572,648 kWh.

Table 5-17: Home Manager Gross Energy and Demand Savings – FY 2018 Delivered

Measure	Gross Energy Savings (kWh)	Gross CP Demand Savings (kW)	Gross NCP Demand Savings (kW)	Gross ERCOT 4CP Demand Savings (kW)
Total	572,648	26,200	31,864	27,532

5.4.4.2 End-of-year Program Capability

Based on a total of 13,041 customers at the end of FY 2018, the Home Manager program was capable of providing the energy and demand savings shown in Table 5-18. End-of-year capability is less than delivered savings due to declining net enrollment in the program.

Table 5-18: Home Manager Gross Energy and Demand Savings – End-of-year Capability

Measure	Gross Energy Savings (kWh)	Gross CP Demand Savings (kW)	Gross NCP Demand Savings (kW)	Gross ERCOT 4CP Demand Savings (kW)
Total	416,949	18,996	22,539	20,070

5.5 BRING YOUR OWN THERMOSTAT (BYOT) PROGRAM

5.5.1 Overview

BYOT (Bring Your Own Thermostat) is a program that integrates customers' own thermostats with load curtailment events. The program began in FY 2015 when CPS Energy partnered with Nest Labs to implement the Rush Hour Rewards (RHR) pilot 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. 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.[43]

Starting in FY 2016, CPS Energy began incorporating existing Nest RHR customers into a more broadly defined BYOT program,[44] which offers similar incentives to customers who self-install any of several qualifying thermostats. In FY 2018, the BYOT program also included thermostats that operate as follows:

[43] Nest Support. *Learn more about Rush Hour Rewards.* Online. Available: https://nest.com/support/article/What-is-Rush-Hour-Rewards.
[44] CPS Energy markets this program as the My Thermostats Rewards program.

- In a schedule the same as those installed under the existing Smart Thermostat single family WiFi 50% cycling group
- Emerson thermostats with a schedule which is the same as Smart Thermostat Whisker Labs cycling group
- EnergyHub thermostats, which have a schedule of their own

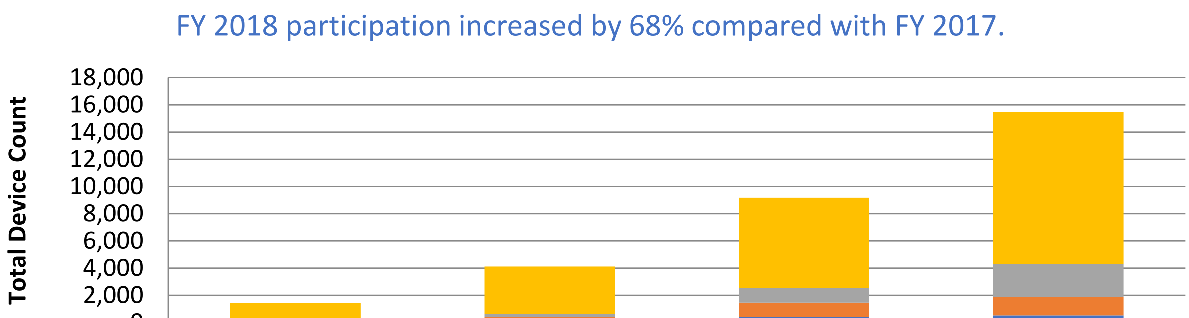
The key differentiator of BYOT relative to other residential DR programs is that the customer purchases and installs the qualifying thermostat under BYOT, reducing direct install costs otherwise incurred by CPS Energy.

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. For a limited time around the Black Friday shopping season, CPS Energy ups the retail credit to $150 toward the customers' purchase of qualifying thermostats from participating vendors.

5.5.2 Participation Trends & Demographics Information

5.5.2.1 BYOT Program Level Overall Participation Trends

CPS Energy has rapidly expanded its BYOT customer base since the introduction of the program. Figure 5-21 shows the number of enrolled BYOT devices by thermostat brand from FY 2015 to FY 2018.



	FY2015	FY2016	FY2017	FY2018
Nest	1,434	3,477	6,671	11,155
EnergyHub	0	244	1,060	2,441
Honeywell	0	387	1,057	1,340
Emerson	0	0	393	519

Figure 5-21: Bring Your Own Thermostat – Participation Trend (FY 2018)

72% of BYOT customers are using Nest thermostats, though there is also rapid growth of EnergyHub thermostats, with the number of devices having more than doubled during FY 2018.

5.5.3 Savings Calculation Method

5.5.3.1 Per Device kW and kWh Savings

Frontier adopted different approaches for calculating the demand reduction and energy savings associated with different brands of BYOT thermostats.

Nest thermostats

In FY 2017, Frontier developed a time temperature matrix (TTM) for Nest customers using per AMI account 15-minute interval data. TTM serves as an expedited method for estimating kW savings by omitting the steps of calculating savings using raw interval consumption data. The time temperature matrix is shown in Table 5-19.

Table 5-19 BYOT Nest AMI household level TTM

	Apartments per household kW Savings estimate			Single family per household kW Savings estimate		
Temperature(°F)	1st hour	2nd hour	3rd hour	1st hour	2nd hour	3rd hour
88	0.71	0.55	0.39	1.4	0.93	0.65
89	0.74	0.58	0.41	1.46	0.97	0.68
90	0.77	0.6	0.42	1.52	1.01	0.71
91	0.8	0.63	0.44	1.58	1.05	0.74
92	0.83	0.65	0.46	1.64	1.09	0.76
93	0.86	0.67	0.48	1.7	1.13	0.79
94	0.89	0.7	0.49	1.76	1.17	0.82
95	0.92	0.72	0.51	1.83	1.21	0.85
96	0.95	0.75	0.53	1.89	1.25	0.88
97	0.98	0.77	0.54	1.95	1.29	0.9
98	1.01	0.79	0.56	2.01	1.33	0.93
99	1.04	0.82	0.58	2.07	1.37	0.96
100	1.08	0.84	0.59	2.13	1.41	0.99
101	1.11	0.87	0.61	2.19	1.45	1.02
102	1.14	0.89	0.63	2.25	1.49	1.05
103	1.17	0.91	0.65	2.31	1.53	1.07
104	1.2	0.94	0.66	2.37	1.57	1.1
105	1.23	0.96	0.68	2.43	1.61	1.13

For each event a device count was provided. The device/household ratio for FY 2018 is 1.25 and the single family/apartment ratio is 16.18:1. Therefore, the number of single family and apartment households can be estimated for each event. Multiplying the estimated kW savings using the TTM by the estimated households yields the estimated total kW savings.

Take the first event in the summer 2017 (06/15/2017, 15:30 – 17:30) as an example. The total number of devices on this event is 7044.[45] Therefore, the numbers of single family and apartment households are estimated at 5307 and 328 respectively. The temperature on the first hour of the event was 96°F and 97°F on the second. Therefore, the total kW savings on that event is estimated as 5307 * (1.89 + 1.29)/2 + 328 * (0.95 + 0.77)/2 = 8720 kW. The average per device savings on this event is 8720 / 7044 = 1.24 kW.

Regarding the energy savings estimate, in FY 2016, Frontier employed billing analysis to quantify the electricity and gas savings attributable to installation of a Nest thermostat and enrollment in the Nest RHR program. Frontier's model found that the presence of a Nest thermostat reduced electricity consumption by 51 kWh per household per month, around 3.2% of conservation effect. We consider this number still valid this year and, therefore, continue using 51 kWh per household per month as a year-round energy savings.

Honeywell thermostats

Since this group of thermostats share the same cycling and schedule with Smart Thermostat WiFi 50% cycling, per device kW savings and kWh savings of 0.76 kW and 1.41 kWh (same as those of Smart Thermostat single family WiFi 50% cycling) are adopted in this group, respectively.

EnergyHub thermostats

For EnergyHub thermostats, CPS Energy provided Frontier with all the available 15-minute interval AMI meter household level data from June 1st, 2017 to September 30th, 2017. The sample size used for analysis is 457.

There are two methodologies used to estimate the energy savings from EnergyHub thermostats. The first is the top 3-of-10 baseline method, which is used to estimate kW savings. This methodology can be expressed in the following equation:

$$kW\ savings = original\ baseline\ kW * adjustment\ factor - event\ kW$$

In the equation above:

Original baseline kW: For each event, the previous 10 non-event, non-holiday weekdays were ranked based on kW during the event period. The three days with the highest load during the curtailment period were selected and averaged as the original baseline.

Adjustment factor: The ratio of event day kW versus average 3 baseline days kW during the 1-hour period starting four hours prior to the event.[46] This ratio was applied to the original

[45] 7044 devices are the total thermostat count of BYOT Nest and Nest DI (Direct Install) combined in the first event of summer 2017. The separated device counts by Nest DI were only provided monthly in FY 2018 rather on every summer 2017 DR event.

[46] Up to 1 hour pre-cooling was scheduled in summer 2017 events, however, it was observed that load increase began to take off 2 to 3 hours before the start time for some of the events. Therefore, we skipped the 3-hour pre event window to calculate the adjustment factor.

baseline kW, intending to make up for variations caused by weather effects and customer operation levels to a certain extent.

Event kW: Event day kW during the event time period.

