Public Service Company of Oklahoma 2019 Energy Efficiency & Demand Response Programs: Annual Report

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Oklahoma Corporation Commission

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Title 165: Oklahoma Corporation Commission
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165:35-41-7. Reporting

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1 Executive Summary

This report presents an evaluation of the performance of the energy efficiency and demand response programs, also known as the Demand Portfolio, offered by Public Service Company of Oklahoma (PSO) in 2019. PSO is submitting this report to fulfill the requirements outlined in Title 165: Oklahoma Corporation Commission Chapter 35. Electric Utility Rules Subchapter 41. Demand Programs 165:35-41-7.

On June 29, 2018, PSO filed a comprehensive portfolio of energy efficiency and demand response programs (Portfolio Filing) to the Oklahoma Corporation Commission (OCC) for Program Years 2019 - 2021. This portfolio was approved by the OCC in Cause No. PUD 201800073, Order No. 688452. The focus of this report is participation during the first program year (PY2019) of the implementation cycle, spanning from January 1, 2019 to December 31, 2019.[1]

For the purposes of this report, projected, reported, and verified impacts are defined as follows:

- **Projected Impacts** refer to the energy savings (kWh) and peak demand reduction (kW) estimates approved by the OCC as part of PSO's 2019 – 2021 portfolio filed on June 29, 2018 and approved on December 18, 2018.[2]
- **Reported Impacts** refer to energy savings (kWh) and peak demand (kW) reduction estimates based on actual customer participation in PY2019 before program evaluation activities.
- **Verified Impacts** refer to energy savings (kWh) and peak demand (kW) reduction estimates for PY2019 developed through independent program evaluation, measurement, and verification (EM&V).

PSO's independent, third-party evaluator, ADM Associates, Inc. (ADM), performs the evaluation, measurement, and verification of PSO's energy efficiency and demand response programs.[3] Verified impacts reflect actual program participation (as opposed to projected participation) and adjust for any findings from ADM's independent evaluation; which includes a detailed review of program materials, interviews with program participants, and, in some cases, detailed on-site data collection. A glossary of these and other energy efficiency and demand response evaluation specific terms is provided in Appendix A.

[1] All the programs represent program participation from January 1, 2019 – December 31, 2019 except the Energy Saving Products program. The reported savings for LED retail discounts span the time period of January 1, 2019 – November 30, 2019. This month offset allows for reconciliation of retail sales data and manufacturer/retailer invoices.

[2] Approved by the OCC in Cause No. PUD 2018000733, Order No. 688452.

[3] A description of ADM and their commitment to safety is included in Appendix G.

All impacts presented in this report represent energy savings or peak demand reduction at-the-meter except for Section 1.4, Appendix B, and Appendix C, where impacts at-the-generator are adjusted using an estimated line loss factor of 1.0586 for calculating program cost-effectiveness.

Program impacts including projected, reported, and verified annual energy savings and peak demand reduction during PY2019 are summarized in the following sections.

1.1 2019 Program Offerings

In 2019, PSO offered customers eight energy-efficiency programs, five residential, one commercial/industrial, and two cross-sector programs. PSO also offered customers two demand response programs, one residential and one commercial/industrial. Program names, PY2019 start dates, and targeted customer sectors are shown in Table 1-1.

Table 1-1: Program Start Dates

Program	Sector	Start Date
Energy Efficiency Programs		
Business Rebates	Commercial & Industrial	January 01, 2019
Multi-Family	Residential & Commercial	January 01, 2019
Home Weatherization	Low-Income Residential	January 01, 2019
Energy Saving Products	Residential	January 01, 2019
Homes Rebates	Residential	January 01, 2019
Education	Residential	January 01, 2019
Behavioral Modification	Residential	January 01, 2019
Conservation Voltage Reduction	Multiple Classes	January 01, 2019
Demand Response Programs		
Power Hours	Residential	January 01, 2019
Business Demand Response	Commercial & Industrial	January 01, 2019

1.2 Summary of Energy Impacts

At the portfolio level, reported energy savings in PY2019 were 151,977 MWh. Total gross verified energy savings were 162,127 MWh. This realization rate for gross energy savings was 107%.

The Net-to-Gross (NTG) ratio indicates the percentage of gross savings directly attributable to program influences. The portfolio-level NTG ratio is estimated as 83%, resulting in a Net Annual Energy Savings of 135,258 MWh.

Table 1-2 summarizes the energy impacts of PSO's energy efficiency and demand response programs during PY2019.

Table 1-2: Summary of Gross Energy Impacts – PY2019[4]

Program	Gross Annual Energy Savings (MWh)				Net Impacts	
	Projected	Reported	Verified	Gross Realization Rate	NTG Ratio	Net Annual Energy Savings (MWh)
Energy Efficiency Programs						
Business Rebates	42,017	61,056	65,015	106%	96%	62,117
Multi-Family	1,532	3,628	3,678	101%	98%	3,604
Home Weatherization	2,423	3,743	3,743	100%	100%	3,743
Energy Saving Products	40,364	53,442	59,165	111%	62%	36,429
Home Rebates	7,283	6,738	5,180	77%	84%	4,373
Education	4,395	3,679	3,508	95%	100%	3,508
Behavioral	18,900	8,476	8,476	100%	100%	8,476
Conservation Voltage Reduction	8,162	9,755	10,439	107%	100%	10,439
Energy Efficiency Totals	**125,076**	**150,517**	**159,204**	**106%**	**83%**	**132,689**
Demand Response Programs						
Power Hours	2,047	1,460	2,377	163%	85%	2,024
Business Demand Response	128	0	545	0%	100%	545
Demand Response Totals	**2,174**	**1,460**	**2,922**	**200%**	**88%**	**2,569**
Portfolio Totals	**127,251**	**151,977**	**162,127**	**107%**	**83%**	**135,258**

1.3 Summary of Peak Demand Impacts

At the portfolio level, reported peak demand reduction in PY2019 was 114.61 MW. Total gross verified peak demand reduction was 93.47 MW. The realization rate for peak demand reduction was 82%.

[4] Rounding may affect totals and net-to-gross ratio multiplication/division in table.

The portfolio-level NTG ratio for peak demand reduction was estimated as 95%, resulting in a Net Peak Demand Savings of 88.82 MW.

Table 1-3 summarizes the peak demand impacts of PSO's energy efficiency and demand response programs during PY2019.

Table 1-3: Summary of Demand Impacts – PY2019[5]

Program	Gross Peak Demand Reduction (MW)				Net Impacts	
	Projected	Reported	Verified	Gross Realization Rate	NTG Ratio	Net Peak Demand Reduction (MW)
Energy Efficiency Programs						
Business Rebates	7.63	12.45	10.76	86%	94%	10.16
Multi-Family	0.28	1.07	1.01	94%	96%	0.96
Home Weatherization	1.16	2.07	2.07	100%	100%	2.07
Energy Saving Products	4.90	7.57	9.40	124%	62%	5.81
Home Rebates	2.76	2.72	2.87	105%	86%	2.45
Education	0.52	0.69	0.67	98%	100%	0.67
Behavioral	3.44	0.97	0.97	100%	100%	0.97
Conservation Voltage Reduction	1.77	1.11	2.06	185%	100%	2.06
Energy Efficiency Totals	**22.45**	**28.65**	**29.81**	**104%**	**84%**	**25.16**
Demand Response Programs						
Power Hours	15.27	16.07	12.26	76%	100%	12.26
Business Demand Response	51.00	69.89	51.41	74%	100%	51.41
Demand Response Totals	**66.27**	**83.96**	**63.66**	**74%**	**100%**	**63.66**
Portfolio Totals	**88.72**	**114.61**	**93.47**	**82%**	**95%**	**88.82**

Table 1-4 compares the verified net MWh impacts to projected net savings for PSO's programs during PY2019. The results indicate verified MWh and MW savings of 135,258 and 88.82, respectively.

[5] Rounding may affect totals and net-to-gross ratio multiplication/division in table.

Table 1-4: Summary of Net Energy Impacts – PY2019

Program	Projected Net		Verified Net		Percent of Goals/Projections	
	MWh	MW	MWh	MW	MWh	MW
Energy Efficiency Programs						
Business Rebates	38,308	6.94	62,117	10.16	162%	146%
Multi-Family	1,432	0.26	3,604	0.96	252%	369%
Home Weatherization	2,423	1.16	3,743	2.07	154%	178%
Energy Saving Products	22,288	2.71	36,429	5.81	163%	215%
Home Rebates	6,190	2.34	4,373	2.45	71%	105%
Education	3,316	0.39	3,508	0.67	106%	173%
Behavioral	18,900	3.44	8,476	0.97	45%	28%
Conservation Voltage Reduction	8,162	1.77	10,439	2.06	128%	116%
Energy Efficiency Totals	**101,020**	**19.01**	**132,689**	**25.16**	**131%**	**132%**
Demand Response Programs						
Power Hours	1,535	15.27	2,024	12.26	132%	80%
Business Demand Response	128	51.00	545	51.41	427%	101%
Demand Response Totals	**1,663**	**66.27**	**2,569**	**63.66**	**155%**	**96%**
Portfolio Totals	**102,682**	**85.28**	**135,258**	**88.82**	**132%**	**104%**

1.4 Summary of Portfolio Benefit-Cost Ratios

ADM calculated the cost-effectiveness of PSO's 2019 programs based on reported total spending, verified net energy savings, and verified net demand reduction for each of the energy efficiency and demand response programs. Additional inputs to the cost effectiveness tests included estimates of natural gas savings, line-loss adjustments, emissions reductions, measure lives, discount rates, participant costs, and avoided costs. All program spending inputs were provided by PSO as shown in Appendix B. The total portfolio spend was $33,487,563. The methods used to calculate cost-effectiveness were informed by the California Standard Practice Manual.[6]

The specific tests used to evaluate cost-effectiveness for the Oklahoma Corporate Commission are the Utility Cost Test and the Total Resource Cost Test. The benefit-cost ratios for those tests as well as the Rate Payer Impact Test, the Societal Cost Test, and

[6] California Standard Practice Manual: Economic Analysis of Demand Side Management Programs, October 2001. Available at: http://www.cpuc.ca.gov/uploadedFiles/CPUC_Public_Website/Content/Utilities_and_Industries/Energy_-_Electricity_and_Natural_Gas/CPUC_STANDARD_PRACTICE_MANUAL.pdf.

the Participant Cost Test are presented in Table 1-5. Detailed cost-effectiveness assumptions and findings are presented in Appendix B.

Table 1-5: Benefit-Cost Ratios

Program	Utility Cost Test	Total Resource Cost Test	Ratepayer Impact Measure	Societal Cost Test	Participant Cost Test
Energy Efficiency Programs					
Business Rebates	4.30	2.58	0.76	2.96	3.45
Multi-Family	3.41	3.04	0.66	3.89	5.88
Home Weatherization	1.55	2.25	0.70	2.70	3.32
Energy Saving Products	7.16	7.10	0.61	11.56	23.45
Home Rebates	1.11	1.24	0.59	1.50	2.30
Education	2.18	2.10	0.54	2.64	4.44
Behavioral	0.43	0.45	0.24	0.45	-
Conservation Voltage Reduction	1.43	1.35	0.55	1.35	30.15
Total – Energy Efficiency Programs	**3.19**	**2.47**	**0.68**	**3.08**	**4.46**
Demand Response Programs					
Power Hours	1.47	1.82	0.81	1.91	6.72
Business Demand Response	2.90	8.13	2.85	8.13	4.08
Total - Demand Response Programs	**2.29**	**4.10**	**1.68**	**4.16**	**5.05**
Portfolio Averages	**3.06**	**2.58**	**0.79**	**3.16**	**4.48**

Another way to view portfolio performance for 2019 is on a levelized dollar per kWh savings or dollar per peak kW reduction basis. Energy-efficiency programs are designed to reduce energy usage while providing the same or improved service to the end-user in an economically efficient way, regardless of whether energy usage occurs during peak or non-peak periods. Energy savings occur for the lifetime of the energy efficiency measures installed. As such, program performance was assessed on a levelized dollar per kWh basis for energy efficiency programs. Levelized cost in $/kWh is calculated as shown in the formula below:

Equation 1-1: Levelized Cost ($/kWh)

$$Levelized\ Cost\ (in\ \$/kWh)\ =\ C\ x\ Capital\ Recovery\ Factor\ /\ D$$

$$Capital\ Recovery\ Factor =\ [A * (1 + A)\text{^}(B)]/[(1 + A)^B - 1]$$

Where:

A = Societal Discount rate (5%)

PSO WACC Discount Rate (7.35%)

B = Estimated measure life in years[7]

C = Total program costs

D = Annual kWh savings

Table 1-6 shows how PSO's portfolio of energy efficiency programs performed on a levelized cost basis for PY2019 from a societal (5% discount rate) and a weighted average cost of capital (WACC) (7.35% discount rate) based calculations. The verified net lifetime energy savings in Table 1-6 include a line loss adjustment factor of 1.0586.

Table 1-6: Levelized $/kWh for Energy Efficiency Programs[8]

Program Year	Total Costs	Verified Net Lifetime Energy Savings (kWh)	Levelized $/kWh	Verified Net Lifetime Energy Savings (kWh)	Levelized $/kWh
		Societal Discount (5%)		Weighted Average Cost of Capital Discount (7.35%)	
2019 Residential[9]	$16,272,029	457,287,810	$0.0356	400,525,390	$0.0406
2019 Commercial[10]	$11,739,217	648,939,439	$0.0181	564,582,352	$0.0208
2019 Multi-class	$801,114	10,713,907	$0.0748	10,482,298	$0.0764
2019 EE Programs	**$28,812,360**	**1,116,941,155**	**$0.0258**	**975,590,040**	**$0.0295**

A study conducted by the American Council for an Energy Efficient Economy (ACEEE)[11] in 2014 compared levelized $/kWh for electric energy efficiency programs in 20 different states between 2009 and 2012. Levelized costs estimated as part of this study ranged from $0.016 to $0.048 with an average of $0.028. A study conducted by Lawrence Berkeley National Laboratory[12] between 2009 and 2013 found the average levelized cost

[7] Calculated as described in Appendix B.

[8] Lifetime savings reduced by 5% societal discount or weighted average cost of capital discount factor.

[9] Residential Programs include: Home Weatherization, Home Rebates, Energy Savings Products, Education, and Behavioral.

[10] Commercial Programs include: Business Rebates and Multi-Family.

[11] Molina, Maggie, "The Best Value for America's Energy Dollar: A National Review of the Cost of Utility Energy Efficiency Programs." *ACEEE,* March 2014.

[12] Hoffman, Ian M., Leventis, Greg, and Goldman, Charles A., "Trend in the Program Administrator Cost of Saving Electricity for Utility Customer-Funded Energy Efficiency Programs." Emp.lbl.gov, January 2017.

for residential electric energy efficiency programs to be $0.028 and commercial to be $0.027. The levelized $/kWh for PSO's energy-efficiency programs is more favorable than 9 of the 20 states from the ACEEE analysis.

Demand response programs are designed to encourage customers to change their normal consumption patterns during periods when prices are high, or system reliability is potentially constrained. These programs encourage load reduction during a short period of time, usually a limited number of days during the summer. As such, demand response program performance was assessed on a peak kW reduction per dollar basis. Table 1-7 shows how PSO's portfolio of demand response programs (Business Demand Response and Power Hours) performed on a $/kW reduction basis for PY2019. The verified net peak demand reduction in Table 1-7 includes a line loss adjustment factor of 1.0586.

Table 1-7: $/kW for Demand Response Programs

Program Year	Total Costs	Verified Net Peak Demand Reduction from DR (kW)	$/kW
2019	$4,673,636	68,782	$67.95

1.5 Cumulative Portfolio Performance

PY2019 was the first program year for the 2019 – 2021 Demand Portfolio. Portfolio-level energy and demand impacts for PY2019 and historical years are shown in Table 1-8.

Table 1-8: 2016 - 2019 Portfolio Performance – Verified Energy and Peak Demand Impacts

Program Year	Verified Gross Annual Energy Savings (GWh)	Verified Net Annual Energy Savings (GWh)	Verified Gross Peak Demand Reduction (MW)	Verified Net Peak Demand Reduction (MW)
Energy Efficiency Programs				
2016	127.23	103.58	25.98	22.83
2017	129.90	104.12	25.59	22.12
2018	153.64	128.72	29.05	24.16
2019	159.20	132.69	29.81	25.16
Cumulative EE Totals	**442.74**	**365.53**	**84.45**	**71.44**
Demand Response Programs				
2016	0.85	0.85	44.02	44.02
2017	0.54	0.54	45.74	45.74
2018	1.15	1.15	54.38	54.38
2019	2.92	2.57	63.66	63.66
Cumulative DR Totals	**4.61**	**4.26**	**163.78**	**163.78**
Cumulative Totals	**447.35**	**369.79**	**248.24**	**235.22**

1.6 Summary of Overall Program Satisfaction

Participants from each program were surveyed about their satisfaction with their overall experience with the program.[13] General satisfaction across the majority of programs was above 85%. The results for all programs are summarized in Table 1-9.

[13] Program participants that report being either somewhat satisfied or very satisfied with the overall program they participated in.

Table 1-9: Overall Program Satisfaction Reported by Program Participants

Program	Percent Satisfied
Business Rebates	85%
Multi-Family[14]	86%
Home Weatherization	97%
Energy Saving Products	84%
Homes Rebates - Single Upgrades	85%
Homes Rebates - Multiple Upgrades	94%
Homes Rebates – New Homes[15]	78%
Education[16]	93%
Behavioral[17]	82%
Power Hours	79%
Business Demand Response	100%

[14] Percent of owners/managers that reported being somewhat satisfied or very satisfied with the overall PSO Multi-Family program.

[15] Percent of builders that reported being somewhat satisfied or very satisfied with the overall PSO New Homes program. The one builder who indicated they were very dissatisfied with the New Homes program had completed one custom home at the time of the survey and may have limited experience with the program and/or PSO staff. The complaint with this builder was centered around arranging a HERS rater to inspect the home and the program requirements for qualifying homes.

[16] Percent of teachers that would participate again in the program if asked to.

[17] Percent of program participants that reported being somewhat satisfied or very satisfied with the information provided in the Home Energy Report about their home's energy use.

2 Introduction

This report presents an evaluation of the performance of the energy efficiency and demand response programs offered by Public Service Company of Oklahoma (PSO) in 2019. PSO is submitting this report to fulfill the requirements outlined in Title 165: Oklahoma Corporation Commission Chapter 35. Electric Utility Rules Subchapter 41. Demand Programs 165:35-41-7.

PSO contracted with ADM to perform comprehensive program evaluation, measurement, and verification (EM&V) for PY2019. ADM's evaluation findings for each 2019 energy efficiency program are provided in Chapter 3 of this report while evaluation findings for the demand response program are provided in Chapter 4.

Table 2-1 summarizes program-level participation, program contribution to portfolio-level savings, and number measures offered.

Table 2-1: Program Level Participation

Program	% of Portfolio Savings (Reported)	Participants*	Number of Measure Types
Business Rebates	40.17%	1,192	11
Multi-Family	2.39%	105	13
Home Weatherization	2.46%	2,048	6
Energy Saving Products	35.16%	1,528,871	15
Homes Rebates	4.43%	3,643	16
Education	2.42%	14,820	4
Behavioral	5.58%	166,937	1
Conservation Voltage Reduction	6.42%	12,828[18]	1
Cumulative EE Totals	**99%**	**1,730,444**	**67**
Power Hours	0.96%	23,151	2
Business Demand Response	0.0%	232	1
Cumulative DR Totals	**1%**	**23,383**	**3**
Cumulative Portfolio Totals	**100%**	**1,753,827**	**70**

*Participants meaning each customer per program, with the exception of the Energy Saving Products program, which is the total number of measures in the program.

2.1 Reduced Emissions and Water Consumption

Reduced emissions occur because of energy savings achieved through PSO's Demand Portfolio displacing marginal fossil fuel based electric generation. The EPA's Emissions and Generation Resource Integrated Database (eGRID) is a comprehensive source of emissions data related to the electric power sector in the U.S. The technical support document for eGRID, based on 2018 data, was released in January of 2020 and revised in March of 2020.[19] Included in the database are estimates of non-baseload emission rates for various greenhouse gasses in different sub regions of the country. The PSO service territory falls into eGRID sub region SPP South (SPSO). Table 2-2 below lists the most recent eGRID non-baseload output emission rates for SPSO.

[18] Represents the number of customers on the service lines that had CVR implemented in 2019.
[19] https://www.epa.gov/energy/egrid.

Table 2-2: Generation Resource Integrated Database Greenhouse Gas Annual Output Emission Rates

eGRID Sub region	Annual Non-baseload Output Emission Rates		
	Carbon dioxide (CO2) (lb/MWh)	Methane (CH4) (lb/GWh)	Nitrous oxide (N2O) (lb/GWh)
SPP South (SPSO)	1,662.55	121	19

Using the eGRID emission rates and lifetime energy savings for measures installed through the PSO Demand Portfolio in 2019 results in the estimated emissions reductions listed in Table 2-3.

Table 2-3: Emission Reduction Estimates

Lifetime Energy Savings[20] (Net at Generator) (MWh)	Carbon dioxide reduction (CO2) (tonnes)	Methane reduction (CH4) (tonnes)	Nitrous oxide reduction (N2O) (tonnes)
1,515,353	1,142,756	83	13

Reductions in water consumption at participant homes/facilities resulting from PSO's 2019 portfolio of programs were not tracked. Many of the energy efficiency measures commonly associated with water savings in the residential sector (faucet aerators, low-flow shower heads, efficient clothes washers and dishwashers, etc.) were limited in the portfolio design because of the high prevalence of natural gas water heating in the PSO service territory. The Business Rebates program does offer incentives for measures that have water saving potential for C&I customers (e.g., variable frequency drives on pump motors). The effects on water consumption for these measures were not quantified for PY2019.

There are also water savings associated with reduced energy generation attributable to PSO's energy efficiency and demand response programs. PSO's generation fuel mix is made up of coal (~14%), natural gas (~21%), purchased power (~43%) and wind (~22%).

All non-wind generation fuel sources are used in thermoelectric power plants which boil water to create steam, which in turn drives turbines. After the steam passes through a turbine, it is cooled so that it condenses, and the water can be reused. The process of cooling the steam accounts for almost all water use in most thermoelectric power plants, as the steam itself circulates in a closed system. A portion of the water used for this

[20] Lifetime energy savings listed are based on measure lives from the OK Deemed Savings Documents, AR TRM, PA TRM, or IL TRM, annual net energy savings estimated through EM&V of the 2019 portfolio, and a line-loss adjustment factor of 1.0611.

cooling process is lost to evaporation. The specifics regarding how much water is consumed in the process depend largely on the technologies used in each power plant (once-through water cooling, recirculating water cooling, dry-cooling).

A 2003 report by the National Renewable Energy Laboratory (NREL)[21] provides estimates of water consumption per kWh of energy consumed for all U.S. states. The estimate in Oklahoma is 510 Gallons per MWh consumed. Using the NREL water consumption estimates and lifetime energy savings for measures installed through the PSO Demand Portfolio in 2019 results in the lifetime water savings estimates listed in Table 2-4.

Table 2-4: Water Savings Estimates, Thermoelectric Generation

Lifetime Energy Savings (Net at Generator) (MWh)	Overall Generation Percentage Thermoelectric	Water Consumption per kWh Consumed (Gallons/MWh)	Lifetime Water Savings (Gallons)
1,515,353	78%	510	602,807,460

2.2 Milestones Achieved in Market Transformation Programs

While nine of PSO's energy-efficiency programs are designed primarily as energy-efficiency resource acquisition programs, there are some market transformation characteristics, briefly summarized below.

Energy Saving Products (ESP) Program: The main component of the ESP program in 2019 was retail markdowns of certain LED light bulbs. The goal of the markdowns is to increase sales to customers who would have otherwise purchased less efficient options in the absence of the price discount. These programs have long been considered to have market transformation effects in terms of retailer stocking decisions and manufacturer shipment decisions.

For 2019, PSO expanded their offerings to include rebates for Level 2 electric vehicle chargers as well as point of sale discounts on an assortment of home maintenance measures (door sweeps, door seals, air filters, and spray foam). The addition of these measures is an example of how PSO continues to transform the market by affecting customer purchasing decisions.

[21] Source: http://www.nrel.gov/docs/fy04osti/33905.pdf.

Home Rebates – New Homes: PSO was recognized again by ENERGY STAR®, receiving Partner of the Year Award. The program provided educational trainings for both builders and raters that influenced energy efficiency offerings in building performance and new homes. During 2019, the program offered no cost HERS ratings to builders who were not yet participating in a home energy rating program.

Commercial Midstream: During 2019 PSO added a midstream commercial program offering. Midstream programs provide opportunities for market transformation by increasing stocking of energy efficient equipment options by participating distributors. Stocking can be increased either directly through the provision of stocking incentives or indirectly through reducing the cost of more expensive efficient equipment, and in that way, reduce the amount of capital the distributor has tied up in stock. Midstream programs leverage distributors to educate end-users and purchasers.

Service Provider Recruitment and Training: PSO's Business Rebates and Home Rebates programs include service provider training opportunities that focus on increasing awareness and knowledge of building science approaches to energy efficiency. PSO held a mechanical seminar with business customers to provide insight into new mechanical energy efficiency options. This aspect of the programs has potential market transformation effects beyond the energy savings induced through the program. For a complete list of service provider training events refer to Appendix D. Service provider participation continues to grow for the Business Rebates program.

2.3 Annual Utility Growth Metrics and Portfolio Ratios

The Oklahoma Title 165:35-41-7 reporting rules provide guidance for providing context on the utility load growth and the Demand Portfolio relative to load and revenue. Table 2-5 shows weather-normalized annual growth rates for PSO's total utility energy sales, distribution, and peak demand, as well as the 2017 - 2019 growth rates.

Table 2-5: Utility Growth Rates 2017 – 2019

Year	Net Sales (GWh)	Sales Growth	Energy at Generator (GWh)	Energy Growth	Peak Demand (MW)	Demand Growth
2017	17,977	-1.38%	19,075	-1.66%	4,201	1.89%
2018	18,877	5.01%	19,957	4.62%	4,166	-0.84%
2019	18,662	-1.14%	19,775	-0.91%	4,206	0.96%
Compound Growth Rate	1.89%	-	1.82%	-	0.06%	-

Table 2-6 shows weather-normalized annual growth rates and 2017 - 2019 growth rates for utility energy sales by customer class.

Table 2-6: 2017 – 2019 Weather Normalized Retail Meter Sales

	Residential		Commercial		Industrial		Other Retail		Total Retail		FERC		Total System	
Year	**GWh**	**%Chg**	**GWh**	**%Chg**	**GWh**	**%Chg**	**GWh**	**%Chg**	**GWh**	**%Chg**	**GWh**	**%Chg**	**GWh**	**%Chg**
2017	6,174	0.00%	4,992	-4.30%	5,876	6.27%	1,240	0.09%	18,281	0.68%	9	-3.26%	18,290	0.68%
2018	6,120	-0.86%	4,944	-0.96%	6,124	4.23%	1,253	1.09%	18,442	0.88%	9	4.82%	18,451	0.88%
2019	6,136	0.26%	4,931	-0.27%	6,156	0.52%	1,240	-1.02%	18,463	0.12%	8	-6.06%	18,472	0.11%
Compound Growth Rate		-0.31%	-	-0.61%	-	2.36%	-	0.03%	-	0.50%	-	-0.77%	-	0.50%

Table 2-7 provides a comparison of program costs to operating revenue.

Table 2-7: 2019 Demand Portfolio Funding

2019 Demand Portfolio Program Cost ($M)	$33.49
2019 Operating Revenues ($M)	$1,481.80
Program Cost as % of Utility Operating Revenue	2.3%

Table 2-8 provides a comparison of energy savings to total utility energy sales.

Table 2-8: 2019 Net Demand Portfolio Energy Savings

2019 Demand Portfolio Energy Savings (GWh)	135
2019 Metered Energy Sales (GWh)	18,662
Savings as % of Utility Sales	0.73%

2.4 High-Volume Electricity User Opt Out

The Oklahoma Title 165:35-41-4 rules allow for High-Volume Electricity Users “to opt out of some or all energy efficiency or demand response programs by submitting a notice of such decision to the director of the Public Utility Division and to the electric utility.” A High-Volume Electricity User is defined as any single customer that consumes more than 15 million kWh of electricity per year, regardless of the number of meters or service locations. The number of customers eligible for High-Volume Electricity User opt out, their aggregate load as a percentage of total sales, the number of such customers that opted out of energy efficiency programs for PY2019, and the opt out percentage of total energy sales.

Table 2-9: High Volume Electricity User Opt Out – Energy Efficiency

Metric	2019	
	Opt-out eligible	Chose to opt-out -EE
Number of accounts	7,323	4,322
2019 Electric Sales (GWh)	7,154	6,660
Aggregate load as a percentage of total sales	38.3%	35.7%

Table 2-10 provides a summary of high-volume customers who opted out of demand response programs.

Table 2-10: High Volume Electricity User Opt Out – Demand Response

Metric	2019	
	Opt-out eligible	Chose to opt-out -DR
Number of accounts	7,323	4,147
2019 Electric Sales (GWh)	7,154	6,234
Aggregate load as a percentage of total sales	38.3%	33.4%

2.5 Fuel Switching Impacts

PSO did not provide incentives for installation of electric heating or electric water heating to replace natural gas fueled equipment during PY2019. A review of the program tracking data found no instances in which natural gas equipment were replaced with electric equipment that was rebated through a PSO program.

2.6 Program Implementation & Strategic Alliances

PSO had ten full-time employees dedicated to the implementation of energy efficiency and demand response programs in 2019. Additionally, PSO entered contracts with several energy services companies (ESCOs) and contractors to aid in program implementation. A complete list of implementation contractors, including contact name, title, business address, phone number, email address, and program associations, is provided in Appendix C.

ICF International (ICF) was contracted to implement the Business Rebates and Home Rebates programs. CLEAResult was contracted to implement the ESP program. The Home Weatherization program was largely implemented by Titan ES, LLC, with some program participation also coming through Revitalize T-Town, a volunteer organization working to preserve and revitalize low-income homes and communities. PSO contracted with Franklin Energy to provide energy-efficiency kits distributed through the Education

program. At PSO's direction, load management events were initiated by the AEP's CPS staff through the Demand Response Automation Server (DRAS) maintained by Honeywell, the third-party implementer for the Power Hours program. Finally, the Business Demand Response program was implemented "in-house" by PSO, with database support provided by AEG. Additional customer engagement materials and services for the entire portfolio of programs were provided by Cubic Creative. Examples of marketing materials used during 2019 to promote PSO's energy efficiency and demand response programs are provided in Appendix E.

For most programs in the 2019 portfolio, service providers were recruited to participate by submitting rebate applications on behalf of customers implementing qualifying energy efficiency measures. PSO's website contains lists of registered service providers and the associated products/services they provide.

2.7 Training and Customer Outreach

PSO regularly conducts various service provider training and customer outreach events, which are summarized in Appendix D. During 2019, PSO's energy efficiency and demand response programs sponsored:

- 49 in-store residential lighting promotional events
- 80 other customer outreach and service provider training events, including:
  - Portfolio overview presentations
  - Program specific service provider training
  - One-on-one presentations with potential participants
  - Trade show and event booths promoting the portfolio

2.8 Summary of Process Evaluation Findings

During the third quarter of 2019, ADM completed their process evaluation for PY2019. Program participants, service providers, and program staff were largely satisfied with PY2019 portfolio offerings. Key process evaluation-related findings are summarized below.

2.8.1 Business Rebates

Custom and Prescriptive

- Survey and interview findings indicate that contractors and vendors were the most frequent source of program awareness and the most important source of influence on customers' decision to participate.

- ADM noted in both trade ally and program staff interviews that PSO's HVAC rebate program would shift to a midstream model in the next program year. Though trade allies voiced uncertainty regarding future program design choices, PSO and ICF staff expressed confidence in the shift in incentive design choice for HVAC projects.
- The Business Rebates Program was on track to achieve the 2019 energy savings goals but reported excess budget available as of October. A late program design change provided bonuses to service providers for projects in the pipeline through the end of the year.
- The program improved its marketing and promotional material.
- Comprehension of the program's measure diversity represents a potential program challenge or weakness.
- Survey results and interviews indicate the program was implemented successfully in 2019 with minimal comments, concerns, or complaints. Participants are generally positive about the program.
- From the trade ally perspective, the program was effectively administered in 2019 and trade allies were generally satisfied with the program's design and participation process. However, some issues exist, such as the inability of ICF staff to meet trade ally expectations and the fact that completing larger projects is time consuming and often requires submitting documents multiple times.

Small Business Energy Solutions (SBES)

- Program staff interviews indicated that the SBES program would not achieve its energy savings goals. Program staff felt that the late start of the program and historic flooding in the state of Oklahoma contributed to the program's inability to meet its goals.
- Lighting continued to drive program activity in 2019. No refrigeration projects were completed in 2019 as of October.
- Program tracking and quality control remained consistent with previous program years and there were no issues reported with the current system for data tracking or quality control.
- Findings from SBES trade ally interviews indicate program marketing improved in 2019, and trade allies voiced overall support for the program and the increased outreach effort.
- Consistent with past program years, program satisfaction remains high. Most survey respondents shared high levels of satisfaction across all aspects of the program as well as the program overall.

- Some participants noted possible areas for program improvement including providing more information about savings/incentive calculations, increasing communication and information regarding other incentives/programs.

Midstream Lighting and HVAC

- PSO and implementation staff noted that establishing a contract for the program delayed the program's start date until summer 2019 and therefore affected the program's ability to achieve its energy-savings goal.
- The program implementation staff successfully recruited four lighting distributors, with multiple locations to participate in the program. Moving forward, the implementation staff noted that they would seek to increase the number of distributors.
- Interviews with program staff and distributors suggest that there has been enough support to grow and establish the program in its first year.
- Program staff and participating distributors generally were satisfied and approved of the design, training, and communication for the midstream avenue.
- Distributors were satisfied with the implementation and program staff, including support and training they received.

2.8.2 Multi-Family

- According to the program's service providers, there was a greater focus on weatherization improvements compared to lighting upgrades.
- Program funding was initially limited but was increased during the program year to support additional projects.
- Staff interviews indicate that the program was successfully marketed and promoted in 2019; however, findings from ADM's service provider interviews suggest that there is an opportunity for ICF/PSO to increase marketing and outreach collaboration efforts.

2.8.3 Home Weatherization

- Changes to program design and acceptance influenced participation. This year, PSO increased the household income level qualification from $45,000 to $50,000, which allowed for more families to partake in the program. The sampled population did not report barriers to enrollment or skepticism of the program's legitimacy. The strategy that most participants reported helped raise awareness of program was word of mouth (23%) from friends, relatives, or colleagues. Many participants were

influenced by the recommendations from past Weatherization program participants.

- Decreasing energy costs was a major factor driving enrollment in the program. Eighty-seven percent of survey respondents indicated that reducing their monthly utility bill appealed to them before they enrolled. When participants were asked whether they were satisfied with the savings found in their monthly bills, 86% were either satisfied or very satisfied with their savings. Additionally, 34% noticed some or a substantial amount of savings when asked if the participant noticed savings on the monthly bill since the weatherization service.
- Program participant satisfaction rates were positive overall. The sampled population reported satisfaction over the utility company, the enrollment process, and customer experience. PSO staff encountered some complaints about waiting times, but participants reported high satisfaction rates. Satisfaction regarding installations varied amongst measures. All five participants who had a water heater pipe or jacket installed were very satisfied, 88% of participants were very satisfied with their attic insulation as well as air sealing, and 87% of participants were very satisfied with their duct sealing.
- Program staff continue to expand their reach throughout the territory. This year, home weatherization services covered a larger proportion of the PSO territory, with most projects completed in Tulsa. Titan staff indicated there are challenges to program access. Program staff plan to explore the possibility of developing more partnerships with local organizations to improve their outreach. .

2.8.4 Energy Saving Products

- New marketing strategies and in-store promotions utilized in PY2019. PSO helped to increase engagement and awareness of ESP. The marketing team created new point-of-purchase materials for store promotions, revamped the website to improve customer experience, updated customer bill inserts, and included information about appliance rebates in the monthly PSO's newsletters. Program outreach also included providing LED bulbs to Food Banks. Implementers offered LED bulbs to reach underserved populations. One hundred thousand bulbs are sent out to three separate food banks each year.
- Keeping retail staff up-to-date and knowledgeable about ESP is a continuous challenge. Retail stores often experience high employee turnover rates. This staffing issue can generate inconsistencies in the level of knowledge one employee can provide customers about the rebated measures. Training retail staff on products continues to be a challenge for program staff.

- Most rebate recipients learned of the program through a retailer and were motivated by saving money on their energy bills. Sixty-seven percent of survey respondents indicated they learned of the program through a retailer. Nine percent of participants learned of the rebates from PSO's website. Saving money on their energy bills was the most common response by participants for all measures regarding their motivation for purchasing the rebated equipment.
- Program participants are satisfied with the rebated equipment they installed, various aspects of the program, and the program overall. Most survey respondents reported that they were satisfied with the equipment that they decided to install, ranging from 89% to 100%, indicating they were either somewhat or very satisfied. Survey participants were least satisfied with clothes washers. Program participants were either very or somewhat satisfied with the various aspects of the program (application process (73%), rebate wait time (60%), quality of equipment available (77%), and variety of incentives offered by PSO (74%)) and the program overall (84%).
- Satisfaction varied among measures. Respondents who purchased LEDs were satisfied with the quality, the discount, and savings on their utility bills. Responses varied for all the non-LED measures. Quality was the factor that most satisfied the participants. Participants recommended to either lower rates or broaden portfolios as potential program improvements for the future. Satisfaction rates amongst the participants varied between measure, the quality of the product, and its financial savings for the consumer.

2.8.5 Home Rebates - Single Upgrades, Multiple Upgrades, and New Homes Components

Single & Multiple Upgrades

- Marketing and outreach efforts included gift cards and bonuses. PSO indicated it did an eblast to market the Single Upgrade program in Bartlesville and Lawton. PSO offered a $25 Walmart gift card for participation in Single Upgrade. Single and Multiple Upgrades provided an additional $500 bonus for HVAC change-out to increase sales due to the low demand for this measure during the summer. According to staff, the offer will probably extend until November. PSO indicated it offered a free home energy check-up to past Single Upgrade participants in the Northern region of their service territory. PSO staff believe its monthly newsletters are helpful for marketing and outreach. PSO staff also stated they used Facebook and billboards to advertise the program in Lawton and Tulsa.
- Communication between PSO and ICF remained consistent. Meetings are still on a biweekly basis through the phone. PSO indicated there was an in-person

meeting this program year. Although service providers have an accessible communication channel to PSO, the program manager indicated that the PSO website could be challenging to navigate and believes the website could improve (e.g., how and where information can be found online).

- Program experienced changes in tracking and reporting. PSO continues to use Vision for data management, and PSO still receives a monthly spreadsheet. PSO does receive an additional report regarding heat pumps. For the Multiple and Single Upgrade component, PSO is now using a mobile intake tool. The tool can be used on site and data is recorded in real time. One staff member also indicated that they created an additional reporting tool for heat pumps. ICF staff member stated they changed the format of their tracking and reporting to improve its understanding. The account manager indicated their clients are satisfied with the formatting changes.
- Program experienced changes to quality assurance and quality control (QA/QC). There has been an increased number of desk reviews for Single and Multiple Upgrade projects, and 10% to 15% of projects are verified out in the field. All rebates are processed in the Tulsa office and are verified before checks are sent out. If mistakes or flaws are found during the process, the processing team reaches out directly to those specific service providers to correct issues. Before and after photos are submitted and geotagged through the rebate app. The most significant change to the QA/QC process was the addition of the Power Rebates app for the Single Upgrade component of the Home Rebates program. Staff believes current procedures for ensuring quality control are adequate and did not anticipate any significant changes in the future.

New Homes

- New Homes experienced changes to its operations. PSO changed the process of payments for New Homes' incentives. Payments now follow a two-week, rather than monthly, cycle. As a result of this change, service providers have finished project completion documentation faster than in previous cycles.
- Innovation budget used for free HERs ratings to encourage participation from new builders. This year PSO staff indicated they offered to copay with ICF (through its innovations budget) for a free assessment to raters who recruited new builders into the program.
- House price, location, and interior features are most important to home buyers. Homebuyer survey respondents rated various factors in their decision to buy their home on a scale ranging from "not at all important" to "extremely important." Survey respondents most frequently rated the house price (68%) as important to

them, followed by location (63%), interior features (53%), and general appearance (47%).