The second methodology is a fixed-effects panel data analysis regression, which is used to obtain a kWh savings estimate and build a "temperature bin." This model takes temperature, precooling and the snapback effect into consideration. The data used is 13:00-19:00, i.e., the summer afternoon. The period model equation is stated as follows:

$$\textit{15-minute kWh Consumption}_{i,t} = \beta_{0i} + \beta_1 * cdh_t + \beta_2 * \ cdhevent_t + \beta_3 * precool_t + \beta_4 * snapback_t + \sum_{k=5}^{7} \beta_k * month + \sum_{m=8}^{13} \beta_m * \textit{day-of-week} + \ \varepsilon_{i,t}$$

In the equation above:

cdh: cooling degree hours. Balance point is set at 65°F, i.e., max(hourly temperature – 65°F, 0)

cdhevent: cooling degree hour and event dummy variable interaction

precool: dummy variable, 1 if within a pre-cool period; 0 otherwise

snapback: dummy variable, 1 if within a post event 1-hour period; 0 otherwise

month: 3 dummy variables indicating month

day-of-week: 6 dummy variable indicating the day of the week (this set of variables are only applied on commercial types)

For example, for a certain event with temperature at 95°F, the average gross kWh savings for each household during the event period is $-\beta_2$ * (95-65) * event duration * 4. Since β_3 and β_4 are the estimates for precool and 1-hour snapback respectively, net kWh savings for each household would be: $-\beta_2$ * 30 * event duration * 4 - β_3*pre-cool duration * 4 – β_4*4. The device/household ratio in EnergyHub cycling group is 1.25 in FY 2018, so the net kWh savings per device is ($-\beta_2$ * 30 * event duration * 4 - β_3* pre-cool duration * 4 – β_4 * 4)/1.25.

Emerson thermostats

As was the case for EnergyHub thermostats, CPS Energy provided Frontier with all the available 15-minute interval AMI meter household level data from June 1st, 2017 to September 30th, 2017. The sample size used for analysis is 178.

There are two methodologies to estimate demand reduction. The first is a top 3-of-10 baseline method, which is used to estimate kW savings. This methodology can be expressed in the following equation:

$$\textit{kW savings} = \textit{original baseline kW} * \textit{adjustment factor} - \textit{event kW}$$

In the equation above:

Original baseline kW: For each event, the previous 10 non-event, non-holiday weekdays were ranked based on kW during the event period. The three days with the highest load during the curtailment period were selected and averaged as the original baseline.

Adjustment factor: The ratio of event day kW versus average 3 baseline days kW during the 15-minute interval starting one hour and fifteen minutes prior to the event to avoid possible pre-cool. This ratio was applied to the original baseline kW, intending to make up for variations caused by weather effects and customer operation levels to a certain extent.

Event kW: Event day kW during event time period.

The second methodology, fixed-effects panel data analysis regression, is used to develop kWh savings estimate and build a "temperature bin." This model takes temperature, precool and snapback effect into consideration. The data used is 13:00-19:00, i.e., all summer afternoon. The model equation is stated as follows:

$$\text{15-minute kWh Consumption}_{i,t} = \beta_{0i} + \beta_1 * cdh_t + \beta_2 * cdhevent_t + \beta_3 * precool_t + \beta_4 * snapback_t + \sum_{k=5}^{7} \beta_k * month + \sum_{m=8}^{13} \beta_m * day\text{-}of\text{-}week + \varepsilon_{i,t}$$

In the equation above:

cdh: cooling degree hours. Balance point is set at 65F, i.e., max(hourly temperature – 65F, 0)

cdhevent: cooling degree hour and event dummy variable interaction

precool: dummy variable, 1 if on a 1-hour pre event period; 0 otherwise

snapback: dummy variable, 1 if on a 1-hour post event period; 0 otherwise

month: 3 dummy variables indicating month

day-of-week: 6 dummy variable indicating day of week (this set of variables are only applied on commercial types)

For example, for a certain event with temperature at 95°F, the average gross kWh savings for each household during event period is $-\beta_2$ * (95-65) * event duration * 4. Since β_3 and β_4 are the estimates for precool and 1-hour snapback respectively, net kWh savings for each household would be: $-\beta_2$ * 30 * event duration * 4 - β_3 * 4 – β_4*4. The device/household ratio in Emerson cycling group is 1.23 in FY 2018, so the net kWh savings per device is ($-\beta_2$ * 30 * event duration * 4 - β_3* 4 – β_4 * 4)/1.23.

5.5.3.2 Coincident Peak (CP) Demand Savings (kW)

To compute coincident peak (CP) demand savings, the per device demand savings is multiplied by the total number of devices for each event. The claimed achieved CP demand savings is the average kW savings across all events. Scaling the average kW savings by the EOY customer count and newly installed customer count yield EOY and incremental CP demand savings.

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

Achieved non-coincident peak savings represents the maximum event demand savings among FY 2018 events. End-of-year and incremental estimates of NCP savings were obtained by scaling the delivered NCP by EOY device count and newly installed devices respectively.

5.5.3.4 ERCOT 4CP Demand Savings (kW)

During the summer of 2017, three of the Nest and EnergyHub events coincided with ERCOT 4CP events, with a rate of success in hitting the event of 75%. Four of the Emerson and Honeywell events coincided with 4CP, with a success rate of 100%. To estimate the 4CP demand savings, we estimated kW savings for each event, selected the 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 devices at the end of FY 2018 and to the number devices added during FY 2018.

5.5.4 Impact Analysis Results

For BYOT DR programs, we present impacts in five sections:

1) Estimated per device kW and net kWh savings by thermostat brands during the summer 2017.
2) Estimated program impacts during the summer 2017 DR events.
3) End-of-year program capability based on program enrollment at the end of FY 2018.
4) End-of-year program capability based on incremental enrollment during FY 2018.
   This information is used for program benefit-cost analysis, consistent with the methods used for energy efficiency programs.
5) “Temperature bins” for EnergyHub and Emerson thermostats, for use in future evaluation activities.

5.5.4.1 Estimated per device kW and net kWh savings by thermostat brands

Table 5-20 summarizes per device kW and net kWh savings by thermostat brands in the summer 2017 BYOT program:

Table 5-20 Estimate per Device kW and Net kWh Savings by Thermostat Brands

Category	Average kW savings per device	Average net kWh savings per device per event
Nest	1.29	NA
EnergyHub	1.34	1.82
Honeywell	0.76	1.41
Emerson	0.84	1.19

5.5.4.2 Estimated Impacts during Summer 2017 DR Events

Event schedules are different for different thermostat brands. The number of events called ranged from 18 (EnergyHub) to 22 events (Nest & Honeywell) during the summer of 2017. The impacts of events ranged from 1,134 kW (the event on 6/14) to 15,734 kW (the event on 9/20), with the Nest thermostats group contributing most of the kW savings across all events. These demand reduction estimates are shown Figure 5-22.

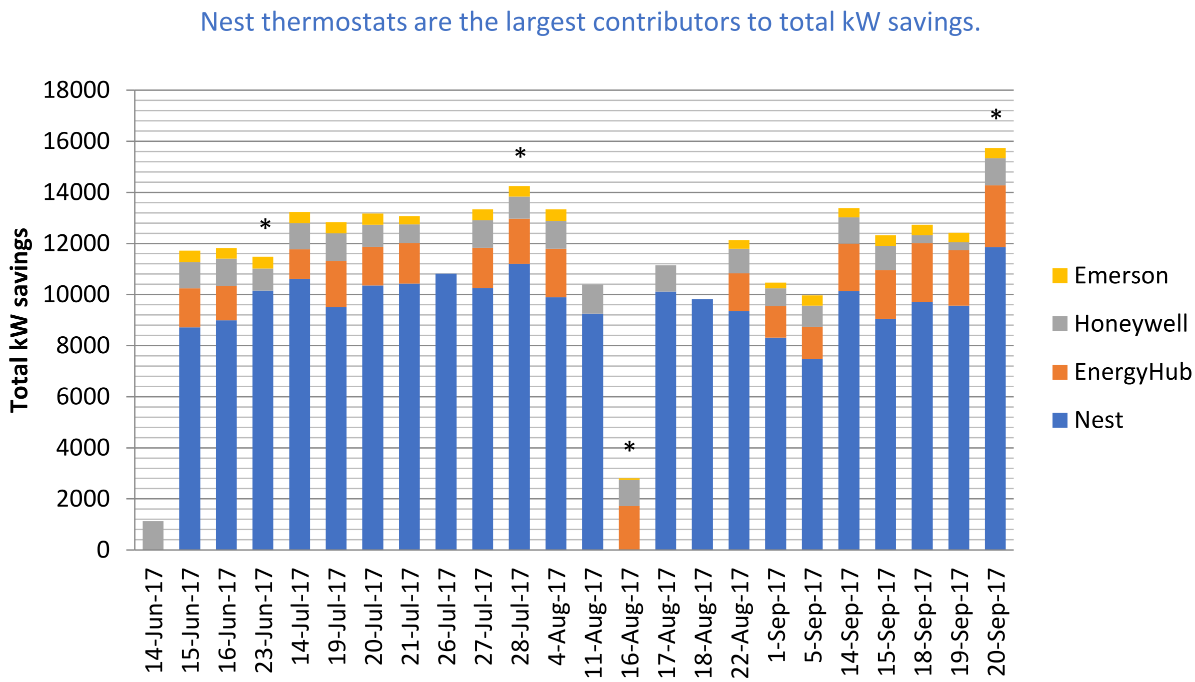


Figure 5-22: Bring Your Own Thermostat – Achieved Demand Reduction during summer 2017 DR Events

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

Table 5-21 shows estimated energy, peak demand, non-coincident peak demand, and ERCOT 4CP demand savings delivered by the program in FY 2018. For each type of thermostat, coincident peak demand savings are the average of estimated savings achieved across all events. ERCOT 4CP savings are the average estimated savings during ERCOT 4CP events, multiplied by success rate. Non-coincident peak savings are the highest savings achieved during any event.

Table 5-21: BYOT Gross Energy and Demand Savings – FY 2018 Delivered

Measure	Gross Energy Savings (kWh)	Gross CP Demand Savings (kW)	Gross NCP Demand Savings (kW)	Gross ERCOT 4CP Demand Savings (kW)
Nest	4,363,805[47]	9,800	11,851	8,301
EnergyHub	32,939	1,693	2,421	1,475
Honeywell[48]	37,115	917	1,134	957
Emerson[49]	8,397	384	471	335
Total	4,442,256	12,794	15,877	11,068

Rows may not sum to total due to rounding.

5.5.4.3 End-of-year Program Capability

End-of-year program capability is based on end-of-year enrollment and is shown in Table 5-22.

Table 5-22: BYOT Gross Energy and Demand Savings – End-of-year Capability

Measure	End-of-year Enrollment	Gross Energy Savings (kWh)	Gross CP Demand Savings (kW)	Gross NCP Demand Savings (kW)	Gross ERCOT 4CP Demand Savings (kW)
Nest	11,155	5,461,488	14,396	16,252	12,125
EnergyHub	2,441	64,017	3,276	4,261	2,761
Honeywell	1,340	41,497	1,025	1,268	1,070
Emerson	519	9,557	437	536	382
Total	15,455	5,576,559	19,134	22,265	16,338

Rows may not sum to total due to rounding.

5.5.4.4 Incremental Impacts

The incremental impacts used in benefit-cost analysis are based on gross incremental enrollment during the program year and are shown in Table 5-23.

[47] To calculate year-round energy savings from the BYOT Nest thermostats, estimated device count throughout FY 2018 is calculated by averaging device count at the start and end of FY 2018 – (6671 + 11155)/2.
[48] For Honeywell group, device count for each event was not available. Therefore, an average device count at the start and end of FY 2018 - (1057 + 1340)/2 is used to estimate the number of participating thermostats for all summer 2017 events.
[49] For Emerson group, device count for each event was not available. Therefore, an average device count at the start and end of FY 2018 - (393 + 519)/2 used to estimate the number of participating thermostats for all summer 2017 events.

Table 5-23: BYOT Gross Energy and Demand Savings – Incremental Impacts

Measure	Gross Incremental Enrollment	Gross Energy Savings (kWh)	Gross CP Demand Savings (kW)	Gross NCP Demand Savings (kW)	Gross ERCOT 4CP Demand Savings (kW)
Nest	4,484	2,195,366	5,787	6,533	4,874
EnergyHub	1,381	36,218	1,853	2,411	1,562
Honeywell	332	10,281	254	314	265
Emerson	126	2,320	106	130	93
Total	6,323	2,244,185	8,000	9,388	6,794

Rows may not sum to total due to rounding.

5.5.4.5 Temperature bin for EnergyHub and Emerson thermostats group

Temperature bins may serve as an expedited method for estimating savings in future years. Based on this year's panel data regression, Frontier generated the temperature bins for the per device savings of EnergyHub and Emerson thermostats shown in Table 5-24.

Table 5-24: Device Level Temperature Bins for EnergyHub and Emerson Thermostats

Temperature (°F)	kW savings per device for EnergyHub	kW savings per device for Emerson
90	1.01	0.53
91	1.05	0.55
92	1.09	0.57
93	1.13	0.59
94	1.17	0.61
95	1.21	0.63
96	1.25	0.66
97	1.29	0.68
98	1.33	0.70
99	1.37	0.72
100	1.41	0.74
101	1.45	0.76
102	1.49	0.78
103	1.53	0.80
104	1.57	0.82
105	1.61	0.85
106	1.65	0.87
107	1.69	0.89

Temperature (°F)	kW savings per device for EnergyHub	kW savings per device for Emerson
108	1.73	0.91
109	1.77	0.93
110	1.81	0.95
	EnergyHub Pre and Post Event Over consumption for kWh savings Calculation (unit: kW))	Emerson Pre and Post Event Over consumption for kWh savings Calculation (unit: kW))
precool:	0.34	-0.11
snapback:	0.89	0.42

For example, for a 2-hour 95°F event with a 1 hour pre-cool period, the kW savings estimate for an EnergyHub thermostat would be 1.21 kW. The net kWh savings estimate per device on this event would be 1.21 kW * 2 Hrs - (0.34 kW * 1 Hr) – (0.89 kW * 1Hr) = 1.19 kWh. Savings for the Emerson thermostat group can be estimated in similar manner.

5.5.1 Recommendations

Frontier provides the following recommendations for the BYOT program:

- For EnergyHub customers, up to 1 hour pre-cooling was included in cycling process in summer 2017 events. However, load began to take off 1-2 hours before pre-cooling for some of the events, judging from the load profile. The reason behind it needs to be investigated.
- The 51 kWh monthly energy savings per Nest household was estimated in FY 2016. This deemed savings might need to be revisited in the future.
- Regarding program cost effectiveness, BYOT is a better program, and CPS Energy could invest more in BYOT.

5.6 NEST DI (DIRECT INSTALL)

5.6.1 Overview

Nest DI (Direct Install) is a new program implemented in FY 2018. Starting in early summer 2017, Home Manager customers were gradually migrated to the Nest DI program. CPS Energy offers these customers free Nest(s) and free installation to replace the older Home Manager Consert devices in their home. After the customer has installed a Nest, customers are automatically enrolled in the Nest RHR (Rush Hour Rewards) in synchronization with BYOT Nest customers. As with BYOT customers, at the end of each September, a $30 bill credit will also be applied to customers’ bills.

5.6.2 Program Participation

By the end of FY 2018, 4596 Nest thermostats were installed in the Nest DI program. The device/household ratio was approximately 1.30. Therefore, approximately 3535 households were in this program by the end of FY 2018.

5.6.3 Savings Calculation Method

5.6.3.1 Per Device kW and kWh Savings

Since Nest DI thermostats are all incorporated in the Nest platform along with BYOT Nests, we directly used this year's BYOT Nest per device savings:

Table 5-25 Nest DI per Device Savings

Category	Savings per device
CP/Average per device kW savings	1.29 kW
NCP per device kW savings	1.46 kW
4CP per device kW savings	1.09 kW
Annual energy (kWh) per household savings	470.77 kWh[50]

5.6.3.2 Coincident Peak (CP) Demand Savings (kW)

To compute coincident peak (CP) demand savings, the per device demand savings is multiplied by the total number of devices for each event.[51] The claimed achieved CP demand savings is the average kW savings across all events. Scaling the average kW savings by the EOY customer count and newly installed customer count yield EOY and incremental CP demand savings. Since Nest DI is a new program in FY 2018, EOY customer count is equivalent to newly installed customer count. Therefore, EOY and incremental savings are identical.

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

Achieved non-coincident peak savings is based on the maximum event demand savings among FY 2018 events. Multiplying the NCP per device demand savings in Table 5-25 by the total number of devices in the summer of 2017 yields the total achieved NCP demand savings value. End-of-year and incremental estimates of NCP savings were obtained by scaling the delivered NCP to the EOY device count and newly installed devices respectively.

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[50] Nest thermostat monthly per household energy savings is estimated at 51kWh, with device/household = 1.3 in Nest DI program, annual household energy savings per device is estimated at 51*12/1.3 = 470.77 kWh.

[51] Only monthly device count is available for Nest DI in FY 2018. Therefore, we estimated participation device # for each event by averaging end of that month device # and end of pervious month device #. For example, for all the August events, we assume the participation number would be: (275 + 723) / 2 = 499, where 275 is the device # by the end of July and 723 is the device # by the end of August.

5.6.3.4 ERCOT 4CP Demand Savings (kW)

During the summer of 2017, three of the Nest DI events coincided with ERCOT 4CP events, with a rate of success in hitting the event of 75%. To estimate ERCOT 4CP demand savings, we estimated kW savings for each event, selected the 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 devices at the end of FY 2018 and to the number of new devices added during FY 2018.

5.6.4 Impact Analysis Results

For Nest DI program, we present impacts in three sections:

1) Estimated program impacts during summer 2017 DR events.

2) End-of-year program capability based on program enrollment at the end of FY 2018.

3) End-of-year program capability based on incremental enrollment during FY 2018.
This information is used for program benefit-cost analysis, consistent with the methods used for energy efficiency programs.

5.6.4.1 Estimated Impacts During Summer 2017 DR Events

Like BYOT Nest, 22 events were called in summer 2017 for the Nest DI program. Event impacts ranged from 1.24 kW (on 6/15) to 1,416 kW (on 9/20). These demand reduction estimates are shown in Figure 5-23.

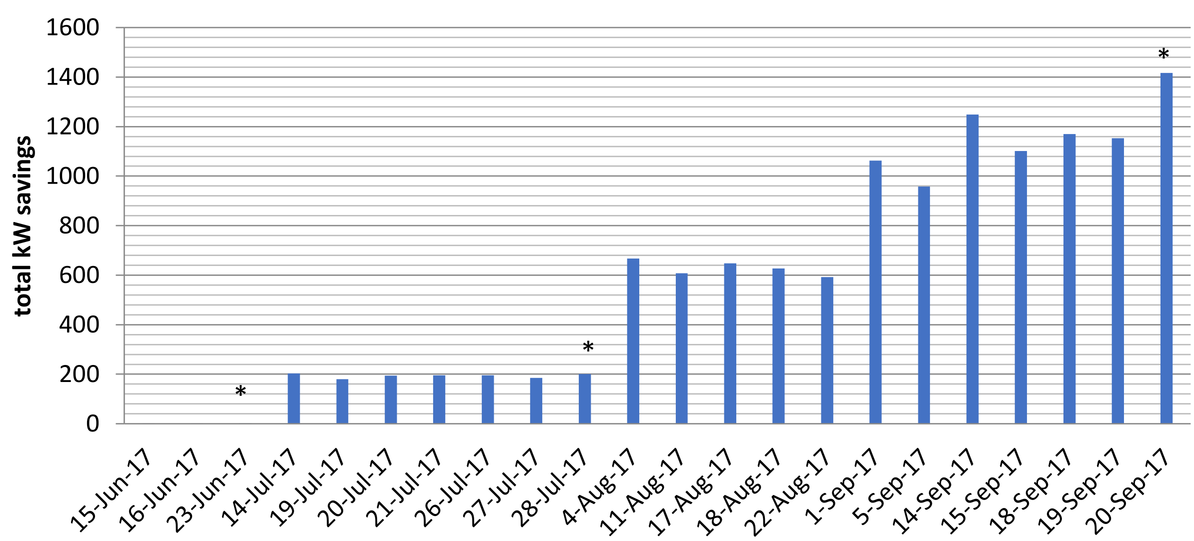

Figure 5-23 Nest DI – Achieved Demand Reduction during summer 2017 DR Events

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

Table 5-26 shows estimated energy, peak demand, non-coincident peak demand, and ERCOT 4CP demand savings delivered by the program in FY 2018.