- Many homebuyers buy homes built to PSO program standards. Builders stated that approximately 86% of their customers purchased a new home that was built to the PSO program standards. Fourteen percent of builders stated that none of their customers purchased a new home built to the PSO program standards. Nearly two-thirds of survey builders were unable to estimate how much more, on average, homes built to the PSO program standards would cost than other comparable homes. Those who provided an estimate indicated the cost difference would range from $2,000 to $7,500. Builder estimates of the percentage of home buyers in the current market who would choose not to pay for the additional process to qualify the home ranged from 15% to 80%.
- New Homes appears to positively influences builder practices. About three-quarters of builders indicated their specifications or building practices have changed since they began with the program and two-thirds indicated they had integrated new construction elements into their building standards. Those elements included: framing techniques, foam insulation, duct sealing, LED lighting, air sealing, insulation, and HERs ratings. Two-thirds of builders indicated it was a great or moderate advantage to have an independent HERs rating in selling a home.
- High satisfaction among builders with the New Homes component. More than two-thirds (78%) of the respondents were very satisfied with the PSO New Homes program. The same percentage of respondents were somewhat or very satisfied with their interactions with the New Homes program staff and more than three-quarter (80%) were somewhat or very satisfied with the program's paperwork and recording-keeping processes.

2.8.6 Education

- The Education Program has high participation and acceptance rates. Through the years, the implementer staff have formed relationships with teachers who utilize the program materials. Many teachers find the materials to be beneficial and complementary to their curriculum according to staff.
- Statistically significant differences in student test scores indicate an increase in knowledge of energy efficiency. Pre- and post-test score analysis suggests that the program was effective in increasing knowledge of energy efficiency among the students. Further analysis of individual questions revealed a statistically significant difference in pre and post score averages improved for each question.

- Many of the teachers who responded to the surveys have participated in the past (81%). Most have participated for more than three years (72%). Ninety-seven percent of teachers stated the educational materials were clearly written and well organized. The respondents also indicated the curriculum was a useful learning tool (91%), and 63% stated that the work and effort they had to invest in teaching the curriculum did not add to their overall workload.
- The instructors perceived high levels of engagement from their students (83%). The instructors perceived better comprehension of energy efficiency from them (90%). Student test score analysis indicates a significant improvement of knowledge regarding energy efficiency.

2.8.7 Behavioral Modification

- Survey respondents largely found the energy report information on their home's energy use to be accurate and information in the report to be valuable. Additionally, respondents generally were satisfied with most aspects of the energy report and reported an increase in knowledge about energy efficiency since receiving the information.
- Consistent with the generally positive attitudes toward the energy reports, satisfaction with PSO among program participants generally increased or remained the same since receiving them.
- Based both on participant self-reports and comparisons between participant and controls, the energy reports appear to induce respondents to take more actions to reduce their energy use – most commonly, things that involved day-to-day activities or relatively little effort, like turning off lights when leaving the room, cleaning or replacing air filters, and running the clothes washer with a full load. Exceptions were that relatively few respondents reported taking shorter showers, lowering the water heater temperature, unplugging electronics or kitchen appliances when not in use, and adjusting the refrigerator temperature – all things that should not involve much effort.

2.8.8 Power Hours

- Opt-out rates remain low for events. The rate of customers who opt out of events is approximately 15% per event.
- Unenrollment from the program is relatively high for demand response program. There are over 23,000 active program participants and program staff estimated there have been approximately 8,000 who have unenrolled over the past five years. PSO has communicated that the high unenrollment rate is due to participants moving out.

- Overall satisfaction with most participants planning to participate next program year. For customers participating in the DLC component, 79% reported they were satisfied with it. A majority (75%) of participants are likely to continue participating in the DLC component of the program another year.

2.8.9 Business Demand Response

- PSO staff is satisfied with Peak Performers. The program has been operating for seven years and has continued to generate reliable load reductions of approximately 40 to 50 megawatts through participants' voluntary load shedding actions. In addition to incentive payments that can range from $30 to $600,000, three appreciation luncheons were held in November in Tulsa, Lawton, and McAlester to recognize participants' efforts.
- Varied approaches were used to market the Peak Performers program to encourage broad awareness of the offer, but individual approaches tend to be most effective. The approaches used to market the program included LinkedIn and Facebook campaigns in the spring and early summer, as well as information sent through Questline. The program also provides YouTube videos to educate potential participants about the program and its benefits. Staff observed that that the social media campaigns generated interest but few of the interested customers enrolled, and that overall, account representatives speaking with customers was the most effective recruitment approach. Additionally, program staff noted that school districts are often reluctant to enroll, and program staff has found that word-of-mouth referral from other school district staff is most effective at encouraging their participation. At this time, about one-third of the program participants are schools and staff commented that "*Schools are not only stewards of our children but also stewards of our facilities and our environment."*
- Seventeen new participants enrolled in PY2019. Staff stated that most of the new participants are small businesses. Most participants are organizations that rolled over their participation from the prior cycle.
- Most participants (94%) reported that they were very likely to participate in the program during 2020. No respondents indicated that they were somewhat unlikely or very unlikely to participate in the next program year.
- All participants were satisfied (75%) or very satisfied (25%) with the program overall. All respondents also reported that they were satisfied with their interactions with PSO staff (5% "satisfied" and 95% "very satisfied"). In addition, participants expressed a high level of satisfaction with the application process (19% "satisfied" and 77% "very satisfied"). Lastly, 81% of respondents reported that they

recommended the program to someone else, suggesting that the program continues to spread by word of mouth among PSO customers.

3 Energy-Efficiency Programs

PSO's energy-efficiency portfolio in 2019 consisted of eight programs: five residential, two commercial/industrial, and one cross-sector program. PSO's Power Hours program savings energy with thermostat rebates. The program is demand response focused and discussed there. Program-level annual savings are summarized in Table 3-1.

Table 3-1: Annual Energy Savings – Energy Efficiency Programs

Program	Gross Peak Annual Energy Savings (MWh)				Net Impacts	
	Projected	Reported	Verified	Gross Realization Rate	NTG Ratio	Net Annual Energy Savings (MWh)
Energy Efficiency Programs						
Business Rebates	42,017	61,056	65,015	106%	96%	62,117
Multi-Family	1,532	3,628	3,678	101%	98%	3,604
Home Weatherization	2,423	3,743	3,743	100%	100%	3,743
Energy Saving Products	40,364	53,442	59,165	111%	62%	36,429
Home Rebates	7,283	6,738	5,180	77%	84%	4,373
Education	4,395	3,679	3,508	95%	100%	3,508
Behavioral	18,900	8,476	8,476	100%	100%	8,476
Conservation Voltage Reduction	8,162	9,755	10,439	107%	100%	10,439
Energy Efficiency Totals	**125,076**	**150,517**	**159,204**	**106%**	**83%**	**132,689**

Program-level peak demand reduction is summarized in Table 3-2.

Table 3-2: Peak Demand Reduction – Energy Efficiency Programs

Program	Gross Peak Demand Reduction (MW)				Net Impacts	
	Projected	Reported	Verified	Gross Realization Rate	NTG Ratio	Net Peak Demand Reduction (MW)
Energy Efficiency Programs						
Business Rebates	7.63	12.45	10.76	86%	94%	10.16
Multi-Family	0.28	1.07	1.01	94%	96%	0.96
Home Weatherization	1.16	2.07	2.07	100%	100%	2.07
Energy Saving Products	4.90	7.57	9.40	124%	62%	5.81
Home Rebates	2.76	2.72	2.87	105%	86%	2.45
Education	0.52	0.69	0.67	98%	100%	0.67
Behavioral	3.44	0.97	0.97	100%	100%	0.97
Conservation Voltage Reduction	1.77	1.11	2.06	185%	100%	2.06
Energy Efficiency Totals	**22.45**	**28.65**	**29.81**	**104%**	**84%**	**25.16**

The remainder of this section provides evaluation findings for each of the PY2019 PSO energy-efficiency programs including program performance metrics, evaluation methodologies, energy and demand impacts, and process evaluation findings.

3.1 Business Rebates Program

3.1.1 Program Overview

PSO's Business Rebates program provided rebates for a total of 1,192 projects in program year (PY) 2019. The program seeks to generate energy and demand savings for small and large commercial and industrial customers, schools, and municipalities by incentivizing high efficiency electric end-use products including, but not limited to, lighting, Heating Ventilation and Cooling (HVAC), and Variable Frequency Drives (VFDs) for motors. Additional incentive avenues were developed in 2019 that include midstream for lighting and HVAC, as well as an oil and gas and energy coaching components.

To participate in the Small Business Energy Solutions (SBES) avenue, businesses must use 220,000 kWh or less annually and use a PSO approved service provider. PSO's customers can participate by self-sponsoring or working through a program service provider to leverage technical expertise.

The midstream program is designed to influence distributor stocking practices, as well as promote the sale of higher efficiency equipment, such as light bulbs, air conditioners, and heat pumps.

The Business Rebates program exceeded annual energy savings goals within budget. Table 3-3 summarizes projected, ex-ante, and ex-post demand impacts as well as other program performance metrics. Detailed Business Rebate program results by program avenue and measure are presented in this chapter.

Table 3-3: Performance Metrics – Business Rebates Program

Metric	PY2019
Number of Customers	1,192
Budgeted Expenditures	$11,191,794
Actual Expenditures	$10,788,034
Energy Impacts (kWh)	
Projected Energy Savings	42,017,009
Reported Energy Savings	61,056,345
Gross Verified Energy Savings	65,015,317
Net Verified Energy Savings	62,116,604
Peak Demand Impacts (kW)	
Projected Peak Demand Savings	7,712
Reported Peak Demand Savings	12,450
Gross Verified Peak Demand Savings	10,756
Net Verified Peak Demand Savings	10,158
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	2.58
Utility Cost Test Ratio	4.30

The evaluation included a process evaluation as well as an impact evaluation. Evaluation activities included surveying, in-depth interviews, program tracking data review, field verification visits, gross energy savings analysis, and net energy savings analysis. Table 3-4 summarizes the achieved sample size for the various data collection activities for the Business Rebates program evaluation.

Table 3-4: Sample Sizes for Data Collection Efforts

Data Collection Activity	Achieved Sample Size	
	Custom/Prescriptive	SBES
On-Site M&V visits (total with desk reviews)	42 (44)	22
Customer Decision Maker Survey	100	45
In-depth Interviews with Program Staff	2	2

The evaluation determined overall gross annual energy savings higher than estimated. The difference can be attributed to the estimate of annual operating hours, baseline condition variables, efficient equipment quantities, and algorithm discrepancies. When accounting for the effects of free-ridership and spillover, the net program savings are approximately 2% above estimated (ex-ante) annual energy savings.

3.1.2 Custom and Prescriptive

For custom and prescriptive projects, ADM found a 108% realization rate for gross energy savings and an 88% realization rate for gross peak demand reduction. ADM found a net-to-gross ratio for energy savings of 95% and 93% for peak demand reduction.

3.1.2.1 Description of Program

PSO's Business Rebates program seeks to generate energy savings for custom and prescriptive projects by promoting high efficiency electric end-use products including, but not limited to, lighting, HVAC, process improvements, and variable frequency drives (VFD's). The program allows PSO's customers to participate by either self-sponsoring or by working through a third-party service provider to leverage technical expertise. The program seeks to combine the distribution of financial incentives with access to technical expertise to maximize program penetration across the range of potential commercial and industrial customers. Additionally, the program aims to accomplish the following:

- Increase customer awareness and knowledge of applicable energy saving measures and their benefits,
- Increase the market share of commercial grade high efficiency technologies sold through market channels,
- And increase the installation rate of high efficiency technologies in C&I facilities by businesses that would not have done so in absence of the program.

Prescriptive rebate amounts are provided to participating customers for some measures including certain types of lighting, lighting controls, hotel & kitchen equipment, and HVAC equipment. Custom projects that do not fall into prescriptive measure categories are rebated on a per kWh and kW impact basis. To assist customers with identifying energy-saving capital improvements, the program offers capital improvement consultation.

3.1.2.2 Impact Evaluation Overview

PSO's prescriptive and custom projects provided rebates for a total of 850 projects. Three projects did not have any associated annual energy savings.

Lighting system retrofit projects continued to be the main source of program savings with approximately 55% of ex-ante annual energy savings (kWh). New Construction lighting projects made up an additional 26% of Custom and Prescriptive projects. Savings attributable to all lighting projects (new construction lighting, custom lighting, and lighting system retrofit) contribute approximately 81% of ex-ante kWh savings for prescriptive and custom projects (projects with multiple measures are not included). Custom projects accounted for approximately 6% of ex-ante savings, and projects with multiple measures accounts for approximately 8%. Individual measures within this category differed across 60 different projects, but most included a lighting component. Refrigeration and Kitchen

Equipment was common across projects with multiple measures. A breakdown of measure type (aggregated by category based on provided measures type) by percentage of program savings is shown in Table 3-5.

Table 3-5: Measure Type as Percentage of Ex-Ante Savings

Aggregated Measure List	Percent of Program
Retrofit Lighting	55%
New Construction Lighting	26%
Multiple	8%
Custom	6%
Oil & Gas	3%
Refrigeration & Kitchen Equipment	2%
Unitary HVAC & VFDs	1%
Agriculture	0.11%
Building Envelope	0.11%
Total	**100%**

Overall, the number of rebated projects decreased from 981 in PY2018 to 850 in PY2019, however, ex-ante annual energy savings (kWh) increased from 50,125 MWh to 52,693 MWh. Thus, an increase in the average annual energy savings per project. Ex-post gross energy savings (kWh) likewise increased from 50,081 MWh (PY2018) to 56,782 MWh (PY2019). The gross energy savings realization rate is 108%, while the gross peak demand reduction realization rate is 88%. The estimated annual energy savings net-to-gross (NTG) ratio changed from 92% in PY2018 to 95% in PY2019. The estimated peak demand reduction NTG ratio changed from 90% in PY2018 to 93% for PY2019. Table 3-6 provides a summary of Custom and Prescriptive project savings in the program.

Table 3-6: Performance Metrics –Prescriptive and Custom

Metric	PY2019
Number of Projects	850
Energy Impacts (kWh)	
Reported Energy Savings	52,692,682
Gross Verified Energy Savings	56,782,124
Net Verified Energy Savings	53,766,485
Peak Demand Impacts (kW)	
Reported Energy Savings	10,128
Gross Verified Energy Savings	8,904
Net Verified Energy Savings	8,285
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	2.81
Utility Cost Test Ratio	6.56

3.1.2.3 Process Evaluation Overview

The process evaluation consisted of participant surveys, trade ally interviews, and program staff interviews. The objective of the participant survey was to assess the source of program awareness, factors that influenced project decision making, experience with the application process or energy consultant, and program satisfaction. A total of 74 customer decision makers responded to the participant survey.

Participation in the program accelerated toward the end of the year. Figure 3-1 displays the accrual of ex-ante energy savings as well as the monthly savings into the program.

Figure 3-1: Accrual of Ex-Ante kWh Savings during the Program Year

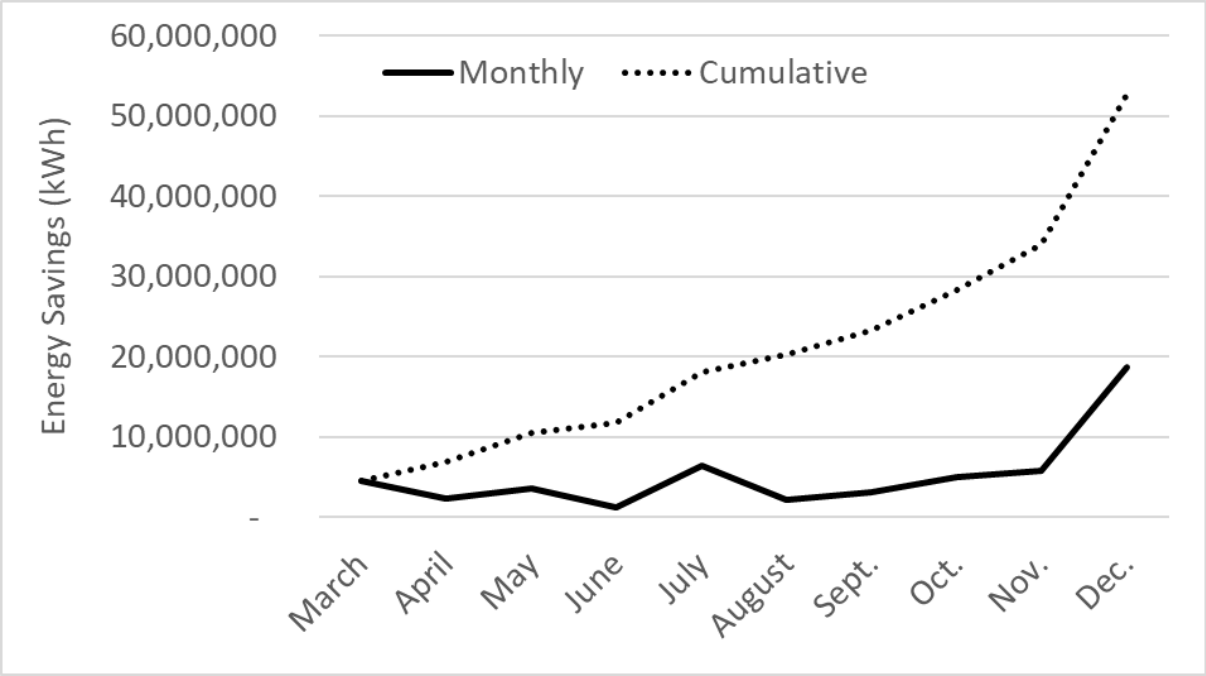


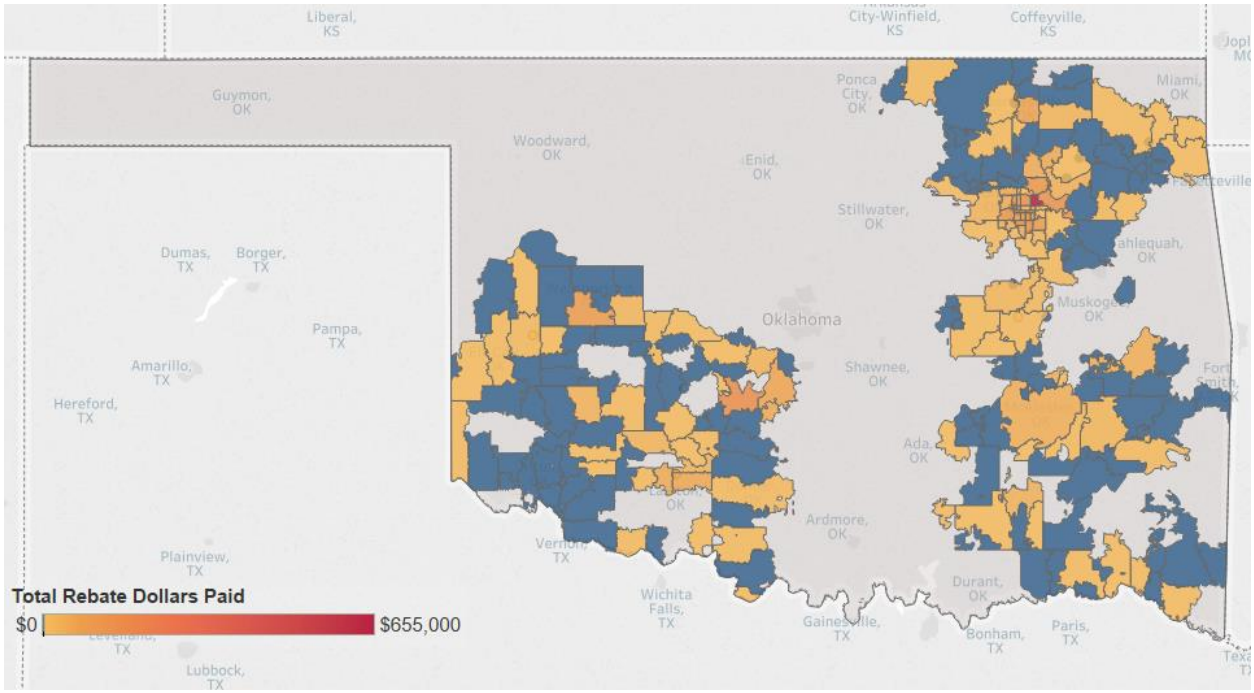
Table 3-7 summarizes the share of ex-ante savings by district. As with past program years, a large amount of savings comes from the Tulsa region; however, energy savings from outside the Tulsa region meets the programs goals. Compared to the previous program year, the Eastern District saw a reduction in annual energy savings. However, there were over 100 reported projects in the Eastern District.

Table 3-7: District Share of Reported kWh Savings

Region	Sum of Ex-Ante Energy Savings (kWh)	Percentage of Program	Reported Rebate Dollars Paid	Percent of Reported Rebate Dollars Paid
Eastern District	2,292,994	4%	167,456	5%
Tulsa District	40,512,245	77%	2,648,479	74%
Tulsa Northern District	3,610,512	7%	195,060	5%
Western District	6,276,931	12%	569,936	16%
Total	**52,692,682**	**100%**	**3,580,932**	**100%**

A detailed depiction of geographic incentive allocation is shown in Figure 3-2. This heat map shows the concentration or incentive dollars throughout the PSO Territory based on zip code. Zip codes in blue did not receive any reported incentives.

Figure 3-2: Distribution of Custom and Prescriptive Projects



*map displays zip codes in PSO territory. PO Boxes or zip codes displayed as points within other zip codes were removed/incorporated into zip codes that included them. **Blue** zip code did not receive funding. . **Sunset colored** zip codes received funding.

3.1.2.4 Evaluation Methodology

This chapter provides a brief overview of the data collection activities and process evaluation activities that ADM employed in the evaluation of the program. Energy savings methodologies are provided in Appendix F of this report.

Data Collection

Data for analysis was collected through review of program materials, on-site inspections, end-use metering, and interviews with participating customers and service providers. PSO uses Sightline in conjunction with an SQL Server Reporting Services (SSRS) system as their central tracking and reporting system. Based on program tracking data provided by PSO through SSRS, a sample was developed for on-site data collection.

On-site visits were used to collect data for gross impact calculations, verify measure installation, and determine measure operating parameters. Facility staff members were interviewed to determine the operating hours of the installed systems and provide any additional operational characteristics relevant to calculating energy savings. For a subset of sampled projects, lighting equipment, HVAC equipment, or motors/Variable Frequency Drives (VFDs) were monitored to obtain accurate operational profiles. Section 3.1.6 provides a description of ADM's safety standards and procedures.

In addition to on-site data collection, customer surveys provided self-reported data for the NTG analysis and process evaluation. A total of 74 customer decision makers completed the survey. Service provider, or trade ally interviews, were conducted to gain feedback on program participation, barriers, and satisfaction from a stakeholder perspective. Trade ally interviews were conducted with eleven program contractors.

In-depth interviews with PSO and implementation staff members were conducted to provide additional perspectives for process evaluation. Table 3-8 shows the achieved sample sizes for the different types of data collection utilized for this study.

Table 3-8: Sample Sizes for Data Collection Efforts

Data Collection Activity	Achieved Sample Size
On-Site M&V visits	42
Sample Desk Review	2
Customer Decision Maker Surveys	74
Trade Ally Interviews	11
Program Staff Interviews	2

Sampling Plan

ADM created a stratified sample based on the amount of energy savings and type of measure installed in each project. For this approach, ADM utilized algorithms in an R programming language package based on the Bethel-Chromy algorithm to determine stratification boundaries.[22] Ratio estimation was then used to determine precision at a 90% confidence interval across all Custom and Prescriptive strata. Realization rates (the ratio of ex-post to ex-ante savings) for projects sampled in each stratum are only extrapolated to other projects within that stratum. Verification of sample precision, by means of each stratum's contribution to variance, is then performed on the ex-post extrapolated annual energy savings (kWh) for the program.

Occasionally the energy savings for a given project are impacted by circumstances that are not consistent with similar projects. In these situations, the verified energy savings are held for the project but are not extrapolated to any other projects. An example of this situation may be the destruction of the facility through natural disasters. No custom or prescriptive projects required removal from extrapolation.

Sample size was designed to meet ex-ante annual energy savings at $\pm$10% precision at the 90% confidence level for the program. Separate samples were drawn for custom and prescriptive projects and SBES projects. Table 3-9 shows the sample design that was used for custom and prescriptive projects. Stratum classifications were based on verified

[22] https://cran.r-project.org/web/packages/SamplingStrata/index.html

measure installations. The 44 projects that were sampled for evaluation verification account for approximately 38% of ex-ante program annual kWh savings.

Table 3-9: Sample Design for Prescriptive and Custom

Stratum Name	Ex-Ante kWh Savings	Strata Boundaries (kWh)	Population of Projects	Design Sample Size
Custom & Other 1	1,068,697	0 - 30,290	192	3
Custom & Other 2	1,860,505	32,290 - 88,851	31	3
Custom & Other 3	2,873,089	95,172 - 292,046	19	3
Custom & Other 4	3,854,921	359,642 - 1,264,301	8	4
HVAC 1	195,373	369 - 11,874	61	2
HVAC 2	287,504	13,653 - 161,303	6	2
NC Lighting 1	118,126	2,433 - 37,986	7	2
NC Lighting 2	605,397	56,486 - 173,735	7	3
NC Lighting 3	12,836,909	12,836,909 - 12,836,909	1	1
Retrofit Lighting 1	2,991,304	157 - 28,950	292	5
Retrofit Lighting 2	8,002,775	29,448 - 99,450	146	6
Retrofit Lighting 3	8,901,753	101,328 - 256,722	59	4
Retrofit Lighting 4	9,096,329	259,774 - 767,964	21	6
Total	**52,692,682**	**-**	**850**	**44**

Impact Evaluation Methodology

The evaluation of gross energy savings and peak demand reduction from projects rebated through the program can be broken down into the following steps:

- The program tracking database was reviewed to determine the scope of the program and to ensure there were no duplicate project entries. The tracking database was used to define a discrete set of rebated projects that made up the program population. A sample of projects was then drawn from the population established in the tracking system review.
- A detailed desk review was conducted for each project sampled for on-site verification and data collection. The desk review process includes a thorough examination of all project materials including invoices, equipment cut sheets, pre- and post-inspection reports, and estimated savings calculators. This review process informs ADM's fieldwork by identifying potential uncertainties, missing

data, and sites where monitoring equipment is needed to verify key inputs to the ex-ante savings calculations.

- After reviewing project materials, on-site verification and data collection visits are scheduled for each sampled project. The visits are used to collect data for savings calculations, verify measure installation, and determine measure operating parameters.
- The data collected during the on-site verification visits is used to revise savings calculations, as necessary. For example, if the ex-ante savings calculations relied on operating hours for a given measure that were found to be inaccurate based on the on-site verification and data collection, changes are made to more accurately reflect actual operating conditions.
- After determining the ex-post savings impacts for each sampled project, results are extrapolated to the program population using project-specific sampling weights. This allows for the estimation of program level gross ex-post energy (kWh) savings with a given amount of sampling precision and confidence.

Net-to-Gross Estimation (NTG)

The purpose of net savings analysis is to determine what portion of gross savings achieved by PSO customers is the direct result of program influence. Information collected from a sample of program participants through a customer decision maker survey was used for the net-to-gross analysis. These survey responses were reviewed to assess the likelihood that participants were free riders or whether there were spillover effects associated with non-rebated purchases by program participants.[23] Both the Custom and Prescriptive and SBES programs utilized the same NTG methodology.

Several criteria were used for determining the likelihood that a customer was a free rider. The first criterion was based on the response to the following questions:

- "Would you have been financially able to complete energy efficient [Measure/Equipment project] at the location without the financial incentive from the program?"
- "To confirm, your organization would NOT have allocated the funds to complete a similar [Measure/Equipment] project if the program incentive was not available. Is that correct?"

Customers that answered "No" to the first question and "Yes" to the second question were not deemed to be free riders.

[23] The spillover analysis is limited to participant spillover. Non-participant spillover effects may exist for the program, but they are not estimated and therefore assumed to be zero.

The second criterion was the impact of the program timing on the decision to implement the energy efficiency measure. Consistent with the Arkansas TRM that defines a free rider as a decision maker who would have installed a measure within one year of when it was installed, customers were determined to not be a free rider if they stated that they would have installed a measure in more than one year of when it was installed. Specifically, respondents were asked the following questions:

- Did you implement the measure earlier than you otherwise would have because of the information and rebates available through the program?
- When would you otherwise have installed the measure?

Respondents who answered yes to the first question and indicate that they would have installed the measure one or more years later in the second question were deemed to not be free riders.

For decision makers that indicated that they were able to undertake energy efficiency projects without financial assistance from the program and would have done so with in one year of when they undertook it, three factors were analyzed to determine the likelihood that they were free riders. The three factors were:

- Plans and intentions of the firm to install a measure even without support from the program.
- Influence that the program had on the decision to install a measure; and
- A firm's previous experience with a measure installed under the program.

For each of these factors, rules were applied to develop binary variables indicating if a participant's behavior indicated free ridership.

The first factor required determining if a participant states that his or her intention was to install an energy efficiency measure even without the program. The answers to a combination of several questions were used with a set of rules to determine whether a participant's behavior indicated likely free ridership. Two binary variables were constructed to account for customer plans and intentions: one, based on a more restrictive set of criteria that may describe a high likelihood of free ridership, and a second, based on a less restrictive set of criteria that may describe a relatively lower likelihood of free ridership.

The first, more restrictive criteria indicating customer plans and intentions that likely signify free ridership was as follows (Definition 1):

- The respondent answers "yes" to the following two questions: "Did you have plans to install energy efficient [Measure/Equipment] before deciding to participate in the program?" and "Would you have gone ahead with this planned project if you had not received the rebate through the program?"

- The respondent answers “definitely would have installed” to the following question: “If the rebates from the program had not been available, how likely is it that you would have installed energy efficient [Measure/Equipment] at the location anyway?”
- The respondent answers “no, program did not affect level of efficiency chosen for equipment” in response to the following question: “Did you choose equipment that was more energy efficient than you would have chosen had you not participated in the program?”
- The respondent answers, “no, the program did not affect timing of project” in response to the following question: “Did you install the [Equipment/Measure] earlier than you otherwise would have because of the information and rebates from PSO’s program?”

The second, less restrictive criteria indicating customer plans and intentions that likely signify free ridership was as follows (Definition 2):

- The respondent answers “yes” to the following two questions: “Did you have plans to install energy efficient [Measure/Equipment] at the location before participating in the program?” and “Would you have gone ahead with this planned installation even if you had not participated in the program?”
- Either the respondent answers “definitely would have installed” or “probably would have installed” to the following question: “If the rebates from the program had not been available, how likely is it that you would have installed energy efficient [Measure/Equipment] at the location anyway?”
- The respondent answers “no, program did not affect level of efficiency chosen for equipment” in response to the following question: “Did you choose equipment that was more energy efficient than you would have chosen had you not participated in the program?”
- The respondent answers, “no, the program did not affect timing of project” in response to the following question: “Did you install the [Equipment/Measure] earlier than you otherwise would have because of the information and rebates from PSO’s program?”

The second factor requires determining if a customer reported that a recommendation from a program representative or experience with the program was influential in the decision to install a piece of equipment or measure.

The criterion indicating that program influence may signify a lower likelihood of free ridership is that either of the following conditions is true:

- The respondent answers “very important” to the following question: “How important was previous experience with the program in making your decision to install energy efficient [Measure/Equipment] at the location?”
- The respondent answers “probably would not have” or “definitely would not have” to the following question: “If the program representative had not recommended [Measure/Equipment], how likely is it that you would have installed it anyway?”

The third factor required determining if a participant in the program indicated that he or she had previously installed an energy efficiency measure like one that they installed under the program without an energy efficiency program incentive during the last three years. A participant indicating that he or she had installed a similar measure is considered to have a likelihood of free ridership.

The criteria indicating that previous experience may signify a higher likelihood of free ridership are as follows:

- The respondent answers “yes” to the following question: “Before participating in the Program, had you installed any equipment or measure like energy efficient [Measure/Equipment] at your facility?”
- The respondent answers “yes, purchased energy efficient equipment but did not apply for financial incentive.” to the following question: “Has your organization purchased any energy efficient equipment in the last three years for which you did not apply for a rebate through the program?”

The four factors described above were used to construct four different indicator variables that address free ridership behavior. For each customer, a free ridership value was assigned based on the combination of variables. With the four indicator variables, there were 12 applicable combinations for assigning free ridership scores for each respondent, depending on the combination of answers to the questions creating the indicator variables. Table 3-10 shows these values.

Table 3-10: Free Ridership Scores for Combinations of Indicator Variable Responses

Had Plans and Intentions to Install Measure without C&I Program? (Definition 1)	Had Plans and Intentions to Install Measure without C&I Program? (Definition 2)	C&I Program had influence on Decision to Install Measure?	Had Previous Experience with Measure?	Free Ridership Score
Y	N/A	Y	Y	100%
Y	N/A	N	N	100%
Y	N/A	N	Y	100%
Y	N/A	Y	N	67%
N	Y	N	Y	67%
N	Y	N	N	33%
N	Y	Y	N	0%
N	Y	Y	Y	33%
N	N	N	Y	33%
N	N	N	N	0%
N	N	Y	N	0%
N	N	Y	Y	0%

The customer decision maker survey also included a series of questions used to analyze whether there were potential spillover effects associated with non-rebated purchases by program participants.[24] Specifically, survey respondents were asked:

- "We would like to know if you have installed any additional energy efficient equipment because of your experience with the program that you DID NOT receive an incentive for. Since participating in the program, has your organization installed any ADDITIONAL energy efficiency measures at this facility or at your other facilities within PSO's service territory that did NOT receive incentives through PSO's program?"

Customers who indicate "yes" were identified as potential spillover candidates. Potential spillover candidates were additionally asked to identify the type of additional equipment installed and provide information about the equipment for use in estimating energy savings. For each type of equipment that respondents report installing, respondents were asked the following two questions, which were used to assess if any savings resulting from the additional equipment installed was attributable to the program.

[24] The spillover analysis is limited to participant spillover. Non-participant spillover effects may exist for the program, but they are not estimated and therefore assumed to be zero.

- [SP1] How important was your experience with the program in your decision to install this [Equipment/Measure]? [Rated on a scale where 0 means not at all important and 10 meant very important]
- [SP2] If you had NOT participated in the program, how likely is it that your organization would still have installed this [Equipment/Measure]? [Rated on a scale where 0 means not at all likely and 10 meant very likely]

A spillover score was developed based on these responses as follows:

Spillover Score = Average (SP1, SP2)

The energy savings of equipment installations associated with a spillover score of greater than six are attributed to the program.

Process Evaluation Methodology

The process evaluation was designed to research and document the program delivery mechanisms and collective experiences of program participants, partners and staff. The process evaluation was designed to answer the following research questions:

- How does PSO market this program?
  - How effective are the marketing efforts for the program?
  - Which marketing methods are most effective?
- How well do PSO staff and service providers work together? Are there rebate processing, data tracking, and/or communication efficiencies that can be gained?
- Did the program implementation reflect its design? Are there underlying assumptions about program implementation and design that are being made about how the program will unfold? Are there ways to improve the design or implementation process?
- Were participants satisfied with their experience? What was the level of satisfaction with the rebate amount, the application process, the rebated measures, and other aspects of program participation?
- How is the program working to meet its regional and measure diversity goals? Are new measures or pilot programs being explored?
- What are PSO staff and implementation staff perspectives on the program? What are reactions to program design choices that have been implemented?
- What types of buildings/facilities participated in the program? Could certain facility types be targeted more effectively?
- What customer barriers to participation do distributors see? How can these be mitigated?

- Were there any significant obstacles during each program year?
- Looking forward, what are the key barriers and drivers to program success within PSO's market?
- What changes, if any, were made to the program design or implementation procedures?

To address these questions, ADM's process evaluation activities included surveys to program participants as well as in-depth interviews with program staff and trade allies. Table 3-11 provides a summary of data collection activities for the process evaluation.

Table 3-11: Custom and Prescriptive Research Questions

Data Collection Activity	Process Evaluation Research Objectives
Program Staff Interviews	Assess program staff perspectives regarding program operations, strengths, or barriers to success.
Participant Surveys	Source of program awareness, factors that influenced project decision making, experience with the application process, energy consultant, and program satisfaction.
Trade Ally Interviews	Assess program changes, barriers to participation, satisfaction with program procedures and how it compares to other programs in the region, assessment of program marketing materials, training, and communications with program staff
Review of Program Tracking Data	Assesses program tracking data through the end of September to present a summary of projects, by location, in the utility service territory.

3.1.2.5 Impact Evaluation Findings

Impact evaluation findings determine net annual energy savings and net coincident peak demand reduction. Net results are achieved by extrapolation of verified (ex-post) project level savings; known as gross results. Gross results are adjusted for program free-ridership and participant spillover to determine net results.

Gross Annual Energy Savings

The ex-post gross kWh savings for Prescriptive and Custom projects are summarized, by sampling stratum, in Table 3-12.

Table 3-12: Ex-Ante and Ex-Post Gross kWh Savings by Sampling Stratum – Prescriptive and Custom

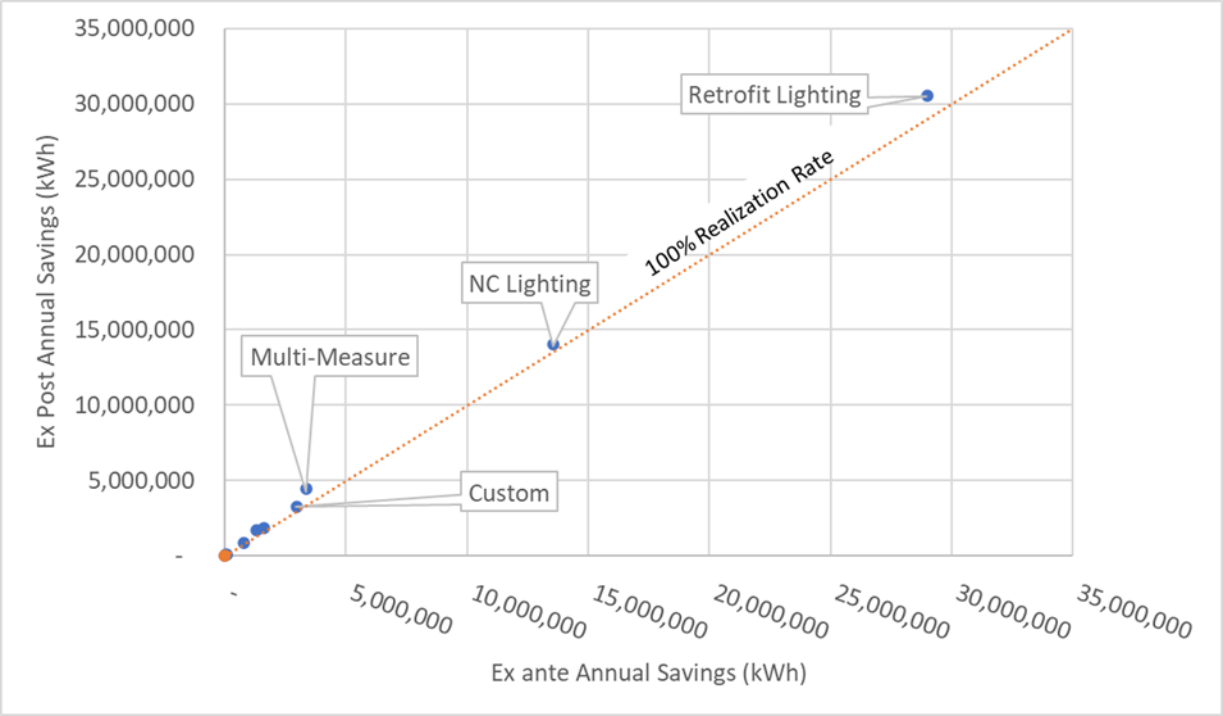
Stratum	Ex-Ante kWh Savings	Ex-Post Gross kWh Savings	Gross kWh Realization Rate
Custom & Other 1	1,068,697	1,369,612	128%
Custom & Other 2	1,860,505	2,310,734	124%
Custom & Other 3	2,873,089	3,870,985	135%
Custom & Other 4	3,854,921	4,179,199	108%
HVAC 1	195,373	213,835	109%
HVAC 2	287,504	287,262	100%
NC Lighting 1	118,126	148,235	125%
NC Lighting 2	605,397	645,102	107%
NC Lighting 3	12,836,909	13,228,873	103%
Retrofit Lighting 1	2,991,304	3,262,023	109%
Retrofit Lighting 2	8,002,775	7,266,658	91%
Retrofit Lighting 3	8,901,753	12,132,591	136%
Retrofit Lighting 4	9,096,329	7,867,015	86%
Total	**52,692,682**	**56,782,124**	**108%**

The achieved sample design results in ex-ante gross kWh estimates with ±8.4% relative precision at the 90% confidence interval, and ±9.5% in ex-post gross kWh.[25] The majority of the variability in annual gross energy savings from ex-ante to ex-post is due to higher energy savings found in retrofit and new construction lighting projects, due to the magnitude of projects and savings.

Overall annual energy savings were found to be higher than expected. Large variability was found within individual projects, with realization rates ranging from 18% to 233%. Figure 3-3 demonstrates the impact of measure type realization rates for the program. The dotted line represents a theoretical realization rate of 100%. As can be seen, retrofit lighting has the largest impact based on magnitude and is at a 105% realization rate.

[25]That is, we are 90% confident that the true verified gross savings are between 51,375,922 and 62,188,326 kWh based on the uncertainty introduced by sampling.

Figure 3-3: kWh Realization Rate Impact



The following sections discuss the results based on specific measure types from the evaluation sample.

Lighting Projects

Dedicated lighting projects were included in two strata categories; retrofit (Retrofit Lighting 1-4), and new construction lighting (NC Light1-3). Due to the difference in energy savings methodologies, new construction lighting is extrapolated separately from retrofit lighting. Project level realization rates ranged from 55% to 191%.

Retrofit Lighting Projects

Differences between ex-ante and ex-post energy savings can be explained by differences in reported and verified hours of use (HOU), with the occasional difference in fixture quantities. ADM used lighting schedules from detailed interviews with facility staff as well as deemed hours of use when applicable. Lighting settings from Energy Management Systems (EMS), timers, and photocells were used, where appropriate, based on fieldwork findings. When an accurate HOU was not available, or the HOU varied, deemed values from the Arkansas TRM v7 were used.

The driver of evaluation risk for retrofit lighting projects continues to be HOU. Findings indicate that some facility types have greater variability in the total annual HOU than others. These include manufacturing, retail, warehousing, and schools. In 2018 ADM analyzed previously incented school lighting projects to determine a territory specific

deemed value for hours of use, which has been used in ex-post analyses for 2019 but not in ex-ante analyses. The overall realization rate was 105%.

New Construction Lighting Projects

Energy savings analyses for new construction lighting projects require a lighting power density (LPD) approach to determine the proper baseline condition. The LPD baseline condition is based on allowable building codes. Project realization rates ranged from 100% to 191%. A single project made up most of the energy savings for new construction lighting. An evaluation pre-construction review and site visit was conducted for this project, mitigating evaluation risk.

The driver of evaluation risk for new construction lighting projects is due to a difference in hours of use as well as verified lighting fixture counts. The overall realization rate was 103%.

Custom & Other Projects

The variance in realization rates for custom and other equipment projects vary by measure and savings algorithm implemented. These strata represent projects with multiple measures and include prescriptive measures such as Refrigeration and & Kitchen Equipment as well as Building Envelope and Agriculture. Custom analyses were performed for measures such as Oil & Gas, large VFD's, and air compressors. These measure types were grouped together in the sample due to the nature of the measure, the number of projects, and the annual energy savings (kWh). Power monitoring was conducted on three custom projects.

Project level realization rates varied from 18% to 233%. Variations in realization rates stem from hours of use and equipment baseline conditions for air compressors and HVAC units. For all custom and equipment strata in the ADM sample, the gross energy realization rate was 121%.

Energy Coaching

PSO recently added Trane Energy Coaching projects as a measure. This measure uses available data to find building specific issues that could be addressed to reduce energy usage. The principle focus is on operational and behavioral improvements. Energy Coaching projects have been listed as Custom projects in the program tracking data. Review of Energy Coaching projects indicates energy savings based on the International Performance Measurement and Verification Protocol (IPMVP) Option C, a whole facility billing regression analysis.[26] Evaluation review found consistent savings with savings estimates.

[26] https://www.nrel.gov/docs/fy02osti/31505.pdf

HVAC Projects

Heating, Ventilation, and Air Conditioning (HVAC) projects represent low evaluation risk due to the magnitude of savings generated. The overall realization rate for HVAC projects is 104%, with individual stratum ranging from 83% to 136%. The most common HVAC type that fell into the ADM sample is rooftop AC units.

Realization rate by measure type (at the project level) is presented in Table 3-13.

Table 3-13: Realization Rate by Project Type

Project Type	Realization Rate	Percent of Custom and Prescriptive
Retrofit Lighting	105%	54%
New Construction Lighting	103%	25%
Multiple	133%	8%
Custom	109%	6%
Oil & Gas	112%	3%
Refrigeration & Kitchen Equipment	131%	3%
Unitary HVAC & VFDs	114%	2%
Agriculture	126%	0.133%
Building Envelope	128%	0.125%
Building Envelope & Plug Load and Controls	128%	0.005%

Gross Coincident Peak Demand Reduction (kW)

The ex-post gross kW reduction is summarized by sampling stratum in Table 3-14. The peak demand reduction realization rate for prescriptive and custom projects is 88%.

Table 3-14: Ex-Ante and Ex-Post Gross kW Reduction by Sampling Stratum

Stratum	Ex-Ante Peak kW Reduction	Ex-Post Gross Peak kW Reduction	Ex-Post Gross kW Realization Rate
Custom & Other 1	162.73	159.56	98%
Custom & Other 2	342.29	303.34	89%
Custom & Other 3	427.40	381.50	89%
Custom & Other 4	298.01	301.60	101%
HVAC 1	40.23	40.41	100%
HVAC 2	38.11	43.61	114%
NC Lighting 1	36.54	32.25	88%
NC Lighting 2	101.68	121.51	120%
NC Lighting 3	3,904.77	2,114.23	54%
Retrofit Lighting 1	470.26	605.77	129%
Retrofit Lighting 2	1,315.14	1,386.77	105%
Retrofit Lighting 3	1,597.45	1,690.50	106%
Retrofit Lighting 4	1,393.67	1,723.23	124%
Total	**10,128.28**	**8,904.29**	**88%**

The achieved sample design resulted in ex-ante gross kW estimates with ±12.33% relative precision at the 90% confidence interval and 15.13% for ex-post kW.[27] Peak kW reduction was variable from project to project, resulting in a high precision value. Differences between ex-ante and ex-post demand reduction may be attributed to:

- Use of stipulated coincidence factors (CF) that did not align well with actual equipment schedules
- Varying peak demand reduction from the defined peak period, or
- Differences in the definition of peak demand savings.[28]

For lighting projects, the ADM ex-post lighting calculators generate an hourly curve (8760 hours) to determine the average kW value across the peak demand period for each lighting schedule. Custom calculations and energy simulations provide similar results. For other prescriptive measures, the ADM calculators used the deemed coincidence factors provided in the AR TRM v7.

[27] That is, we are 90% confident that the ex-post gross peak demand reduction is between 7,557 and 10,252 kW based on the uncertainty introduced by sampling.
[28] Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures. National Renewable Energy Laboratory (NREL), 2013.

Net-to-Gross Estimation

The data used to assign free ridership scores were collected through a survey of customer decision makers for projects rebated through the Business Rebates program during program year. Free ridership was estimated using the methodology described in the section, "Custom and Prescriptive Net-to-Gross Estimation". Table 3-15 shows percentages of total gross ex-post savings associated with different combinations of free ridership indicator variable values for the custom and prescriptive incentive component.

Table 3-15: Estimated Free Ridership for Custom and Prescriptive

Had Plans and Intentions to Install Measure without C&I Program? (Definition 1)	Had Plans and Intentions to Install Measure without C&I Program? (Definition 2)	C&I Program had influence on Decision to Install Measure?	Had Previous Experience with Measure?	Percentage of Total Gross kWh Savings	Free Ridership Score
Y	Y	Y	Y	0%	100%
Y	Y	N	N	1%	100%
Y	Y	N	Y	0%	100%
Y	Y	Y	N	5%	67%
N	Y	N	Y	0%	67%
N	Y	N	N	0%	33%
N	Y	Y	N	0%	0%
N	Y	Y	Y	0%	33%
N	N	N	Y	2%	33%
N	N	N	N	17%	0%
N	N	Y	N	57%	0%
N	N	Y	Y	13%	0%
Required program to implement measures				5%	0%
Project would have been deferred by one year or more in the absence of a program				0%	0%
Total				**100%**	**5.31%**

Overall, the estimated percentage of program free ridership is 5.31%. Project specific free ridership was determined on a measure level basis. ADM found high levels of free ridership in several projects that consisted of lighting, air conditioning units, and an economizer. In addition, respondents representing 5% of ex-ante energy savings could not have completed the project with an incentive.

Customer decision maker survey responses were also analyzed to estimate participant spillover effects. No respondents reported installing efficient equipment that met the attribution criterion and for which energy savings could be estimated; thus, no spillover was determinant.

The final net-to-gross ratio (NTGR) for the program is calculated as 1 – free-ridership + participant spillover. This results in a NTGR of 94.69% for kWh savings and 93.01% for peak demand reductions. Table 3-16 shows the amount of savings and peak demand reduction impacted by free ridership and spillover. These values were calculated based on the percent of free-ridership and spillover found in the sample of survey respondents.

Table 3-16: Free-Ridership and Spillover for Custom and Prescriptive

Savings	Free Ridership	Spillover
kWh	3,015,639	0
kW	619.22	0

The gross and net ex-post energy savings and peak demand reduction for Custom and Prescriptive projects is summarized in Table 3-17.

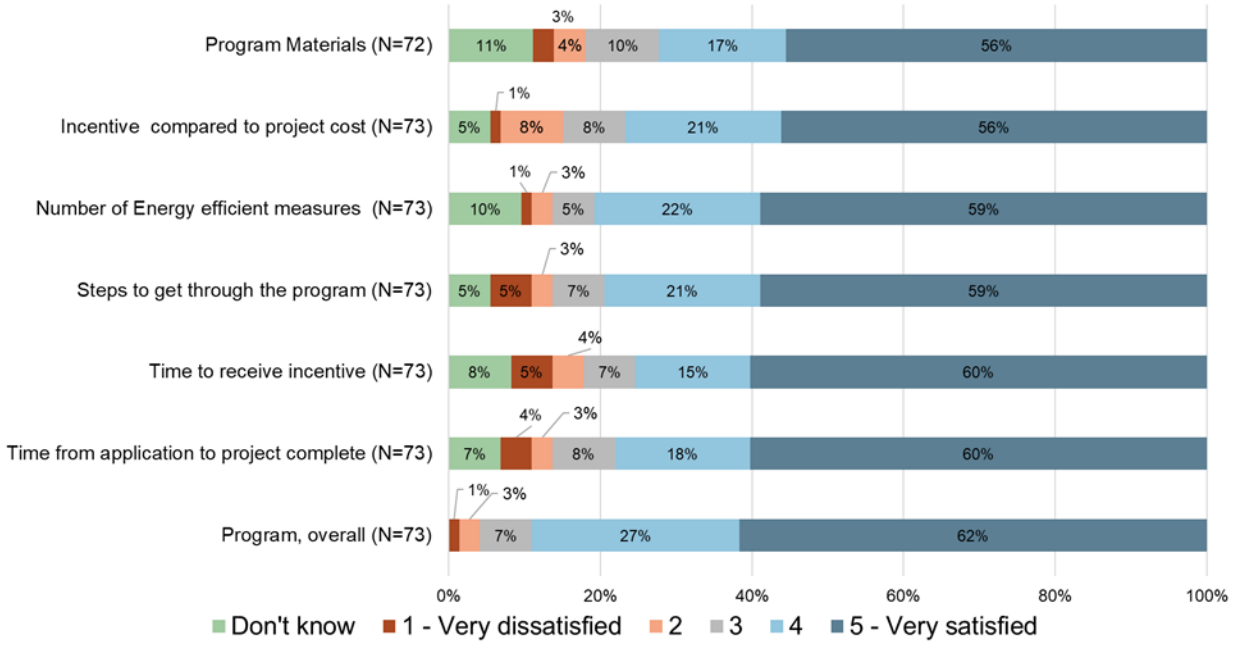
Table 3-17: Summary of Ex-Post Gross and Net Impacts

Program	Ex-Post Gross kWh Savings	Ex-Post Net kWh Savings	Net-to-Gross Ratio	Ex-Post Gross kW Reduction	Ex-Post Net kW Reduction
Custom and Prescriptive	56,782,124	53,766,485	94.7% - kWh 93.0% - kW	8,904.29	8,285.07

3.1.2.6 Process Evaluation Findings

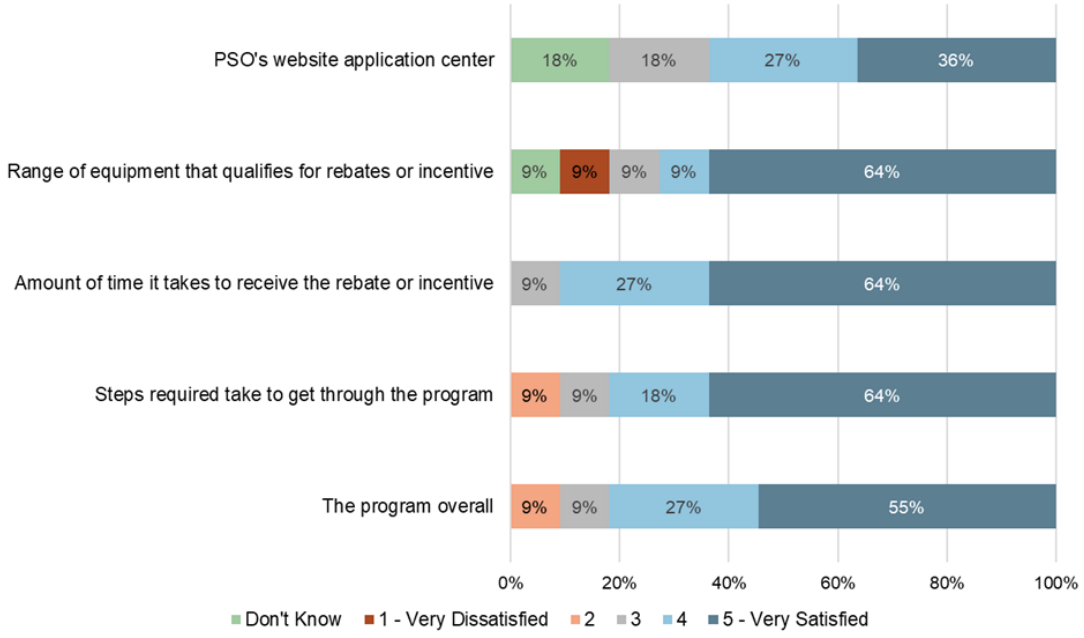
A total of 74 Custom and Prescriptive customer decision makers completed a survey about their experience with the Business Rebates. Like past program years, most respondents were satisfied with their overall experience as well as individual aspects of the program such as the incentive amount and the variety of eligible measures available through the program. Participants were most pleased with the variety of energy efficient measures incentivized as well as the program overall. A process evaluation memo was provided with detailed results. This section presents a summary of findings. Conclusions and recommendations based on the process evaluation are found in section 3.1.5. Program satisfaction is shown in Figure 3-4.

Figure 3-4: Program Satisfaction



ADM spoke with eleven business rebate trade allies, including electrical, HVAC, and lighting contractors. Trade allies noted the largest barriers to participation are financial factors such as lack of capital. Overall satisfaction with the program was high, with notably high satisfaction on the amount of time it takes to receive an incentive. Results are shown in Figure 3-5.

Figure 3-5: Trade Ally Satisfaction



3.1.3 Small Business Energy Solutions (SBES)

This section reports the findings from the Small Business Energy Solutions (SBES) projects. ADM performed an impact and process evaluation. The gross ex-post annual energy savings estimates for SBES resulted in a 98% realization rate for gross energy savings and an 80% realization rate for gross peak demand reduction.

3.1.3.1 Description of Program

The program seeks to generate energy savings for small commercial and industrial customers by promoting high-efficiency electric end-use lighting products. The program seeks to combine provision of financial inducements with access to technical expertise to maximize program penetration across the range of potential small business customers. The program has the following additional goals:

- Increase customer awareness and knowledge of applicable energy saving measures and their benefits
- Increase the market share of commercial grade high-efficiency technologies sold through market channels
- Increase the installation rate of high-efficiency technologies in small businesses by customers that would not have done so absent the program

Direct install rebates are available to customers that qualify for the SBES portion of the program. To qualify for the program, businesses must use 220,000 kWh or less annually and use a PSO approved service provider. Customers may request an exemption of these requirements. Exemptions are granted on a case-by-case basis, determined by how a customer fits within the program goals. Offerings in this portion of the program are limited to lighting retrofits.

3.1.3.2 Impact Evaluation Overview

PSO's SBES projects provided rebates for a total of 323 projects. All projects consisted of direct install lighting measures. Overall, the number of rebated projects remained relatively consistent from 346 in PY2018 to 323 in PY2019. The ex-ante energy savings decreased from 8,402 MWh (PY2018) to 8,303 MWh (PY2019). The ex-post gross annual energy savings decreased from 9,554 MWh (PY2018) to 8,173 MWh (PY2019). SBES projects reported coincident peak demand reductions of 2,307 kW while verified savings were 1,836 kW.

The estimated annual energy savings NTG ratio increased from 99% in 2018, to 101% in 2019. The estimated peak demand NTG ratio changed from 99% in PY2018 to 101% for PY2019. Table 3-18 provides projected, ex-ante, and ex-post energy and demand impacts, as well as other program performance metrics for SBES projects.

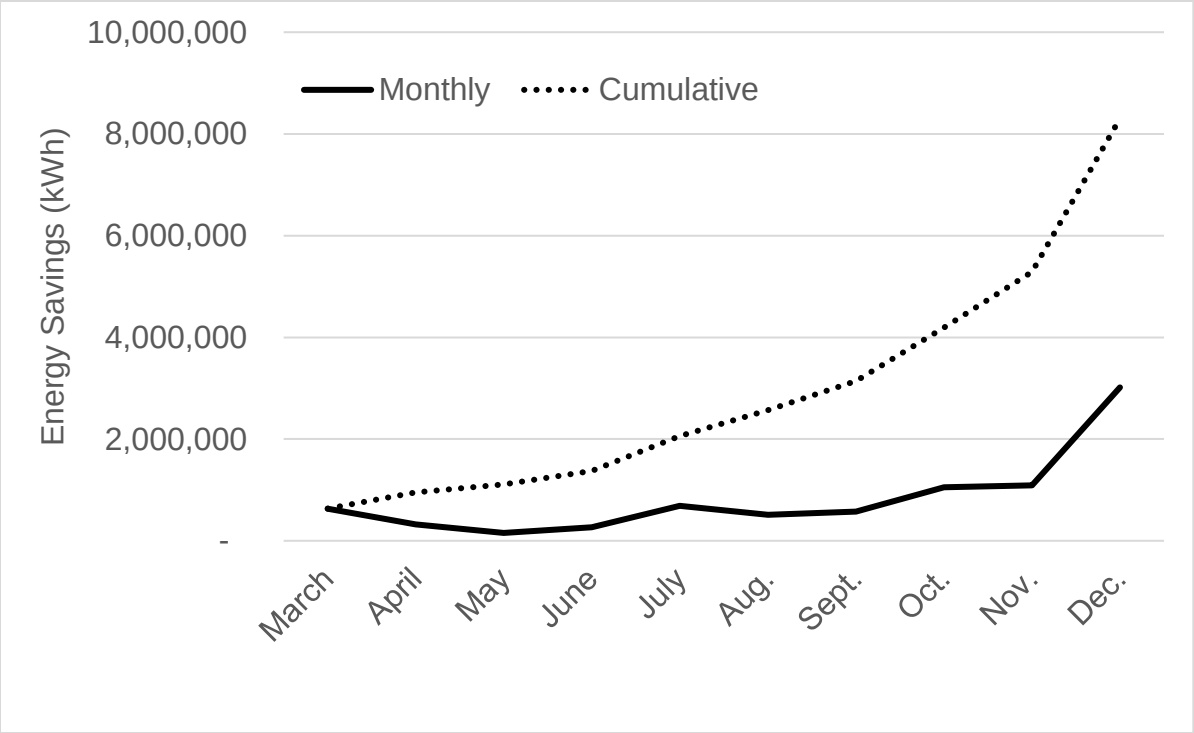
Table 3-18: Performance Metrics –Small Business Energy Solutions

Metric	PY2019
Number of Projects	323
Energy Impacts (kWh)	
Reported Energy Savings	8,302,623
Gross Verified Energy Savings	8,172,719
Net Verified Energy Savings	8,307,493
Peak Demand Impacts (kW)	
Reported Energy Savings	2,307
Gross Verified Energy Savings	1,836
Net Verified Energy Savings	1,863
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	2.65
Utility Cost Test Ratio	1.90

3.1.3.3 Process Evaluation Overview

Participation in SBES increased steadily as the year progressed, with a notable increase at the end of the year. Figure 3-6 displays the accrual of ex-ante energy savings.

Figure 3-6: Accrual of Reported kWh Savings during the Program Year



The process evaluation included participant surveys, trade ally interviews, and interviews with program staff. The objectives of the participant survey were to assess the source of program awareness, factors that influenced project decision making, experience with the application process or energy consultant, and program satisfaction. A total of 34 customer decision makers responded to the participant survey.

Table 3-19 summarizes program activity by service provider. Four service providers represented most of the energy savings. 2019 differed from 2018 in that a refrigeration contractor was not represented, two new contractors were added, and the variation in energy savings brought into the program has shifted contractors. US Energy Recovery represented 34% of energy savings in 2018 compared to 4% for 2019.

Table 3-19:Summary by Service Provider

Service Provider	Sum of Ex-Ante Energy Savings (kWh)	Percentage of Projects kWh
Bridgepoint Electric	1,782,046	21%
Entegrity Partners	2,233,678	27%
First Light Systems	1,995,792	24%
Lighting Inc.	193,408	2%
Luminous of OK	1,757,719	21%
US Energy Recovery	339,979	4%

Project Activity by Location

Table 3-20 displays the share of SBES savings by district. The distribution of savings is consistent with program goals. As expected, savings are associated with regions that have a higher density of businesses.

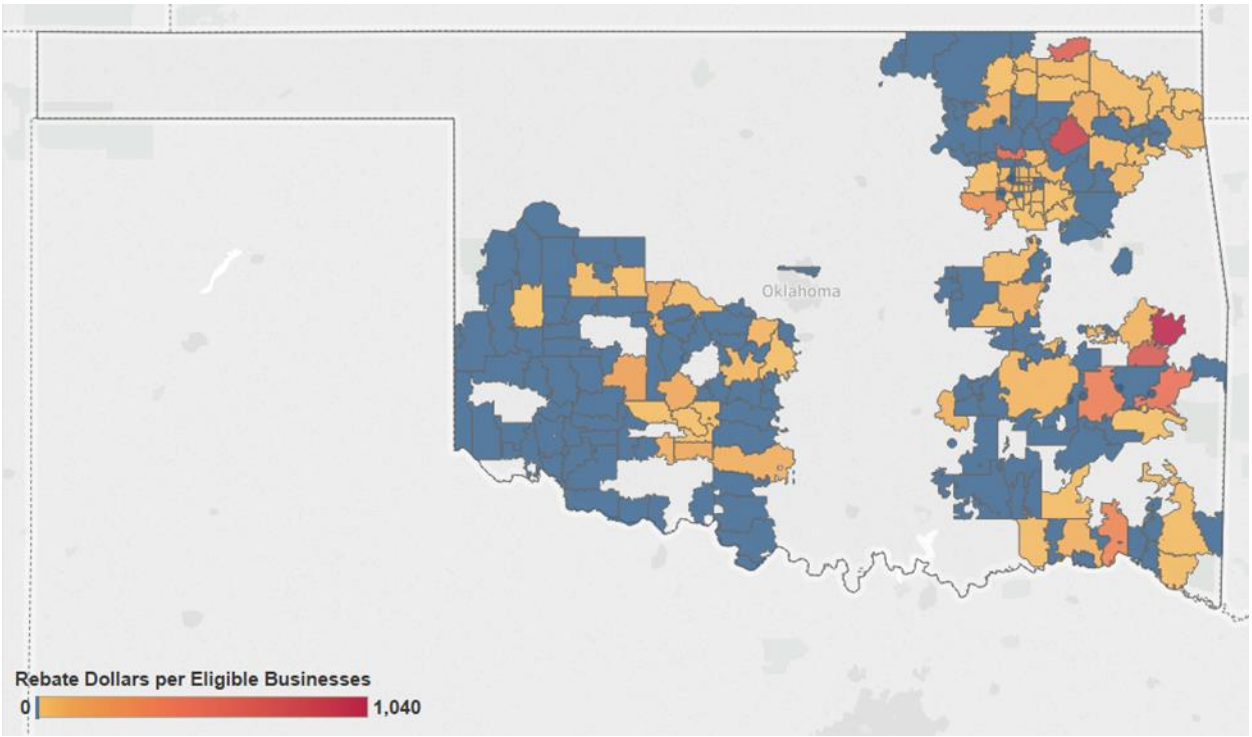
Table 3-20: District Share of Ex-Ante kWh Savings

Region	Sum of Ex-Ante Total Energy Savings (kWh)	Percentage of Projects kWh
Eastern District	2,206,804	27%
Tulsa District	3,745,255	45%
Tulsa Northern District	669,429	8%
Western District	1,647,050	20%
Not Reported	34,085	0.41%
Total	**8,302,623**	**100%**

Twenty-three different building types participated in the SBES. Buildings types with highest energy savings include education, Office, Retail, Manufacturing, and Other. The classification of Other appears to include self-storage, retail and service store fronts, and community assembly facilities.

Figure 3-7 shows a heat map of the location of SBES projects across the service territory based on zip code. The density of projects increases as the color darkens; based on the number of projects. Zip codes represented in blue indicate that no incentives were achieved.

Figure 3-7: Distribution of Small Business Energy Solutions Projects



*map displays zip codes in PSO territory. PO Boxes or zip codes displayed as points within other zip codes were removed/incorporated into zip codes that included them. **Blue** zip code did not receive funding. **Sunset colored** zip codes received funding.

Five projects consisting of reported annual energy savings over 200,000 kWh represented 18% of SBES projects annual energy savings. Four out of five projects were for schools, located in Tulsa, Tulsa North, and Eastern District.

3.1.3.4 Evaluation Methodology

This section provides a brief overview of the data collection activities, gross and net impact calculation methodologies, and process evaluation activities that ADM employed in the evaluation of the SBES projects. Energy savings methodologies are provided in Appendix F of this report.

Data Collection

Data for the analysis were collected through review of program materials, on-site inspections, end-use metering (for one project), and interviews with participating customers and service providers. A sample was developed for on-site data collection based on data obtained via SSRS.

Participating contractors used an online proposal tool called Audit Direct Install (ADI) software. Within ADI, space-by-space inventories are created for each project. The implementation team can generate reports directly from ADI which contain enough information to conduct on-site verification visits. On-site visits were used to collect data for gross impact calculations, to verify measure installation, and to determine measure operating parameters. Facility staff members were interviewed to determine the operating hours of the installed systems and provide any additional operational characteristics relevant to calculating energy savings. For one sampled project, lighting controls were monitored to obtain accurate operational profiles.

In addition to the on-site data collection effort, customer surveys provided self-report data for the net-to-gross analysis and process evaluation. A total of 34 customer decision makers who completed SBES incentive projects completed the survey. Service provider, or trade ally interviews, were conducted to gain feedback on program participation, barriers, and satisfaction from a stakeholder perspective. Trade ally interviews were conducted with three program contractors.

In-depth interviews with two PSO and implementation staff members were conducted to provide additional perspectives for the process evaluation. Table 3-21 shows the achieved sample sizes for the different types of data collection employed for this study.

Table 3-21: Sample Sizes for Data Collection Efforts – SBES

Data Collection Activity	Achieved Sample Size
On-Site M&V visits	22
Customer Decision Maker Survey	34
Program Staff Interviews	2
Trade Ally interviews	3

Sampling Plan

As with Custom and Prescriptive projects, ADM created a stratified sample based on the amount of energy savings and type of measure installed in each project. Sample sizes were designed to meet ±10% precision at the 90% confidence level at the program level. Table 3-22 below shows the sample design that was used for SBES projects. Stratum classifications were based on verified measure installations. The 22 projects that were sampled for on-site measurement and verification account for approximately 19% of reported program kWh savings.

Table 3-22: Sample Design for the Business Rebates Program Small Business

Stratum Name	Reported kWh Savings	Strata Boundaries (kWh)	Population of Projects	Design Sample Size
Lighting 1	925,543	614 - 11,901	155	5
Lighting 2	1,680,109	12,078 - 25,257	93	4
Lighting 3	1,903,906	26,101 - 62,001	49	4
Lighting 4	1,641,515	62,503 - 130,470	17	5
Lighting 5	1,176,543	149,346 - 279,787	6	3
Lighting 6	975,008	288,208 - 381,640	3	1
Total	**8,302,623**	**-**	**323**	**22**

Impact Evaluation Methodology

The evaluation of gross ex-post energy savings and peak demand reduction from projects rebated through the SBES program can be broken down into the following steps:

- The program tracking database was reviewed to determine the scope of the program and to ensure there were no duplicate project entries. The tracking database was used to define a discrete set of rebated projects that made up the program population. A sample of projects was then drawn from the population established in the tracking system review.
- A detailed desk review was conducted for each project sampled for on-site verification and data collection. The desk review process included a thorough examination of all project materials including invoices, equipment cut sheets, pre- and post-inspection reports, and estimated savings calculators. This review process informed ADM's fieldwork by identifying potential uncertainties, missing data, and sites where monitoring equipment was needed to verify key inputs to the reported savings calculations. Additionally, the review process involved assessing the reasonableness of deemed savings values and calculation input assumptions.

- After reviewing the project materials, on-site verification and data collection visits were scheduled for each sampled project. The visits were used to collect data for savings calculations, to verify measure installation, and to determine measure operating parameters.
- The data collected during the on-site verification visits was used to revise savings calculations, as necessary. For example, if the reported savings calculations relied on certain measure operating hours that were determined inaccurate based on the facilities actual schedule, changes were made to more accurately reflect actual operating conditions.
- After determining the ex-post savings impacts for each sampled project, results were extrapolated to the program population using project-specific sampling weights. This allows for the estimation of program level gross ex-post energy (kWh) savings with a given amount of sampling precision and confidence. For the SBES projects, the sample was designed to ensure ±10% or better relative precision at the 90% confidence level for kWh reductions.

Net-to-Gross Estimation (NTG)

The purpose of net savings analysis is to determine what portion of gross savings achieved by PSO customers is the direct result of program influence. The NTG for the SBES Program was estimated using the same methodology as for the Custom and Prescriptive projects, as described above in the section, “Custom and Prescriptive Net-to-Gross Estimation”. This methodology includes both free ridership and participant spillover.

Process Evaluation Methodology

The process evaluation was designed to research and document the program delivery mechanisms and collective experiences of program participants, partners and staff. The process evaluation was designed to answer the following research questions:

- How does PSO market this program?
  - How effective are the marketing efforts for the program?
  - Which marketing methods are most effective?
- How well do PSO staff and service providers work together? Are there rebate processing, data tracking, and/or communication efficiencies that can be gained?
- Did the program implementation reflect its design? Are there underlying assumptions about program implementation and design that are being made about how the program will unfold? Are there ways to improve the design or implementation process?

- Were participants satisfied with their experience? What was the level of satisfaction with the rebate amount, the application process, the rebated measures, and other aspects of program participation?
- How is the program working to meet its regional and measure diversity goals? Are new measures or pilot programs being explored?
- What are PSO staff and implementation staff perspectives on the program? What are reactions to program design choices that have been implemented?
- What types of buildings/facilities participated in the program? Could certain facility types be targeted more effectively?
- What customer barriers to participation do distributors see? How can these be mitigated?
- Were there any significant obstacles during each program year?
- Looking forward, what are the key barriers and drivers to program success within PSO's market?
- What changes, if any, were made to the program design or implementation procedures?
- Are small business service providers satisfied with the program? Are referrals effectively shared among them? How does PSO's small business program compare to other small business programs? Are service providers aware of any barriers to participation?

To address these questions, ADM's process evaluation activities included surveys to program participants as well as in-depth interviews with program staff and trade allies. Table 3-23 provides a summary of data collection activities for the process evaluation.

Table 3-23: SBES Research Questions

Data Collection Activity	Process Evaluation Research Objectives
Program Staff Interviews	Assess program staff perspectives regarding program operations, strengths, or barriers to success.
Participant Surveys	Source of program awareness, factors that influenced project decision making, experience with the application process, energy consultant, and program satisfaction.
Trade Ally Interviews	Assess program changes, barriers to participation, satisfaction with program procedures and how it compares to other programs in the region, assessment of program marketing materials, training, and communications with program staff

Data Collection Activity	Process Evaluation Research Objectives
Review of Program Tracking Data	Assesses program tracking data through the end of September to present a summary of projects, by location, in the utility service territory.

3.1.3.5 Impact Evaluation Findings

Impact evaluation findings determine net annual energy savings and net coincident peak demand reduction. Net results are achieved by extrapolation of verified (ex-post) project level savings; known as gross results. Gross results are adjusted for program free-ridership and participant spillover to determine net results.

Gross Annual Energy Savings

The ex-post gross kWh savings for SBES projects are summarized by sampling stratum in Table 3-24. Projects saw an overall realization rate of 98%.

Table 3-24:Ex-Ante and Ex-Post Gross kWh Savings by Sampling Stratum – SBES

Stratum	Ex-Ante kWh Savings	Ex-Post Gross kWh Savings	Gross kWh Realization Rate
Lighting 1	925,543	871,497	94%
Lighting 2	1,680,109	1,633,187	97%
Lighting 3	1,903,906	1,825,156	96%
Lighting 4	1,641,515	1,587,934	97%
Lighting 5	1,176,543	1,319,617	112%
Lighting 6	975,008	935,329	96%
Total	**8,302,623**	**8,172,719**	**98%**

The achieved sample design resulted in ex-ante gross kWh estimates with ±8.13% relative precision at the 90% confidence interval and ex-post at ±9.30% for kWh.[29] Realization rates varied from project to project and stratum to stratum. Variations in project realization rates were consistent from strata to strata.

Differences from reported to verified energy savings stem from annual hours of operation and baseline wattages for T-12 fixtures. In cases where baseline wattage was not able to be determined during field verification visits, ADM used default baseline wattages as presented in the Arkansas TRM v7 (AR TRM). Annual hours of use for ex-post calculations was determined either through field verification interviews or referenced the

[29]That is, we are 90% confident that the true verified gross savings are between 7,412,606 and 8,932,833 kWh based on the uncertainty introduced by sampling.

AR TRM; however, annual operating hours for schools was based on the 2018 analysis conducted by ADM to determine an annual hour of use of 2,556.

Gross Coincident Peak Demand Reduction (kW)

The ex-post gross kW reduction is summarized by sampling stratum in Table 3-25. Overall, the ex-post gross kW is equal to 80% of the reported reduction for SBES projects.

Table 3-25: Ex-Ante and Ex-Post Gross kW Reduction by Sampling Stratum

Stratum	Ex-Ante Peak kW Reduction	Ex-Post Gross Peak kW Reduction	Ex-Post Gross kW Realization Rate
Lighting 1	309.01	245.25	79%
Lighting 2	471.26	376.23	80%
Lighting 3	515.56	450.36	87%
Lighting 4	429.74	278.38	65%
Lighting 5	324.89	274.73	85%
Lighting 6	256.46	211.43	82%
Total	**2,306.93**	**1,836.38**	**80%**

The achieved sample design resulted in ex-ante gross kW estimates with ±18.46% relative precision at the 90% confidence interval and ex-post at ±19.20%.30 The high level of uncertainty associated with peak kW reductions is due to the significant amount of variance from project to project. Much of the difference between ex-ante and ex-post demand reduction, as in past program years, is explained by either 1) variation of annual operating hours, or 2) use of stipulated coincidence factors (CF) that did not align well with actual equipment schedules.

For lighting projects, the ADM ex-post lighting calculators generate an hourly curve (8760 hours) to determine the average kW value across the peak demand period for each lighting schedule.

Net-to-Gross Estimation

The data used to assign free ridership scores were collected through a survey of customer decision makers for projects rebated. Free ridership was estimated using the methodology described in “Small Business Energy Solutions: Net-to-Gross Estimation” section.

30 That is, we are 90% confident that the ex-post gross peak demand reduction is between 1,484 and 2,189 kW based on the uncertainty introduced by sampling.

Table 3-26 shows percentages of total gross ex-post savings associated with different combinations of free ridership indicator variable values for the SBES incentive component.

Table 3-26: Estimated Free Ridership for SBES

Had Plans and Intentions to Install Measure without C&I Program? (Definition 1)	Had Plans and Intentions to Install Measure without C&I Program? (Definition 2)	C&I Program had influence on Decision to Install Measure?	Had Previous Experience with Measure?	Percentage of Total Gross kWh Savings	Free Ridership Score
Y	Y	Y	Y	0%	100%
Y	Y	N	N	0%	100%
Y	Y	N	Y	0%	100%
Y	Y	Y	N	0%	67%
N	Y	N	Y	0%	67%
N	Y	N	N	0%	33%
N	Y	Y	N	0%	0%
N	Y	Y	Y	0%	33%
N	N	N	Y	0%	33%
N	N	N	N	29%	0%
N	N	Y	N	14%	0%
N	N	Y	Y	0%	0%
Required program to implement measures				47%	0%
Project would have been deferred by one year or more in the absence of the program				9%	0%
Total				**100%**	**100%**

No free ridership was found during surveying efforts for SBES. Respondents representing 47% of the annual energy savings did not have the financial needs to complete the project without the program incentive. In addition, respondents representing 9% of annual energy savings would have postponed the project in the absence of the program.

Customer decision maker survey responses were also analyzed to estimate participant spillover effects. Overall, three respondents reported installing efficient equipment that met the attribution criterion and for which energy savings could be estimated. These measures include LED tubes replacing linear fluorescents and LED exit signs replacing incandescent exit signs for a total of 53 fixtures. These measures equate to annual energy

savings that represent 1.65% of the survey sample or 134,774 kWh of additional savings attributed to SBES.

The final net-to-gross ratio for SBES projects is calculated as 1 – free-ridership + participant spillover. This results in an NTGR of 101.65% for kWh savings and 101.43% for peak demand reductions. The gross and net ex-post energy savings and peak demand reduction are summarized in Table 3-27.

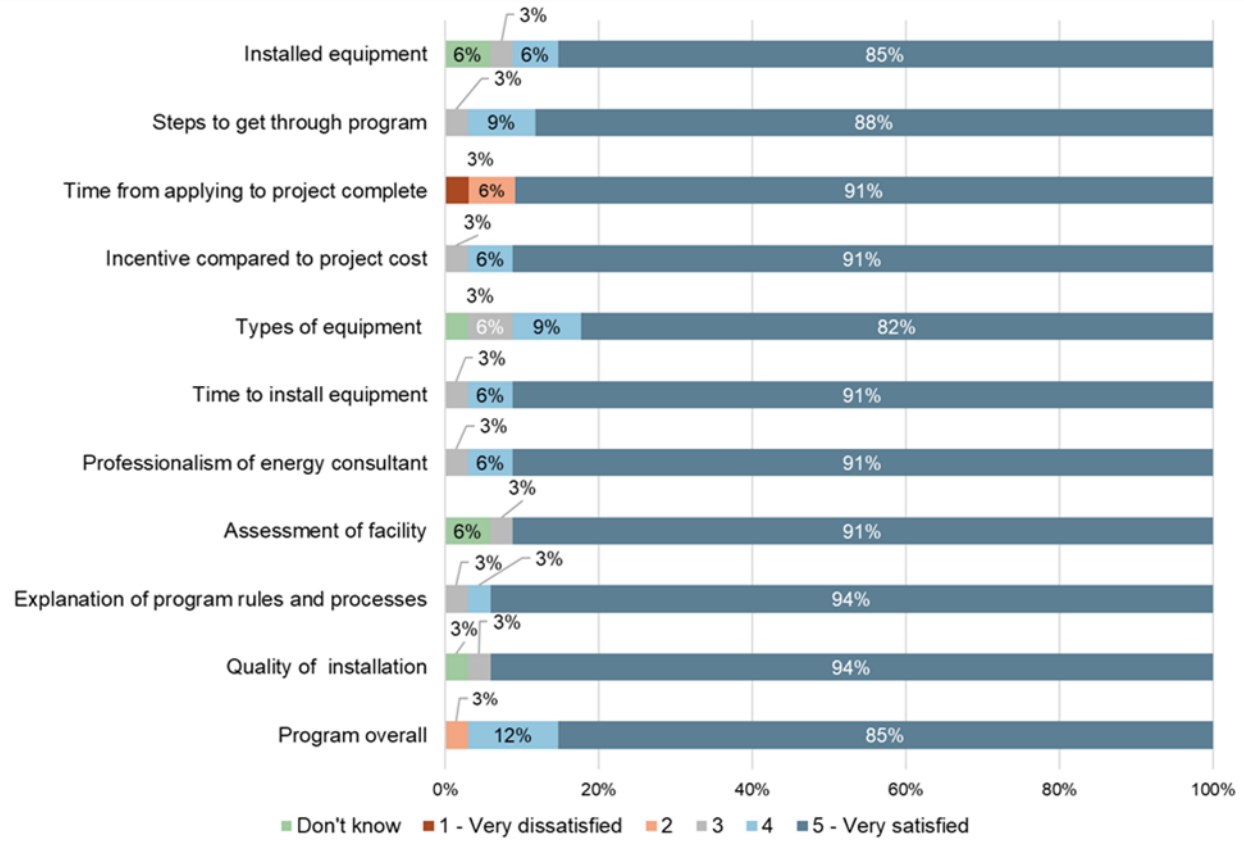
Table 3-27: Summary of Ex-Post Gross and Net Impacts

Program	Ex-Post Gross kWh Savings	Ex-Post Net kWh Savings	Net-to-Gross Ratio	Ex-Post Gross kW Reduction	Ex-Post Net kW Reduction
SBES	8,172,719	8,307,493	101.6% - kWh 101.4% - kW	1,836.38	1,862.57

3.1.3.6 Process Evaluation Findings

An online survey was administered to program participants. A total of 34 customer decision makers completed the survey about their experience with the Small Business Energy Solutions Program. Overall, participants show a high degree of program satisfaction. Ninety-seven percent of the respondents reported that they were somewhat or very satisfied with the program overall. Survey participants were also generally satisfied with all aspects of the program, as summarized below in Figure 3-8. A process evaluation memo was provided with detailed results. This section presents a summary of findings. Conclusions and recommendations based on the process evaluation are found in section 3.1.5.