Table 5-26 Nest DI Gross Energy and Demand Savings – FY 2018 Delivered

Measure	Gross Energy Savings (kWh)	Gross CP Demand Savings (kW)	Gross NCP Demand Savings (kW)	Gross ERCOT 4CP Demand Savings (kW)
Nest DI	676,142	573	1,416	405

5.6.4.2 End-of-year Program Capability

End-of-year program capability is based on end-of-year enrollment and is shown in Table 5-27.

Table 5-27 Nest DI Gross Energy and Demand Savings – End-of-year Capability

Measure	End-of-year Enrollment	Gross Energy Savings (kWh)	Gross CP Demand Savings (kW)	Gross NCP Demand Savings (kW)	Gross ERCOT 4CP Demand Savings (kW)
Nest DI	4,596	2,163,655	5,931	6,748	4,996

5.6.4.3 Incremental Impacts

Incremental impacts used in benefit-cost analysis are based on gross incremental enrollment during the program year. Since Nest DI is a new program started in FY 2018, all the EOY device counts are new installations. The incremental impacts are the same as EOY impacts.

Table 5-28 Nest DI Gross Energy and Demand Savings – Incremental Impacts

Measure	Gross Incremental Enrollment	Gross Energy Savings (kWh)	Gross CP Demand Savings (kW)	Gross NCP Demand Savings (kW)	Gross ERCOT 4CP Demand Savings (kW)
Nest DI	4,596	2,163,655	5,931	6,748	4,996

5.7 REDUCE MY USE/BEHAVIORAL DEMAND RESPONSE (BDR)

5.7.1 Overview

CPS Energy partnered with Opower to implement a pilot behavioral demand response (BDR) program for residential customers beginning in the summer of 2017. This program was implemented as an opt-out randomized controlled trial (RCT). Participating households were all equipped with AMI meters, and did not participate in other CPS Energy DR programs.

Participants received a welcome letter before the program started. One day before each Reduce My Use event, participants received a notification message through email and/or a phone call. This notification also contained information explaining what a peak day is and personalized energy conservation tips.

After each event, customers received a follow-up call and/or email with personalized customer performance feedback to participants.

In the summer of 2017 one event was successfully called.[52] This event lasted 2 hours, from 3:30 p.m. to 5:30 p.m. on 09/20/2017.

5.7.2 Program Participation

In summer 2017, 103,689 households participated in the treatment group and 23,342 households in the control group. Among all the treatment and control group participants combined, most participants are single house dwellers. An overall population breakdown by dwelling type is shown in Figure 5-24.

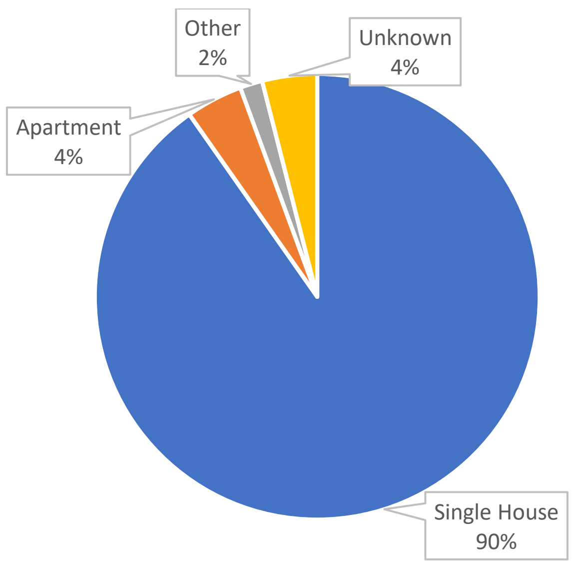

Figure 5-24 Reduce My Use BDR Program Overall Population Breakdown by Dwelling Type

5.7.3 Savings Calculation Method

5.7.3.1 Per Device kW and kWh Savings

CPS Energy provided Frontier with 15-minute interval AMI meter level data from 06/01/2017 to 09/30/2017 for a sample of participants. The sample was randomly selected, with 2,477 households in the treatment group and 2,466 in the control group. The treatment and control sample breakdown by dwelling type is shown in Figure 5-25.

The sample selected is a representative sample based on dwelling type.

[52] Another event was planned on 07/28/2017, however we did not include that in this report due to technical errors that prevented notifications from being sent out successfully on the prior day.

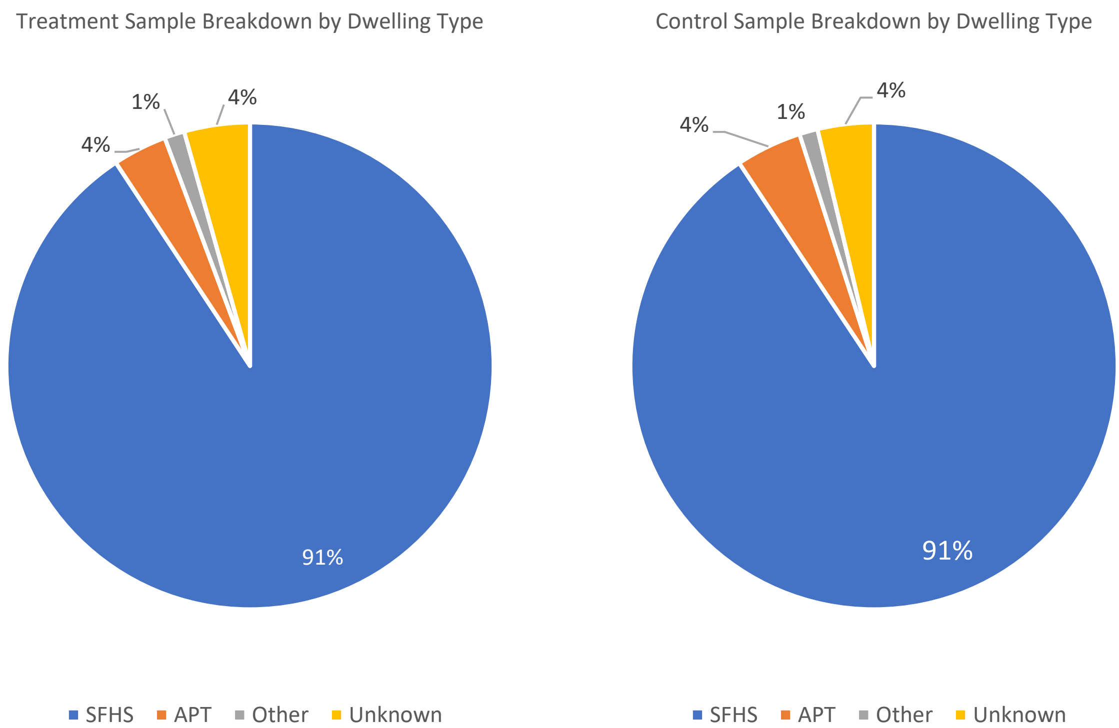

Figure 5-25 Treatment and Control Sample Breakdown by Dwelling Type

The composition of the treatment and control samples are almost the same with respect to the types of dwellings, and both are similar to the entire population's dwelling type composition. This indicates that the sample selected is a representative sample with respect to dwelling type.

Frontier employed Difference-in-Difference (DID) model to calculate per household kW savings. Since there is a control group in this program, difference-in-difference (DID) model fits the situation well. DID model can be used when outcomes are observed for two groups for two time periods. One of the groups is exposed to a treatment in the second period but not in the first period. The second group (control group) is not exposed to the treatment during either period. The average change in the control group is subtracted from the average change in the treatment group. DID model can also be illustrated using the equation below:

$$15\text{-}minute\ kWh_{i,t} = \alpha_0 + \beta_0 * pre\text{-}or\text{-}post_t + \alpha_1 * trt\text{-}or\text{-}cntl_i + \beta_1 * pre\text{-}or\text{-}post_t * trt\text{-}or\text{-}cntl_i + \varepsilon$$

In the equation above:

15-minute kWh: 15-minute kWh consumption for each AMI account/household

Pre-or-post: A dummy variable, indicating if it's an event period (15:30 – 17:30, 09/20/2017, with a temperature of at least 97.5°F) or a pre-event period (15:30 – 17:30, 09/14/2017). It is preferred to choose a day similar to the event day as the pre-event day to best approximate what could have happened on an event day had there been no events. 09/14/2017 was selected because it's a day that is close enough to the event day and has a similar temperature during 15:30 – 17:30 (96.4°F).

Trt-or-cntrl: A dummy variable, indicating if it belongs in a treatment group or control group

The estimated 15-minute kWh savings is -β_1. Therefore, the per household kW savings estimate would be –β_1 * 4. We did not assume load shifting right before or after event this year. Therefore, the per household kWh savings estimate is –β_1 * 4 * 2 (Hrs).

5.7.3.2 Coincident Peak (CP) Demand Savings (kW)

To compute coincident peak (CP) demand savings, kW savings per household is multiplied by the total number of treatment group on the 09/20/2017 event. Since participants are recruited each year, the EOY and incremental savings are identical to the FY 2018 achieved savings.

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

Achieved non-coincident peak savings represent selected the maximum event demand savings among FY 2018 events. Only one event was successfully called in FY 2018. Therefore, NCP kW savings is equivalent to CP kW savings.

5.7.3.4 ERCOT 4CP Demand Savings (kW)

Only one event was called on 09/20/2017, which happened to be a 4CP day. Therefore, the success rate of hitting 4CP is 25%. To estimate ERCOT 4CP demand savings, we multiplied the kW savings result on 09/20/2017 by the ERCOT 4CP success rate.

5.7.4 Impact Analysis Results

For the BDR program, we present impacts in three sections:

1) Estimated program impacts during summer 2017 DR events.
2) End-of-year program capability based on program enrollment at the end of FY 2018.
3) End-of-year program capability based on incremental enrollment during FY 2018.
   This information is used for program benefit-cost analysis, consistent with the methods used for energy efficiency programs.