Figure 3-8: SBES Projects Satisfaction



3.1.4 Midstream Lighting and HVAC

This section reports the findings from the Midstream lighting and HVAC projects. ADM performed an impact and process evaluation. The gross ex-post annual energy savings estimates for midstream projects resulted in a 99% realization rate for gross energy savings and a 100% realization rate for gross peak demand reduction.

3.1.4.1 Description of Program

The midstream portion of the Business Rebates program, started in 2019, is designed to generate long-term energy savings for PSO business customers. The goal of the program is to influence distributor stocking practices, as well as promotion and sales of higher efficiency equipment to encourage energy efficiency. The program provides rebates and support directly to qualifying distributors who then work directly with service providers or customers to promote the sale of higher efficiency equipment.

3.1.4.2 Impact Evaluation Overview

PSO's midstream projects provided rebates for a total of 12 projects. Eleven projects consisted of lighting measures and one project consisted of HVAC equipment. This

avenue of the business rebates program began in 2019. Table 3-28 provides projected, ex-ante, and ex-post energy and demand impacts, as well as other program performance metrics for midstream projects.

Table 3-28: Performance Metrics –Midstream Lighting and HVAC

Metric	PY2019
Number of Projects	12
Energy Impacts (kWh)	
Reported Energy Savings	61,040
Gross Verified Energy Savings	60,473
Net Verified Energy Savings	42,626
Peak Demand Impacts (kW)	
Reported Energy Savings	15.07
Gross Verified Energy Savings	15.19
Net Verified Energy Savings	10.69
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	3.69
Utility Cost Test Ratio	4.98

Net-to-gross estimations could not be determined directly from participant or trade ally survey information due to the number of participants. For the HVAC project, a free-ridership score of 11% was determined based on industry literature, resulting in a NTG - ratio of 89%. For lighting projects, using industry information, a free-ridership score of 30.6% was applied, resulting in a NTG ratio of 69.4%.

3.1.4.3 Process Evaluation Overview

ADM planned to perform a process evaluation which would include a review of program materials, distributor interviews, customer surveys, and program staff interviews. The process evaluation was designed to answer research questions focused on gaining feedback on marketing, program expectations, satisfaction, and barriers to participation. Due to the level of participation in this program avenue, customer surveys were not obtained. A list of the process evaluation activities is shown in Table 3-29.

Table 3-29: Process Evaluation Data Collection Activities Summary

Data Collection Activity	Process Evaluation Research Objectives
Review Program Materials	Review any marketing materials, program procedure manuals, program websites, and other program documentation as it becomes available.
Program Staff Interviews	Assess program staff perspectives regarding program operations, strengths, or barriers to success.
Distributor Interviews	Investigate benefits of program participation, satisfaction with program training, feedback on the program provided marketing support and program direct marketing to customers, feedback on program materials and guidelines; and satisfaction with program processes and the program overall.

3.1.4.4 Evaluation Methodology

This section provides a brief overview of the data collection activities, gross and net impact calculation methodologies, and process evaluation activities that ADM employed in the evaluation of the midstream projects.

Data Collection

Data for the analysis were collected through review of program materials and interviews with distributors and service providers. Program materials and documentation was gathered through the Sightline data management system. Three of the four lighting distributors were interviewed, and five of the six HVAC distributors were interviewed. In-depth interviews with two PSO and implementation staff members were conducted to provide additional perspectives for the process evaluation.

Impact Evaluation Methodology

ADM performed a review of all midstream projects and line items. Ex-post savings from the Midstream Lighting program channel were determined through a review of the implementation database. For lighting, we employed an engineering analysis to determine the ex-post verified energy savings for each lamp type sold through the program. The verified energy savings per fixture or lamp was calculated with methods consistent with chapter 6 of The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures. For HVAC units, we employed the methodology from the Arkansas TRM v7.

Net-to-Gross Estimation (NTG)

The purpose of net savings analysis is to determine what portion of gross savings achieved by PSO customers is the direct result of program influence. The NTG for midstream projects was estimated using industry-based information due to the amount of participation in this avenue. Future evaluations will utilize survey-based information and follow a similar protocol that is used for both Custom and Prescriptive projects, and SBES.

For HVAC, ADM referenced a NTG ratio of 89%.[31] For lighting projects, a NTG ratio of 69.4% was referenced from previous evaluation work of lighting in midstream programs.

Process Evaluation Methodology

The process evaluation was designed to research and document the program delivery mechanisms and collective experiences of program participants, partners and staff. The process evaluation was designed to answer the following research questions:

- How did PSO market this program?
  - How effective were the marketing efforts for the program?
  - Which marketing methods were most effective?
- How well did PSO staff and distributors work together? Is there rebate processing, data tracking, and/or communication efficiencies that can be gained?
- Did the program implementation reflect its design? Are there underlying assumptions about program implementation and design that are being made about how the program will unfold? Are there ways to improve the design or implementation process?
- Were distributors satisfied with their experience? What was the level of satisfaction with the rebate amount, the application process, the rebated measures, and other aspects of program participation?
- What are PSO staff and implementation staff perspectives on the program? What are the reactions to program design choices that have been implemented?
- What do distributors like about the program? Why? What would they like to change about the program? Why?
- What share of projects are associated with specific distributors? How are savings distributed across them? Are there any differences in opinion between active and less active distributors?
- What types of buildings/facilities participated in the program? Could certain facility types be targeted more effectively?
- What customer barriers to participation do distributors see? How can these be mitigated?
- Were there any significant obstacles during the 2019 program year?

[31] Based on results from the 2017 Colorado Cooling Efficiency Product Evaluation. https://www.xcelenergy.com/staticfiles/xe-responsive/Company/Rates%20&%20Regulations/Regulatory%20Filings/Cooling-Efficiency-Evaluation.pdf

- Looking forward, what are the key barriers and drivers to program success within PSO's market?

3.1.4.5 Impact Evaluation Findings

Impact evaluation findings determine net annual energy savings and net coincident peak demand reduction. Net results are achieved by extrapolation of verified (ex-post) project level savings; known as gross results. Gross results are adjusted for program free-ridership and participant spillover to determine net results. Energy savings methodologies are provided in Appendix F of this report.

Gross Annual Energy Savings

The ex-post gross kWh savings for midstream projects are summarized by measure type in Table 3-30. Projects saw an overall gross realization rate of 99%.

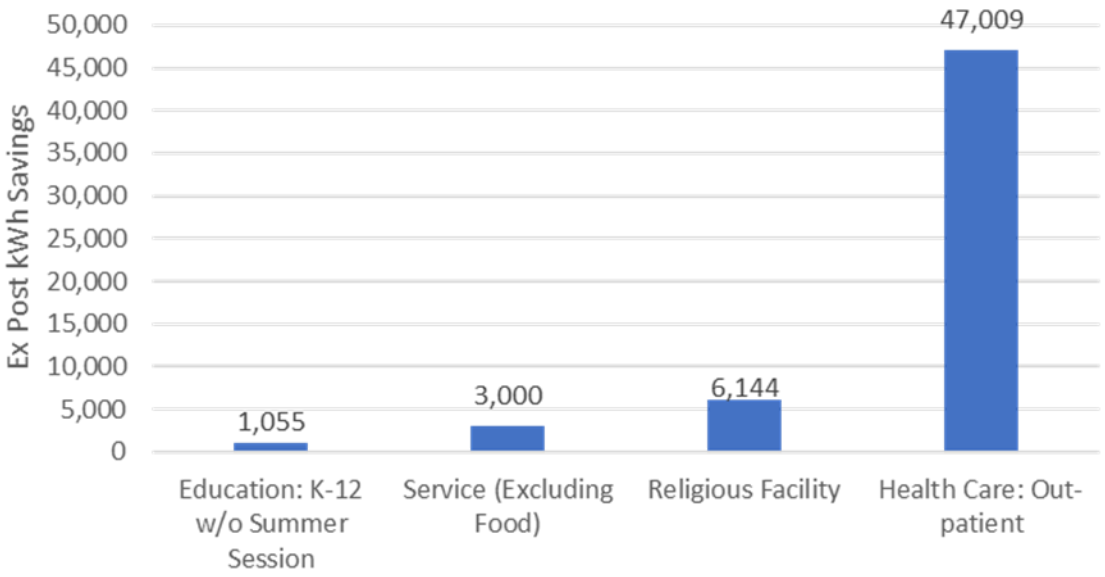
Table 3-30:Ex-Ante and Ex-Post Gross kWh Savings by Measure Type - Midstream

Measure Type	Ex-Ante kWh Savings	Ex-Post Gross kWh Savings	Gross kWh Realization Rate
Lighting	58,049	57,207	99%
HVAC	2,991	3,266	109%
Total	**61,040**	**60,473**	**99%**

For the HVAC project, the difference in energy savings is due to a difference in equivalent full load hours (EFLH). The slight variation in energy savings for lighting projects may be due to slight differences in baseline and verified wattages. ADM used baseline wattages for LED tubes based on the Mid-Atlantic TRM and agreed upon baseline wattages for other fixture types. Efficient condition wattages were based on Design Lighting Consortium (DLC) ratings.

A summary lighting project savings by facility can be seen in Figure 3-9. The most common facility was Healthcare: Out-Patient. These facilities include medical offices, one day clinics, or rehabilitation.

Figure 3-9: Ex-Post Annual Energy Savings by Facility Type - Midstream



Gross Coincident Peak Demand Reduction (kW)

The ex-post gross kW reduction is summarized by sampling stratum in Table 3-31. Overall, the ex-post gross kW is equal to 80% of the reported reduction for the program.

Table 3-31: Ex-Ante and Ex-Post Gross kW Reduction by Measure Type

Measure Type	Ex-Ante Peak kW Reduction	Ex-Post Gross Peak kW Reduction	Ex-Post Gross kW Realization Rate
Lighting	14.37	14.45	100%
HVAC	0.70	0.74	106%
Total	**15.07**	**15.07**	**101%**

Net-to-Gross Estimation

As stated previously in section, free-ridership scores were referenced from industry documentation due to participation in the program. Future evaluations will utilize survey-based information to calculate free-ridership and spillover consistent with custom and prescriptive projects, and SBES. The gross and net ex-post energy savings and peak demand reduction are summarized by program in Table 3-32.

Table 3-32: Summary of Ex-Post Gross and Net Impacts

Program	Ex-Post Gross kWh Savings	Ex-Post Net kWh Savings	Ex-Post Gross kW Reduction	Ex-Post Net kW Reduction
Midstream Projects	60,473	42,626	15.19	10.69

3.1.4.6 Process Evaluation Findings

Participation in midstream projects for the first year was low, however, distributors for both HVAC and lighting are in place going into the next program year. PSO and the implementation contractor have provided training and support to distributors. Feedback from distributor interviews indicated that they are satisfied overall with the program and ready to promote the sale of energy efficient equipment. Distributors have received support from the implementation contractor through both documentation provided and face to face interactions. Distributors plan to market the program to service providers and customers through these same techniques.

3.1.5 Conclusions

Evaluation of the Business Rebates program consisted of a process and impact evaluation to determine ex-post verified energy savings estimates as well as assess achievement of the program's objectives. ADM found that the magnitude and estimation of annual energy savings and peak demand reduction exceeded projections. There is also a high level of satisfaction among program participants and trade allies. A summary of program level impacts is shown in Table 3-33 and Table 3-34.

Table 3-33: Summary of Program Level Annual Energy Savings Impacts (kWh)

Program	Ex-Ante Gross kWh Savings	Ex-Post Gross kWh Savings	Realization Rate	Net-to-Gross Ratio	Ex-Post Net kWh Savings
Custom and Prescriptive	52,692,682	56,782,124	108%	95%	45,974,529
Small Business Energy Solutions	8,302,623	8,172,719	98%	102%	9,487,336
Midstream	61,040	60,473	99%	70%	42,626
Total	**61,056,345**	**65,015,317**	**106%**	**96%**	**62,116,604**

Table 3-34: Summary of Program Level Coincident Peak Demand Impacts (kW)

Program	Ex-Ante Gross kW Savings	Ex-Post Gross kW Savings	Realization Rate	Net-to-Gross Ratio	Ex-Post Net kW Savings
Custom and Prescriptive	10,128.28	8,904.29	88%	93%	8,285.07
Small Business Energy Solutions	2,306.93	1,836.38	80%	101%	1,862.57
Midstream	15.07	15.19	101%	70%	10.69
Total	**12,450.28**	**10,755.86**	**86%**	**94%**	**10,158.33**

The following summarizes the key findings of the evaluation of the custom and prescriptive projects:

- Overall verified gross and net annual energy savings resulted in higher values than reported.
- Differences between reported and verified annual energy savings were results of different annual hours of use, baseline conditions and equipment, efficient condition quantities, and algorithm assumptions.
- Evaluation risk was mitigated for custom and new construction lighting projects that received evaluation pre-construction reviews.
- Projects with multiple measures accounted for 8% of the program energy savings. This is an indication of program influence across measures and may lead to additional opportunities.
- Survey and interview findings indicate that contractors and vendors were the most frequent source of program awareness and the most important source of influence on customers' decision to participate.
- The program improved its marketing in 2019 with the addition of a marketing coordinator that is helping to coordinate all PSO's marketing activities and publish new marketing and promotional material.
- Survey results and interviews indicate the program was implemented successfully in 2019 with minimal comments, concerns, or complaints. Participants are generally positive about the program.
- From the trade ally perspective, the program was effectively administered in 2019 and trade allies were generally satisfied with the program's design and participation process.
- The program continues to strive to meet both regional and measure diversity goals. The regional goal strives to have at least 20% of program activity come from

regions outside of Tulsa. The measure diversity goal strives to have at least 2.5% of program activity come from non-lighting measures on an annual basis, with at least 7.5% of program activity coming from non-lighting measures by the end of the program cycle. These goals have been realized.

- Based on survey data and interviews, the largest barrier to participate in the program is financial factors.

The following recommendations are offered for Custom and Prescriptive projects.

- Continue to focus on projects or customers who could benefit from additional energy efficiency measures within PSO programs.
- Increase communication with HVAC trade allies of the change in program design and incentive plans for future program years.
- Continue exploring and piloting new measures and program designs that can increase program participation.
- Continue to review and update the application and project review process. Most survey-respondents and trade allies were satisfied with the program and participation process, but a portion of trade allies and survey respondents indicated that the participation process could be improved.
- Continue evaluation pre-construction reviews to mitigate evaluation risk. Applying a more formal structure with reported energy savings thresholds would support additional reviews.
  - Recommend a threshold of 300,000 kWh for non-lighting projects, and 400,000 kWh for lighting projects.
- Increased transparency between implementation and evaluation in terms of energy savings methodologies and variables, such as annual operating hours for schools.

The following summarizes the key findings of the evaluation of the SBES component of the Business Rebates Program.

- Program staff felt that the late start of the program and historic flooding in the state of Oklahoma contributed to the program's difficult in meeting its goals.
- Projects consisted solely of lighting measures.
- Findings from SBES trade ally interviews indicate program marketing improved in 2019, and trade allies voiced overall support for the program and the increased outreach effort.

- Consistent with past program years, program satisfaction remains high. Most survey respondents shared high levels of satisfaction across all aspects of the program as well as the program overall.
- Some participants noted possible areas for program improvement including providing more information about savings/incentive calculations, increasing communication and information regarding other incentives/programs.

The following recommendations are offered for the SBES Program:

- Continue to seek local refrigeration contractors to expand measures offered within SBES.
- Increase participant awareness of other PSO incentives through additional communication (emails, phone calls) to participants about other PSO programs.
- Geo-targeting based on energy usage benchmarking may provide insight into potential for energy efficient equipment across the PSO territory.

The following summarizes the key findings of the evaluation of the midstream component of the Business Rebates program.

- PSO and implementation staff noted that establishing a contract for the program delayed the program's start date until summer 2019 and therefore affected the program's ability to achieve its energy-savings goal.
- Program participation was low, without any impact on the distributor's sales or stocking practices; most likely due to the late program start and the fact that the PSO prescriptive and custom program continued to offer HVAC rebates.
- The program implementation staff successfully recruited four lighting distributors, with multiple locations to participate in the program. Moving forward, the implementation staff noted that they would seek to increase the number of distributors.
- Interviews with program staff and distributors suggest that there has been enough support to grow and establish the program in its first year.
- Program staff and participating distributors generally were satisfied and approved of the design, training, and communication for the midstream avenue.
- Distributors were satisfied with the implementation and program staff, including support and training they received.

The following recommendations are offered for the midstream portion of the Business Rebates Program:

- Plans to increase distributor participation and awareness of the midstream program may help meet energy-savings goals.
- Discontinuation of downstream HVAC incentives may help manage the overlap between the two programs; however, transparent communication with all parties involved is essential to maintain satisfaction.
- Continue to support participating distributors and service providers with in-person, email, and phone support and training. Maintaining strong communication with distributors will help to ensure program success as participation increases in the second year of the program.

3.1.6 M&V Safety

ADM is dedicated to creating a safe work environment and to provide training for our employees. All ADM employees undergo general safety training. Our field technicians and engineers undergo additional safety training related to fieldwork. We encourage all our employees to be responsible and alert to identify hazardous conditions wherever they may exist be it in transportation to the customer or at the customer's facility. If hazardous conditions are found, they are to report them immediately to their supervisor or the ADM Safety Officer. Never are they to proceed to work in an identified hazardous situation. ADM follows Cal/OSHA rules and guidelines for safety in the workplace and these rules are as or more stringent than the federal OSHA rules.

Personal Protective Equipment (PPE) is provided and the procedures to use it as appropriate for the work expected. Our field staff is provided training to safely conduct activities they may encounter. Specifically, this includes the use of ladders and the rules associated with working at heights. Three points of contact on ladders are always required. It is trained that body harnesses are required when being lifted by a man lift or bucket, although we also train to avoid the use of lifts. If rooftops need to be accessed, our field staff is trained to identify if it is safe to be there and the requirements for perimeter protection. For those that will make electrical measurements, electrical safety training is given for new hires and periodically reviewed for all employees working in such conditions. Electrical safety training includes the use of PPE and the voltage the PPE is appropriate for use around. Arc flash training reinforces the reason for using PPE. ADM does not conduct any measurement activity on systems over 500 Volts. Other training includes exposure to asbestos, lead, and hydrogen sulfide. Employees are trained to follow safety procedures and there are consequences for not following proper procedures which can include termination of employment.

3.2 Multi-Family Program

ADM has completed an impact and process evaluation of PSO's multifamily program. The impact evaluation consists of verification of annual energy savings and peak demand reduction (ex-post) with the inclusion of in-service rates, and net-to-gross. The process evaluation provides insights into program design and implementation.

3.2.1 Program Overview

The Multifamily Program is new to the Public Service Company of Oklahoma (PSO) portfolio in program year 2019 (PY2019). The performance metrics for the Multifamily Program exceeded expectations in all but one category. The Program exceeded energy savings estimates by 101%. The Multifamily Program sought to serve 100 customers and exceeded the goal by five customers. While program expenditures exceeded budget, the additional energy savings outweighed the additional cost. Table 3-35 below illustrates performance metrics for the Multifamily Program.

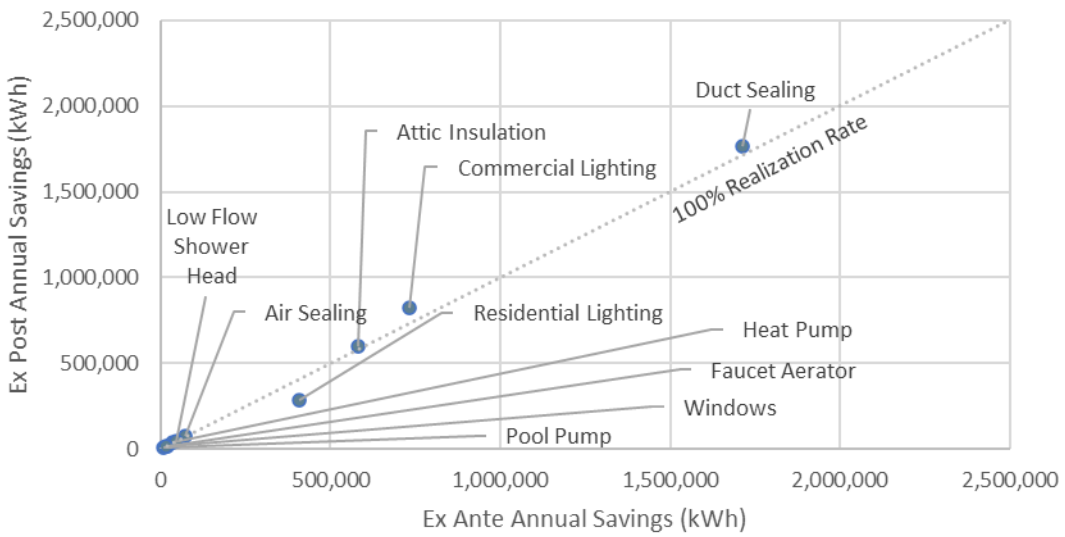
Table 3-35: Performance Metrics - Multifamily Program

Metric	PY2019
Number of Customers	105
Budgeted Expenditures	$973,599
Actual Expenditures	$951,182
Energy Impacts (kWh)	
Projected Energy Savings	1,532,410
Reported Energy Savings	3,627,763
Gross Verified Energy Savings	3,677,562
Net Verified Energy Savings	3,604,404
Peak Demand Impacts (kW)	
Projected Peak Demand Savings	281
Reported Peak Demand Savings	1,065.22
Gross Verified Peak Demand Savings	1,005.11
Net Verified Peak Demand Savings	964.18
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	3.04
Utility Cost Test Ratio	3.41

The Multifamily Program provides comprehensive energy efficient measures for qualifying Multifamily properties in the PSO service territory. The Program offers direct install measures (ENERGY STAR® LEDs, faucet aerators, and low-flow showerheads) at

no cost to the participating Multifamily property. Tenant dwellings that receive direct install measures are eligible for an energy survey. The energy survey is turned into a report that compares the energy use of the property to similar properties in the neighborhood, recommends ways to be more energy efficient, and shows potential savings of energy upgrades. The Multifamily Program offers Commercial measures in addition to the Residential measures. The Commercial measures include LED lamps and fixtures, air infiltration, ceiling insulation, duct sealing, HVAC system replacements, water heaters, ENERGY STAR® windows, ENERGY STAR® Pool Pumps, vending machine controls, and ice machines. A graphical representation of the relative contribution of measures to the overall Multifamily Program savings and realization rates is in Figure 3-10 below. As shown in the figure, duct sealing is the measure with the largest impact on the program, which also has a high realization rate.

Figure 3-10: Ex-Ante vs. Ex-Post Measure Level Energy Savings



The Multifamily Program combines the provision of financial inducements with access to technical expertise. The aim is to maximize Program penetration across a range of potential Multifamily customers. The Program has the following goals:

- Increase owner/operator awareness and knowledge of applicable energy-saving measures and their benefits
- Increase the market share of Commercial-grade high-efficiency technologies sold through market channels
- Increase the installation rate of high-efficiency technologies in Multifamily facilities by businesses that would not have done so absent the Program

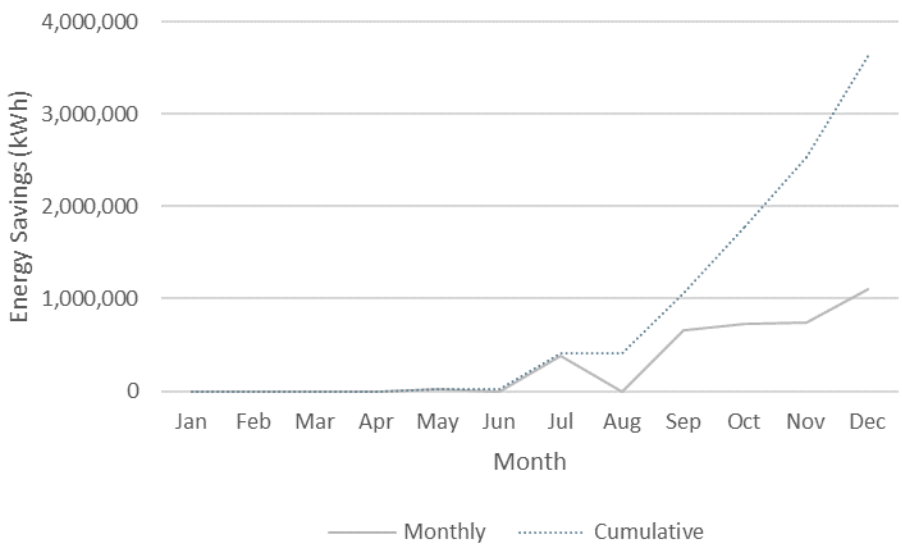
The Multifamily Program defines prescriptive rebate amounts to participating customers for some measures, including certain types of lighting, lighting controls, HVAC equipment, water-related equipment, and other equipment. The Multifamily Program pays rebates for custom projects (e.g., chillers) that do not fall into prescriptive measure categories on a per kWh and kW impact basis. Table 3-36 summarizes Multifamily Program activity by the percentage of reported savings by measure type.

Table 3-36: Percentage of Reported Savings by Measure Type

Measure Type	Percent of Program
HVAC	48.06%
Lighting	31.39%
Building Envelope	18.51%
Domestic Hot Water	1.81%
Pool Pumps	0.24%

Participation in the Multifamily Program was mostly achieved in the second half of the year, which is expected for the first year of a program (Figure 3-11). Program Activity began in May, with participating ramping up from July through the end of the year.

Figure 3-11: Accrual of Reported kWh Savings during the Program Year



Overall participation and energy savings goals were exceeded. The Tulsa and Western Districts had the most activity.

3.2.2 EM&V Methodology

This chapter provides an overview of the data collection activities, gross and net impact calculation methodologies that ADM employed in the evaluation of the Multi-Family Program. Energy savings methodologies are provided in Appendix F of this report.

Data collection activities for the analysis consisted of a review of program materials, on-site inspections, and interviews with participating owners/managers, tenants, and service providers. PSO uses Sightline in conjunction with an SQL Server Reporting Services (SSRS) system as its central tracking and reporting system. ADM created a sample for on-site data collection based on the Program tracking data provided by PSO.

ADM used the data collected from on-site visits to modify gross impact calculations, verify measure installation, and determine measure operating parameters. Interviews with facility staff members determined the operating hours of the installed systems and provided any additional operational characteristics relevant to calculating energy savings.

In addition to on-site data collection, customer surveys provided self-reported data for the NTG analysis and process evaluation. A total of 16 customer decision-makers completed the survey.

The process evaluation gained additional perspective from In-depth interviews with PSO, ICF, and the two leading service providers. Table 3-37 shows the achieved sample sizes for the different types of data collection activities utilized for this study.

Table 3-37: Sample Sizes for Data Collection Efforts

Data Collection Activity	Achieved Sample Size
On-Site M&V visits	16
Property Owner/Manager Survey	7
Tenant Survey	16
In-depth Interviews with Program Staff	2
In-depth Interviews with Service Providers	2

ADM performed a census review of program tracking data to determine gross energy savings program results. In order to capture in-service rate information, ADM attempted site verification visits to as many properties as possible. We identified 29 unique company names (premise company) in the tracking data. ADM was able to schedule site visits with 16 of the companies.

3.2.2.1 Impact Evaluation Methodology

ADM used the following steps to evaluate the Multifamily Program gross energy savings and peak demand reduction:

- We reviewed the Program tracking data to determine the scope of the Program and to ensure there were no duplicate project entries. We used the tracking data to define a discrete set of projects that made up the program population.
- After reviewing the tracking data, ADM created a list of all premise companies and attempted to schedule on-site verification and data collection visits. On these visits, ADM collected data for savings calculations, verified installed measures, and determined measure operating parameters.
- ADM conducted a detailed desk review for each on-site verification and data collection project scheduled. The desk review process includes a thorough examination of all project materials, including invoices, equipment cut sheets, pre, and post-inspection reports, and estimated savings calculators. This review process informs ADM's fieldwork by identifying potential uncertainties, missing data, and sites where monitoring equipment is needed to verify critical inputs to the reported savings calculations.
- ADM then calculated verified gross savings. The sources for deemed savings algorithms are the 2013 Oklahoma Deemed Savings Document and the Arkansas Technical Reference Manual v.7 (AR TRM).
- ADM used the data collected during the on-site verification visits to revise savings calculations as necessary. For example, if the reported savings calculations relied on operating hours for a given measure that was inaccurate based on the on-site verification and data collection, changes are made to more accurately reflect actual operating conditions.
- After determining the verified savings impacts for each sampled project, results are extrapolated to the program population using project-specific sampling weights. Project-specific sampling weights allow for the estimation of program level gross verified energy (kWh) savings with a given amount of sampling precision and confidence.

ADM used the algorithms in the table below to calculate energy savings and demand reductions for the Multifamily Program.

Table 3-38: References for Savings Calculations

Measure	Ex Post 2019 References
Air Infiltration	Arkansas TRM v.7.0, section 2.2.9
Ceiling Insulation	Arkansas TRM v.7.0, section 2.2.2
Duct Sealing	OKDSD, section 5.
Faucet Aerators	Arkansas TRM v.7.0, section 2.3.4
Heat Pumps	OKDSD, section 12.
Low-Flow Showerheads	Arkansas TRM v.7.0, section 2.3.5
ENERGY STAR® Pool Pumps	Arkansas TRM v.7.0, section 2.4.5
ENERGY STAR® Windows	OKDSD, section 6.
Retrofit Lighting	Arkansas TRM v.7.0, section 2.5.1.4
	Arkansas TRM v.7.0, section 2.5.1.3
Lighting Efficiency	Arkansas TRM v.7.0, section 3.6.3

3.2.2.2 Net-to-Gross Estimation (NTG)

To determine what portion of gross savings achieved by PSO customers is the direct result of program influence, we used net-to-gross estimation. ADM administered one survey to owners/managers of Multifamily properties and another to the tenants. ADM reviewed the survey responses to assess the likelihood that participants were free riders. The process used for determining what portion of a customer's savings are attributable to the program varied by survey. A discussion of the two processes is below.

Free-Ridership (non-direct install)

The survey questioned program participants to assess the program's influence on the installation of Multifamily non-direct install measures. These include program measures besides lighting, faucet aerators, and low flow showerheads. The questions asked to program participants are:

- If they could afford to install the equipment without the financial support of the program.
- If they had plans to complete the project.
- The likelihood of installing the equipment without the financial and informational support of the program provided for free; and
- The timing of the project in the absence of the program.

In this methodology, financial ability was a gateway value, in that if a participant did not have the financial ability to purchase energy efficient equipment absent an incentive, the other components of free ridership become moot. The assessment of free ridership

scores factored the other components of free ridership if the participant had financial capability. An overall free ridership score was calculated based on participant plans, a likelihood of installing the measure in the absence of the Program score, and a timing score.

ADM assessed prior plans to implement a measure using the responses to the following questions:

- Prior to learning about the program, did you have plans to implement the energy efficient measure?
- (For applicable measures) Did you have plans to specifically implement the energy efficient measure as opposed to a standard efficiency measure?

Respondents who indicated that they previously installed the measure at the property and had prior plans to implement the energy efficient measure are scored 1 on this component. The prior plans score for all other respondents was 0.

The estimation of free ridership incorporated the program's influence on the timing of the project in one of two ways. First, consistent with the Arkansas TRM definition of free ridership, respondents who indicated that the project would have been completed in more than one year if the program was not available are assigned a free ridership score of 0. The program's impact on timing modified the score for all other respondents in the follow ways.

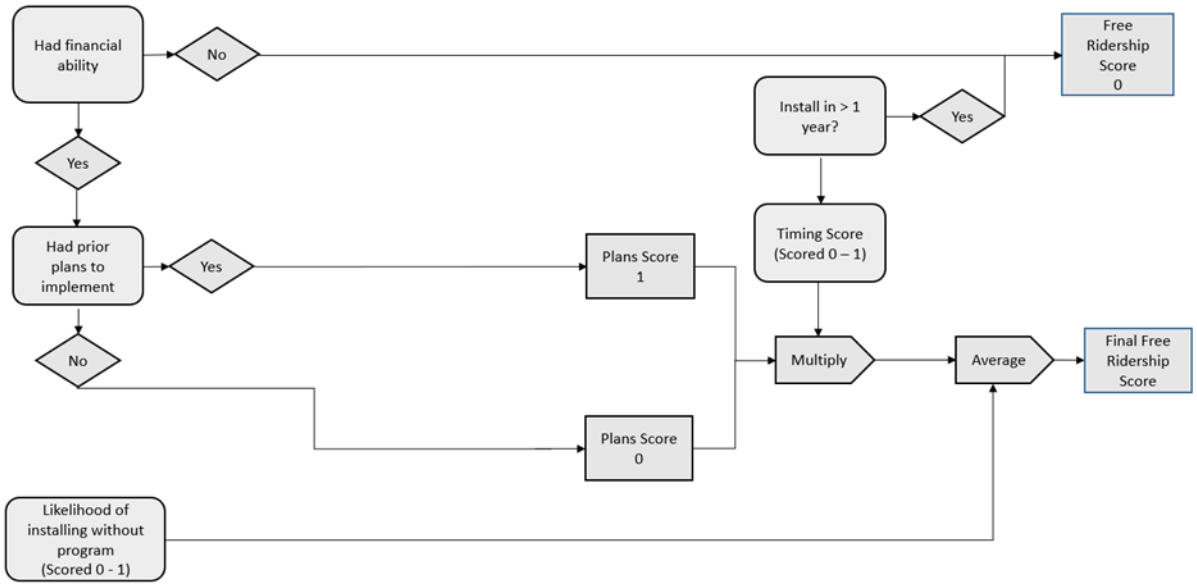
- If the respondent stated that they would have installed the measure in 6 months to one year, then the score is reduced by one-half; and
- If the respondent stated that they would have installed the measure at the same time or within 6 months of when the measure was initially installed, the score is not adjusted.

The respondents' stated their likelihood of installing a measure if the financial support wasn't provided or if the measure wasn't recommended through the energy survey. Respondents rated the likelihood of installing the measure on a scale of 1-4, where 1 means that they would not have installed the measure without the program and 4 means that they would have installed the measure without the program. The scoring of responses is as follows:

- 1 (Definitely would not have installed) = 0
- 2 (Probably would not have) = 0.25
- 3 (Probably would have) = 0.75
- 4 (Definitely would have installed) = 1
- 98 (Don't Know) =0 .5

A flow diagram of free ridership scoring of non-direct install measures is shown in Figure 3-12.

Figure 3-12: Non-Direct Install Scoring Flow Chart



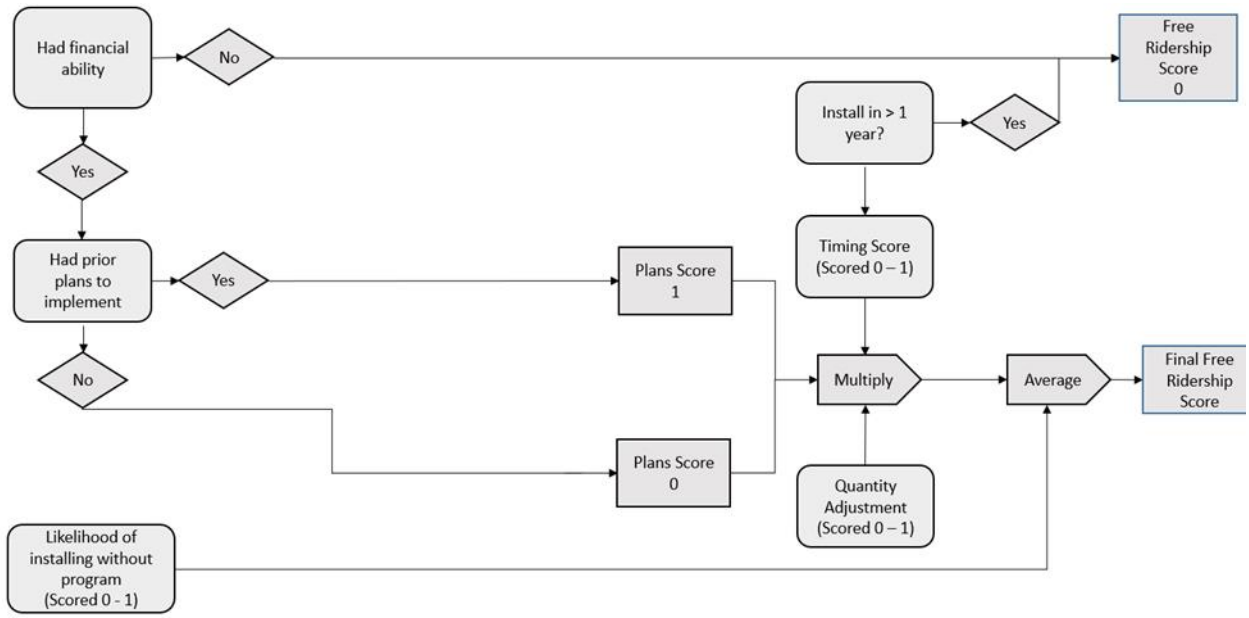
Free-Ridership (Direct Install)

The approach to assess free ridership for direct install measures was like the approach used for non-direct install measures with the following differences:

- Re-wording questions based on direct-install versus incentive.
- An indication that a participant had previous direct install measures at the property in addition to stating that they had plans to install the measure before learning about the program.
- A quantity adjustment was applied because different numbers of direct install measures could potentially be installed at each dwelling in a property.

A flow diagram for free ridership scoring of direct install measures is shown in Figure 3-13.

Figure 3-13 Direct Install Scoring Flow Chart



Participant Spillover Methodology

ADM asked participant survey respondents if they had purchased any additional items because of their experience with the program without receiving an incentive to estimate participant spillover impacts. Participants that indicated one or more energy efficiency purchases triggered logic to ask additional questions about what was purchased, and the number of units purchased to estimate the savings impact.

Additionally, to determine whether energy savings resulted from measures attributable to the program ADM asked the following questions:

- On a scale of 0 to 10, where 0 represents “not at all important” and 10 represents “extremely important,” how important was the experience with the program in your decision to purchase the items you just mentioned?
- On a scale of 0 to 10, where 0 represents “not at all likely” and 10 represents “extremely likely,” how likely would you have been to purchase those items if you had not participated in the Program?

ADM attributed savings to the program if the average of the first and 10 minus the second response was greater than 7.

Spillover Score = Average (SP1, 10-SP2)

3.2.3 Impact Evaluation Findings

The verified gross annual energy savings (kWh) and peak demand reduction (kW) for the Multifamily Program are summarized by measure in Table 3-39. The overall realization

rates for energy savings and demand reduction was 101% and 94%. Detailed descriptions of the difference in savings calculations are in the measure level findings below.

Table 3-39: Verified Gross kWh and kW

Equipment	Total Ex-Ante kWh	Total Ex-Ante kW	Total Ex-Post kWh	Total Ex-Post kW	kWh RR	kW RR
Air Infiltration	73,890.07	5.28	74,422.47	5.24	101%	99%
Ceiling Insulation	582,515.34	110.60	598,941.26	104.05	103%	94%
Duct Sealing	1,710,496.66	269.19	1,764,354.28	221.27	103%	82%
Faucet Aerator	19,750.94	2.05	19,970.60	2.08	101%	101%
Heat Pump	32,877.82	10.89	37,373.79	7.05	114%	65%
Low Flow Shower Head	45,756.00	4.92	45,586.33	4.74	100%	96%
ENERGY STAR® Pool Pump	8,632.00	1.98	8,678.40	1.98	101%	100%
ENERGY STAR® windows	14,979.66	8.20	14,979.71	8.20	100%	100%
Residential Lighting	406,394.26	132.06	288,516.53	92.56	71%	70%
Commercial Lighting	732,470.15	520.03	824,877.41	557.95	113%	107%
Total	**3,627,762.90**	**1,065.22**	**3,677,700.79**	**1,005.11**	**101%**	**94%**

3.2.3.1 Air Infiltration

The annual energy savings realization rate for air infiltration measures is 101%. The difference in energy savings can be attributed to a difference in weather zones chosen for a few calculations. For these calculations, ex-ante energy savings appear to use the deemed savings values from zone 7 (table 136 in AR TRM v7) where we used the deemed savings values from zone 8 (table 135 in AR TRM v7). The peak demand reduction realization rate for air infiltration measures is 99%.

3.2.3.2 Ceiling insulation

The annual energy savings realization rate for ceiling insulation measures is 103%. We believe that the ex-ante calculations used kWh and kW deemed savings values from weather zones 6, 7, and 8 for most line items in the tracking data. ADM used the deemed savings kWh and kW values from zone 8 (table 83 & 87 in AR TRM) for all lines in the tracking data. The AR TRM specifies the use of linear interpolation when the post-retrofit R-value falls between R-38 and R-49. We believe that the some of the line items in the

data may have omitted linear interpolation where we could not recreate the ex ante kWh and kW.

3.2.3.3 Duct Sealing

The annual energy savings realization rate for duct sealing measures is 103%. We believe that the difference in energy savings is due to a combination of factors. We recreated ex-ante savings by utilizing most inputs from Zone 9 (Fayetteville, AR). The Zone 9 inputs that we believe were used in the energy savings calculations are $EFLH_C$, h_{out}, h_{in}, and p_{out}. ADM calculated the energy savings and demand reductions for Duct Sealing in the Multifamily Program using the OKDSD Zone 8a (Oklahoma City, OK) inputs for all line items.

The annual demand reduction realization rate for duct sealing measures is 82%. The difference in demand reduction can be attributed to a difference in SEER rating. The OKDSD specifies a default value of 13, but if the rated SEER is below 10, then a SEER of 10 should be used. We believe that the demand reduction calculations used SEER equal to 10 for all line items. ADM used the OKDSD default value (13).

3.2.3.4 Faucet Aerator

ADM calculated the energy savings and demand reductions for Faucet Aerators in the Multifamily Program using AR TRM version 8.1.

3.2.3.5 Heat Pump

ADM calculated the energy savings and demand reductions for Heat Pumps in the Multifamily Program using OKDSD; and determined the total measure level kWh and kW impacts as 37,373.79 and 7.05, respectively. The measure level realization rates for kWh and kW are 114% and 65%, respectively. ADM determined the efficient condition of the heat pumps using data from the AHRI database, whereas the ex-ante used the claimed specifications from the tracking data. Furthermore, we believe the ex-ante energy savings and demand reductions calculations used the $EFLH_C$ and $EFLH_H$ from Zone 8b (Tulsa, OK), whereas ADM used Zone 8a.

3.2.3.6 Low-Flow Showerhead

ADM calculated the deemed savings values for Low-Flow Showerheads in the Multifamily Program and determined the total measure level kWh and kW impacts as 45,586.33 and 4.74, respectively. The measure level realization rates for kWh and kW are 100% and 96%, respectively.

The ex-ante calculations used Low-Flow 2.0 GPM Showerhead Energy (kWh), and Demand (kW) deemed savings values from the 2013 Oklahoma Deemed Savings

Document (table 81 & 82 in OKDSD). ADM used the deemed savings values from the AR TRM. That difference was the source of the deviation from a 100% realization rate.

3.2.3.7 ENERGY STAR® Pool Pumps

ADM calculated the deemed savings values for ENERGY STAR® Pool Pumps in the Multifamily Program using the AR TRM.

3.2.3.8 ENERGY STAR® Windows

ADM did not find any discrepancy in annual energy savings and peak demand reduction for the installation of ENERGY STAR® Windows.

3.2.3.9 Residential Lighting

ADM calculated the deemed savings values for Residential Lighting in the Multifamily Program using the AR TRM; and determined the total measure level kWh and kW impacts as 288,516.53 and 92.56, respectively. The measure level realization rates for kWh and kW are 71% and 70%, respectively. The ex-ante energy savings and demand reduction calculations utilize the AR TRM. However, the ex-ante savings calculations did not utilize the EISA Tier 1 baseline wattages from Table 217 of the Arkansas TRM. The lower EISA Tier 1 baseline wattage reduces the ΔWatts portion of the energy savings and demand reduction calculations, which is responsible for the discrepancy in realization rates.

3.2.3.10 Commercial Lighting

The annual energy savings realization rate for commercial lighting measures is 113%. We believe that ex-ante energy savings and demand reduction calculations use the AR TRM. However, the difference in energy savings can be attributed to the use of an IEF_e that is not from the AR TRM. Ex-ante energy savings appear to use the average IEF_e (1.05) value from the Mid-Atlantic TRM, where we used the IEF_e value 1.09 from Table 383 in the AR TRM v7.

The annual demand reductions realization rate for commercial lighting measures is 107%. The AR TRM specifies the use of IEF_D when calculating the demand reductions. However, we believe the ex-ante demand reduction calculations used the Residential IEF_e (1.10-gas heat with electric AC) instead of the Commercial IEF_D (1.20) for calculating kW reduction. Furthermore, ADM identified some lighting measure line items that were classified as commercial/residential that were installed in a tenant dwelling. The ex-ante demand reduction calculations used the “multifamily: common areas” coincidence factor (0.87) for those line items, where the residential coincidence factor would have been more appropriate.

3.2.3.11 Net-To-Gross Estimation Impact Findings

ADM collected survey data to assign free ridership scores as described in Section 3.2.2.2 Due to low participation in surveying efforts, we will use industry references for measures where sufficient information is available. For the direct installation of light bulbs, we will use a free ridership value of 4% and spillover value of 0%. This results in a NTG ratio of 96%[32]. Our survey based NTG ratio for direct install of light bulbs would only have included 4 participating building owners or managers. Low-flow showerheads and faucet aerators will use a free ridership value of 0% and a spillover value of 0%. This results in a NTG ratio of 100%

Based on collected survey data, the estimated percentage of free ridership for non-direct install measures is 1.3%. ADM performed a literature review of similarly designed programs and found these values to be reasonable.

None of the Multifamily representatives that were asked questions regarding the installation of additional energy efficient improvements following program participation indicated program influence. Therefore, ADM found that there were no attributable participant spillover effects. The tables below summarize the results of the net savings analysis.

Table 3-40: Net Energy Savings for Major & Direct Install Measures

Component	Expected kWh Savings	Verified Gross kWh Savings	Free Ridership	Spillover	Verified Net kWh Savings	Net to Gross Ratio
Non-Direct Install	2,423,391.55	2,498,749.92	33,128.77	0	2,465,621.15	98.7%
Direct Install	1,204,371.35	1,178,950.87	40,167.64	0	1,138,783.23	96.6%
Total	**3,627,762.90**	**3,677,700.79**	**73,296.41**	**0**	**3,604,404.38**	**98.0%**

Table 3-41: Net Peak Demand Savings for Major & Direct Install Measures

Component	Expected Peak kW Reductions	Verified Gross kW Reductions	Free Ridership	Spillover	Verified Net kW Reductions	Net to Gross Ratio
Non-Direct Install	405.17	347.79	16.06	0	331.73	95.4%
Direct Install	659.07	657.32	24.87	0	632.45	96.2%
Total	**1,064.24**	**1,005.11**	**40.93**	**0**	**964.18**	**95.9%**

[32] 2018 Multifamily Initiative Tenant and Property Manager Survey NTGR Results. https://s3.amazonaws.com/ilsag/AIC_Multifamily_2018_NTG_Memo_2019-09-04_FINAL.pdf

3.2.4 Process Evaluation Findings

ADM's process evaluation activities included two surveys (one of property owners/managers and one of the tenants at participating Multifamily properties), service provider interviews, and Program staff interviews.

3.2.4.1 Service Provider Perspectives

ADM interviewed the two primary service providers that participated in the PSO Multifamily Program. Both companies' staff stated that they utilized word-of-mouth outreach with their existing customer networks. They also mentioned that they promoted the program as part of a large lunch and learn style event they hold each October. Respondents noted that their customers had not heard of the program before their own marketing efforts but that the implementation team had provided their staff with training to introduce them to the program application and participation process. Respondents observed that program communication was an area in which there was room for improvement.

Respondents noted that participation in PSO's Multifamily Program has increased the volume of their home energy efficiency improvement projects. One respondent observed that the program's key strengths were that it helped property owners and managers reduce their utility costs and to increase their properties' value. Staff at both service provider organizations noted property owners and managers viewed the Program as an excellent opportunity to improve their buildings' and potentially extend equipment operating life.

3.2.4.2 Owner/Manager Survey

ADM conducted a telephone survey of participants in PSO's Multifamily Program. The provided contact information was often not for the most relevant respondent which made surveying efforts difficult. ADM spoke with seven contacts from participating properties, including five property managers, a service technician, and a property management company owner. Six of the seven respondents worked for companies that owned and managed multiple properties. Though all respondents were able to provide answers to survey questions, six respondents were not the sole or principal decisionmaker. They, therefore, responded to the best of their ability based on their experience and information available to them.

Overall, respondents were satisfied with the process of having equipment installed, the performance of the equipment installed, wait time to receive services, and the quality of the contractor's work.[33] Furthermore, four respondents reported having recommended the program to someone else after their company had participated. All survey-takers

[33] Rated their satisfaction a 4 or 5 on a scale from 1 (very dissatisfied) to 5 (very satisfied)

noted being satisfied with PSO as their electric utility and with their overall program experience.

Only one respondent noted dissatisfaction with any aspect of program participation. They noted that the quality of installation work was less than satisfactory and said one of the units that the contractor sealed the heater doors closed. However, they said the process of doing insulation was terrific and said their heating is working to better capacity and shared high levels of satisfaction with all other aspects of program participation.

3.2.4.3 Tenant Survey

ADM sought to survey tenants at Multifamily properties that participated in the program. We recruited sixteen participants for this survey using door hangers at participating Multifamily properties. The door hangers had a short description of the survey data-gathering effort and included a web link as well as a QR code to direct customers to the survey. The survey gathered data regarding in-service rates and hours of use for direct install measures as well as participant knowledge and awareness of the program, satisfaction, and general attitudes and behaviors regarding energy efficiency, PSO's Multifamily Program, and PSO as their utility.

We asked the tenants to confirm the energy efficient measures that were made during their home audits. Nine of the respondents noted that they had LED light bulbs installed as part of the program. Eight respondents said they had bathroom faucet aerators, and five respondents said they had kitchen faucet aerators installed. Four respondents noted other improvements that had been made to their apartment, including new air conditioning and heating units and air infiltration and insulation. All the respondents reported that the measures they received through the program were still installed.[34]

Five of the nine respondents who reported receiving LED bulbs could not recall what type of light bulbs they had replaced. One respondent noted that the new LED bulbs had replaced incandescent and CFL light bulbs. One respondent said the new LED bulbs replaced incandescent light bulbs, while another respondent reported that the new LED light bulbs only replaced old LED light bulbs. The last respondent said the LED light bulbs they received through the program were installed where there previously were no lamps installed.

Only one of the nine respondents who reported receiving LEDs through the program said they had LEDs installed in their home before they had participated. Six of the nine respondents who received LEDs through the program said they would buy LEDs in the future.

[34] One respondent said they were unsure of whether the spray foam insulation in their attic was still installed.

Fourteen of the sixteen respondents were satisfied with the measures they received. One respondent said they were dissatisfied with the bathroom aerator they received because they prefer a more substantial flow. None of the respondents noted dissatisfaction with the quality of the contractor's work, their interactions with the contractor, or their overall experience of working with the contractor.[35] Eleven survey-takers noticed savings on their monthly electricity bill since having the home audit.[36]

3.2.5 Conclusions and Recommendations

Evaluation of the Multifamily Program consisted of a process and impact evaluation to determine ex-post verified energy savings estimates as well as assess achievement of the program's objectives. ADM found that the magnitude and estimation of annual energy savings and peak demand reduction exceeded projections. A summary of program level impacts is shown in Table 3-42 and Table 3-43.

Table 3-42: Summary of Program Level Annual Energy Savings Impacts (kWh)

Program	Ex-Ante Gross kWh Savings	Ex-Post Gross kWh Savings	Realization Rate	Net-to-Gross Ratio	Ex-Post Net kWh Savings
Multifamily	3,627,762	3,677,700	101%	98.0%	3,604,404

Table 3-43: Summary of Program Level Coincident Peak Demand Impacts (kW)

Program	Ex-Ante Gross kW Savings	Ex-Post Gross kW Savings	Realization Rate	Net-to-Gross Ratio	Ex-Post Net kW Savings
Multifamily	1,065.22	1,005.11	94%	95.9%	964.18

ADM developed the following conclusions from the evaluation findings.

- Overall energy savings and peak demand reduction goals were achieved, however, allocation of goals by region were not all achieved.
- According to the program's service providers, there was a greater focus on weatherization improvements compared to lighting upgrades.
- Program funding was initially limited but was increased during the program year to support additional projects.

[35] Fifteen respondents rated the quality of the contractors' work and their overall satisfaction with their contractor a 4 or 5 on a scale from 1 (very dissatisfied) to 5 (very satisfied). Fourteen respondents rated their Interactions with the contractor a 4 or 5 (the remaining respondents did not know how to rate their interaction).

[36] Rated their level of savings since participating in the program a 2 or higher on a scale from 1 (no savings) to 5 (substantial savings)

- Staff interviews indicate that the program was successfully marketed and promoted in 2019; however, findings from ADM's service provider interviews suggest that there is an opportunity for ICF/PSO to increase marketing and outreach collaboration efforts.
- The following recommendations are offered for the Multifamily Program.
- Review the measure-mix implementation strategy to ensure the program is optimized from a cost-effectiveness perspective.
- Review the limits or allocations for different energy efficiency improvements to ensure the program is supporting holistic energy efficiency improvements at participating Multifamily properties.
- Increase program funding to support the strong demand from Multifamily properties for energy efficiency improvements. Both service providers noted strong demand for the program and that the program's main limitation was funding.
- Evaluation and implementation teams work closely to ensure consistency and accuracy in M&V methodologies and program tracking data.
- Increase collaboration with service providers to market and promote the program to eligible Multifamily properties. The program had effective marketing and promotion strategies in 2019 but including the program's foremost service providers in the marketing strategy to a greater extent would provide multiple benefits. Increased collaboration would bolster the relationship with service providers and potentially reach a wider variety of Multifamily properties.
- Increase recruitment efforts in districts where program failed to meet goals (i.e., Northern and Eastern).

3.3 Home Weatherization Program

3.3.1 Program Overview

PSO's Home Weatherization program objective is to generate energy savings and peak demand reduction for limited income residential customers through the direct installation of weatherization measures in eligible dwellings. The weatherization program provides no-cost energy efficiency improvements to PSO customers with household incomes of $50,000 or less a year. PY2019 performance metrics are summarized in Table 3-44.

Table 3-44: Performance Metrics – Weatherization

Metric	PY2019
Number of Customers	2,048
Budgeted Expenditures	$3,568,107
Actual Expenditures	$3,659,104
Energy Impacts (kWh)	
Projected Energy Savings	2,423,301
Reported Energy Savings	3,743,243
Gross Verified Energy Savings	3,743,243
Net Verified Energy Savings	3,743,243
Peak Demand Impacts (kW)	
Projected Peak Demand Savings	1,188
Reported Peak Demand Savings	2,072
Gross Verified Peak Demand Savings	2,072
Net Verified Peak Demand Savings	2,072
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	2.25
Utility Cost Test Ratio	1.55

In 2019, PSO partnered with three organizations to deliver the efficiency improvements: Titan ES, Rebuilding Tulsa Together (RTT), and KI BOIS Community Action Foundation.

Titan ES provided diagnostic energy assessments, customer education, and installation of weatherization measures to improve energy efficiency. Titan ES delivered services to single-family homes that are either leased or owner-occupied.

RTT is a Tulsa based non-profit organization that provides a variety of home improvement services for limited income homeowners. The services provided by RTT include program-sponsored energy efficiency improvements, as well as other repairs such, as roof repairs.

KI BOIS Community Action, Inc. is a private, non-profit corporation 501(c)3 operating in Southeast Oklahoma. The agency was organized as a part of the national "War on Poverty." Administered by a 30-member Board of Directors, the agency represents all segments of the community, including elected officials, minority groups, businesses, social services, low-income, and the clients served.

Through the Home Weatherization program, participants received diagnostic energy assessments, which identify a list of cost-effective improvements such as air sealing, attic insulation, duct sealing, and water heater tank/pipe insulation. Table 3-45 shows measures installed through the program in 2019. LEDs were removed from the program in 2019 but 4 homes did receive LEDs in early 2019. Air Infiltration was the most common measure type and in, conjunction with attic insulation and duct sealing, made up the majority of the program.

Table 3-45: Summary of Measures Implemented

Measure	Number of Projects	% Share of Reported kWh Savings
Air Infiltration	1,767	25%
Attic insulation	1,686	32%
Duct System Sealing	1,616	43%
LED	4	<1%
Water Heater Jacket	61	<1%
Water Heater Pipe Insulation	2	<1%

PSO's Home Weatherization program serviced 2,048 households during the 2019 program year. Participants saved an average of 1,828 kWh and had an average of 3 measure types. Table 3-46 shows number of homes serviced by agency.

Table 3-46: Homes by Agency

Agency	Number of Homes
Titan	1,980
RTT	64
KI BOIS Community Action, Inc.	4
Total	**2,048**

Participation in the Home Weatherization program was consistent throughout the year. Figure 3-14 displays the accrual of reported energy savings throughout 2019.

Figure 3-14: Accrual of Reported kWh Savings During the Program Year

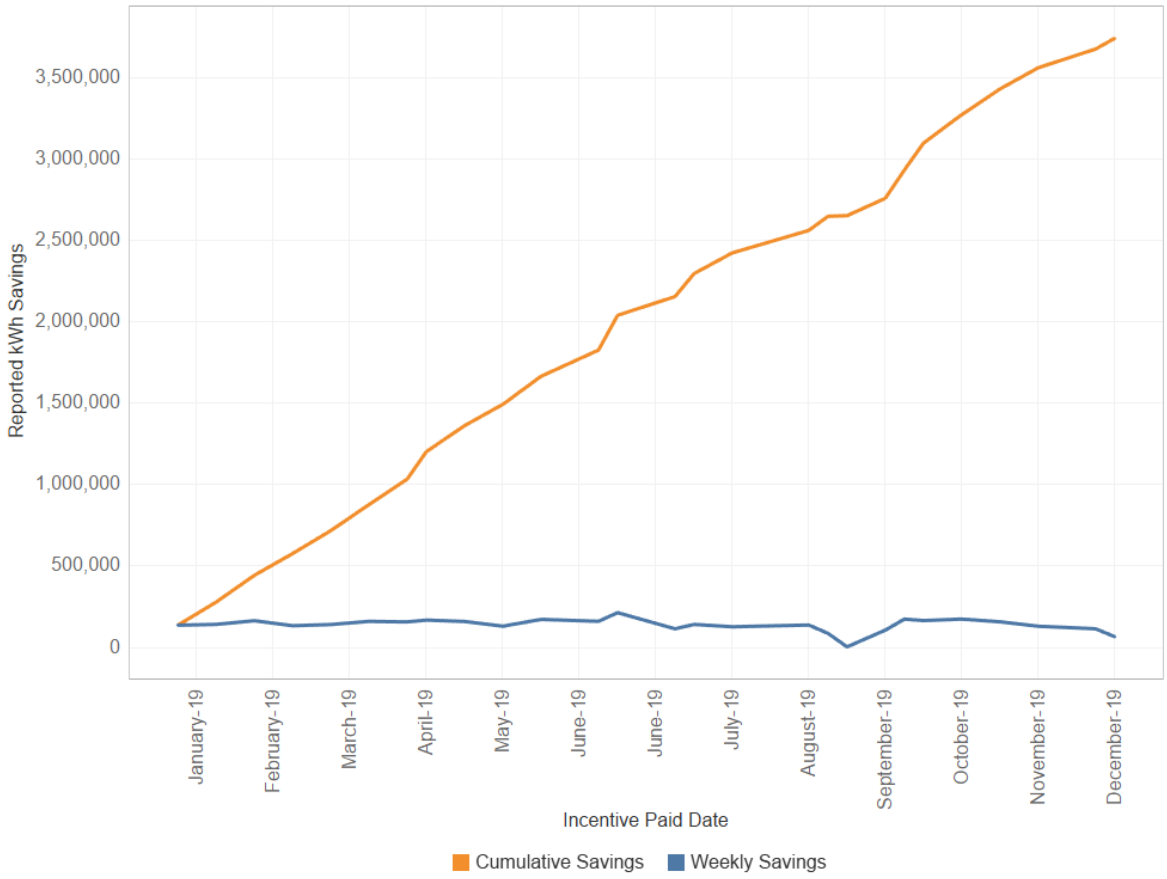
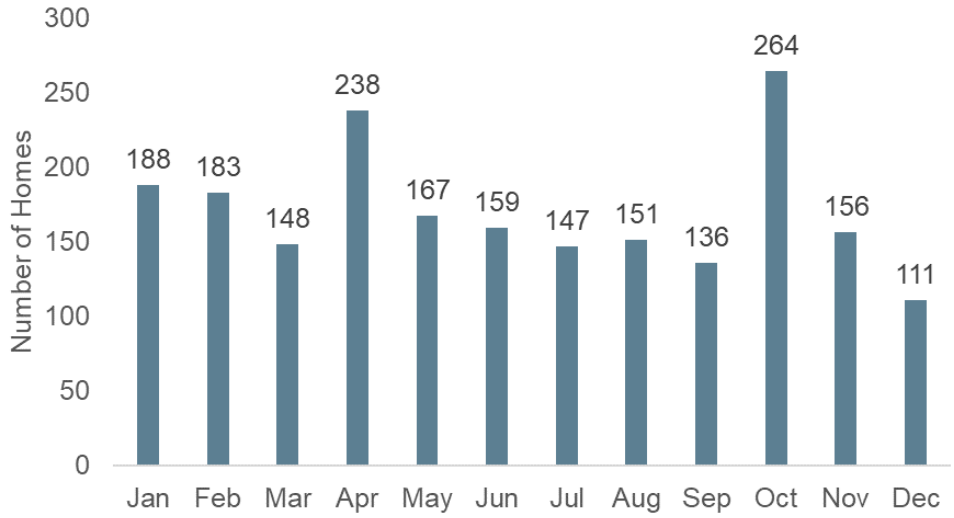


Figure 3-15 displays the approximate number of homes serviced monthly during 2019, based on the invoice paid date listed in the program tracking data. April and October had the highest number during the year, while December had the fewest number.

Figure 3-15: Project by Month



3.3.2 EM&V Methodologies

This section provides an overview of the data collection activities, gross and net impact calculation methodologies that ADM utilized in the evaluation of the Home Weatherization program.

3.3.2.1 Data Collection

Several primary and secondary data sources were used for the evaluation. Tracking data and supporting documentation for the program was obtained from SQL Server Reporting Services (SSRS). This tracking data was used as the basis for quantifying participation and assessing program impacts. Additional data was collected through the phone surveys, staff interviews, and onsite verification visits. Table 3-47 summarizes the data collection activities and purpose.

Table 3-47: Data Collection

Data Collection Activity	Achieved Size	Purpose
On-site Verification Visits	45	Measure Verification/Operation and In-Service Rate
Customer Survey	142	Measure Verification, In-Service Rate, and Customer Satisfaction
In-Depth Interviews with Program Staff	2	Process Evaluation
Program Tracking Data Download	2048	Calculate Energy (kWh) and Demand Impact (kW), ex-ante/ex-post Comparison

ADM conducted two separate sampling activities for the evaluation of the program. One activity was a telephone survey and the other was an on-site verification effort. A sample of participants is necessary because visiting/surveying every single home in the program would be difficult and costly. Hence a sample is designed to be a statistically representative of the program population and ensures accurate program insights. In both telephone surveys and on-site visits, our sample approach was designed to achieve a minimum 10% precision and 90 confidence level (90/10). The participants surveys and on-site visits were utilized to calculated in service rates (ISR). Table 3-48 shows the installation rates by measure type for the phone and field verification survey effort.

Table 3-48: Home Weatherization In-Service Rates

Measure	Verified/Claimed	Phone Survey	On-site Verification	ISR
Attic Insulation	Verified	120	43	100%
	Claimed	120	43	
Duct System Sealing	Verified	119	41	100%
	Claimed	119	41	
Infiltration	Verified	124	41	100%
	Claimed	124	41	
Water Heater Insulation	Verified	5	2	100%
	Claimed	5	2	
LED Bulbs	Verified	0	0	100%
	Claimed	0	0	

LEDs were removed from the program in 2019, however, four homes received them in January 2019. None of these participants fell within ADM's sample. Based on limited LED participation, an ISR of 100% was applied.

3.3.2.2 Telephone Survey Sampling Plan

For the calculation of sample size for survey completes, a coefficient of variation of 0.5 was assumed.[37] With this assumption, a minimum sample size of 68 participants was required, as shown in the following formula:

[37] The coefficient of variation, cv(y), is a measure of variation for the variable to be estimated. Its value depends on the mean and standard deviation of the distribution of values for the variable (i.e., cv(y) = sd(y)/mean(y)). Where y is the average savings per participants. Without data to use as a basis for a higher value, it is typical to apply a CV of 0.5 in residential program evaluations.

Equation 3-1: Minimum Sample Size Formula for 90 Percent Confidence Level

$$n_0 = \left(\frac{Z*CV}{RP}\right)^2 = \left(\frac{1.645*0.5}{0.10}\right)^2 = 68$$

Where:

n_0	= minimum sample size
Z	= Z-statistic value (1.645 for the 90% confidence level)
CV	= Coefficient of Variation (assumed to be 0.5)
RP	= Relative Precision (0.10)

ADM selected a target sample of 136 (double the minimum) completed telephone surveys. In order to accomplish this, random sample of 1,380 was drawn from the participant population. 1380 was selected because ADM assumed a response rate of ~10%. Although 68 was the minimum sample size, ADM conducted phone surveys with 142 participants across the service territory. The additional survey completes were obtained to increase the chance of participation in all areas the program impacted. ADM's in-house survey team called 465 participants and completed 142 surveys (response rate of 30%). Table 3-49 below shows the counties surveyed.

Table 3-49: Number of Survey Participants by County

County	Survey Participants
Caddo	1
Comanche	22
Craig	2
Delaware	1
Grady	5
Jefferson	1
McClain	1
McCurtain	1
Okmulgee	5
Osage	7
Pittsburg	2
Rogers	3
Stephens	1
Tulsa	77
Wagoner	4
Washington	5
Washita	4
Total	**142**

3.3.2.3 Telephone Survey Procedure

The survey informed the gross impact analysis by verifying the presence of reported tracking data measures. Respondents were asked to confirm whether they had received the reported measures. These responses are utilized as part of the In-Service Rate (ISR) calculation. The telephone survey questions also seek to evaluate the customer satisfaction with individual measure as well as the program as a whole. Participants were given a $10 Walmart gift card for their time.

3.3.2.4 On-site Sampling Plan

The calculation of sample size for in-home inspections was based on stratification boundaries. The reported home savings values were placed in one of four strata and the number of in-home inspections needed per stratum was calculated. Table 3-50 shows the strata boundaries and the achieved sample design.

Table 3-50: Sample Design Home Weatherization

Stratum	Reported kWh	Strata Boundaries (kWh)	Population Size	CV	Sample Size
1	310,229	< 800	549	0.30	4
2	1,440,411	800- 2,250	1101	0.28	19
3	1,500,377	2,250 – 8,000	349	0.39	17
4	492,226	> 8,000	49	0.18	5
Total	**3,743,243**	**-**	**2,048**	**-**	**45**

It was calculated that a total of 45 in-home visits were required to achieve a minimum 10% precision and 90 confidence level (90/10). In order to accomplish this, random sample of 500 was drawn from the participant population. Assuming a 10% participant agreement rate to home visits, a sample of 500 was chosen to meet the 45 required home visits. ADM's in-house scheduling team called 191 participants and scheduled 45 home inspections. (success rate of 24%). ADM visited homes in Tulsa, Lawton, Chickasha, Broken Arrow, and Bixby.

3.3.2.5 On-site Procedure

The primary goal of the on-site verification effort was to ensure that the reported measures were installed and operating correctly in participants homes. Data collected through these activities was used to develop measure level verification rates, which were then used to adjust the deemed savings estimates where necessary. Participants were given a $10 Walmart gift card for their time.

During the on-site visits, our field technician accomplished the following:

- Verified the implementation status of the measures; verified that the measures were indeed installed, that they were installed correctly, and were functioning properly. Photographs are also taken of the installed measures.
- Collected data at each site regarding the characteristics of the home where the measures were implemented.
- A field visit form was completed for each visited site to document measure quantities, home characteristics, and any additional commentary regarding the visit.

3.3.2.6 Gross Impact Methodologies

The methodology used to calculate energy (kWh) and demand impacts (kW) consisted of:

- **Reviewing a census of program tracking data:** The tracking data was reviewed for a census of homes and measures. ADM verified there were not any duplicate

project data entry errors. All residences were located at the addresses provided within the tracking data.

- **Verifying measure installation:** ADM calculated installation rates (ISR) by measure for a sample of program participants utilizing data from phone and onsite verification visits. Based on the small number of LED installations in the tracking data no verification visits or phone survey were made for LEDs. No ISR adjustment was made to this measure. ADM attempted to survey LED participants but was unsuccessful.
- **Reviewing reported savings estimates for each measure:** ADM reviewed reported savings calculations for all measures to provide an explanation of any savings discrepancies.
- **ADM calculated verified savings utilizing:**
  - Oklahoma Deemed Savings Document (OKDSD)
  - Arkansas Technical Reference Manual v7 (AK TRM)

A brief description of each measure calculation methodology follows. Appendix F includes the measure level algorithms and deemed savings values utilized for the verified energy (kWh) and demand (kW) impact savings calculations.

3.3.2.6.1 Air Infiltration Reduction

ADM continued to utilize the AR TRM to calculate energy and demand impacts of infiltration reduction measures.

This measure involves sealing leaks in conditioned areas of the homes. This is achieved by installing door gaskets, door sweeps, foam sealing plumbing penetrations, and caulking around windows. Savings are calculated by multiplying the air infiltration reduction (CFM), with the energy savings factor corresponding to the climate zone and HVAC type. The air infiltration reduction estimate in CFM is obtained through blower door testing performed by the program contractor pre and post measure installation for each home serviced. Only homes with central AC (or room AC) cooling systems are eligible for the measure.

3.3.2.6.2 Attic Insulation

This measure requires adding ceiling insulation above a conditioned area in a residential dwelling of existing construction to a minimum ceiling insulation value of R-38. Deemed savings values were calculated for each home in accordance to the AR TRM with scaled values. Attic insulation deemed savings are listed based on the R-value of the baseline insulation and weather zone. Savings are calculated by multiplying the corresponding savings value by the square footage insulated.

3.3.2.6.3 Duct Sealing

This measure involves sealing leaks in ducts of the distribution system of homes with either central AC or a ducted heating system. ADM utilized the OKDSD[38] in conjunction with the duct leakage reduction results in order to calculated measure savings. The duct leaked reduction estimate in CFM is obtained through duct blaster testing performed by the program contractor pre and post measure installation for each home serviced.

3.3.2.6.4 LED Light Bulbs

LEDs were removed from the program in 2019 but a very small numbers homes did receive LEDs in early 2019. This measure provides savings for replacing an inefficient lamp with an Omni-directional LED in residential applications. The replacement must be ENERGY STAR® qualified. The OKDSD specifies the algorithms for use in calculating energy and demand impacts of ENERGY STAR® LEDs. ADM utilized these algorithms with a modification to the hours of use per year (960.61 HOU per year). The modification of the hours of use was sourced from a benchmarking study performed in 2016.[39]

3.3.2.6.5 Pipe Insulation and Water Heater Jackets

Electric water heating is required for the installation of pipe insulation and/or water heater jackets. As such, the number of recipients was significantly smaller than other program measures.

The deemed savings for water heater jackets installed on electric water heaters are sourced from the OKDSD. For water heater jackets, a review of the tracking system showed that conservative assumptions were used to inform the use of the deemed savings. The deemed savings for this measure depend on 1) insulation thickness and 2) water heater tank size.

Water heater pipe insulation involves insulating all hot and cold vertical lengths of pipe, plus the initial length of horizontal hot and cold-water pipe, up to three feet from the transition, or until wall penetration, whichever is less. The OKDSD specifies deemed values for energy and demand impacts of water heater pipe insulation measures. The deemed values can be found in Appendix F.

3.3.3 Net-to-Gross Estimation

The Home Weatherization program specifically targets customers with limited income, providing all services at no cost to the customer. It is likely that participating customers

[38] OKDSD calls for a SEER value of 13 be used in the algorithm. ADM utilized a SEER value of 11.5, which is the average of U.S. DOE minimum allowed SEER for new AC from 1992-2006 (10 SEER) and after January 2006 (13 SEER). This adjustment is not done across all programs, it is specific to home weatherization.

[39] ADM HOU Memo, 2016.

would not have funded the installed energy efficiency measures on their own. As a result, ADM assumed an NTG ratio of 100%.

3.3.4 Impact Evaluation Findings

3.3.4.1 Air Infiltration

All survey respondents verified air infiltration reduction measures were installed. Similarly, evidence of air infiltration reduction measures were verified during all on-site visits. Based on these findings, an ISR of 100% was applied.

ADM calculated the deemed savings values for each home and determined the total program level energy (kWh) and demand impacts (kW) savings for air infiltration as 919,550 kWh and 292 kW, respectively. The program level realizations rates for air infiltrations was 100%.

3.3.4.2 Attic Insulation

All 120 survey respondents asked about attic insulation verified that insulation was installed. Similarly, ADM verified attic insulation at all 43 site visits of homes that received attic insulation through PSO's Home Weatherization program. During the on-site verification visits, the pre-existing and new insulation levels along with square feet installed were measured. As a result, an ISR of 100% was applied for attic insulation.

ADM calculated the deemed savings values for each home and determined the total program level energy (kWh) and demand impacts (kW) savings for attic insulation as 1,198,332 kWh and 1,072 kW, respectively. The program level realizations rates for attic insulation was 100%.

3.3.4.3 Duct Sealing

A total of 119 survey respondents represented homes where duct sealing was reported to have occurred. All of these respondents confirmed that their home had received duct sealing. The on-site verification visits included 41 homes where duct sealing savings had been claimed. ADM's on-site verification work found evidence of duct sealing at all visited homes where savings had been claimed. An ISR of 100% was applied for duct sealing.

ADM calculated the deemed savings values for each home and determined the total program level energy (kWh) and demand impacts (kW) savings for duct sealing as 1,620,977 kWh and 706 kW, respectively. The program level realizations rates for duct sealing was 100%.

3.3.4.4 LED Light Bulbs

LEDs were removed from the program in 2019; however, four homes received them in January 2019. None of these participants fell within ADM's sample. Based on limited LED participation, an ISR of 100% was applied to the ex-post energy saving calculation.

ADM calculated the deemed savings values for each home and determined the total program level energy (kWh) and demand impacts (kW) savings for LED as 123 kWh and 0.018 kW, respectively. LED bulb calculations resulted in realization rates of 100% kWh and 107% for peak demand reduction. The 107% realization rate for peak demand reduction can be attributed to ex-ante savings using an ISR of 91%. This did not have a significant impact on program level realization rates as LED savings made up a small portion of total program savings (0.003%).

3.3.4.5 Water Heater Jackets and Pipe Insulation

Installation of pipe insulation and/or water heater jackets required electric water heating in serviced homes. As such, the number of recipients was significantly smaller than other program measures. ADM completed 5 verification surveys and 2 on-site verification for customers that had water heater insulation done in their homes through the program. In all sampled cases, the measure was verified as installed resulting in an ISR 100%.

ADM calculated the deemed savings values for each home and determined the total program level energy (kWh) and demand impacts (kW) savings for water heater jackets and pipe insulation as 4,262 kWh and 0.34 kW, respectively. The program level realizations rates for these measures was 100%.

3.3.4.6 Impact Summary

Overall, the program design and operations remained unchanged. In an effort to expand the program in 2020, PSO is planning the addition of mobile home weatherization measures. The following summarizes the key findings of the impact evaluation of the Home Weatherization program.

- Historically, program realization rates have been high, but not 100%. The 2019 savings estimates resulted in a gross annual kWh savings realization rate of 100% and a peak kW demand impact realization rate of 100%.
- The program's measure level in service rates (ISR) were all found to be 100%.
- Total program savings of 3,743,217 kWh met and exceeded the projected portfolio savings of 2,435,674 kWh.

The verified savings were calculated utilizing the OKDSD and the AR TRM. Ex-post and ex-ante kWh and peak demand by measure are shown in Table 3-51.

Table 3-51: Reported and Verified kWh and Peak kW

Measure	Reported Energy Savings (kWh)	Reported Peak Demand Savings (kW)	Verified Gross Energy Savings (kWh)	Verified Gross Peak Demand Savings (kW)	kWh Realization Rate	kW Realization Rate
Air Infiltration	919,550	292	919,550	292	100%	100%
Attic Insulation	1,198,332	1072	1,198,332	1072	100%	100%
Duct Sealing	1,620,977	706	1,620,977	706	100%	100%
LED	122	0.017	123	0.018	100%	107%
Water Heater Jacket	4,174	0.31	4,174	0.31	100%	100%
Water Heater Pipe Insulation	88	0.03	88	0.03	100%	100%
Total	**3,743,243**	**2072**	**3,743,243**	**2072**	**100%**	**100%**

3.3.5 Process Evaluation Findings

ADM's process evaluation activities included participant surveys, an interview with the PSO Program manager, and an interview with the Titan co-owner. ADM provided a process evaluation memo to PSO in December of 2019. The following summarizes the key finding from the process evaluation of the Home Weatherization program.

3.3.6 Conclusions and Recommendations

The following summarizes the key findings from the evaluation of the Home Weatherization program.

- **High realization rates.** Program savings realization rate is historically very high, but in PY2019 it was 100%.
- **PY2019 savings goal exceeded.** The program projected savings of 2,435,674 kWh for 2019 was met and significantly exceed in 2019 (3,743,243 kWh).
- **Program staff correctly anticipated the program was on track to meet PY2019 saving goals.** During the October interview, staff anticipated they would meet goals for this year, meet the demands of the program, and continue to deliver quality service. Titan implemented minor changes to their data management and improved their staff training process. Communication structure between utility company and implementers show no issues at this time.
- **Historical program success.** The program continues to be implemented and administered very well. Program staff and implementation teams have remained consistent throughout the years. The program has been around a long time and

has serviced tens of thousands of homes. The programs has had small changes throughout its history but for the most part, remains unchanged.

- **Changes to program design and acceptance influenced participation.** This year, PSO increased the household income level qualification from $45,000 to $50,000, which allowed for more families to partake in the program. The sampled population did not report barriers to enrollment or skepticism of the program's legitimacy. The strategy that most participants reported helped raise awareness of program was word of mouth (23%) from friends, relatives, or colleagues. Many participants were influenced by the recommendations from past Weatherization program participants.
- **Changes to marketing and outreach influenced participation.** The marketing strategies implemented through the social media platform had more engagement from participants than in other years. Program staff also implemented print and electronic channels to promote the program. Yet, most of the participants learned about the program through verbal recommendations, bill inserts, and the Power Forward website.[40]
- **Decreasing energy costs was a major factor to enrolling in the program.** Eighty-seven percent of survey respondents indicated that reducing their monthly utility bill appealed to them before they enrolled. When participants were asked whether they were satisfied with the savings found in their monthly bills, 86% were either satisfied or very satisfied with their savings. However, 34% noticed some or a substantial amount of savings when asked if the participant noticed savings on the monthly bill since the weatherization service.
- **Program participant satisfaction rates were positive overall.** The sampled population reported satisfaction over the utility company, the enrollment process, and customer experience. PSO staff encountered some complaints about waiting times, but participants reported high satisfaction rates. Satisfaction regarding installations varied amongst measures. All five participants who had a water heater pipe or jacket installed were very satisfied, 88% of participants were very satisfied with their attic insulation as well as air sealing, and 87% of participants were very satisfied with their duct sealing.
- **Program staff continue to expand their reach throughout the territory**. This year, home weatherization services covered a larger proportion of the PSO territory, with most projects completed in Tulsa. Titan staff indicated there are challenges for customers in rural communities in terms of accessing the program due to a lack of available contractors to complete projects.