5.7.4.1 Estimated Impacts During Summer 2017 DR Events

On 09/20/2017, the estimated kW savings per household is 0.11kW, with program level kW savings estimate of 11,532kW. Per household savings for single family is estimated at 0.12kW, and 0.11kW[53] per household for apartment dwellers. The average load profile per household for the treatment versus the control sample on 09/20/2017 is shown in Figure 5-26.

[53] The 0.11kW savings estimate for apartment category is not statistically significant, i.e., we do not have high confidence that apartment dwellers actually achieved savings. The 0.11kW average apartment household savings estimate for apartment category has a p-value = 0.36 which means that there's a 36% chance of observing savings of 0.11kW/household or higher even in the absence of the program.

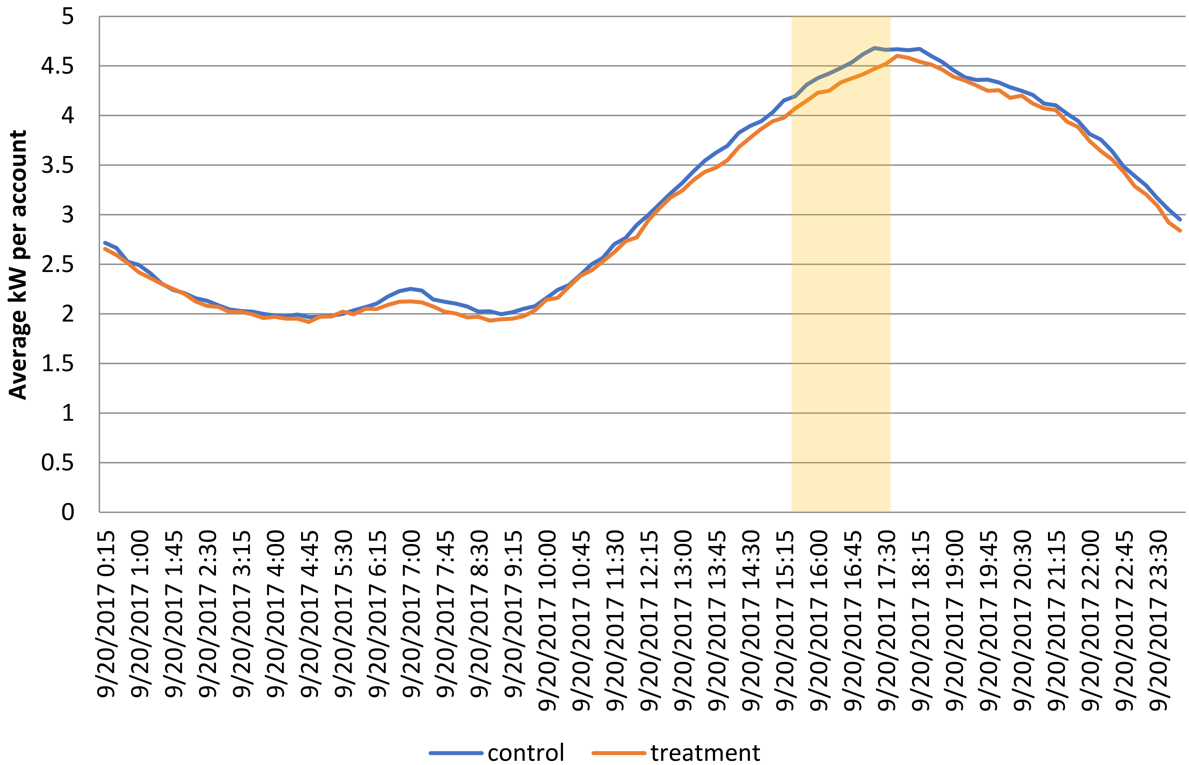

Figure 5-26 09/20/2017 Load Profile for Treatment vs Control Sample

The table below shows estimated energy, peak demand, non-coincident peak demand, and ERCOT 4CP demand savings delivered by the program in FY 2018.

Table 5-29 Reduce My Use (BDR) Program Energy and Demand Savings – FY 2018 Delivered

Measure	Energy Savings (kWh)	Peak Demand Savings (kW)	Non-Coinc. Demand Savings (kW)	ERCOT 4CP Demand Reduction (kW)
Total	23,064	11,532	11,532	2,883

5.7.4.2 End-of-year Program Capability

End-of-year program capability is based on end-of-year enrollment and are shown in the Table 5-30. These values are the same as the achieved savings.

Table 5-30 Reduce My Use (BDR) Program Energy and Demand Savings – End of FY 2018

Measure	End-of-year Enrollment	Energy Savings (kWh)	Peak Demand Savings (kW)	Non-Coinc. Demand Savings (kW)	ERCOT 4CP Demand Reduction (kW)
Total	103,689	23,064	11,532	11,532	2,883

5.7.4.3 Incremental Impacts

Incremental impacts used in benefit-cost analysis are based on gross incremental enrollment during the program year. In this case, incremental impacts are the same as the achieved and EOY impacts.

Table 5-31 Reduce My Use (BDR) Program 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 Reduction (kW)
Total	103,689	23,064	11,532	11,532	2,883

5.7.5 Recommendations

Frontier provides the following recommendations for the BDR program:

- Participation incentives, such as for highest ranking among the neighborhood, might be explored in the future. New incentives might encourage incremental changes in customers' consumption behavior.
- Consumption behaviors right before and after each event may be investigated in the coming year.
- Consumption data for the entire population may be used next year to further reduce estimation error.

6. SOLAR ENERGY PROGRAMS

6.1 SUMMARY OF SOLAR ENERGY IMPACTS

CPS Energy offered the following solar energy programs in FY 2017:

- Solar Rebate – Residential and Commercial - offers incentives for the installation of both solar photovoltaic systems and solar water heaters.
- SolarHostSA Pilot - offers residential and commercial customers a bill credit for hosting a third party owned solar energy system on their rooftop.

The contribution of each solar energy program to peak demand, non-coincident peak demand, and energy savings are shown the follow figures.

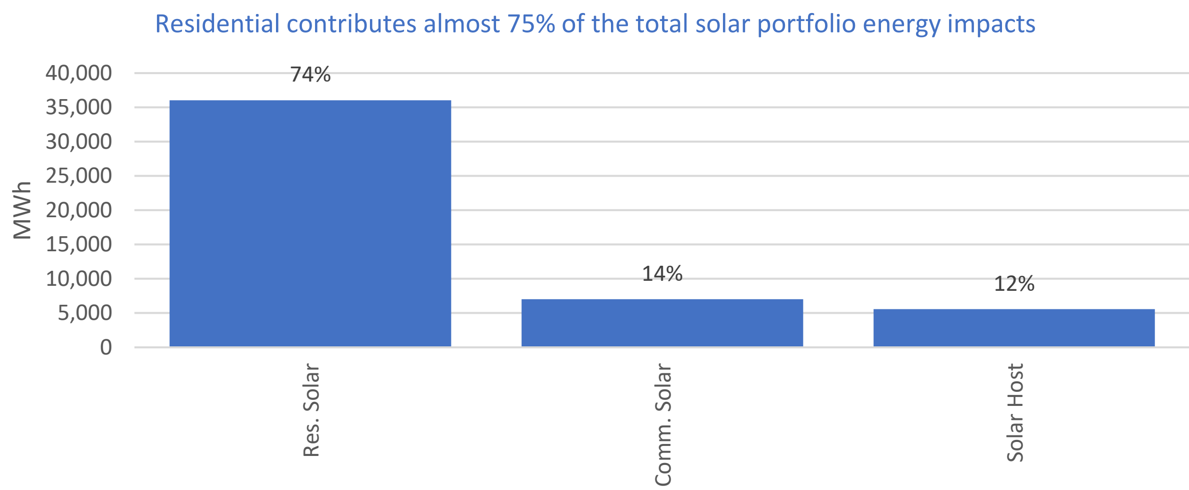

Figure 6-1: Summary of Solar Energy Impacts – Energy (kWh) by Program

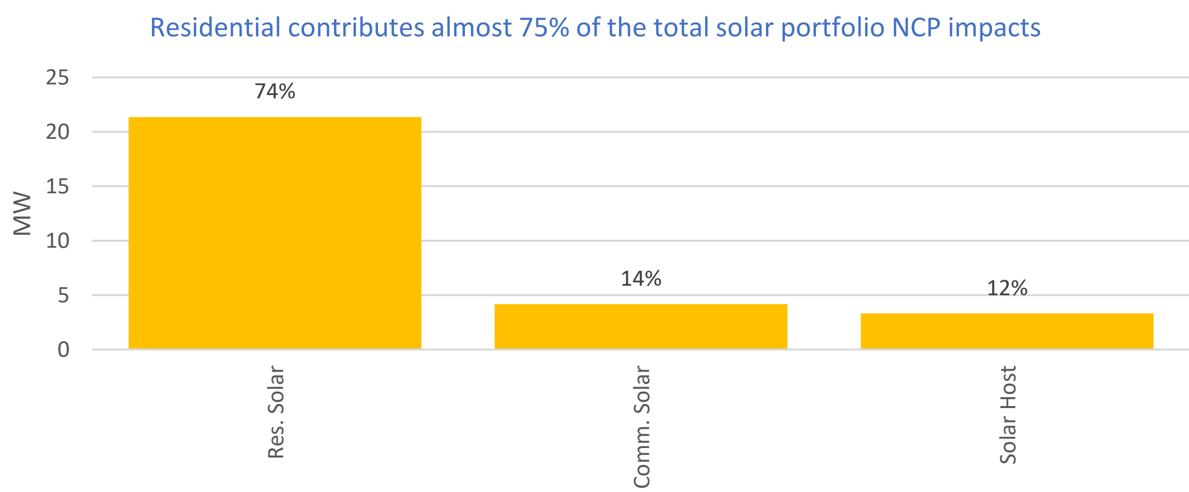

Figure 6-2: Summary of Solar Energy Impacts – Non-Coincident Peak Demand (kW) by Program