[40] https://powerforwardwithpso.com/

The following recommendations are offered for continued improvement of the Home Weatherization program:

- **Continue expanding the program to reach customers with mobile homes.** Program staff has noted year after year they have had to turn down mobile home customers from the weatherization program. Mobile homes present different challenges simply due to how they are constructed. Typical weatherization measures like attic insulation and duct sealing are difficult to implement. Consider offering a mobile home package which would include LED bulbs, advance power strips, faucet aerators, low-flow showerheads, and bathroom ventilation fans.
- **Add an email address field to the program tracking data** to enable additional, easier customer contact for feedback and program evaluation, as well as education and community outreach.

3.4 Energy Saving Products Program

3.4.1 Program Overview

PSO's Energy Saving Products (ESP) program seeks to generate energy and demand savings for residential customers through the promotion of a variety of energy efficient measures. The overall purpose of this program is to provide PSO residential customers financial incentives for purchasing products that meet high efficiency standards.

The ESP upstream program in PY2019 consisted of retail price discounts for qualifying LED light bulbs, room air purifiers, advanced power strips, bathroom ventilation fans, water dispensers, spray foam, door sweeps and seals, room air conditioners and air filters. The upstream component of the program used a price mark down mechanism where participating retailers advertise and offer discounted pricing for program sponsored products. The retailers/manufacturers were then reimbursed by PSO for the difference between the discounted price and the normal retail price. This program component also included distribution of free LEDs in partnership with food banks and local food pantries within the PSO service territory during PY2019. Discounted LED bulbs, including the free LEDs distributed through local food pantries, made up approximately 89% of the reported energy savings for the PY2019 ESP program.

In PY2019 the ESP program also offered mail-in rebates from PSO for qualifying heat pump water heaters, clothes dryers, clothes washers, refrigerators, and level 2 electric vehicle chargers. This downstream portion of the program accounted for approximately 3% of the non-lighting reported energy savings realized through the program.

The actual number of participants in the ESP lighting component of the program is unknown, as upstream measure purchaser information is not tracked by participating retailers. In total, 348,480 packages of LEDs and 1,484,038 individual bulbs were discounted through participating retailers or distributed in partnership with local food pantries. The total number of all other upstream measures discounted in the ESP program was 43,373, while the total number of measures rebated through the downstream portion of the program was 1,460. Overall, the ESP program supported the purchase of 1,528,871 energy efficient measures during PY2019.

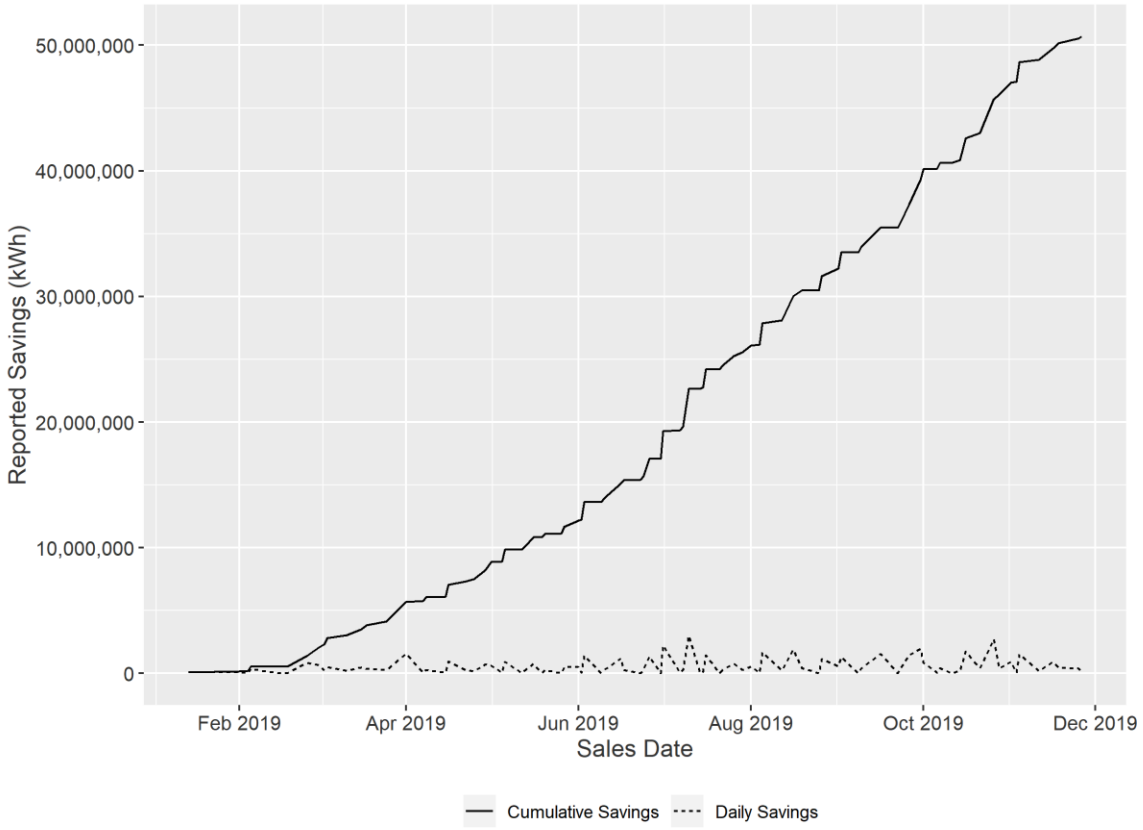
Table 3-52 provides a summary of program metrics for the 2019 program year. Program costs were $2,306,064, while reported kWh savings exceeded program projections. Overall, gross verified energy savings developed through ADM's impact evaluation were higher than reported savings and reported demand reduction, representing a gross realization rate over 100% for both.

Table 3-52: Performance Metrics – Energy Saving Products Program

Metric	PY2019
Number of Products	1,528,871
Budgeted Expenditures	$3,295,840
Actual Expenditures	$3,613,293
Energy Impacts (kWh)	
Projected Energy Savings	40,364,095
Reported Energy Savings	53,442,050
Gross Verified Energy Savings	59,165,098
Net Verified Energy Savings	36,428,573
Peak Demand Impacts (kW)	
Projected Peak Demand Savings	5,157.00
Reported Peak Demand Savings	7,571.98
Gross Verified Peak Demand Savings	9,403.51
Net Verified Peak Demand Savings	5,806.88
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	7.10
Utility Cost Test Ratio	7.16

Participation in the ESP program were mostly consistent throughout the 2019 program period. The only exception was during late June and early July, when participation was much higher than average. On the following page, Figure 3-16 shows the reported daily kWh savings and the cumulative reported kWh savings throughout the 2019 program year.

Figure 3-16: Accumulation of Reported Savings during the 2019 Program Year



The remainder of this section details the EM&V methodologies and findings for the Energy Saving Products (ESP) program.

3.4.2 EM&V Methodologies

The following section details the methodologies ADM used to verify retail sales, estimate energy and peak demand impacts, and assess the performance for the ESP program.

3.4.2.1 Data Collection

Several primary and secondary data sources were used for the evaluation. Tracking data and supporting documentation for the program was obtained from the program implementor, CLEAResult and their database. This tracking data was used as the basis for quantifying participation and assessing program impacts. Supplemental tracking data was also provided by CLEAResult and included the following information for each combination of retailer, model number, and discount level for upstream lighting:

- Package sales per week (program sales only)
- Original retail price
- Manufacturer/Retailer sponsored discounts (if any)

- PSO sponsored discounts
- Retail price, including all discounts
- Number of bulbs per package
- Rated wattage
- Rated lumens
- Rated lifetime (in hours)

Additional documentation including retailer agreements, retailer/manufacturer invoices, promotional event documentation, and general program materials were reviewed as part of the evaluation.

Primary data collection activities included an online general population survey, two surveys of downstream rebate participants, and interviews with program staff members. The general population survey was administered between October 2019 and November 2019. The final sample size for each primary data collection activity is presented in Table 3-53 below.

Table 3-53: ESP Data Collection Activities

Data Collection Activities		N
General Population Survey		505
Downstream Rebate Participant Survey	Appliance Survey	125
	Electric Vehicle Level 2 Charger Survey	2
Program Staff Interviews		2

There were three survey efforts conducted: a general population survey covering upstream purchases of discounted measures and two downstream rebate participant surveys; all three survey efforts were conducted online through emailed invitations. For the general population survey, a sample of PSO's residential customers within Oklahoma were contacted via email and asked a variety of questions about recent purchases of energy efficient measures discounted via the upstream program. Because customer contact information is not tracked for marked-down measures in the upstream program, the methodology implemented provided a cost-effective way of reaching many potential program participants. The survey instrument employed several screening questions to determine whether respondents had (a) purchased measures discounted through the upstream program within the program year and (b) that those purchases had been made through participating retailers.

In total, the general population survey was completed by 505 PSO customers. To qualify for the survey, participants had to meet two conditions. They needed to have purchased

at least one discounted measure during the program year and the purchase needed to have been done through a participating retailer. Twenty percent of the PSO customers contacted began the survey (970 individuals). Of these individuals, 200 customers did not qualify to participate, and an additional 265 participants failed to complete the survey fully. For a disaggregation of qualifying survey responses by measure, see Table 3-54. The survey collected data on program awareness and insights into energy-saving product purchases for lighting and non-lighting measures in addition to data regarding measure satisfaction and household demographics.

Table 3-54: Measures Bought During 2019

Measure	Number of Eligible Respondents
LED light bulbs	486
Air filters	66
Spray foam, door seals, or door sweeps	43
Energy saving advanced power strips	10
ENERGY STAR® Room air conditioners	9
ENERGY STAR® Bathroom ventilation fans	5
ENERGY STAR® Room air purifiers	None
ENERGY STAR® Water dispensers	1

Note: the number of eligible responses column does not sum to 505 (the number of surveys completed) since surveyed customers could have purchased more than 1 discounted measure.

For the downstream rebate participant survey, customers that had received rebates for heat pump water heaters, clothes dryers, clothes washers, refrigerators, and level 2 electric vehicle chargers through the PSO ESP program were invited to participate in online surveys. Screening questions were asked to assess customer program awareness. Table 3-55 compares the measures purchased by customers contacted to complete the survey with measures purchased by customers who completed the survey.

Table 3-55: Rebated Measure Participants Contacted vs. Survey Responses

Rebated Equipment	Percent of Measures Purchased by Customers Invited to the Survey (n = 485)*	Percent of Survey Respondents (n = 142)**
ENERGY STAR® Clothes Dryer	20%	13%
ENERGY STAR® Clothes Washer	41%	45%
ENERGY STAR® Refrigerator	38%	40%
ENERGY STAR® Heat Pump Water Heater	<1%	<1%
Level 2 Electric Vehicle Charger	<1%	<1%

**Four hundred and eighty-five distinct measures were purchased by the 394 program participants invited to participate in the survey. ** Similarly, surveyed participants answered questions about one hundred and forty-two distinct measures.*

To inform the process evaluation, ADM also conducted in-depth interviews with program staff at PSO and implementation contractor CLEAResult. These interviews provided insight into various aspects of the program and its organization, but also focused on changes to the program that occurred during 2019. Interviewees also discussed aspects of the program operations that they considered to be successful as well as the challenges faced over the course of the program year. These results, along with program feedback collected via the participant surveys, have been consolidated in a separate memo, the "2019 Process Evaluation Memo".

3.4.2.2 Gross Impact Estimation Methodology: Upstream Program

3.4.2.2.1 Lighting

Reported energy and peak demand impacts for the program were calculated using deemed per-unit impacts from the Oklahoma Deemed Savings Documents (OKDSD). For LEDs, the deemed savings algorithms came from the 2013 updated Deemed Savings Documents, which reflect baseline bulb wattage changes resulting from the Energy Independence and Security Act of 2007 (EISA). ADM's evaluation consisted of: (1) verifying the quantity of program eligible measures that were discounted in-store, (2) reviewing the assumptions and inputs associated with the deemed savings values, (3) verifying that the deemed per-unit impacts were applied appropriately and (4) making appropriate adjustments for in-service rates, leakage, and cross sector sales.

Verification

For LED markdowns, ADM reviewed the program tracking database consisting of retailer transaction data. Important fields included: item description, number and type of package sold, bulbs per package, bulb lumens, bulb wattage, program and original retail pricing,

retail location, and transaction period. This tracking data was compared to participating retailer/manufacturer invoices to verify the quantity of units sold and discounted through the program. The retailer/manufacturer invoices submitted to the program rebate processing center are based on actual sales transaction data from each retailer. Manufacturer invoices were also reviewed for the bulbs distributed through local food pantries.

Calculation of Gross Annual kWh Savings

For discounted LEDs, savings are realized when an inefficient lamp is replaced with an Omni-directional LED in residential applications. The replacement must be ENERGY STAR® qualified. The OKDSD specifies the algorithms for use in calculating energy and demand impacts of ENERGY STAR® LEDs. ADM utilized these algorithms with a modification to the hours of use per year (960.61 hours of use (HOU) per year). The modification of the hours of use was sourced from a benchmarking study performed in 2016.[41] The savings algorithm is described in Appendix F, Section F.1.3.1.

In-Service Rate Adjustments

The cost-effectiveness testing for the program requires calculating lifetime energy savings for purchased LEDs. Less efficient incandescent and EISA compliant halogen bulbs typically have rated lifetimes considerably lower than LEDs. Additionally, calculating lifetime energy savings requires an estimate of when the newly purchased bulbs are installed. The Deemed Savings Documents stipulate an in-service rate (ISR) of 97%, but this reflects the percentage of bulbs estimated to be installed eventually by the purchaser rather than immediately installed. Previous studies have found that immediate or first-year installation rates are generally lower, as some bulbs are shelved for later use.

To estimate a second-year ISR, ADM asked survey respondents from the general population survey to estimate the number of purchased light bulbs they had purchased as well as the number that they had installed. It was then assumed that the full ISR of 97% is achieved within three years.[42] The second-year ISR is assumed to be the average of the first-year ISR and the full ISR, reflecting an assumed linear rate of installation. The ISR only affects first and second-year savings as well as the discounting of energy and demand impacts for cost-effectiveness testing purposes. Annual savings estimates are unaffected.

Leakage Adjustments

Leakage refers to cross-territory sales that occur when program discounted bulbs are installed outside of PSO's service territory. When this occurs, the energy and demand impacts from the discounted bulbs are not realized within the territory that financially

[41] ADM HOU Memo, 2016.
[42] This three-year period for achieving the full ISR is recommended by the DOE Uniform Methods Project Residential Lighting Evaluation Protocol.

supported and claimed the savings. For program year 2019, ADM conducted a study to estimate leakage for each of the retailers in the program that will be used for EM&V analysis for program years 2019-2021.

Estimates of leakage were assessed using an approach that combined responses from the general population survey with a geo-mapping analysis using the following methodology:

- First, ADM developed a mapping of concentric circles (drive-times) surrounding each participating retailer. The initial modeling assumed the "reach" of a retailer is a 60-minute drive, which is then modified by the presence of an alternative sponsoring retailer (i.e., if a customer is within a 60-minute drive of two sponsoring retailers, it is assumed they purchased from the closest one). Non-participating retailers are also included as alternative retailers within the construction of the drive-times. ADM use data obtained from InfoUSA[43] to create a comprehensive list of retailers by retailer type (e.g. Discount, Do-it-yourself, Mass Merchant) within the 60-minute drive-time area.
- Second, ADM used 2010 Census block data from Environmental System Research Institute (ESRI) to determine the proportion of the population that falls within each drive-time circle (from Step 1), as well as the proportion of the population that falls within the PSO Oklahoma (OK) territory and within the state of Oklahoma. Thus, for each drive-time circle and retail location, ADM determined the proportion of the population within the PSO OK territory, outside of PSO OK territory and within the state of OK, and outside of the state of OK.
- Third, a general population survey was used to assess the shopping habits of PSO customers. The results of this survey were used to assess the drive-time in miles that OK consumers accepted when shopping for products incentivized by the ESP program. This gauge of consumer behavior was used to modify the initial 60-minute drive assumption established in Step 1 by weighting drive-times according to customers' willingness to drive a maximum distance for a given retailer type. The approach uses a log transformation of the drive-times to smooth the data and estimates the cumulative percent via a second order polynomial regression.
- Fourth, for each drive-time, ADM calculate the relative propensity of the population within that drive-time to visit the store. This relies on the predicted cumulative percent of willingness to drive in step 3 above. The first drive-time of 0 to 5 minutes is assigned 100% relative propensity, since it is assumed all customers making trips to stores are willing to drive the minimum distance. The relative propensity of

[43] https://www.infousa.com/lp/infousa/?mediacode=USAGAWS00471&bas_phone=800.868.5249&sfcid=7010d000001K9ERAA0&gclid=Cj0KCQiAq97uBRCwARIsADTziyYs_ck0OVKuaxW7dS4GJcCEJXeTMMfqXzeOjZwbpXuK5xmZ-0uOOkQaAvv7EALw_wcB

the remaining drivetimes is the lag of one minus the predicted cumulative percent of willingness to drive.

- Fifth, the relative propensity is multiplied by each of the populations found in Step 2 above for each participating retailer. The populations from Step 2 are then summed for each retailer and three separate leakage values are computed. The first leakage rate measures leakage in state and out of PSO territory. This is measured by the sum of the adjusted population[44] that is within state and out of territory divided by the adjusted total population for a given retailer. The second leakage rate measures leakage out of state, which is given by the sum of the adjusted population out of state divided by the adjusted total population. The final leakage rate is the sum of the first two leakage rates and measures overall leakage out of PSO territory.
- Lastly, an overall leakage rate for the program is calculated by weighing the individual retailer leakage rates by the total number of bulbs sold for each retailer.

Further detail on this analysis can be found in a separate report entitled "*2019 Lighting Sales Leakage Memo*". ADM found that PSO's overall leakage rate was 8.4%; however, per UMP discussion[45], ADM will rely only on the calculated out-of-state leakage rate, 0.2%, as neighboring utility territories in Oklahoma also offer incentivized bulbs and incented bulbs likely cross both in and out of the neighboring service territories.

Cross Sector Sales Adjustments

ADM used estimated annual hours of use (HOU) of 960.61 (as described in Calculation of Gross Annual kWh Savings). This reflects an average daily HOU of 2.63 times 365.25 days per year. While this is within the range of HOU estimates from previous studies[46] of residential lighting use, it likely underestimates HOU for bulbs that are installed in non-residential buildings. The higher annual HOU for bulbs in non-residential savings implies a shorter expected useful life for the bulbs (in years). The time period in which the savings occur affects the applicable baseline wattage and discount factor for cost-effectiveness savings. ADM used responses from the general population survey to estimate the percentage of purchased bulbs that are installed in non-residential facilities. For these bulbs, HOU were estimated to be 3,253 based on EUL stipulations for integrated-ballast CFLs from the Arkansas TRM.[47] A corresponding coincidence factor

[44] Adjusted population is equal to the population multiplied by the relative propensity to visit the store.
[45] The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures: Chapter 6, Section 5, page 26.
[46] The DOE Uniform Methods Project Residential Lighting Evaluation Protocol summarizes nine recent studies with HOU estimates ranging from 1.5 to 2.98 hours per day. See: http://energy.gov/sites/prod/files/2013/11/f5/53827-6.pdf.
[47] Table 362: Estimated Useful Life by Lamp Type found in the Arkansas TRM v6.1 states the weighted-average annual operating hours for integrated-ballast CFLs as 3,253. See http://www.apscservices.info/EEInfo/TRM6-1.pdf.

(CF) of 0.55 is assumed. This has the effect of increasing annual energy savings and peak demand reduction for the percentage of bulbs estimated to be installed in non-residential settings.

3.4.2.2.2 Non-Lighting Measures

Savings calculations for non-lighting measures are outlined in the sections below. The detailed algorithms can be found in Appendix F**,** Section F.1.3. ADM's evaluation consisted of (1) verifying the quantity of program eligible measures that were discounted in-store, (2) reviewing the assumptions and inputs associated with the deemed savings values and (3) verifying that the deemed per-unit impacts were applied appropriately.

3.4.2.2.3 Air Filters

Deemed savings for air filters (AF) were not available in the OKDSD, so the Texas TRM was used to calculate savings.[48]

Verification

For AFs, ADM reviewed the program tracking database consisting of retailer transaction data. Important fields included: item description, number and type of AFs sold, program and original retail pricing, retail location and transaction period.

3.4.2.2.4 Advanced Power Strips

Due to data differences between the program tracking data and the OKDSD, deemed kWh and peak demand kW savings values for advanced power strips (APS) were referenced using the Arkansas TRM v7.0[49] instead of OKDSD.

Verification

For APS, ADM reviewed the program tracking database consisting of retailer transaction data. Important fields included: item description, number of APS, program and original retail pricing, retail location, and transaction period.

Calculation of Gross Annual kWh Savings

The PSO ESP program provided rebates for Tier 1 APS only. Deemed savings were calculated for Tier 1 by average complete system as the type of installation was unknown.

[48] Texas Technical Reference Manual, version 6.0 volume 2: Residential Measures, November 7, 2018. Section 2.2.1, pg. 2-57 – 2-63.

[49] Arkansas Technical Reference Manual, version 7.0 volume 1: EM&V Protocols, *prepared by* The Independent Evaluation Monitor, *approved in Docket* 10-100-R, August 31, 2017. Section 2.4.4, pg. 182-189.

3.4.2.2.5 Bathroom Ventilation Fan

Deemed kWh and peak demand kW savings values for bathroom ventilation fans (BVF) were unavailable in the OKDSD; however, the Illinois TRM v7.0 has established deemed kWh savings and peak kW demand values that were used for this analysis.[50]

Verification

For BVFs, ADM reviewed the program tracking database consisting of retailer transaction data. Important fields included: item description, number of BVFs sold, program and original retail pricing, retail location and transaction period.

3.4.2.2.6 Room Air Conditioners

The Arkansas TRM v7.0 has established deemed kWh savings and peak kW demand values that were used for this analysis.[51]

Verification

For room air conditioners (RAC), ADM reviewed the program tracking database consisting of retailer transaction data. Important fields included: item description, number and type of RACs sold, cooling capacity, equivalent full-load cooling hours, program and original retail pricing, retail location and transaction period.

3.4.2.2.7 Room Air Purifiers

Deemed kWh and peak demand kW savings values for room air purifiers were unavailable in the OKDSD; however, the Illinois Technical Reference Manual (TRM) v7.0 has established deemed kWh savings and peak kW demand values that were used for this analysis.[52]

Verification

For room air purifiers, ADM reviewed the program tracking database consisting of retailer transaction data. Important fields included: item description, number and type of room air purifier sold, Dust CADR, program and original retail pricing, retail location, and transaction period. This tracking data was compared to participating retailer/manufacturer invoices to verify the quantity of units sold and discounted through the program. The retailer/manufacturer invoices submitted to the program rebate processing center are based on actual sales transaction data from each retailer.

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[50] Illinois Statewide Technical Reference Manual for Energy Efficiency, version 7.0 volume 3: Residential Measures, September 28, 2018. Section 5.3.9, pg. 124-126.
[51] Arkansas Technical Reference Manual, version 7.0 volume 1: EM&V Protocols, *prepared by* The Independent Evaluation Monitor, *approved in Docket* 10-100-R, August 31, 2017. Section 2.1.10, pg. 73-75.
[52] Illinois Statewide Technical Reference Manual for Energy Efficiency, version 7.0 volume 3: Residential Measures, September 28, 2018. Section 5.1.1, pg. 6-8.

Calculation of Gross Annual Energy Savings and Peak Demand Reduction

Gross annual energy savings for discounted room air purifiers were calculated using the algorithm from the Illinois TRM v7.0 and can be found in Appendix F, Section F.1.3.2.

3.4.2.2.8 Water Dispensers

Deemed kWh and peak demand kW savings values for water dispensers (WD) were unavailable in the OKDSD; however, the Pennsylvania TRM has established deemed kWh savings and peak kW demand values that were used for this analysis.[53]

Verification

For WDs, ADM reviewed the program tracking database consisting of retailer transaction data. Important fields included: item description, number, and type of WD sold, type of storage, program and original retail pricing, retail location and transaction period.

3.4.2.2.9 Weatherization Measures: Spray Foam, Door Seals, and Door Sweeps

The Pennsylvania TRM's Interim Measure Protocol for Weather Stripping has established kWh savings and peak kW demand values that were used for this analysis.[54]

Verification

For these weatherization measures (WM), ADM reviewed the program tracking database consisting of retailer transaction data. Important fields included: item description, number, and type of WMs sold, program and original retail pricing, retail location and transaction period.

3.4.2.3 Gross Impact Estimation Methodology: Downstream Program

3.4.2.3.1 Clothes Dryers

Deemed kWh and peak demand kW savings values for clothes dryers (CD) were unavailable in the OKDSD; however, the Illinois TRM v7.0 has established deemed kWh savings and peak kW demand values that were used for this analysis.[55]

Verification

For CDs, ADM reviewed the program tracking database consisting of retailer transaction data. Important fields included: item description, number and type of CD sold, dryer type, vented/ventless, voltage, drum size, automatic termination controls, program and original retail pricing, retail location, and transaction period.

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[53] Pennsylvania Technical Reference Manual, June 2016. Section 2.4.9, pg. 164-165.
[54] Addendum document to the 2016 Pennsylvania TRM for weather stripping, caulking, and outlet gaskets.
[55] Illinois Statewide Technical Reference Manual for Energy Efficiency, version 7.0 volume 3: Residential Measures, September 28, 2018. Section 5.1.10, pg. 45-48.

3.4.2.3.2 Clothes Washers

The AR TRM v7.0 has established deemed kWh savings and peak kW demand values that were used for this analysis.[56]

Verification

For clothes washers (CW), ADM reviewed the program tracking database consisting of retailer transaction data. Important fields included: item description, number and type of CW sold, fuel type, program and original retail pricing, retail location and transaction period.

3.4.2.3.3 Electric Vehicle Chargers

For Level 2 electric vehicle chargers (EVC), ADM used a saving algorithm co-developed with implementor CLEAResult.

Verification

For EVCs, ADM reviewed the program tracking database consisting of retailer transaction data. Important fields included: item description, number, and model of EVCs sold, program and original retail pricing, retail location and transaction period.

3.4.2.3.4 Heat Pump Water Heaters

ADM checked heat pump water heater (HPWH) model numbers listed in the program tracking system against ENERGY STAR® databases to verify that each HPWH distributed in 2019 was ENERGY STAR® certified and assigned the correct capacity and efficiency ratings.

Deemed kWh savings values for HPWH were unavailable in the OKDSD; however, they were available in the Arkansas TRM v7.0.[57] The variables that affect deemed savings are the following: storage tank volume, HPWH Energy Factor (EF), HPWH installation location (conditioned vs. unconditioned space) and weather zone. Weather zones were based on established zones in Arkansas. Similar weather zones have been established in Oklahoma that are commiserate with the numbered weather zones in Arkansas.

[56] Arkansas Technical Reference Manual, version 7.0 volume 1: EM&V Protocols, *prepared by* The Independent Evaluation Monitor, *approved in Docket* 10-100-R, August 31, 2017. Section 2.4.1, pg. 165-170.

[57] Arkansas Technical Reference Manual, version 7.0 volume 1: EM&V Protocols, *prepared by* The Independent Evaluation Monitor, *approved in Docket* 10-100-R, August 31, 2017. Section 3.3.1, pg. 357-368.

3.4.2.3.5 Refrigerators

The AR TRM v7.0 has established deemed kWh savings and peak kW demand values that were used for this analysis.[58]

Verification

For refrigerators (FR), ADM reviewed the program tracking database consisting of retailer transaction data. Important fields included: item description, number and type of FR sold, program and original retail pricing, retail location and transaction period.

3.4.3 Net-to-Gross Estimation

3.4.3.1 Lighting

Program measures will be separated into two categories for net-to-gross estimation. Two participating locations have an assumed net-to-gross (NTG) ratio of 100%.

- For LEDs distributed through local food pantries, the NTG ratio is assumed to be 100%. For the 25,208 LED packages (100,232 bulbs) distributed through local food banks, the 100% net-to-gross ratio is assumed because customers do not shop for the lighting products but rather are simply offered LEDs without prompting. Individuals who received LEDs through the food banks are also more likely to represent low income customers, potentially limiting their ability or willingness to purchase high efficiency lighting products. Overall, the LEDs giveaways represent less than 7% of reported gross energy savings from the ESP program lighting component.
- For the LED packages distributed through Dollar General, the 100% net-to-gross ratio will be assumed because the retailer has specifically stated that they would not stock any ENERGY STAR® LEDs in the absence of the program."

For LEDs discounted at any other participating retail stores, ADM will estimate free ridership as described throughout the rest of this section.

Determining the net effects of the in-store retail discounts requires estimating the percentage of energy savings from efficient lighting purchases that would have occurred without program intervention. Ideally, participating retailers could provide light bulb sales data for non-program time periods and/or from similar non-program retail locations. This data would provide adequate information from which to calculate the lift in LED sales attributable to the program price markdowns. However, retailers are reluctant to release sales data for this purpose, and non-program sales data was not made available to ADM.

[58] Arkansas Technical Reference Manual, version 7.0 volume 1: EM&V Protocols, *prepared by* The Independent Evaluation Monitor, *approved in Docket* 10-100-R, August 31, 2017. Section 2.4.3, pg. 174-181.

As a result, evaluating the net effects of the price discounts requires estimating free ridership without non-program sales data. Several methodologies have been used in similar evaluations across the country, all of which have certain advantages and disadvantages. For this evaluation of the PY2019 ESP program lighting component, ADM developed two separate estimates of free ridership, each using a different methodology. Table 3-56 provides a summary of the methodologies and their relative advantages and disadvantages. Details regarding each methodology are provided in Table 3-56.

Table 3-56: Free Ridership Estimation Methodologies – Advantages and Disadvantages

Methodology	Advantages	Disadvantages
General Population Survey	▪ Allows for a more truly random sample than intercept surveys. ▪ Allows for discussion of bulbs post-installation. ▪ Large sample size more cost-effective than intercept surveys.	▪ Relies on customer self-reporting of purchase decision making. ▪ Potential for recall bias is higher than intercept surveys (discuss purchases over the past six months). This may also affect whether the respondent purchased program bulbs. ▪ Potential for bias in scoring algorithm.
Consumer Demand Model	▪ Estimate is developed from actual sales data, eliminating potential biases that customer self-report data can exhibit.	▪ The model is estimated using program sales data only. While the model may fit program sales data well, it is possible that it does not predict sales levels at non-program prices well.

3.4.3.1.1 Survey Based Methodology

The first methodology is based on self-report surveys with a sample of customers aimed at understanding decision making for light bulb purchases. The goal of these surveys is to elicit information from which to estimate the number of bulbs that the customers would have purchased in the counterfactual scenario where LEDs were not discounted. Self-report survey methods for determining free ridership are generally recognized as susceptible to certain biases and error. This may be especially true for upstream price markdown programs, where the counterfactual scenario of regular retail prices may be difficult to explain or grasp. The self-report methodologies also rely on specific scoring algorithms, which may bias the free ridership estimates if they do not accurately reflect the customer decision making process. This evaluation relies on self-report survey data from two surveying efforts:

- The survey-based effort for calculating free ridership was conducted using emails from a sample of randomly selected residential customers. The strength of this

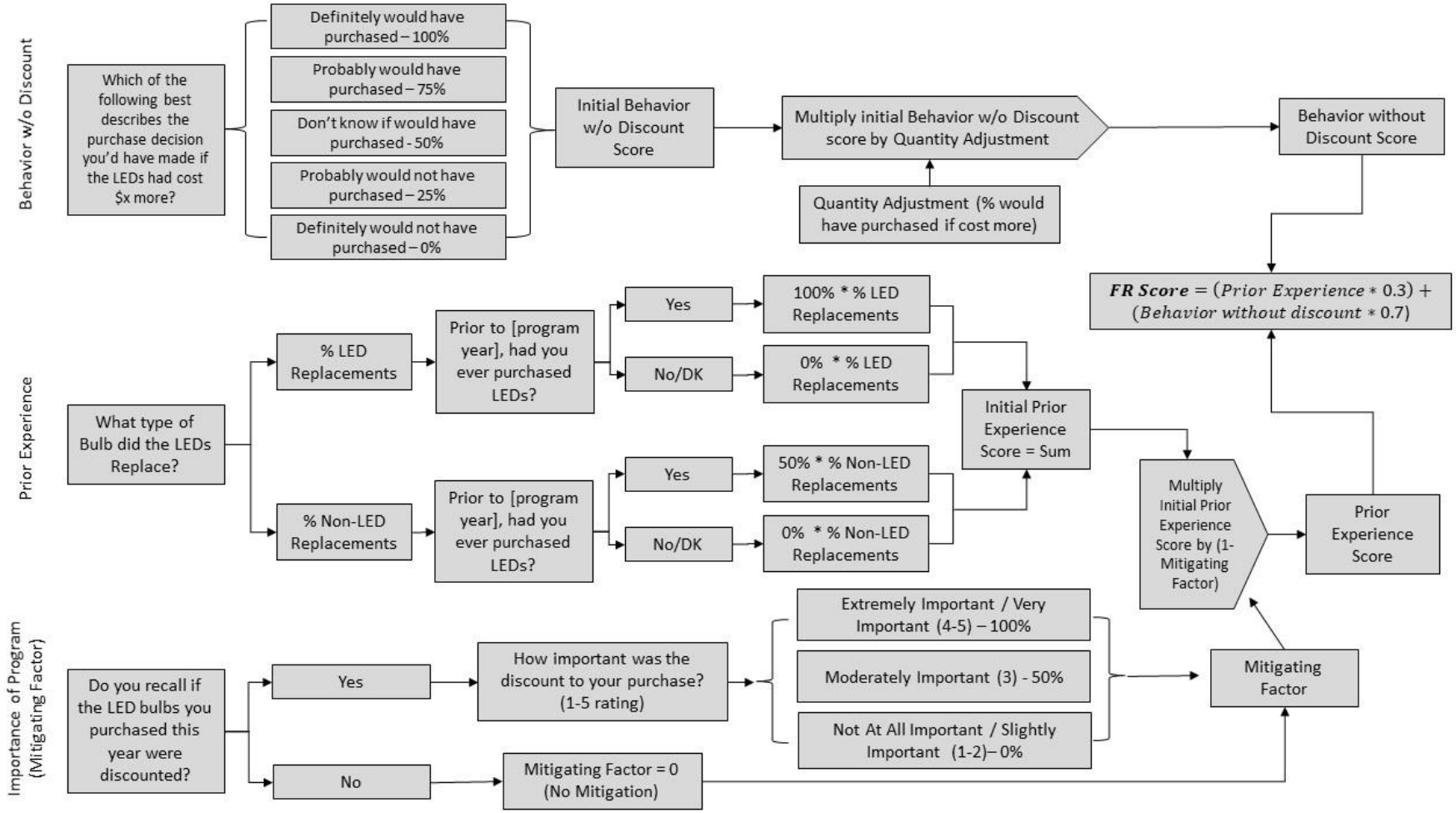
approach is the ability to obtain a random and relatively large sample size cost-effectively. It also allows for further questioning regarding the fate of recently purchased bulbs (e.g., installed immediately, stored for future use, location of installation, etc.). The biggest drawback to the approach is the potential for respondent recall bias. For example, it may be difficult to get accurate responses to questions about the number of bulbs the respondent recently purchased and whether they were discounted through the program.

Survey respondents were asked a series of questions to elicit feedback regarding influences on their light bulb purchasing decisions. Each respondent was then assigned a free ridership score based on a consistent free ridership scoring algorithm. The free ridership scoring algorithm developed for the survey instruments is shown in Figure 3-17.

The “behavior without discount” scoring is the primary determinate of respondents’ free ridership scores. This section asked whether the respondent would have purchased the same light bulbs if they had cost the regular retail price. This may be a question that is particularly prone to social desirability bias – the tendency to respond in a manner that might be viewed favorably by others. For this reason, a consistency check was performed. In the survey, each respondent was asked to state light bulb characteristics that are important to them when choosing between available options. If a respondent lists price as the most important characteristic, but then goes on to indicate that they would have still purchased efficient options at full retail price, their response will be eliminated from the data population.

When responses from the general population survey were compiled, each response had equal weight in estimating the average free ridership level for the program.

Figure 3-17: Free Ridership Scoring for General Population Survey Respondents



3.4.3.1.2 Non-Survey Based Methodology

The second estimate of free ridership was developed through the estimation of a price response model which was used to predict sales levels in the absence of the program. The program tracking data included package and bulb sales for each retailer, by model number and week.[59] For each retailer and model number combination, original retail price and program price data were available. As program price discounts and/or retailer original pricing changed throughout the year, the tracking data was updated, allowing for the comparison of same-bulb sales under slightly different pricing conditions. Price effects are the main program tool for encouraging the purchase of high efficiency lighting choices. However, there are also regular promotional events sponsored by PSO within participating retail locations. The dates, location, and duration of in-store promotional events were also tracked, allowing for estimation of their effects on sales levels as well. The final price response model is used to estimate a free ridership as described in the equation below:

Equation 3-2: Estimation of Free Ridership

$$Free\ ridership\ ratio = \frac{\sum_i^n (E\left[Bulbs_{NoProgram_i}\right] * kWh_i)}{\sum_i^n (E\left[Bulbs_{Program_i}\right] * kWh_i)}$$

Where:

$E\left[Bulbs_{NoProgram_i}\right]$ = the expected number of bulbs of type, i, purchased given original retail pricing (as predicted by the model).

$E\left[Bulbs_{Program_i}\right]$ = the expected number of bulbs of type, i, given program discounted pricing (as predicted by the model).

kWhi = the average gross kWh savings for bulb type, i.

The price response modeling approach is advantageous in that it is built upon actual sales data from participating retailers (as opposed to relying on consumer self-report surveys). There are, however, several limitations for the approach. Most importantly, non-program sales data is unavailable for inclusion in the model. As a result, the modeling of price impacts may fit program sales data well, but it is uncertain whether those price effects apply well to prices outside of program ranges. Additionally, the lack of non-program sales data means that for many bulb types and time ranges, the available sales data lists zero sales. These “zeros” in most cases do not actually represent zero sales, but rather a lack of information because program pricing was not in effect for a given bulb during a given week. This presents a challenge in modeling the sales data using typical time-series or

[59] The majority of bulb sales were recorded on a weekly basis. However, some retailer/manufacturer partners reported bulb sales bi-weekly or monthly. In order to produce weekly sales estimates for these bulbs, the bi-weekly sales were divided by two and monthly sales were divided by four. While this may not be entirely accurate over a given timespan, it is a reasonable assumption in the absence of weekly data.

panel data methods. Additionally, during the sales period analyzed there was only pricing variation for a subset of bulb models, limiting the ability of the model to predict price response effects in a robust manner. Finally, there are likely variables that affect sales levels for LEDs that are not captured by the program tracking data; thus, there is a risk of omitted variable bias in addition to the inherent amount of error from statistical modeling. Appendix H provides further technical details regarding the price response model development and results.

3.4.3.1.3 Spillover and Market Effects

It is worth noting that none of the methodologies used to estimate program free ridership include estimates of spillover or market effects. Spillover refers to savings that occur as a result of program influences on customers but for which an incentive or rebate is not given. In the context of a program for LED price markdowns, the following examples illustrate potential sources of spillover:

- Participant spillover: a customer who purchases program discounted bulbs is influenced to install additional (non-rebated) energy efficiency measures or change their energy usage behavior as a result of their program experience.
- Nonparticipant spillover: a customer notices PSO sponsored discounts or receives educational resources from an in-store promotional event. While they do not ultimately purchase program discounted bulbs, their interaction with the program encourages them to install other (non-rebated) energy efficiency measures or change their energy usage behavior.

Market effects refer to changes in market structure or market actor behavior due to program influence that results in non-incentivized adoption of energy efficiency measures. In the context of a program for LED price markdowns, the following examples illustrate potential sources of market effects:

- Market pricing related effects: it is possible that the program sponsored discounts for certain lighting products cause downward pressure on prices for competing products (non-program bulbs). The competing products could potentially be LEDs at participating retailers or non-participating retailers. If pricing for these competing products is lowered in response to program discounts and a corresponding increase in purchases (and installations) occurs, then there may be additional savings attributable to program influences.
- Market manufacturing/stocking effects: it is possible that the program sponsored incentives caused bulb manufacturers and retailers to adjust their lighting product offerings. To the extent that the program causes lesser efficiency bulbs to be displaced with higher efficiency bulbs at the manufacturer/retailer level, there may be additional savings attributable to program influences.

It is likely that some combination of these effects increases the savings attributable to the ESP lighting portion of the program. However, there is also reason to believe these effects may be small overall. Participant and non-participant spillover typically occurs through customer education. The ESP program component does include regular in-store promotional/educational event, but the number of customers reached relative to overall program sales is likely small. Additionally, the promotional events usually provide information designed to encourage customers to participate in other PSO energy efficiency programs, which would not constitute spillover if these customers ultimately did participate and receive a rebate. The implementor's field team educates customers regarding the incentives provided in the PSO ESP program; however, these are not explicitly quantified and therefore cannot provide reliable estimates of spillover.

Market effects may exist to some extent but disaggregating the PSO program influences from other influences such as technological advances and other lighting discount programs across the country is difficult. The current ESP program component covers a substantial share of the bulbs sold in the PSO service territory, with no immediate plans for discontinuing the price markdowns.

Overall, it should be noted that spillover and market effects likely remain a minor factor, and the net-to-gross estimate developed in this evaluation should be considered with these omitted effects in mind.

3.4.3.2 Non-Lighting Measures

For all upstream measures (discounted at the retail level), ADM applied the same NTG ratio as found for upstream sales of LEDs. For downstream measures, which make up a significantly smaller percentage of energy and demand savings from the ESP program and the overall PSO energy efficiency portfolio, their respective net-to-gross values will be applied based on previously stipulated NTG ratios collected from publicly available sources.

Based on ComEd's Appliance Rebates Program Evaluation Report for PY8, the stipulated net-to-gross ratio for HPWH is 0.86.[60] For refrigerators, clothes washers, and electric vehicle chargers, a stipulated value of 0.8 NTG ratio will be used.

ADM performed a meta-analysis on reported net-to-gross ratios for clothes dryers across different utility programs that sold electric clothes dryers through energy efficiency programs. Based on this meta-analysis, an average net-to-gross ratio of 0.66 was calculated and will be used as shown in Table 3-57. Our review was based upon publicly available net savings results for this measure for programs offering a similar incentive amount and design.

[60]http://ilsagfiles.org/SAG_files/Evaluation_Documents/ComEd/ComEd_EPY8_Evaluation_Reports_Final/ComEd_Appliance_Rebates_PY8_Evaluation_Report_2016-12-09.pdf

Table 3-57: Meta-Analysis of Net-to-Gross Estimates for Clothes Dryers

Utility	Report Date	NTGR
Penelec First Energy	11/23/2015	0.58
EmPower Maryland	9/15/2016	0.48
Rhode Island TRM	PY2016	0.90
ComEd	12/9/2016	0.68
Average NTGR		0.66

ADM has sought to confine our review to studies that most closely match the design and region served by the PSO program. That said, there is limited data available for several of these measures. More importantly, ADM's approach is based on the need to optimally utilize the evaluation resources available. We expect that these measures combined would represent a small share of PSO's residential portfolio savings. As such, the use of net-to-gross ratios that differ from those presented in this section would have minimal impacts on portfolio savings.

3.4.4 Impact Evaluation Findings

3.4.4.1 Lighting Gross Energy Savings and Peak Demand Impact

The tracking data compiled by CLEAResult and provided through AEG for the ESP program lighting component identified a total of 348,480 packages of LEDs were discounted through participating retail stores (2,096 of which were packages of LEDs included with fixtures). An additional 25,208 packages of LEDs were distributed free-of-charge through local food banks. Table 3-58 shows the reported quantities and impacts of measures discounted or distributed free-of-charge through the ESP program during PY2019.

Table 3-58: Reported Measure Quantities and Impacts – Lighting Only

Distribution Type	Measure Type	Package Quantity	Bulb Quantity	Reported kWh	Reported kW
Retail Discounts	Directional LEDs (with Fixture)	2,096	2,639	130,393	19.47
	Directional LED	70,703	229,225	8,961,140	1,338.07
	Omni-directional LED	275,681	1,151,942	35,392,680	5,284.81
Food Bank	Omni-directional LED	25,208	100,232	3,003,684	448.51
Total		**373,688**	**1,484,038**	**47,487,897**	**7,091**

3.4.4.1.1 Verification

To verify the types and quantities of distributed measures, ADM performed a census review of all retailer/manufacturer invoices for LED sales. This review verified that the reported quantity of light bulbs sold through retail stores and distributed free-of-charge through local food pantries matched exactly with the invoices that PSO paid.

ADM also reviewed the program tracking database to determine if energy and demand impacts were correctly calculated according to the Oklahoma Deemed Savings Document algorithms for each LED type. For PY2019, ADM calculated verified energy and demand impacts based on OKDSD but used an adjusted HOU (960.61). ADM found that for all light bulbs, reported impacts were calculated in accordance with the deemed savings algorithms. Each program eligible bulb was checked to determine the correct bulb wattage and ensure the correct lumen output and baseline wattage was applied. The discrepancies identified through the database review required adjustment for the actual wattages and/or baseline wattages used in the calculation of energy and demand impacts for some bulbs.

On the following page, Table 3-59 provides the estimated impact each of these adjustments had over reported kWh savings. As shown in the table, ADM identified a total of 31 LED models in the program tracking data with parameters such as wattage, baseline wattage, or lumens that were reported differently from the verified values in the ENERGY STAR® database. Though these discrepancies impacted 207,334 individual LEDs discounted through the program, equivalent to an estimated 105,911 kWh in additional program savings, 65% of these discrepancies impact savings by 1 kWh or less per bulb. The table column “Estimated Savings Difference” represents the estimated difference between the reported kWh savings values and verified kWh savings multiplied by the total quantity of each model LED sold. Note that the values presented in this column are shown only to illustrate how discrepancies found in the program tracking data may affect the verified kWh savings values. Because the reported kWh savings values and their verified kWh savings values are not calculated using similar assumptions and deemed values the difference has no bearing on actual reported kWh and verified kWh savings values.

Table 3-59: Gross kWh Savings Adjustments – Lighting Only

Model Number	Wattage		Baseline Wattage		Lumens		Energy Savings (kWh)		Estimated Savings Difference
	Reported	Verified	Reported	Verified	Reported	Verified	Reported	Verified	
1003005641	**5.3**	**5.5**	45	45	515	515	35.5	35.3	-92
1003004382	**5.3**	**5.5**	45	45	515	515	35.5	35.3	-119
18741201	**9.5**	**9**	43	43	800	800	30.0	30.4	13,513
34903	**9.5**	**9**	43	43	800	800	30.0	30.4	44,740
952357	**8**	**8.5**	43	43	800	800	31.3	30.9	-8,739
566831004	**3**	**3.5**	25	25	250	250	19.7	19.2	-649
952355	**8**	**8.5**	43	43	800	800	31.3	30.9	-3,204
563577005	**16**	**15**	72	72	1600	1600	50.1	51.0	9,741
564269900	**16**	**15**	72	72	1650	1650	50.1	51.0	1,243
557277173	**8**	**9**	65	65	650	650	51.0	50.1	-11,234
557957792	**8**	**9**	65	65	700	700	51.0	50.1	-4,168
1002313961	**16**	**14**	72	72	1150	1200	50.1	51.9	288
1002313939	**16**	**14**	72	72	1200	1200	50.1	51.9	265
1001517246	**9**	**10**	65	65	650	800	50.1	49.2	-519
1001862292	**9**	**7.2**	65	65	650	650	50.1	51.7	1,038
1001862035	**16**	**23**	72	72	1600	2150	50.1	43.8	-2,210
1004852967	**15**	**15**	25	72	16	1600	8.9	51.0	336
567452314	**7**	**5**	45	45	500	500	34.0	35.8	5,975
567452341	**7**	**5**	45	45	500	500	34.0	35.8	1,682
566831009	**3**	**3.5**	25	25	250	250	19.7	19.2	-494
1240610	**7**	**8**	43	43	800	800	32.2	31.3	-377
567427596	**4**	**3.5**	25	25	300	300	18.8	19.2	1,964
555057445	**7.4**	**7.5**	45	45	525	525	33.6	33.5	0
3560497	**9**	**7.2**	45	45	540	540	32.2	33.8	64
952409	32	32	**250**	**90**	3000	3000	195.0	51.9	-37,785
LED12636	9.5	9.5	**43**	**65**	800	800	30.0	49.6	7,793
085-02-0233	10	7	**43**	**65**	800	530	29.5	49.2	72,184

Model Number	Wattage		Baseline Wattage		Lumens		Energy Savings (kWh)		Estimated Savings Difference
	Reported	Verified	Reported	Verified	Reported	Verified	Reported	Verified	
085-02-0728	6	7	**29**	**45**	480	500	20.6	34.0	16,101
085-02-0721	13	20	**72**	**90**	**1070**	**1485**	52.8	62.6	738
1002313942	13.5	12	**72**	**65**	**945**	**900**	52.3	47.4	-1,122
1002313960	13.5	12	**72**	**65**	**950**	**900**	52.3	47.4	-1,043

**Discrepancies between reported and verified parameters are indicated with bold font.*

3.4.4.1.2 In-Service Rate Adjustments

For the purpose of calculating program cost effectiveness, an average of the first-year ISR from the general population survey, 78%, and the full year ISR of 97% was assumed (87%). This does not affect annual kWh savings estimates, as it was assumed that 97% of the bulbs are installed within three years based on the stipulations in the deemed savings documents.[61]

3.4.4.1.3 Leakage Adjustments

Leakage refers to cross-territory sales that occur when program discounted bulbs are installed outside of PSO's service territory. When this occurs, the energy and demand impacts from the discounted bulbs are not realized within the territory that paid for and claimed the savings. For PY2019-2021, ADM conducted an appraisal study and estimated out-of-state leakage to be 0.2%, which corresponds to a reduction of approximately 9,518.76 kWh and approximately 1.42 kW.

3.4.4.1.4 Cross Sector Sales Adjustments

An adjustment to gross impacts was made to account for the proportion of program bulbs estimated to be installed in non-residential settings, where HOU and CF are typically higher than residential sockets. The general population survey included a question related to cross sector sales. Respondents who indicated they had purchased LEDs in the past eight months were asked: "Were any of the LEDs you purchased in the past eight months installed in a business or commercial setting?" Of the 483 LED purchasers who responded to this question, 8 indicated that they installed bulbs in a non-residential setting. Those 8 participants reported installing a total of 49 LEDs in non-residential

[61] Calculating cost-effectiveness requires an estimation of when the bulbs are installed in order to correctly discount future year savings. The cost-effectiveness estimates for the ESP program presented in this report assume that 85% of the bulbs are installed within the first year. By the third year, it is assumed that 97% of bulbs are installed, based on the deemed savings document. For the second year, 91% are assumed to be installed (a linear interpolation of years one and two).

settings, which represents less than 1% of all LEDs described by survey participants. The resulting non-residential allocation is therefore 0.84%.

The estimated cross-sector adjustment derived from the general population survey is within the range of values that previous evaluations of residential lighting markdown programs have estimated. A meta-analysis conducted in 2015 of 23 evaluation reports found cross-sector sales estimates ranging from 0.0% to 18.7%, with various methodologies used.[62] The average non-residential allocation estimate from these studies was 6.7%. In 2019, only 1.7% of survey respondents installed light bulbs in a commercial setting, since this is too small of a sample size to accurately calculate cross-sector sales estimates, ADM utilized the 5.0% non-residential allocation estimate from the average of the intercept and RDD surveys from PY2015.

To account for cross-sector sales, the verified gross savings methodology developed by ADM uses weighted values for hours of use (HOU) and coincidence factor (CF). For commercial bulbs, ADM set HOU to 3,253 hours and used a CF of 0.55. These variables were weighted at 5.0%, while the residential adjusted HOU of 960.61 and CF of 0.09 were weighted at 95%. Following this method, ADM estimates that cross-sector sales increase program savings by 5,678,869 kWh and similarly increase demand reduction by 1,816.15 kW.

3.4.4.1.5 Final Verified Gross Savings Estimates

Without considering leakage and cross-sector sales adjustments, the initial verified gross energy savings estimates for the ESP program were 47,593,807 kWh. The initial verified gross peak demand reduction estimated was 7,106.67 kW. These results were determined by summing together the measure level initial verified gross energy savings and peak demand savings calculated using the methodologies stipulated in the Oklahoma Deemed Savings Documents. Table 3-60 compares reported and verified impact estimates for this program component following the verification review.

[62] Strom, M., Russell, C., Wilson-Wright, L., Hoefgen, L., NMR Group, Inc., Bruchs, D., Ward, B., and Cadmus (2015) Massachusetts Residential Lighting Cross-Sector Sales Research Memorandum. *Last accessed:* October, 2019; *Accessed via*: http://ma-eeac.org/wordpress/wp-content/uploads/Residential-Lighting-Cross-Sector-Sales-Research-Memo.pdf

Table 3-60: ESP Program Impact Findings – Initial Gross Verified Lighting Savings Only

Distribution Type	Measure Type	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW
Retail Discounts	Directional LEDs (with Fixture)	2,639	130,393	131,196	19.47	19.59
	Directional LED	229,225	8,961,140	9,011,209	1,338.07	1,345.55
	Omni-directional LED	1,151,942	35,392,680	35,402,978	5,284.81	5,286.34
Food Bank	Omni-directional LED	100,232	3,003,684	3,048,424	448.51	455.19
Total		**1,484,038**	**47,487,897**	**47,593,807**	**7,090.85**	**7,106.67**

After considering leakage, annual energy savings for the ESP program were estimated to be 53,166,131 kWh and verified peak demand savings were 8,904.97 kW. The application of the leakage and cross-sector adjustments is presented in Table 3-61.

Table 3-61: ESP Program Impact Findings – Leakage and Cross-Sector Adjusted Gross Verified Lighting Savings

Distribution Type	Measure Type	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW
Retail Discounts	Directional LEDs (with Fixture)	2,639	130,393	146,556	19.47	24.55
	Directional LED	229,225	8,961,140	10,066,249	1,338.07	1,686.03
	Omni-directional LED	1,151,942	35,392,680	39,547,989	5,284.81	6,624.02
Food Bank	Omni-directional LED	100,232	3,003,684	3,405,336	448.51	570.37
Total		**1,484,038**	**47,487,897**	**53,166,131**	**7,090.85**	**8,904.97**

3.4.4.2 Air Filter Gross Energy Savings and Peak Demand Impacts

AFs were a new addition to the ESP program in 2019. ADM's review of CLEAResult's program tracking data identified that a total of 1,285[63] qualifying AFs were sold at participating retail stores during the 2019 program year. Table 3-62 shows the reported quantities and impacts of AFs through the ESP program during PY2019.

[63] A grand total of 1,299 qualifying air filers were sold; however, 14 were returned.

Table 3-62: Reported Measure Quantities and Impacts – Air Filters

Distribution	Measure	Total Quantity	Reported kWh	Reported kW
Retail Discounts	AFs	1,285	71,062	233.26

3.4.4.2.1 Verification

To verify the types, quantities, and savings associated with distributed measures, ADM performed a census review of the program tracking data for AFs sold through the program. This review found that all AFs were assigned the correct kWh and kW savings aside from 2 line items in the program tracking data. These line items along with their reported and verified savings are recorded in Table 3-63. These discrepancies result in a difference of 3,309 kWh (no difference in demand impact was found).

Table 3-63: Air Filter Savings Discrepancies

Project Number	Total Quantity	Reported kWh	Reported kW	Verified kWh	Verified kW
POEPPS1544379938	13	1,804	2.36	672	2.36
POEPPS1544379574	25	3,469	4.54	1,292	4.54

3.4.4.2.2 Final Verified Gross Savings Estimates

Table 3-64 compares reported and verified impact estimates for AFs rebated through the program in 2019. The total verified energy savings for all AFs was calculated to be 67,753 kWh and the verified demand impact was 233.26 kW.

Table 3-64: ESP Program Impact Findings – Air Filters

Distribution	Measure	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW
Retail Discounts	AFs	1,285	71,062	67,753	233.26	233.26

3.4.4.3 Advanced Power Strip Gross Energy Savings and Peak Demand Impact

ADM's review of CLEAResult's program tracking data identified that a total of 5,126 qualifying APS were sold at participating retail stores during the 2019 program year. Table 3-65 shows the reported quantities and impacts of APS through the ESP program during PY2019.

Table 3-65: Reported Measure Quantities and Impacts – Advanced Power Strips Only

Distribution	Measure	Total Quantity	Reported kWh	Reported kW
Retail Discounts	APS	5,126	429,046	48.70

3.4.4.3.1 Verification

To verify the types, quantities, and savings associated with distributed measures, ADM performed a census review of the program tracking data for APS sold through the program. The APS were sold as an upstream component, making it difficult to assess whether customers were installing APS correctly. To account for this, ADM applied an ISR of 0.5.

3.4.4.3.2 Final Verified Gross Savings Estimates

Table 3-66 compares reported and verified impact estimates for APS discounted through the program in 2019. The total verified energy savings for all APS was calculated to be 429,046 kWh and the verified demand impact was 48.70 kW. ADM found no discrepancies between the reported and verified impact findings.

Table 3-66: ESP Program Impact Findings – Advanced Power Strips

Distribution	Measure	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW
Retail Discounts	APS	5,126	429,046	429,046	48.70	48.70

3.4.4.4 Bathroom Ventilating Fan Gross Energy Savings and Peak Demand Impact

ADM's review of CLEAResult's program tracking data identified that a total of 230[64] qualifying BVFs were sold at participating retail stores during the 2019 program year. Table 3-67 shows the reported quantities and impacts of BVFs through the ESP program during PY2019.

Table 3-67: Reported Measure Quantities and Impacts – Bathroom Ventilating Fans

Distribution	Measure	Total Quantity	Reported kWh	Reported kW
Retail Discounts	BVFs	230	6,302	0.78

[64] A grand total of 249 qualifying bathroom ventilation fans were sold; however, 19 were returned.

3.4.4.4.1 Verification

To verify the types, quantities, and savings associated with distributed measures, ADM performed a census review of the program tracking data for BVFs sold through the program. This review found that all BVFs were assigned the correct kWh and kW savings based on BVF specification in the IL TRM.

3.4.4.4.2 Final Verified Gross Savings Estimates

Table 3-68 compares reported and verified impact estimates for BVFs rebated through the program in 2019. The total verified energy savings for all BVFs was calculated to be 6,302 kWh and the verified demand impact was 0.78 kW.

Table 3-68: ESP Program Impact Findings – Bathroom Ventilating Fans

Distribution	Measure	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW
Retail Discounts	BVFs	230	6,302	6,302	0.78	0.78

3.4.4.5 Clothes Dryer Gross Energy Savings and Peak Demand Impacts

ADM's review of CLEAResult's program tracking data identified that a total of 339 qualifying CDs were rebated during the 2019 program year. Table 3-69 shows the reported quantities and impacts of CDs through the ESP program during PY2019.

Table 3-69: Reported Measure Quantities and Impacts – Clothes Dryers

Distribution	Measure	Reported Quantity	Reported kWh	Reported kW
Downstream Rebates	CDs	339	54,634	7.34

3.4.4.5.1 Verification

To verify the types, quantities, and savings associated with distributed measures, ADM performed a census review of the program tracking data for CDs sold through the program. This review found that 2 CDs discounted through the program were not eligible to receive energy efficiency savings (i.e. were not found in ENERGY STAR® Efficient Products database); as a result, no verified kWh savings and no kW reduction were attributed to these two items.

3.4.4.5.2 Final Verified Gross Savings Estimates

Table 3-70 compares reported and verified impact estimates for CDs rebated through the program in 2019. The total verified energy savings for all CDs was calculated to be 54,634 kWh and the verified demand impact was 7.29 kW. ADM found no discrepancies between the reported and verified impact findings for the 337 qualifying measures.

Table 3-70: ESP Program Impact Findings – Clothes Dryers

Distribution	Measure	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW
Downstream Rebates	CDs	337	54,634	54,313	7.34	7.29

3.4.4.6 Clothes Washer Gross Energy Savings and Peak Demand Impact

ADM's review of CLEAResult's program tracking data identified that a total of 623 qualifying CWs were rebated during the 2019 program year. Table 3-71 shows the reported quantities and impacts of CWs through the ESP program during PY2019.

Table 3-71: Reported Measure Quantities and Impacts – Clothes Washers

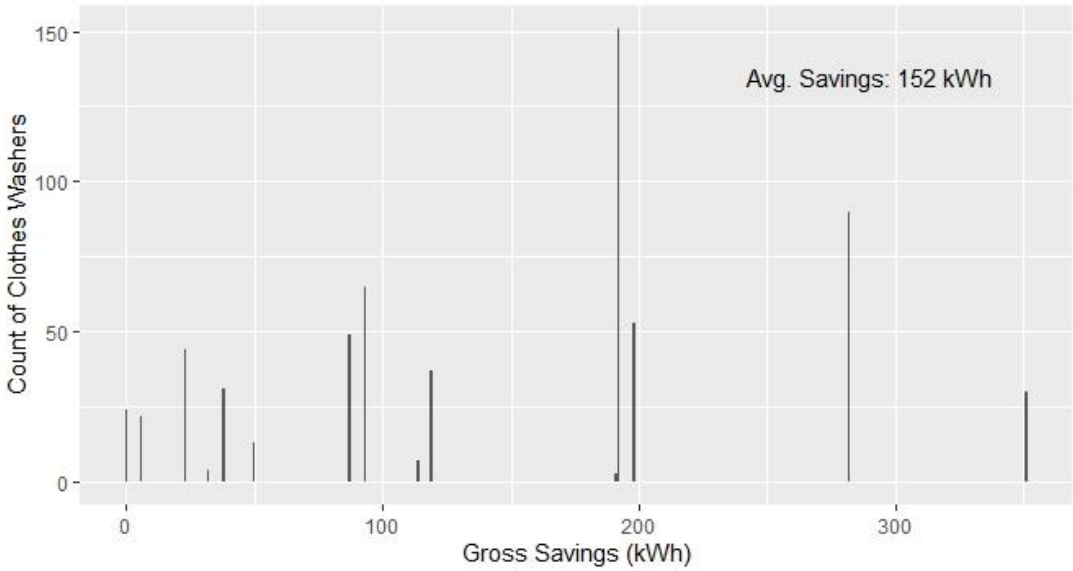
Distribution	Measure	Reported Quantity	Reported kWh	Reported kW
Downstream Rebates	CWs	624	94,861	22.42

3.4.4.6.1 Verification

To verify the types, quantities, and savings associated with distributed measures, ADM performed a census review of the program tracking data for CWs sold through the program. This review found that 1 CW discounted through the program was not eligible to receive energy efficiency savings (i.e. was not found in ENERGY STAR® Efficient Products database); as a result, no verified kWh savings and no kW reduction were attributed to this item.

For all remaining CWs in the program, ADM's verified gross savings for clothes washers align with reported savings. However, to account for clothes washer configurations with negative savings (e.g. scenarios in which top load CWs replace front load CWs and gas is the primary fuel source in the home for end uses such as water heating and dryers), ADM calculated a weighted average savings per clothes washer. For this exercise, CWs with potentially negative savings were assigned savings values of 0 kWh and demand reduction values of 0 kW. The overall distribution of verified clothes washer savings for PY2019 is plotted in Figure 3-18. ADM determined a deemed savings value of approximately 152 kWh per CW and a deemed demand reduction value of 0.04 kW per CW.

Figure 3-18: Distribution of Clothes Washer Savings



3.4.4.6.2 Final Verified Gross Savings Estimates

Table 3-72 compares reported and verified impact estimates for CWs rebated through the program in 2019. The total verified energy savings for all CWs was calculated to be 94,578 kWh and the verified demand impact was 22.36 kW.

Table 3-72: ESP Program Impact Findings – Clothes Washers

Distribution	Measure	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW
Downstream Rebates	CWs	623	94,861	94,578	22.42	22.36

3.4.4.7 Electric Vehicle Charger Gross Energy Savings and Peak Demand Impacts

Level 2 EVCs were a new addition to the ESP program in 2019. ADM's review of CLEAResult's program tracking data identified that a total of 2 qualifying EVCs were rebated through the program during the 2019 program year. Table 3-73 shows the reported quantities and impacts of EVCs through the ESP program during PY2019.

Table 3-73: Reported Measure Quantities and Impacts – Electric Vehicle Chargers

Distribution	Measure	Total Quantity	Reported kWh	Reported kW
Downstream Rebates	EVCs	2	777	0.06

3.4.4.7.1 Verification

To verify the types, quantities, and savings associated with distributed measures, ADM performed a census review of the program tracking data for EVCs rebated through the program. This review found that all EVCs were assigned the correct kWh and kW savings. Any differences in total verified savings and demand reduction are attributable to differences in rounding.

3.4.4.7.2 Final Verified Gross Savings Estimates

Table 3-74 compares reported and verified impact estimates for EVCs rebated through the program in 2019. The total verified energy savings for all EVCs was calculated to be 778 kWh and the verified demand impact was 0.06 kW.

Table 3-74: ESP Program Impact Findings – Electric Vehicle Chargers

Distribution	Measure	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW
Downstream Rebates	EVCs	2	777	778	0.06	0.06

3.4.4.8 Heat Pump Water Heater Gross Energy Savings and Peak Demand Impact

ADM's review of CLEAResult's program tracking data identified that a total of 4 qualifying heat pump water heaters (HPWHs) were rebated during the 2019 program year. Table 3-75 shows the reported quantities and impacts of HPWHs through the ESP program during PY2019.

Table 3-75: Reported Measure Quantities and Impacts – Heat Pump Water Heaters

Distribution	Measure	Total Quantity	Reported kWh	Reported kW
Downstream Rebates	HPWHs	4	12,458	1.09

3.4.4.8.1 Verification

To verify the types, quantities, and savings associated with distributed measures, ADM performed a census review of the program tracking data for HPWHs sold through the program. This review found a significant difference in the savings attributed to each item in the program which may be due to differences in weather zone mapping or methodology. Reported savings were nearly twice as high as previously reported savings for similar water heaters.

3.4.4.8.2 Final Verified Gross Savings Estimates

Table 3-76 compares reported and verified impact estimates for HPWHs rebated through the program in 2019. The total verified energy savings for all HPWHs was calculated to be 6,223 kWh and the verified demand impact was 0.55 kW.

Table 3-76: ESP Program Impact Findings – Heat Pump Water Heaters

Distribution	Measure	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW
Downstream Rebates	HPWHs	4	12,458	6,223	1.09	0.55

3.4.4.9 Refrigerator Gross Energy Savings and Peak Demand Impacts

ADM's review of CLEAResult's program tracking data identified that a total of 494 qualifying FRs were rebated during the 2019 program year. Table 3-77 shows the reported quantities and impacts of FRs through the ESP program during PY2019.

Table 3-77: Reported Measure Quantities and Impacts –Refrigerators

Distribution	Measure	Reported Quantity	Reported kWh	Reported kW
Downstream Rebates	FRs	494	28,257	4.12

3.4.4.9.1 Verification

To verify the types, quantities, and savings associated with distributed measures, ADM performed a census review of the program tracking data for FRs sold through the program. This review found that only seven FRs were reported with incorrect savings values. The discrepancies for these seven models are detailed in Table 3-78 and decrease the overall savings by 38 kWh and 0.01 kW.

Table 3-78: Refrigerator Savings Discrepancies

Model Number	Number in Program	Reported kWh	Verified kWh	Reported kW	Verified kW
GFE28GBL****	1	72	70	0.01	0.01
GFE28GEL****	1	72	70	0.01	0.01
GFE28GSK****	1	72	70	0.01	0.01
GFE28HMK****	1	72	70	0.01	0.01
GFE28HSK****	1	72	70	0.01	0.01
GYE22HSK****	1	67	65	0.01	0.01
RFR320	1	51	25	0.01	0.00

3.4.4.9.2 Final Verified Gross Savings Estimates

Table 3-79 compares reported and verified impact estimates for FRs rebated through the program in 2019. The total verified energy savings for all FRs was calculated to be 28,219 kWh and the verified demand impact was 4.11 kW.

Table 3-79: ESP Program Impact Findings – Refrigerators Only

Distribution	Measure	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW
Downstream Rebates	FRs	494	28,257	28,219	4.12	4.11

3.4.4.10 Room Air Conditioner Gross Energy Savings and Peak Demand Impacts

ADM's review of CLEAResult's program tracking data identified that a total of 849[65] qualifying room air conditioners (RACs) were sold at participating retail stores during the 2019 program year. Table 3-80 shows the reported quantities and impacts of RACs through the ESP program during PY2019.

Table 3-80: Reported Measure Quantities and Impacts – Room Air Conditioners

Distribution	Measure	Total Quantity	Reported kWh	Verified kWh
Retail Discounts	RACs	849	50,508	87.01

[65] A grand total of 867 qualifying room air conditioners were sold; however, 18 were returned.

3.4.4.10.1 Verification

To verify the types, quantities, and savings associated with distributed measures, ADM performed a census review of the program tracking data for RACs sold through the program. This review found that all RACs were assigned the correct kWh and kW savings for all but one qualifying model. For this one model, ADM found the cooling capacity (Btu/Hr) of the model to differ from the cooling capacity listed in the program tracking data. As shown in Table 3-81, using the corrected cooling capacity increase energy savings by 8,725 kWh and increased demand reduction by 14.94 kW.

Table 3-81: Room Air Conditioner Savings Discrepancies

Model Number	Number in Program	Cooling Capacity (Btu/Hr)		Reported kWh	Verified kWh	Reported kW	Verified kW
		Reported	Verified				
1002800392	47	18,000	22,000	10,929	19,654	18.72	33.66

All other discrepancies between reported energy savings and verified energy savings can be traced to rounding differences.

3.4.4.10.2 Final Verified Gross Savings Estimates

Estimates for RACs rebated through the program in 2019. The total verified energy savings for all RACs was calculated to be 59,233 kWh and the verified demand impact was 101.95 kW. Table 3-82 compares reported and verified impact estimates for RACs rebated through the program in 2019. The total verified energy savings for all RACs was calculated to be 59,233 kWh and the verified demand impact was 101.95 kW.

Table 3-82 ESP Program Impact Findings – Room Air Conditioners

Distribution	Measure	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW
Retail Discounts	RACs	849	50,508	59,233	87.01	101.95

3.4.4.11 Room Air Purifier Gross Energy Savings and Peak Demand Impact

ADM's review of CLEAResult's program tracking data identified that a total of 325[66] qualifying RAPs were sold at participating retail stores during the 2019 program year. Table 3-83 shows the reported quantities and impacts of RAPs through the ESP program during PY2019.

[66] A grand total of 328 room air purifiers were sold; however, 3 were returned.

Table 3-83: Reported Measure Quantities and Impacts – Room Air Purifiers

Distribution	Measure	Total Quantity	Reported kWh	Reported kW
Retail Discounts	RAPs	325	217,562	24.83

3.4.4.11.1 Verification

To verify the types and quantities of distributed measures, ADM performed a census review of all retailer/manufacturer invoices for RAP sales. This review verified that the reported quantity of RAPs sold through retail stores matched exactly with the invoices that PSO paid. This review also determined that the kWh and kW deemed savings values were appropriately applied.

3.4.4.11.2 Final Verified Gross Savings Estimates

Table 3-84 compares the total reported and verified impact estimates for this program component. The total verified kWh value for all RAP measures was calculated to be 217,562 kWh and the verified demand impact was 24.87 kW. Any differences between the reported kW savings and the verified kW savings are due to rounding discrepancies.

Table 3-84: ESP Program Impact Findings – Room Air Purifiers

Distribution	Measure	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW
Retail Discounts	RAPs	325	217,562	217,562	24.83	24.87

3.4.4.12 Water Dispenser Gross Energy Savings and Peak Demand Impacts

ADM's review of CLEAResult's program tracking data identified that a total of 172[67] qualifying WDs were sold at participating retail stores during the 2019 program year. Table 3-85 shows the reported quantities and impacts of WDs through the ESP program during PY2019.

[67] A grand total of 174 qualifying water dispensers were sold; however, 2 were returned.

Table 3-85: Reported Measure Quantities and Impacts – Water Dispensers

Distribution	Measure	Total Quantity	Reported kWh	Reported kW
Retail Discounts	WDs	172	82,870	9.27

3.4.4.12.1 Verification

To verify the types, quantities, and savings associated with distributed measures, ADM performed a census review of the program tracking data for WDs sold through the program. This review found that all WDs were not assigned savings in a manner that accounted for the water storage type for each measure. The difference between the total reported savings and total verified savings is attributable to savings not captured when water storage type is not regarded in the savings calculations.

3.4.4.12.2 Final Verified Gross Savings Estimates

Table 3-86 compares reported and verified impact estimates for WDs rebated through the program in 2019. The total verified energy savings for all WDs was calculated to be 101,758 kWh and the verified demand impact was 11.39 kW.

Table 3-86: ESP Program Impact Findings – Water Dispensers

Distribution	Measure	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW
Retail Discounts	WDs	172	82,870	101,758	9.27	11.39

3.4.4.13 Weatherization Measures Gross Energy Savings and Peak Demand Impacts

In the context of this report, “weatherization measures” (WMs) include door seals, door sweeps, and spray foam. These three measures were new to the ESP program in 2019 and are discussed collectively in this report as ADM used the same savings algorithm to evaluate them. ADM’s review of CLEAResult’s program tracking data identified that a total of 2,175 door seals, 2,649 door sweeps, and 30,562 cans of spray foam were sold at participating retail stores during the 2019 program year[68]. Table 3-67 shows the reported quantities and impacts of WMs through the ESP program during PY2019.

[68] An additional 66 door seals, 36 door sweeps, and 44 cans of spray foam were sold through the program; however, these 146 measures were returned.

Table 3-87: Reported Measure Quantities and Impacts – Weatherization Measures

Distribution	Measure	Total Quantity	Reported kWh	Reported kW
Retail Discounts	Door Seals	2,175	85,586	0.74
Retail Discounts	Door Sweeps	2,649	104,237	0.90
Retail Discounts	Spray Foam	30,562	4,715,994	40.62
WM Total		**35,386**	**4,905,817**	**42.25**

3.4.4.13.1 Verification

To verify the types, quantities, and savings associated with distributed measures, ADM performed a census review of the program tracking data for all WMs sold through the program. Any discrepancies between ADM's verified savings and the reported savings are tied to discrepancies in rounding.

3.4.4.13.2 Final Verified Gross Savings Estimates

Table 3-68 compares reported and verified impact estimates for WMs rebated through the program in 2019. The total verified energy savings for door seals was calculated to be 86,061 kWh, for door sweeps energy savings was calculated to be 104,817 kWh, and for spray foam, energy savings was calculated to be 4,742,324 kWh. Overall, ADM calculated the verified energy savings for WMs to be 4,933,202 kWh and the verified demand impact for WMs to be 43.22 kW.

Table 3-88: ESP Program Impact Findings – Weatherization Measures

Distribution	Measure	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW
Retail Discounts	Door Seals	2,175	85,586	86,061	0.74	0.75
Retail Discounts	Door Sweeps	2,649	104,237	104,817	0.90	0.92
Retail Discounts	Spray Foam	30,562	4,715,994	4,742,324	40.62	41.55
WM Total		**35,386**	**4,905,817**	**4,933,202**	**42.25**	**43.22**

3.4.4.14 Summary of Impact Evaluation Findings

Table 3-89 on the following page provides a detailed summary of ADM's impact evaluation findings for all measures included in the ESP program in 2019. Overall, the program's realization rates (RR) were high, with a RR of 111% for the gross verified energy savings and a RR 125% for the gross verified demand impact.

For advanced power strips and bathroom ventilation fans, RRs for gross verified energy savings and gross verified demand impact were both 100%. For room air purifiers, room air conditioners, electric vehicle chargers, and weatherization measures, RRs for gross verified energy savings and gross verified demand impact were both approximately 100%, with minor differences due to rounding discrepancies. The gross energy savings RR for air filters was slightly low (95%) due to 2 discrepant savings values listed in the tracking data; however, gross demand impact RR was 100% for this measure. Similarly, the RRs for gross verified energy savings and gross verified demand impact for clothes dryers and refrigerators were just under 100% (99%) due to discrepancies with several measures in the program. Both RRs for clothes washers were also 99%, though this was due to a minor difference in how the reported and verified savings values were calculated.

The most discrepant RRs found pertain to water dispensers, heat pump water heaters, and LEDs. For water dispensers, RRs for gross verified energy savings and gross verified demand impact were found to be 122% and 123%, respectively. These values are elevated because the reported savings did not account for the water storage type of each measure. For heat pump water heaters, RRs for both energy savings and demand impact were 50%, which may be tied to differences in weather zone mapping or methodology. Reported savings for this measure were nearly twice as high as reported savings for similar water heaters in previous program years. LEDs also exhibited high realization rates (112% and 126% for gross verified energy savings and gross verified demand impact, respectively); however, this is due in large part to ADM's accounting for cross sector sales of program discounted bulbs. If adjustments for cross sector sales and leakage were excluded, both RRs for LEDs would be only 101%.

Table 3-89: Summary of Impact Evaluation Findings

Distribution Type	Measure Type	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW	RR kWh	RR kW
Non-LED Retail Discounts	AFs	1,285	71,062	67,753	233.26	233.26	95%	100%
	APS	5,126	429,046	429,046	48.70	48.70	100%	99%
	BVFs	230	6,302	6,302	0.78	0.78	99%	99%
	RACs	849	50,508	59,233	87.01	101.95	117%	117%
	RAPs	325	217,562	217,562	24.83	24.87	100%	100%
	WDs	172	82,870	101,758	9.27	11.39	122%	123%
	WMs	35,386	4,905,817	4,933,202	42.25	43.22	101%	102%
Non-LED Retail Discount Totals		***43,373***	***5,763,167***	***5,814,857***	***446.10***	***464.16***	***101%***	***104%***
LED Retail Discounts	LEDs	1,484,038	47,487,897	53,166,131	7,090.85	8,904.97	112%	126%

Distribution Type	Measure Type	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW	RR kWh	RR kW
LED Retail Discount Totals		***1,484,038***	***47,487,897***	***53,166,131***	***7,090.85***	***8,904.97***	***112%***	***126%***
Downstream Rebates	CDs	337	54,634	54,313	7.34	7.29	99%	99%
	CWs	623	94,861	94,578	22.42	22.36	99%	99%
	EVCs	2	777	778	0.06	0.06	101%	100%
	HPWHs	4	12,458	6,223	1.09	0.55	50%	50%
	FRs	494	28,257	28,219	4.12	4.11	99%	99%
Downstream Rebate Totals		***1,460***	***190,987***	***184,111***	***35.03***	***34.37***	***96%***	***98%***
Non-LED Program Totals		***44,833***	***5,954,154***	***5,998,967***	***481.13***	***498.53***	***101%***	***104%***
Program Totals		**1,528,871**	**53,442,050**	**59,165,098**	**7,571.98**	**9,403.50**	**111%**	**124%**

3.4.5 Net-to-Gross Estimation Results – Lighting Only

The NTG analysis for the ESP program was conducted using the methodologies outlined in Section 3.4.2. The results of this analysis are summarized below.

3.4.5.1 Free Ridership Estimate Derived from the General Population Survey

ADM evaluators analyzed survey responses from 505 people who participated in the 2019 Energy Saving Products program. ADM conducted a general population survey of PSO customers using email invitations, an online survey platform, and offering monetary incentives to those who completed the questionnaire. A total of 486 surveyed customers reporting having purchased LEDs from participating retailers within the program year, though the responses from only 472 customers were fully validated for use in calculating free-ridership.[69] Calculated scores from the survey responses are presented in Table 3-90.

[69] Responses were removed if surveyed participants did not pass consistency checks pertinent to their responses. For example, if a survey participant indicated that price was the most important factor in their purchasing decision, but later indicated that they would have purchased the items regardless of the incentive discount, the response would no longer qualify for use in the free-ridership calculations.

Table 3-90: Survey Free Ridership Estimate

Year	Respondent Type	N	Prior Experience Score	Behavior without Program Score	Free Ridership Estimate	Mitigating Factor
2019	LED Purchasers	472	0.36	0.44	0.41	-0.129

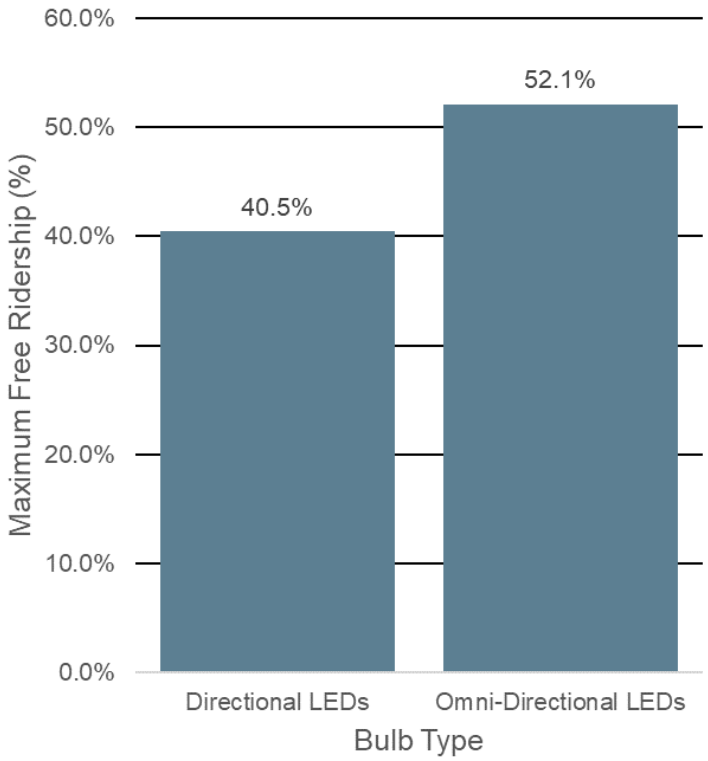
The average free ridership score for all 472 respondents was 41%. This is 11% lower than the free ridership level estimated from a survey in PY2018, a difference likely due to the scale of the survey in 2019 (only 151 participants completed the survey in 2018).