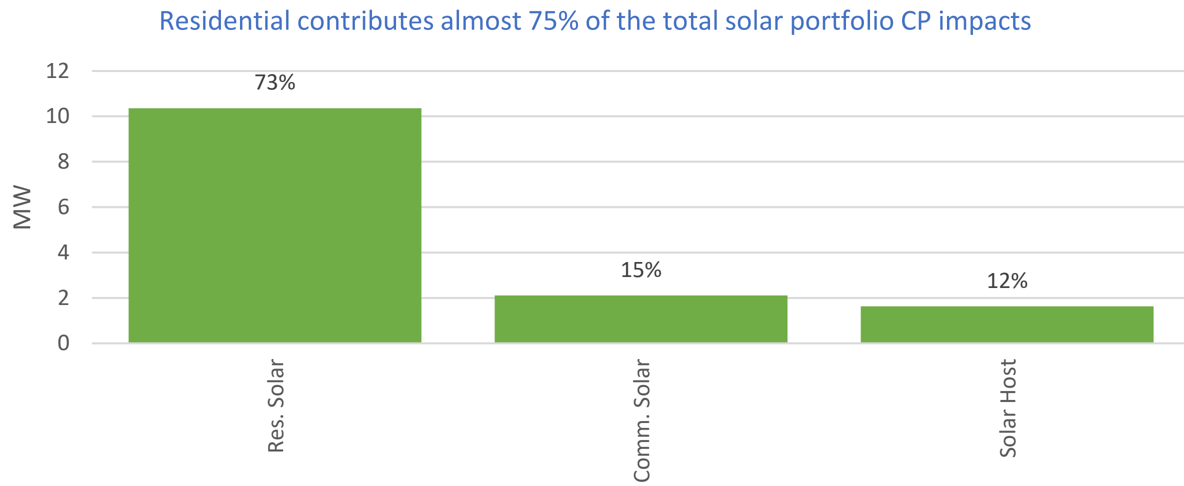

Figure 6-3: Summary of Solar Energy Impacts – Peak Demand (kW) by Program

6.2 SOLAR REBATE - RESIDENTIAL PROGRAM

6.2.1 Overview

CPS Energy offers rebates for residential solar photovoltaic (PV) systems. In December 2015, CPS Energy announced a commitment of $30 million to its solar rebate programs, to be available in three tranches to residential and commercial solar projects alike:

- 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
- Tranche 3 – last $10 million at a Rebate Level of $0.80 per watt

Starting in April 2017, CPS Energy allocated an additional $15 million in rebates - $9 million for residential and $6 million for commercial solar projects. The base rebate is $0.60 per watt with an additional $0.10 per watt for systems that use locally-manufactured components:

- $0.60/AC Watt base incentive
- $0.08/AC Watt premium for local modules
- $0.02/AC Watt premium for local inverters

The current rebate limit is $25,000 for residential projects. Rebates are also capped at 50% of project cost. The rebate for non-local installers is reduced to 75% of the local installer rebate amount, starting at $0.45 per ac watt. All residential solar PV systems are required to be installed by a CPS Energy-registered contractor. Rebates are not available for leased equipment.

Throughout FY 2018, solar projects were rebated based on the applicable rebate tier at the time of application. During FY 2018, some solar rebates were paid at higher rebate levels. These were projects that applied for and were approved for solar rebates at earlier dates. Table 6-1 presents a summary of the number and capacity of residential solar projects at various rebate levels paid during FY 2018.

Table 6-1: Residential Solar Rebates in FY 2018

Rebate Level ($/Wac)	Number of Projects	Capacity (kWdc)	Rebated Amount
<$0.60	5	39	$16,650
$0.60 - <$0.70	1,643	12,789	$6,612,522
$0.70 - <$0.80	4	29	$18,020
$0.80 - <$1.00	1,435	11,248	$7,559,644
$1.00 or greater	44	306	$280,757
Total[54]	3,131	24,410	$14,487,593

All systems are required to be interconnected to the CPS Energy distribution system on the customer's side of the meter. Net metering is available to systems less than 25 kW per CPS Energy's ES Tariff. Systems must be permitted, pass all required inspections, and comply with CPS Energy's requirements for interconnection.

In FY 2018, 3,131 residential solar PV systems totaling 24,410 kWdc were installed, and $14.5 million in rebates distributed. The average residential solar PV system size was 7.80 kWdc. The figure below summarizes the residential solar PV program history in terms of capacity installed, average system prices and rebate levels annually.

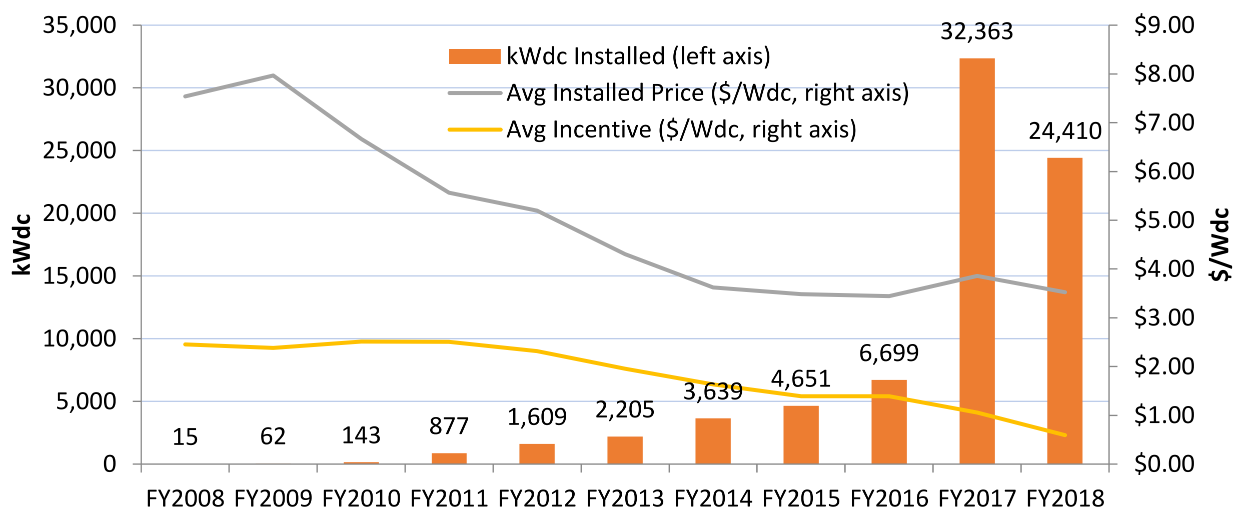

Figure 6-4: Residential Solar PV Program History - Annual Capacity Installed, Average System Price, and Average Rebate Levels

[54] The sum of the individual measures may not match the total due to the individual measure savings having been rounded to the nearest whole number.

6.2.2 Savings Calculation Methods

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

6.2.2.1 Energy Savings (kWh)

Energy savings estimates were generated via a deemed savings methodology as described in the *CPS Energy Guidebook* provided by Frontier. The method assumes an average production index of 1,402 kWh per kWdc installed among a variety of residential PV systems at various tilts and orientations.

The method is based on 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.[55] The representative fleet was constructed from a weighted average of 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.

6.2.2.2 Coincident Peak (CP) Demand Savings (kW)

Frontier's approach to estimating peak demand savings utilizes a deemed savings factor of 0.39 kW of coincident peak savings per kWdc installed and is described in the *CPS Energy Guidebook*.

The *CPS Energy Guidebook* methodology utilizes 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 Energy 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.

6.2.2.3 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 in any hour. The *CPS Energy Guidebook* presents a deemed value of 0.804 kW of NCP savings per kWdc installed.

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[55] 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 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.

6.2.2.4 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 during ERCOT 4CP intervals. The *CPS Energy Guidebook* presents a deemed value of 0.351 kW of ERCOT 4CP savings per kWdc installed.

6.2.3 Results and Recommendations

The gross energy and demand savings for the Residential Solar Rebate are presented in Table 6-2.

Table 6-2: Residential Solar Rebate Gross Energy and Demand Savings

Measure	Gross Energy Savings (kWh)	Gross CP Demand Savings (kW)	Gross NCP Demand Savings (kW)	Gross ERCOT 4CP Demand Savings (kW)
Residential Solar PV	34,222,890	9,520	19,626	8,568

Frontier's recommendations pertaining to an extended solar 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.
- Additional data on each solar energy installation should be captured in CPS Energy's program database, including data on the module type, capacity and quantity; and on the tilt, orientation and shading level of each array.
- CPS Energy should ensure that interconnection inspectors and/or M&V contractors verify installed equipment, as well as array tilt and orientation data, in addition to ensuring interconnection requirements are met (such as performing a backfeed test) when they visit the site, at least for larger installations and for a randomly-selected sample of smaller installations.
- CPS Energy has recently began installing AMI meters at solar customers' premises. 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.

6.3 SOLAR REBATE – COMMERCIAL PROGRAM

6.3.1 Overview

CPS Energy offers rebates for solar photovoltaic (PV) systems installed on commercial buildings. In December 2015, CPS Energy announced a commitment of $30 million to its solar rebate programs, to be available in three tranches to residential and commercial solar projects alike:

- 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
- Tranche 3 – last $10 million at a Rebate Level of $0.80 per watt

Starting in April 2017, CPS Energy allocated an additional $15 million - $9 million for residential and $6 million for commercial solar projects. The base rebate is $0.60 per watt with an additional $0.10 per watt for systems that use locally-manufactured components:

- $0.60/AC Watt base incentive
- $0.08/AC Watt premium for local modules
- $0.02/AC Watt premium for local inverters

The current rebate limit is $80,000 for commercial projects. Rebates are also capped at 50% of project cost. The rebate for non-local installers is reduced to 75% of the local installer rebate amount, starting at $0.45 per ac watt, applicable to both residential and commercial projects. Rebates are not available for leased equipment.

Throughout FY 2018, solar projects were rebated based on the applicable rebate tier at the time of application. During FY 2018, some solar rebates were paid at higher rebate levels. These were projects that applied for and were approved for solar rebates at earlier dates. Table 6-3 presents a summary of the number and capacity of commercial and school solar projects at various rebate levels awarded during FY 2018.

Table 6-3. Commercial and School Solar Rebates in FY 2018

Rebate Level ($/Wac)	Number of Projects	Capacity (kWdc)	Rebated Amount
<$0.60	3	638	$166,317
$0.60 - <$0.70	16	878	$495,099
$0.70 - <$0.80	2	244	$159,400
$0.80 - <$1.00	12	521	$393,535
$1.00 or greater	63	2,523	$2,271,288
Total	96	4,805	$3,485,639

Rows may not sum to total due to rounding.

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

In FY 2018, 96 commercial solar PV systems totaling 4,805 kWdc were installed, and $3.5 million in rebates distributed. The average commercial solar PV system size was 50 kWdc. The figure below summarizes the commercial solar PV program history in terms of capacity installed, average system prices and rebate levels annually.

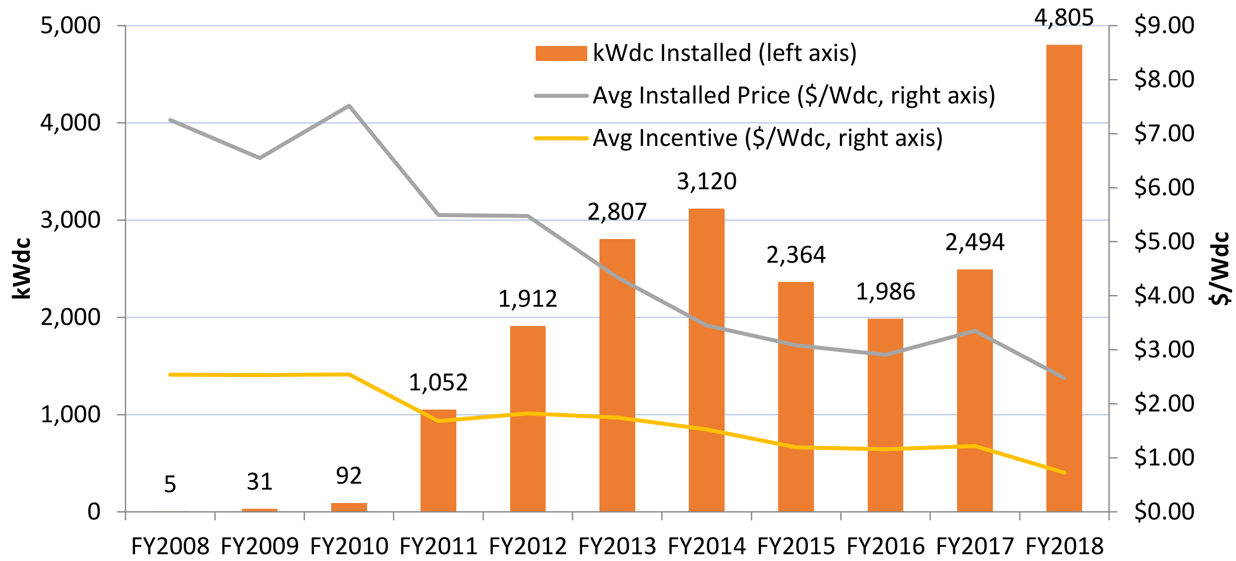

Figure 6-5: Solar Rebate – Commercial Program History: Annual Capacity Installed, Average System Price, and Average Rebate Levels

6.3.2 Savings Calculation Method

The following subsections describe Frontier's approach to estimating savings for commercial and school PV installations.

6.3.2.1 Energy Savings (kWh)

Energy savings estimates were generated via a deemed savings methodology as described in the *CPS Energy Guidebook* provided by Frontier. The method assumes an average production index of 1,385 kWh per kWdc installed among a variety of commercial PV systems at various tilts and orientations.

The method is based on modeling the annual energy production from a representative fleet of commercial 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.[56] The representative fleet was constructed from a weighted average of 7 different array tilt and orientation combinations, with weightings conforming to expected commercial/school 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.

[56] 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 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.

6.3.2.2 Coincident Peak (CP) Demand Savings (kW)

Frontier's approach to estimating peak demand savings utilizes a deemed savings factor of 0.403 kW of coincident peak savings per kWdc installed and is described in the *CPS Energy Guidebook*.

The *CPS Energy Guidebook* methodology utilizes a probabilistic analysis based on modeled system performance during the 20 highest probability summer peak hours. 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 Energy zone. Estimates of CPS Energy's commercial 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.

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

Non-coincident demand savings represent the maximum kW produced by the modeled representative fleet of commercial PV systems installed in any hour. *CPS Energy Guidebook* presents a deemed value of 0.797 kW of NCP savings per kWdc installed.

6.3.2.4 ERCOT 4CP Demand Savings (kW)

The ERCOT 4CP demand savings estimate represents the average estimated demand savings produced by the modeled representative fleet of commercial PV systems installed during ERCOT 4CP intervals. The *CPS Energy Guidebook* presents a deemed value of 0.351 kW of ERCOT 4CP savings per kWdc installed.

6.3.3 Results and Recommendations

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

Table 6-4: Solar Rebate – 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 Solar PV	6,654,482	1,936	3,829	1,686

Frontier's recommendations for the Commercial Solar Rebate are equivalent to those offered for the Residential Solar Rebate, and are outlined in Section 6.2.3.

6.4 SOLARHOST SA PROGRAM

6.4.1 Overview

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. Unlike typical customer-owned residential and commercial PV systems, which are interconnected on the customer's side of the utility meter and reduce a customer's metered demand and energy consumption, these systems inject energy directly onto the CPS Energy distribution system. CPS Energy pays the developer a contracted price for energy generated from the systems, and in addition credits host customers 3 cents/kWh generated for the use of their rooftops for this purpose.

The SolarHostSA program thus works as a long-term generation contract for solar energy that is produced locally, on the distribution system. An advantage of the program design is that it enables customers who otherwise could not afford to make an investment in solar PV the opportunity to host such generators and to earn financial rewards for doing so. All installed systems are directly metered by CPS Energy.

By the end of FY 2018, the SolarHostSA program had resulted in the installation of 5,136 kWdc of solar capacity on 592 local rooftops, including additions of 3,793 kWdc at 392 rooftops in FY 2018. A few additional installations are continuing to achieve the program goal of 5MWac. The figure below shows the cumulative capacity of installations over the past two program years.

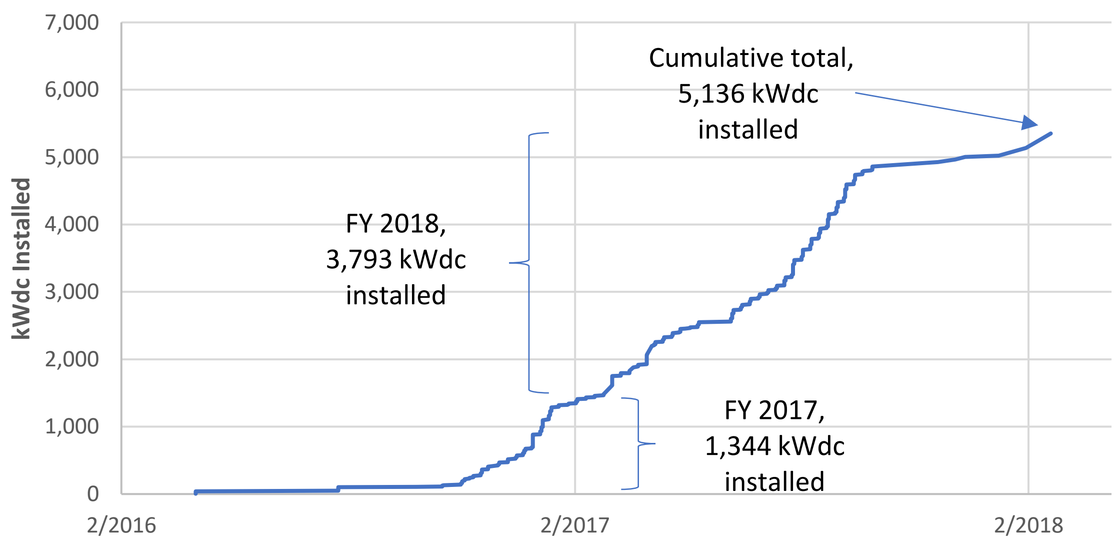

Figure 6-6: SolarHostSA Program - Cumulative Capacity Installed by Fiscal Year

6.4.2 Savings Calculation Methods

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

6.4.2.1 Energy Savings (kWh)

All systems installed via the SolarHostSA program in FY 2018 were hosted by residential and commercial customers on residential and commercial rooftops. Therefore, energy savings estimates were generated via the residential and commercial solar deemed savings methodology as described in the *CPS Energy Guidebook* provided by Frontier. The method assumes an average production index of 1,402 kWh per kWdc installed for residential, and 1,385 kWh per kWdc installed for commercial, assuming a distribution of PV systems at various tilts and orientations.

6.4.2.2 Coincident Peak (CP) Demand Savings (kW)

Frontier's approach to estimating peak demand savings utilizes a residential solar deemed savings factor of 0.39 kW, and a commercial deemed savings factor of 0.403, of coincident peak savings per kWdc installed and is described in the *CPS Energy Guidebook*.

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

Non-coincident demand savings represent the maximum kW produced by the modeled representative fleet of PV systems installed in FY 2017 in any hour. The *CPS Energy Guidebook* presents a deemed value of 0.804 kW of NCP savings per kWdc installed for residential solar systems, and a deemed value of 0.797 kW of NCP savings per kWdc installed for commercial solar systems.

6.4.2.4 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 2017 during ERCOT 4CP intervals from 2011-2015. The *CPS Energy Guidebook* presents a deemed value of 0.351 kW of ERCOT 4CP savings per kWdc installed for residential and commercial solar systems.

6.4.3 Results and Recommendations

The gross energy and demand savings for the FY 2018 incremental additions to the SolarHostSA program are presented in Table 6-2. These represent the estimated annual energy and demand savings that would have been produced had all systems installed during FY 2018 been operational throughout the fiscal year, and is consistent with how savings are estimated for all energy efficiency programs.

Table 6-5: SolarHostSA Gross Energy and Demand Savings

Measure	Gross Energy Savings (kWh)	Gross CP Demand Savings (kW)	Gross NCP Demand Savings (kW)	Gross ERCOT 4CP Demand Savings (kW)
SolarHost SA	5,298,477	1,494	3,042	1,331

6.5 ROOFLESS SOLAR 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 larger "community" solar installation elsewhere and see the benefits monthly on their electric bill.

In FY 2017, CPS Energy contracted with a developer to build a 1,212.6 kWdc single-axis tracking solar photovoltaic system at a site south east of the San Antonio urban core, and provided the developer with a solar rebate designed to be roughly equivalent to those offered in the residential and commercial solar rebate programs. The developer, in turn, passed these rebates on to customers who purchased shares of the community solar system from the developer.

The community solar system became commercially operational on August 26, 2016, with 245 CPS Energy customers owning shares. CPS Energy monitors production from the community system, and offers bill credits to participating customers designed to approximate the value customers would have received had the generation occurred behind the customer's meter, less 15% held in escrow to pay for operations and maintenance on the community solar system.

Costs and savings for this program were credited in the FY 2017 evaluation. No additional generation was added to the program in FY 2018. Therefore, no incremental savings are evaluated in this report.

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 5.08%. 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 8.15%.

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, except for 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 2.25.

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

1. Cost of Saved Energy (includes DR) ($/kWh) = $0.0372
2. Reduction in Revenue Requirements (includes DR) = $118,208,161
3. Benefit-Cost Ratio = 2.25

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

Table 7-1: FY 2018 Net Portfolio Impacts and Cost-Effectiveness

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	Rebate $	Admin and Marketing $	Total Program $	Program Administrator Benefit-Cost Ratio
Weatherization Program										
Weatherization	100%	15,261,975	6,552	15,775	6,201	$15,994,756	$16,969,245	$1,546,895	$18,516,140	0.86
Energy Efficiency Programs										
CPSE Legacy Residential HVAC	99%	1,676	1	1	1	$1,998	$1,140	$24	$1,164	1.72
Residential HVAC	95%	15,161,650	6,429	6,572	5,515	$16,421,301	$4,259,686	$109,267	$4,368,954	3.76
Home Efficiency	93%	3,209,782	1,336	2,606	1,116	$3,873,710	$1,362,019	$33,497	$1,395,516	2.78
CPSE Legacy New Homes	100%	114,067	66	101	80	$205,791	$131,300	$2,836	$134,136	1.53
New Home Construction	100%	990,436	577	816	666	$1,769,741	$1,326,225	$32,623	$1,358,848	1.30
Retail Channel Partnerships	77%	11,625,723	1,168	5,786	1,830	$7,485,707	$3,063,740	$74,969	$3,138,709	2.38
AC/Duct Tune-Up	95%	151,493	54	69	51	$98,176	$100,337	$2,417	$102,754	0.96
Energy Savings Through Schools	95%	1,734,151	106	608	128	$611,566	$523,495	$12,954	$536,449	1.14
Home Energy Assessments	84%	6,510,930	604	2,825	884	$3,626,892	$4,324,332	$105,732	$4,430,064	0.82
Multifamily	92%	7,392,774	784	2,638	1,000	$3,672,265	$1,767,084	$42,949	$1,810,033	2.03
Cool Roof	100%	12,780	5	6	4	$12,477	$8,458	$19,877	$28,335	0.44
Residential Subtotal		46,905,461	11,130	22,028	11,276	$37,779,624	$16,867,815	$437,145	$17,304,961	2.18

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	Rebate $	Admin and Marketing $	Total Program $	Program Administrator Benefit-Cost Ratio
Energy Efficiency Programs										
CPSE Legacy Lighting	96%	55,666,401	7,326	9,125	7,426	$30,087,051	$8,835,129	$273,104	$9,108,233	3.30
CPSE Legacy Commercial HVAC	96%	184,406	35	39	38	$165,926	$153,275	$7,540	$160,815	1.03
CPSE Legacy Commercial Custom	96%	20,881	74	70	63	$158,243	$15,445	$1,676	$17,121	9.24
C&I Solutions	96%	39,267,943	7,235	10,368	6,657	$20,526,626	$5,769,623	$179,495	$5,949,118	3.45
Schools & Institutions	96%	12,082,465	2,012	3,623	1,897	$5,613,745	$2,468,233	$74,660	$2,542,893	2.21
Small Business Solutions	95%	8,773,980	1,400	2,137	1,401	$4,717,343	$1,529,714	$47,099	$1,576,813	2.99
Whole Building Optimization	96%	3,008,363	414	400	435	$405,941	$644,884	$19,174	$664,058	0.61
Commercial Subtotal		119,004,438	18,497	25,763	17,916	$61,674,874	$19,416,303	$602,748	$20,019,051	3.08
Energy Efficiency Subtotal		165,909,899	29,627	47,791	29,192	$99,454,497	$36,284,118	$1,039,893	$37,324,012	2.66
Demand Response Programs										
C&I DR	100%	3,143,263	71,574	89,823	54,394	$9,615,079	$4,119,614	$130,101	$4,249,715	2.26
Auto DR	100%	272,075	7,881	9,703	7,207	$1,110,815	$637,961	$19,493	$657,454	4.37
Smart Thermostat	100%	1,112,260	32,179	44,157	35,431	$3,905,102	$2,565,728	$82,914	$2,648,642	3.11
Home Manager	100%	453,946	20,682	24,539	21,851	$0	$1,590,347	$160,817	$1,751,164	0.00
BYOT	100%	6,071,376	20,832	24,241	17,788	$10,850,277	$1,465,579	$37,919	$1,503,498	5.09
Nest DI	100%	2,355,640	6,457	7,347	5,439	$8,242,697	$2,723,900	$59,440	$2,783,340	2.89
Reduce My Use (Behavioral DR)	100%	25,111	12,555	12,555	3,139	$1,317,787	$450,000	$11,825	$461,825	2.85
Demand Response Subtotal		13,433,670	172,160	212,364	145,249	$35,041,758	$13,553,129	$502,509	$14,055,638	3.08

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	Rebate $	Admin and Marketing $	Total Program $	Program Administrator Benefit-Cost Ratio
Renewable Energy Programs										
Res. Solar Rebates	100%	36,054,456	10,365	21,367	9,328	$43,348,890	$15,274,749	$557,176	$15,831,925	2.74
Comm. Solar Rebates	100%	7,010,621	2,108	4,169	1,836	$8,596,384	$3,538,621	$128,349	$3,666,970	2.34
Solar Host SA	100%	5,582,045	1,626	3,311	1,449	$5,362,470	$0	$337,869	$337,869	0.93
Solar Energy Subtotal		48,647,123	14,099	28,848	12,614	$57,307,743	$18,813,370	$1,023,394	$19,836,764	2.27
Grand Total		243,252,666	222,437	304,778	193,256	$207,798,754	$85,619,861	$4,112,691	$89,732,554	2.25

* Home Manager did not have any incremental participation. Therefore, no PACT score was calculated. Savings and costs reported are for end-of-year participation.

**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. Demand response program net energy and demand savings (in lighter shade) represent end-of-year program capability, based on end-of-year enrollment.

*** In calculating the PACT for the SolarHostSA Pilot program, Frontier considered all energy purchases and bill credits paid to host site customers as part of the program costs. This differs from CPS Energy's accounting, which shows $0 in rebates paid to customers. Thus, the PACT for the SolarHostSA Pilot program cannot be directly calculated from the data presented in the table.

Additional table notes: Net savings = gross savings * Net to Gross ratio / (1 – line loss factor). Rows may not sum to total due to rounding.

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: Emissions Reduction Impacts by Program (lbs.)

Program	CO2	NOx	SO2	TSP
Weatherization	14,041,017	6,257	9,310	580
CPSE Legacy Residential HVAC	1,542	1	1	0
Residential HVAC	13,948,718	6,216	9,249	576
Home Efficiency	2,953,000	1,316	1,958	122
CPSE Legacy New Homes	104,941	47	70	4
New Home Construction	911,201	406	604	38
Retail Channel Partnerships	10,695,665	4,767	7,092	442
AC/Duct Tune-Up	139,374	62	92	6
Energy Savings Through Schools	1,595,419	711	1,058	66
Home Energy Assessments	5,990,055	2,669	3,972	247
Multifamily	6,801,352	3,031	4,510	281
Cool Roof	11,758	5	8	0
Residential Subtotal	43,153,024	19,231	28,612	1,782
CPSE Legacy Lighting	51,213,088	22,823	33,957	2,115
CPSE Legacy Commercial HVAC	169,653	76	112	7
CPSE Legacy Commercial Custom	19,210	9	13	1
C&I Solutions	36,126,508	16,100	23,953	1,492
Schools & Institutions	11,115,868	4,954	7,370	459
Small Business Solutions	8,072,061	3,597	5,352	333
Whole Building Optimization	2,767,694	1,233	1,835	114
Commercial Subtotal	109,484,083	48,792	72,593	4,522
C&I DR	2,891,802	1,289	1,917	119
Auto DR	28,854	13	19	1
Smart Thermostat	111,817	50	74	5
Home Manager	0	0	0	0
BYOT	2,247,850	1,002	1,490	93
Nest DI	2,167,188	966	1,437	90
Reduce My Use (Behavioral DR)	22,354	10	15	1
Demand Response Subtotal	7,469,866	3,329	4,953	309
Res. Solar Rebates	33,170,100	1,002	1,490	93
Comm. Solar Rebates	6,449,772	966	1,437	90
Solar Host SA	5,135,481	10	15	1
Solar Energy Subtotal	44,755,353	1,978	2,942	183
Grand Total	204,862,326	73,330	109,100	6,796

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