Price Response Model Free Ridership Estimate

Free ridership was also estimated using an econometric price response model that estimates the effect of program discounts and promotional events on bulb sales. Coefficients from the model were used to predict sales quantities at regular retail pricing and with an absence of program promotional events. The difference in model predictions for sales quantities under program and non-program conditions produces an estimate of free-rider (or naturally occurring) bulb sales. Multiplying the free-rider bulb sales quantities by SKU specific deemed gross savings estimates results in the final estimate of free-ridership. The analysis resulted in a program level free ridership estimate of 42.4%.

The price response model also allows for estimating free ridership by bulb type. The estimated free ridership for omni-directional LEDs is slightly higher than for directional LEDs, as shown below in Figure 3-19.

Figure 3-19: Price Response Model Free Ridership Estimates by Bulb Type



A detailed explanation of both the methodology and results from the price response model can be seen in Appendix H.

3.4.5.2 Lighting Net-to-Gross Ratio

The discussion above outlines the results of two efforts to understand the level of attribution appropriate for the energy savings resulting from the lighting bulb sales through the ESP program. The methodology dependent on the general population survey resulted in an estimate of free-ridership of 41.0%. The price response modeling resulted in a free ridership estimate of 42.4%.

Aligning with previous years' methods, ADM decided to use the average of the free ridership estimate from the general population survey and the price response model. The final free ridership ratio applied to retail discounted bulbs in this evaluation is therefore 41.5%. Ultimately, both a survey-based and non-survey-based methodology resulted in a similar estimate for free ridership that was 7.9% lower than the estimate in PY2018 (48.0%).

3.4.5.3 Final Net-to-Gross Ratio

The measure level net-to-gross ratios are calculated as *1- estimated free ridership*.[70] The final net-to-gross ratios and associated net savings for each measure in the ESP program are shown on the following page, in Table 3-91. Similarly, LEDs distributed through the food bank giveaways and sold at Dollar General are assumed to have a net-to-gross ratio of 1.0.

Table 3-91: Verified Gross and Net Impacts – ESP Program

Measure Type		Gross Verified kWh	Gross Verified kW	NTGR	Net kWh	Net kW
Directional LED		10,212,805	1,710.58	0.584	5,964,278	998.98
Omni-directional LED	Other Retailers	38,521,551	6,452.10	0.584	22,496,586	3,768.03
	Dollar General	1,026,439	171.92	1.000	1,026,439	171.92
	Food Bank	3,405,336	570.37	1.000	3,405,336	570.37
Air Filters		67,753	233.26	0.584	39,568	136.22
Advanced Power Strips		429,046	48.70	0.584	250,563	28.44
Bathroom Ventilation Fans		6,302	0.78	0.584	3,680	0.46
Clothes Dryers		54,313	7.29	0.660	35,847	4.81
Clothes Washers		94,578	22.36	0.800	75,662	17.89
Electric Vehicle Chargers		778	0.06	0.800	622	0.05
Heat Pump Water Heaters		6,223	0.55	0.860	5,352	0.47
Refrigerators		28,219	4.11	0.800	22,575	3.29
Room Air Conditioners		59,233	101.95	0.584	34,592	59.54
Room Air Purifiers		217,562	24.87	0.584	127,056	14.52
Water Dispensers		101,758	11.39	0.584	59,427	6.65
Weatherization Measures		4,933,202	43.22	0.584	2,880,990	25.24
Total		**59,168,098**	**9,403.51**	**0.64**	**36,428,573**	**5,806.88**

3.4.6 Process Evaluation Findings

ADM's process evaluation activities included participant surveys, an interview with the PSO Program manager, and an interview with CLEAResult. ADM provided a portfolio level process evaluation memo to PSO after the completion of the 2019 program year. The following summarizes the key finding from the process evaluation of the ESP program.

[70] This is sometimes referred to as a net-of-free-ridership ratio, as it excludes any estimation of spillover or market effects.

- **ESP met the energy savings goals**. When interviewed, PSO staff indicated the ESP program would achieve the kWh savings goals set for PY2019. A review of the final program data confirmed that they were correct and that the program did attain its savings goals. Staff also stated they were pleased with the performance of the measures and the offerings available through the program. The increased number of retailers within the PSO territory allowed the program to reach more customers in rural areas of the territory.
- **New marketing strategies and in-store promotions utilized in PY2019**. PSO marketing helped to increase engagement and awareness of ESP. The marketing team created new point-of-purchase materials for store promotions, revamped the website to improve customer experience, updated customer bill inserts, and included information about appliance rebates in the monthly PSO's newsletters. Program outreach also included providing LED bulbs to food banks. Implementers offered LED bulbs to reach underserved populations. One hundred thousand bulbs are sent out to three separate food banks each year.
- **Keeping retail staff up-to-date and knowledgeable about ESP is a continuous challenge**. Retail stores often experience high employee turnover rates. This staffing issue can generate inconsistencies in the level of knowledge one employee can provide customers about the rebated measures. Training retail staff on products continues to be a challenge for program staff.
- **QA/QC procedures changed in PY2019**. CLEAResult made some changes to the QA/QC procedures as a result of processing incentives in-house. CLEAResult ensures rebated measures are ENERGY STAR® and that they are qualified for the ESP program.
- **Most rebate recipients learned of the program through a retailer and were motivated by saving money on their energy bills.** Sixty-seven percent of survey respondents indicated they learned of the program through a retailer. Nine percent of participants learned of the rebates from PSO's website. Saving money on their energy bills was the most common response by participants for all measures regarding their motivation for purchasing the rebated equipment.
- **Program participants are satisfied with the rebated equipment they installed, various aspects of the program, and the program overall.** Most survey respondents reported that they were satisfied with the equipment that they decided to install, ranging from 89% to 100%, indicating they were either somewhat or very satisfied. Survey participants were least satisfied with clothes washers. Program participants were either very or somewhat satisfied with the various aspects of the program (application process (73%), rebate wait time (60%), quality of equipment available (77%), and variety of incentives offered by PSO (74%)) and the program overall (84%).

- **Satisfaction varied among measures**. Respondents who purchased LEDs were satisfied with the quality, the discount, and savings on their utility bills. Responses varied for all the non-LED measures. Quality was the factor that most satisfied the participants. Participants recommended to either lower rates or broaden portfolios as potential program improvements for the future. Satisfaction rates amongst the participants varied between measure, the quality of the product, and its financial savings for the consumer.

3.4.6.1 Upstream Measures

The following highlights findings affecting all the upstream measures component of the program.

- **LED light bulbs were the most purchased measure in the program for PY2019.** Many participants were not aware of the discounted LED light bulbs or that it was provided by PSO; however, among those who were aware of the PSO, incentive, they reported it to be important in their decision to purchase the light bulbs. The bulb's energy-efficiency, lifespan, and brightness were among the top three factors considered when purchasing a light bulb. Most participants surveyed bought LED light bulbs from Walmart, Lowe's, and The Home Depot.
- **Participants who purchased non-lighting discounted measures through the Upstream program channel were unaware of the incentives offered by PSO**. Participants bought their non-LED measures from either home improvement stores or general merchandisers. Although the amount of each measure purchase varied, most people bought up to five of a given measure. Very few customers were aware the non-lighting measures they purchased were discounted, and none knew they were discounted by PSO. Room air conditions were the measure with the highest percentage (22%) of respondents who knew it was discounted, but none attributed the discount to PSO.
- **Additional measures converted to upstream or added to the program in PY2019.** Measures that converted to upstream resulted in a reported uptick in the number of measures incented compared to the previous program year. Home maintenance measures were also added to the list of upstream measures. Staff indicated LED costs decreased at the beginning of the year, which helped with reducing rebates levels per bulb.

3.4.6.2 Downstream Measures

The following highlights findings affecting all the downstream measures component of the program.

- **Utility companies continue to offer rebates at a downstream markdown.** Many Utility companies continue to depend on individual consumer choices rather than influencing the markets from a top-down approach.
- **Online rebate application process implemented in PY2019.** The new portal and online application launched by CLEAResult was described as one of the major successes and challenges for this program year. Customers still have the option of completing mail-in rebates, but they are encouraged to use the portal. Through the online rebate process, customers could receive their rebates within four weeks of submission. Due to this new change, there were some changes to the data management of the ESP program. Less than half (44%) of survey respondents reported they received their rebate in four weeks or less, and four percent had not yet received their rebate. Among those who reported a longer time to receive their rebate, satisfaction declined for aspects of the program (e.g., rebate wait time and the application process).
- **EV charger pilot launched in September 2019.** Electric Vehicle (EV) charger rebates were piloted in PY2019 and are a new measure. PSO staff described EV chargers as a measure growing in popularity but have a limited reach (e.g., only available to those who own or are considering purchasing an electric vehicle). PSO performed outreach with car dealerships to promote the availability of the EV charger rebate more broadly.
- **Level 2 EV Charger rebate participants are satisfied with their chargers and the rebate program.** All survey participants indicated they were very satisfied with the EV charger they purchased. All survey respondents indicated they were very or somewhat satisfied with the program overall and the application process. One respondent indicated they were somewhat dissatisfied with the wait time to receive the rebate, although it has been noted that the implementor that rebate paperwork indicated that rebates will arrive within 4-6 weeks. Both program participants bought their level 2 EV charger when they bought their vehicle. Being able to charge their vehicle more quickly was important to program participants (rated as a 9 or 10 on a 10-point scale). Both survey participants reported they learned of the rebate through the PSO website**.** Both survey respondents indicated it took 3 – 4 weeks to receive their rebate payment after they submitted their application.

3.4.7 Conclusions and Recommendations

The following summarizes the key findings from the evaluation of the Energy Saving Products Program.

- The verified net kWh savings for PY2019 is 36,428,573 kWh, and net peak kW reduction is 5,806.88 kW. The lighting net-to-gross ratio increased in 2019 compared to 2018. This was identified both through the significantly larger

population of program participants who completed the general population survey and was supported by the net-to-gross results calculated through the price response model.

ADM recommends the following are considered to support the continued improvement and development of PSO's ESP program:

- **Review program tracking data quarterly.** To facilitate open communication and enhanced program tracking, ADM strongly recommends that quarterly data reviews of program-year-to-date tracking data are completed with the involvement of PSO program staff, ADM, and program implementors.
- **Explore unique marketing channels to increase customer awareness and understanding of the ESP rebate program.** PSO program staff should explore offering rebates that also engage the customer with their other programs. Program staff could potentially develop digital and/or other mass media campaigns to increase the awareness of the rebates. Partner with other local community service organizations to increase the awareness of energy-efficiency products. Customer attribution for upstream discounts was very low. Program staff could examine marketing materials and point-of-purchase signage to ensure that the PSO sponsorship is emphasized appropriately.
- **Expand outreach to and/or program education for retail representatives about the downstream program incentive amounts for each appliance.** Customers expressed confusion about the amount of incentive they received and explained that the dollar amount of the rebate was less than what was advertised to them. This could signal that retail staff are not providing current and accurate information about rebates and/or the program.
- **Develop a faster delivery of downstream rebates and increased communication with customers about the processing of their rebate.** Many customers expressed confusion with their status in the downstream rebate program and were upset by the length of time that it took to receive their actual rebate. This confusion and dissatisfaction impacted their satisfaction with other aspects of the program. Program staff can develop a system that provides program participants with a status update of their rebates (e.g., received, processing, sent, completed).
- **Further develop the program tracking data pipeline.** Additional efforts to streamline the tracking data could facilitate more prompt surveying of downstream rebate participants as well as enhance the transparency of the rebate process for PSO as well as ADM.
- **Explore additional program channels for advertising the EV charger rebates.** Advertising or incorporating EV chargers into either PSO's New Homes Program

or as a part of time-of-day education for the Power Hours Program could help boost the adoption of the measure and increase participation for this measure within the rebate program.

3.5 Home Rebates

3.5.1 Program Overview

The Home Rebates program offered by the Public Services Company of Oklahoma (PSO) seeks to generate energy and demand savings for residential customers through the promotion of comprehensive efficiency upgrades to building envelope measures and HVAC equipment for both new construction homes and retrofits to existing homes. Offering PSO customers direct inducements for higher efficiency measures offsets the first cost obstacle, encouraging customers to choose the upgraded products. This evaluation will report on the program in its three components: New Homes, Multiple Upgrades, and Single Upgrade.

The New Homes component of the program provided prescriptive incentives to builders of single-family homes. Builders received $800 for construction that met the following standards:

- 95% CFL Lighting
- Insulation (15 R-value blown insulation walls; 38 R-value blown insulation attic) or (13 R-value foam insulation walls; 21 R-value foam insulation attic)
- HVAC – SEER 15 Air Conditioner
- Home infiltration (6 air changes per hour at 50 pascals)
- Duct infiltration (6 cfm_{25} /100 sq. ft. of conditioned floor area)
- 100% ENERGY STAR® certified windows

Additionally, bonus rebates were offered for:

- $300 for 95% LED lighting
- $400 for installing SEER 16 Air Conditioner
- $600 for installing SEER 17 Air Conditioner
- $800 for installing SEER 18+ Air Conditioner
- $1,000/ton geothermal
- $200 for duct infiltration less than 4 cfm25 /100 sq. ft. of conditioned floor area
- $800 for meeting ENERGY STAR® V 3.1 revision 08 certification requirements

The program provided design assistance for up to three house plans per builder, a value of $3,000, to help design program compliant homes. In addition, one Parade of Homes Bonus rebate was available per builder. To receive the Parade of Homes Bonus rebate, a builder must be an ENERGY STAR® v3.1 certified builder and include PSO sponsored information at their Parade of Homes information booth.

HERs raters received a $50 rebate per rated home or $150 rebate per ENERGY STAR® rated home.

The program was promoted to builders of single-family dwellings and to customers buying new homes.

Key program activities included:

- Adopted Ekotrope as the home energy modeling software.
- PSO staff and the implementation team had regularly scheduled conference calls every two weeks. Topics usually included budgets, safety issues, current projects in the pipeline, and program performance. Program staff noted they are comfortable with the current communication between all parties and are in frequent communication outside of the bi-weekly calls. There were no immediate concerns raised by staff, therefore the current level of communication was sufficient for supporting the administrative needs of the New Homes program.

The Multiple Upgrades component of the program focused on energy efficiency upgrades to existing residential homes. To qualify for the program in 2019, customers needed to install three or more eligible equipment upgrades. Eligible measures included:

Table 3-92: Multiple Upgrades Rebates Offered

Upgrades	Multiple Upgrades Rebates
Attic/Ceiling Insulation (R-22 or less existing)	$600
Knee Wall Insulation	$525
Wall Insulation (R-0 existing)	$450
Floor/Crawlspace Insulation (R-0 existing)	$450
Air Sealing	Up to $500
Air Conditioner/Heat Pump Replacement	-
ENERGY STAR® SEER 16-16.99	$750
ENERGY STAR ® SEER 17-17.99	$825
ENERGY STAR ® SEER 18-19.99	$900
ENERGY STAR ® SEER 20	$1,200
Ground Source Heat Pump	$900 + $525 per ton
Furnace Electronically Commutated Motor (ECM)	$25
Duct Replacement (based on HVAC tonnage)	Up to $1,600
Duct Sealing (based on HVAC tonnage)	Up to $800

In addition to the measures offered, the program incentivized ENERGY STAR® windows and doors, but only to a limited number of participants at the beginning of 2019. The applications for window and glass door replacements were submitted in 2018 when the measure was offered, but the installation was completed in 2019. There was also one program participant who received an incentivized radiant barrier as part of the program in 2019. However, these incentives were removed from the program and will no longer be included as part of the Multiple Upgrades program. The program also incentivized 9-watt omnidirectional LEDs that were not offered through the website and were available only on special request.[71] The Multiple Upgrades program included a walk-through assessment from a PSO approved contractor to help identify energy-efficiency measures that could improve customers' comfort level while reducing energy costs. After the initial audit was complete, a PSO/ICF contracted employee, also referred to as PSO Third Party Verifier (TPV), performed a diagnostic test on the home before the upgrades were installed, then returned after the installation. This process measured and documented the efficiency gains from infiltration reduction and duct sealing measures along with HVAC equipment.

The Single Upgrade component of the program also focused on energy efficiency upgrades to existing residential homes. To qualify for this component of the program,

[71] Energy savings from ENERGY STAR® windows and doors, radiant barriers, and 9-watt omnidirectional LEDs were included in the final program savings for 2019.

customers needed to install one or two eligible equipment upgrades. Eligible measures included:

Table 3-93: Single Upgrade Rebates Offered

Upgrades	Single Upgrade Rebates
Attic/Ceiling Insulation (R-22 or less existing)	$400
Air Conditioner/Heat Pump Replacement	-
ENERGY STAR® SEER 16-16.99	$500
ENERGY STAR® SEER 17-17.99	$550
ENERGY STAR® SEER 18-19.99	$600
ENERGY STAR® SEER 20	$800
Ground Source Heat Pump	$600 + $350 per ton
ENERGY STAR® Swimming Pool Pump	$400

PY2019 performance metrics are summarized in Table 3-94. Overall, reported energy savings exceeded projected values.

Table 3-94: Performance Metrics – Home Rebates Program

Metric	PY2019
Number of Participants	3,643
Budgeted Expenditures	$7,424,826
Actual Expenditures	$7,008,892
Energy Impacts (kWh)	
Projected Energy Savings	7,282,680
Reported Energy Savings	6,737,964
Gross Verified Energy Savings	5,180,243
Net Verified Energy Savings	4,373,200
Peak Demand Impacts (kW)	
Projected Peak Demand Savings	2,812
Reported Peak Demand Savings	2,723
Gross Verified Peak Demand Savings	2,867
Net Verified Peak Demand Savings	2,450
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	1.24
Utility Cost Test Ratio	1.11

The EM&V methodologies and findings for the Home Rebates program are in the next sections. The New Homes, Multiple Upgrades, and Single Upgrade components are reported in Section 3.5.2, Section 3.5.3, and Section 3.5.4, respectively.

3.5.2 New Homes

3.5.2.1 EM&V Methodology

This section provides an overview of the gross and net impact evaluation of the New Homes component of the Home Rebates program. The process evaluation for all program components is provided in Section 3.5.6.

ADM employed a site-specific evaluation approach to quantify electric impacts from the New Homes program. The impact evaluation for this program included the following steps:

- Establishing a sample design and selecting a random sample of homes for evaluation,
- Data collection activities (including both HERS rater documentation and On-Site visits), and
- Engineering analysis of site-level and program level impacts

At the end of this section, discuss our impact evaluation results and findings relevant to those results are discussed. One unique aspect to this evaluation was the introduction of Ekotrope RATER as a tool used in developing program ex-ante savings estimates. The standard tool employed by many residential new construction programs for both implementation and evaluation is REM/Rate. Thus, this evaluation also performed an investigative analysis on the inputs/outputs of Ekotrope as compared to the current industry standard tools. The results of this analysis are also discussed in Section 3.5.2.2.

3.5.2.1.1 Sampling Plan

In developing the sample plan, ADM first reviewed program tracking data to explore potential designs and to ensure there were no duplicate entries or other inconsistencies. In this review ADM found that only four HERS raters accounted for the 95% of program savings. As such, it was determined that the sample design would stratify the program population by each of these HERS raters, with the remaining HERS raters allocated to a fifth strata denoted as ‘other’ (as they collectively only accounted for 5% of program impacts). While this stratification proved an efficient sample design, it also enabled the evaluation to explore whether there were statistically significant differences between the HERS raters and provide program feedback.

The sample for the engineering review of building simulation models was designed to achieve ±10% relative precision or better at the 90% confidence interval. Table 3-95 below summarizes the final sample framework and demonstrates that the evaluation exceeded the targeted 10% precision.

Table 3-95: Sample Design New Homes

Strata	Measure	Reported Energy Savings (kWh)	Population Size	CV*	Sample Size	Relative Precision
Stratum 1	Rater 1	485,252	181	0.30	9	16%
Stratum 2	Rater 2	439,628	241	0.30	13	13%
Stratum 3	Rater 3	396,704	250	0.30	8	17%
Stratum 4	Rater 4	372,152	148	0.30	8	17%
Stratum 5	Other	79,985	59	0.30	4	24%
Total	**-**	**1,773,721**	**879**	**-**	**42**	**<10%**

** In all cases the CV of the ex-post energy savings (and realization rates) were lower than 0.3. However, it is our judgement that the sample sizes were insufficient to substantiate such a low CV. As such, the evaluation elected to 'cap' the CV to 0.3.*

3.5.2.1.2 Data Collection

Data collection activities that supported the evaluation included builder interviews, verification site visits, engineering desk reviews, in-depth interviews with program staff at PSO and an implementation contractor, and homeowner surveys.

For each sampled home, ADM was provided project documentation and energy models from the implementation contractor. The provided project documentation included the following types of documents: HERs rating certificates, HVAC Manual J calculations, floor plans, photos and Air-Conditioning, Heating & Refrigeration Institute (AHRI) certificates.

The engineering desk reviews were supplemented with ride-along field visits, independent site verification visits, and builder interviews. The ride along visits allowed ADM to observe the program data collection process. ADM documented simulation model inputs during their site visits. The builder interviews were used for the program attribution analysis and to obtain builder feedback about the program. The program staff interviews were used for the process evaluation. Table 3-96 summarizes the data collection activities and sample size for the New Homes program.

Table 3-96: Sample Sizes for Data Collection Efforts – New Homes

Data Collection Activity	Achieved Sample Size
New Homes: Engineering Reviews*	42
New Homes: On-Site M&V	28
In-depth Interviews with Program Staff	3
Interviews with Participants (Builders)	10

** This number is inclusive of On-Site M&V.*

3.5.2.1.3 Gross Impact Methodology

A sample of homes were randomly selected following the sample design previously discussed. Site-level gross impacts were then quantified using engineering reviews of the building simulation models used to generate the ex-ante savings estimates. Relevant project documentation, interviews with HERS raters, and site visit data collection efforts were used to verify building simulation model inputs were consistent with the physical residences.

The process by which ADM executed this engineering review can be formalized into the following steps:

- Obtain and Initial Review of Simulation Models
- Establishing Appropriate Baseline Assumptions to Measure Site-Level Savings
- Verify Model Inputs
- Execute Building Simulation Analysis and Quantify Site Impacts

Obtain and Initial Review of Simulation Models

The simulation models for each rebated home were initially submitted by participating builders/HERs raters to the implementation contractor. The implementation contractor then provided these models to ADM. As discussed elsewhere in this report, the building simulation models obtained by ADM were in the format generated by a new software called Ekotrope RATER.

ADM engineering staff reviewed these models within the Ekotrope software[72] and confirmed that Ekotrope RATER uses the same RESNET algorithms as REM/Rate when calculating internal loads (e.g. lighting and appliances). Ekotrope also has an option to export the model as an XML file which was compatible with REM/Rate. This export function provided ADM engineering staff an additional tool by which they could review the ex-ante model inputs, as well as Ekotrope RATER's algorithms. However, it was later

[72] ADM purchased a temporary license from Ekotrope to facilitate this evaluation.

found that Ekotrope uses a slightly different data model than REM/Rate and that the export process resulted in changes to the models which were non-recoverable.

Baseline Assumptions Levied for Key Simulation Inputs

New construction programs are unique in that they must measure energy impacts against a hypothetical baseline as there is no pre-existing structure or equipment to reference. This baseline is typically the prevailing building codes/standards for the state and/or region. In this case, the applicable building codes are OK residential building code which amends the 2015 International Residential Building (IRC) code to 2009 IRC energy code standards. This amended version of the IRC represents the baseline for all homes incentivized through this program.

The key modeling assumptions impacted by the relevant building energy codes are outlined in Table 3-97. Values for the listed parameters were taken from either the Oklahoma residential building code.[73] Note that the modeling software used in this evaluation employs the term 'reference home' to denote the baseline home and the term 'design home' to denote the as-built residence. ADM tries to employ similar terminology for consistency, though they can be used interchangeably.

Table 3-97: Key Baseline Home Assumptions

Input	Verified Reference Home	Source
Attic Insulation	R-30	2015 IRC with amendments
Wall Insulation	R-13	2015 IRC with amendments
Window U	0.50	2015 IRC with amendments
Window SHGC	0.30	2015 IRC with amendments
Infiltration	0.00036 specific leakage area	2015 IRC with amendments
Slab Edge Insulation	0	2015 IRC with amendments
Cooling Efficiency (SEER)	14	NAECA minimum values.
Heating Efficiency (AFUE)	80	NAECA minimum values.
Heat Pump Heating Efficiency (HSPF)	8.2	NAECA minimum values, for both GSHP and ASHP.
Percent Efficient Lighting	75%	2015 IRC with amendments

[73] Or AR TRM version 8 as applicable.

While ADM included the program implementer in the process by which baseline assumptions for the program were determined (ensuring everyone was operating with the same assumptions). It is noted that the reference home assumptions were pre-programmed into the Ekotrope RATER modeling software and ADM was not afforded with sufficient access to the software to directly verify that they were programmed correctly.[74] The baseline values were verified to be accurate for the sample of homes reviewed.

Verification of Key Model Inputs

The measures implemented by this program are represented by above code improvements to key aspects of the participant residences. Typical aspects included envelope improvements (e.g. insulation, windows, and infiltration reduction), HVAC efficiencies, and interior lighting. Each of these aspects have corresponding inputs to define/simulate their physical characteristics within the simulation models. ADM used documentation collected from the HERS raters, HERS rater interviews, and On-Site visits to collect data required to substantiate, and in some cases correct, these inputs.

The model inputs representing home improvements seen in this program include:

- Home layout, size, shape, location, and orientation
- Duct sealing test results
- Infiltration test results
- Attic Insulation: R-values and area
- Interior, exterior, and garage lighting counts
- Heating and cooling temperature set points
- HVAC size and efficiencies (kBtu, SEER, EAE, AFUE, HSPF, COP)

Changes made to any of the above inputs represent differences between what was assumed to be present in the ex-ante simulations and what ADM found to be physically present through our evaluation and data collection. The effect of these differences across all sampled homes contributed to the differences in the ex-ante and verified ex-post energy savings estimates being reported.

[74] It will be discussed later that in the investigative analysis of the Ekotrope software ADM employed REM/Rate as a benchmarking tool. Of relevance here is that the reference home within REM/Rate was defined by ADM, which allowed certainty that baseline assumptions were accurately defined for those simulations.

Execute Building Simulation Analysis and Quantify Site Impacts

As discussed in the summary of our methodology (Section 3.5.2.1) this program used a new to the market tool called Ekotrope RATER to develop ex-ante savings estimates. Due to its recent emergence, not much is known regarding the algorithms and processes employed by Ekotrope RATER. Furthermore, our introduction to Ekotrope showed that the maker of this software was unwilling to provide the evaluation with details regarding their algorithms – forcing the evaluation to treat it as a 'black box' (albeit one with some relation to REM/Rate). Therefore, ADM conducted side-by-side review of Ekotrope RATER results with REM/Rate which is a known benchmark.[75]

Consistent with the above, ADM ran three parallel simulations for each sampled home:

- An *ex-ante simulation run* through the Ekotrope RATER software which was the model as received from the implementers. The evaluation team at ADM did this in an attempt to 're-produce' the ex-ante values and gain a better understanding about the internal consistency of the software as well as later comparisons between Ekotrope and REM/Rate.
- An *ex-post simulation* run through the Ekotrope RATER software which included our findings/changes to key model inputs.
- An *ex-post simulation* run through the REM/Rate software which included our findings/changes to key model inputs.

The verified energy and demand savings for each home were calculated by taking the difference in energy consumption between the simulated reference home and simulated design home.

Realization rates for gross energy and demand savings were calculated for each sampling strata. Program results were derived by extrapolating the results from each sampling strata to the population of participating homes per the sample weights calculated in the sample design.

3.5.2.1.4 Net-to-Gross (NTG) Estimation

The evaluation team at ADM estimated the net impacts of the New Homes program using participating builder survey responses. The surveyed builders responded to questions on the influence of the individual program components, the overall level of influence of the program on the construction practices incorporated into rebated homes, and the share of homes that would have been built to program standards if the program was not available. The scoring procedures described below were used to calculate a free ridership score for each builder.

[75] Since any simulation program must be fundamentally rooted in physical first principals, their results should be similar – with the only differences being related to potential modeling uncertainties.

Program Components Score:

A Program Component's score was calculated based on how influential various program factors were in the builders' decisions to construct efficient homes. Specifically, interview respondents rated the influence of the following factors on their decisions to build efficient homes using a scale where 1 meant "not at all influential" and 5 meant "extremely influential":

- Component 1: ENERGY STAR® design assistance
- Component 2: The rebates provided by the program
- Component 3: Program informational documents or marketing materials

A score was assigned to the ratings as follows:

1 (Not at all influential) = 0
2 = .25
3 = .50
4 = .75
5 (Extremely influential) = 1

The Program Components score equaled the highest scored component.

Program Influence Score:

The Program Influence Score was based on builders' ratings of the likelihood of having built homes to the same efficiency standards in the PSO service territory if the rebate program was not available. The Program Influence Score was developed from the rated likelihood as follows:

1 (Not at all likely) = 0
2 = .25
3 = .50
4 = .75
5 (Very likely) = 1

No Program Score:

The No Program Score was developed from the builder responses to the following questions:

- NPS1: Now, thinking about your history of working with the program, if the program had never been available, would you have built fewer or the same number of homes in [YEAR] to the PSO efficiency standards?
- NPS2: [IF FEWER] You said that you would have built fewer homes that met the efficiency standards of the program if the program had never been available.

- NPS3: What percent of those homes would you have built to those same standards if the program had never been available?

The intent of these questions was to capture the effect that builders' recent and previous experience with the program educational efforts had on their current construction practices. The No Program Score was equal to:

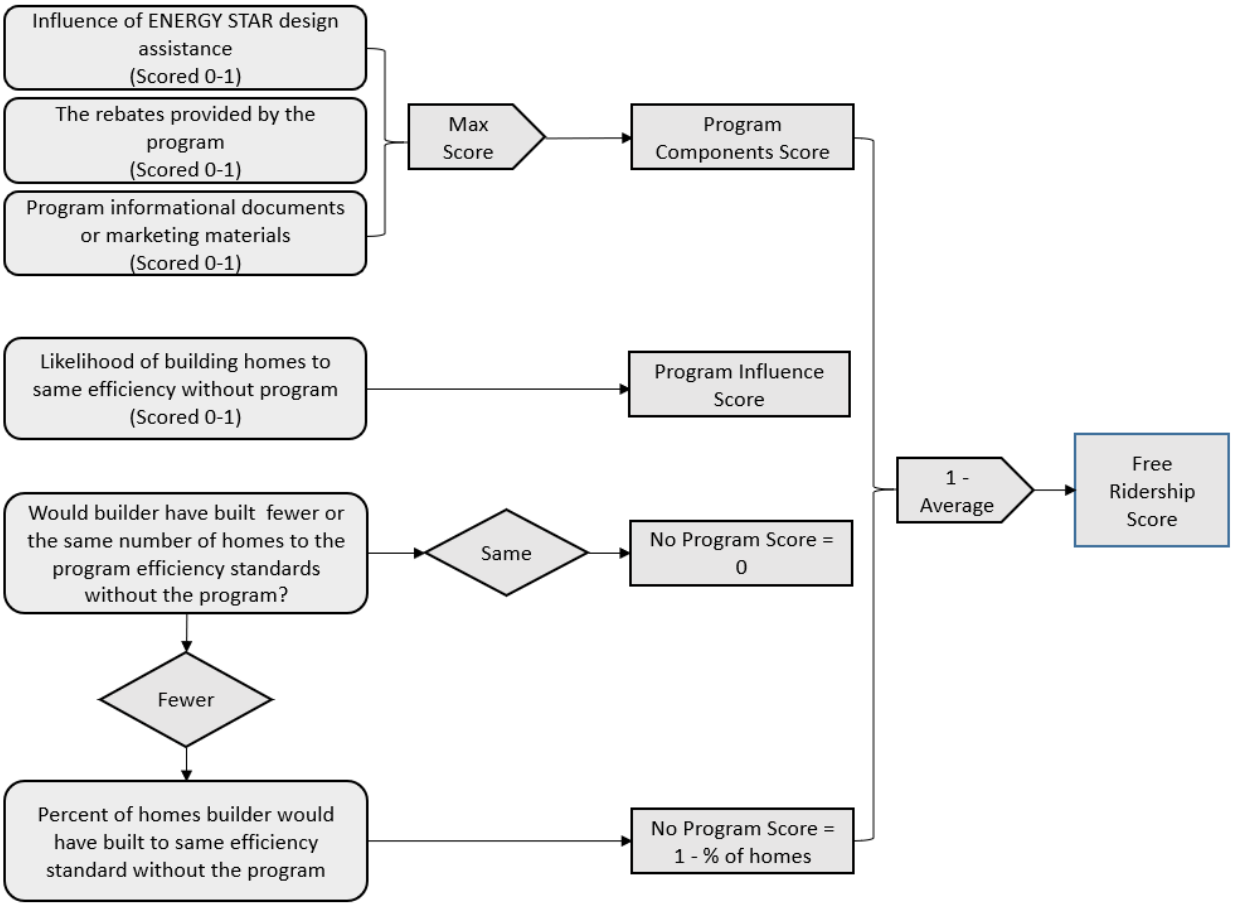
1 – Average (% Homes Built in Absence of the Program/100)

Free Ridership Score:

The evaluation team at ADM calculated the final free ridership score for each builder as equal to:

1 – Average (Program Components Score, Program Influence Score, No Program Score) Figure 3-20 summarizes the scoring procedure.

Figure 3-20: New Homes Builder Free Ridership Scoring



To estimate participant spillover, builders were asked if they completed any additional homes built to the program efficiency standards inside the PSO service territory without submitting them for a program rebate. None of the builders reported building additional homes that met the program efficiency standards.

3.5.2.2 Impact Evaluation Findings for New Homes

This section details the reported and verified gross savings. The NTG estimates that ADM applied to the gross savings to produce the net savings are reported in Section 3.5.2.2.3.

3.5.2.2.1 Program Activity for New Homes

Participation and savings per builder are shown below in Table 3-98. The top participating builders contributed most of the homes and savings.

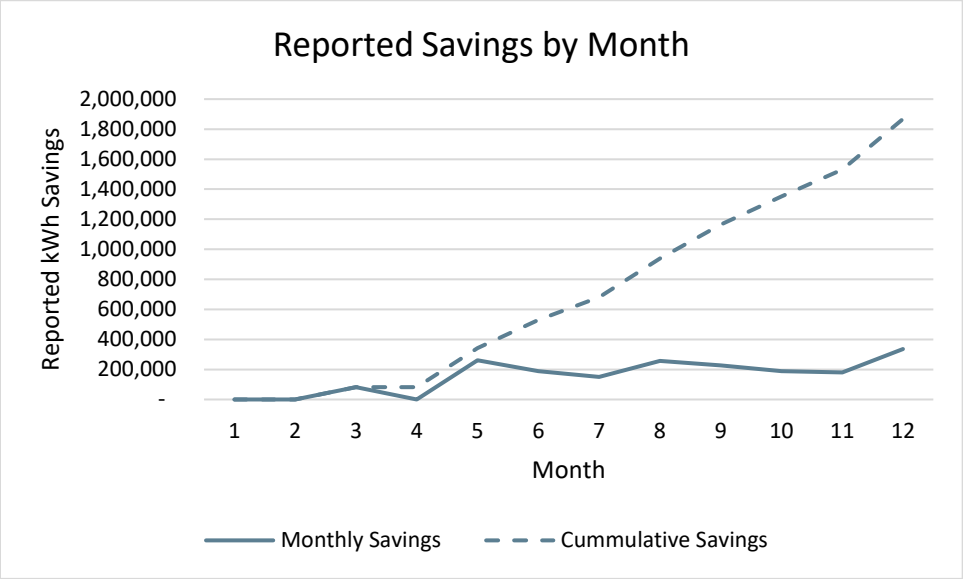
Table 3-98: Participation and Savings per Builder

Builder	Number of Homes	Reported Energy (kWh)	Reported Demand (kW)	Percent of Program Energy Savings
Builder 1	205	289,816	106	16%
Builder 2	194	351,320	141	20%
Builder 3	117	281,846	42	16%
Builder 4	94	252,124	98	14%
Builder 5	51	59,232	31	3%
Builder 6	45	74,248	29	4%
Builder 7	33	96,650	14	5%
Builder 8	29	59,826	23	3%
Builder 9	15	32,797	12	2%
Builder 10	14	28,451	11	2%
Builder 11	8	20,439	8	1%
Builder 12	8	24,802	10	1%
Builder 13	7	18,540	7	1%
Builder 14	7	16,351	7	1%
Builder 15	7	27,788	4	2%
Builder 16	5	7,980	3	0%
Builder 17	5	9,517	4	1%
Builder 18	5	10,325	4	1%
Builder 19	4	9,658	2	1%
Builder 20	4	9,234	4	1%
Builder 21	3	6,171	2	0%
Builder 22	2	6,846	3	0%
Builder 23	2	5,347	2	0%
Builder 24	1	1,864	1	0%
Builder 25	1	10,812	1	1%
Builder 26	1	5,348	1	0%

Builder	Number of Homes	Reported Energy (kWh)	Reported Demand (kW)	Percent of Program Energy Savings
Builder 27	1	6,960	1	0%
Builder 28	1	3,646	1	0%
Builder 29	1	1,796	1	0%
Builder 30	1	17,145	2	1%
Builder 31	1	2,942	2	0%
Builder 32	1	2,188	1	0%
Builder 33	1	11,744	1	1%
Builder 34	1	1,677	1	0%
Builder 35	1	1,442	1	0%
Builder 36	1	2,529	1	0%
Builder 37	1	1,071	0	0%
Builder 38	1	3,247	1	0%
Total	**879**	**1,773,721**	**582**	**100%**

Participation in the New Homes program is shown below in Figure 3-21. There was consistent participation from May to November, with an uptick in participation in December.

Figure 3-21: Cumulative Reported kWh during the Program Year – New Homes



Based on the impact evaluation results, the total verified net energy and demand savings are presented in Table 3-99 below.

Table 3-99: Gross and Net Savings Impacts – New Homes

Program	Verified Annual Energy Savings (kWh)	Verified Peak Demand Reduction (kW)	NTG Ratio kWh	NTG Ratio kW	Net Annual Energy Savings (kWh)	Net Peak Demand Reduction (kW)
New Homes	1,751,077	822	80%	81%	1,400,862	666

3.5.2.2.2 New Homes Reported and Verified Gross Savings

Reported and gross annual energy savings are summarized in Table 3-100 for the program, and then broken down by strata in Table 3-101.

Table 3-100: Reported and Gross Impacts - New Homes

Program	Reported Annual Energy Savings (kWh)	Reported Peak Demand Reduction (kW)	Verified Annual Energy Savings (kWh)	Verified Peak Demand Reduction (kW)	kWh Realization Rate	kW Realization Rate
New Homes	1,773,721	582	1,751,077	822	99%	141%

Table 3-101: Gross Impact Results by Strata - New Homes

Strata	Reported Annual Energy Savings (kWh)	Reported Peak Demand Reduction (kW)	Verified Annual Energy Savings (kWh)	Verified Peak Demand Reduction (kW)	kWh Realization Rate	kW Realization Rate
Rater1	485,252	175	487,434	272	91%	152%
Rater2	439,628	172	429,472	251	95%	150%
Rater3	396,704	141	338,245	141	83%	121%
Rater4	372,152	55	388,622	111	98%	191%
Other	79,985	38	107,304	46	119%	143%

The difference in the reported and gross annual energy savings results were generated by two main factors:

- Uncertainties contributed by Ekotrope RATER software
- Differences between ex-ante model assumptions and physical homes verified by ADM (e.g. differences in key model inputs).

The following discussions first start with the uncertainties introduced by the Ekotrope Rater software and how they impacted the program realization rate because this was the largest contributor to the differences between ex-ante and ex-post impacts.

Uncertainties Introduced by Ekotrope RATER

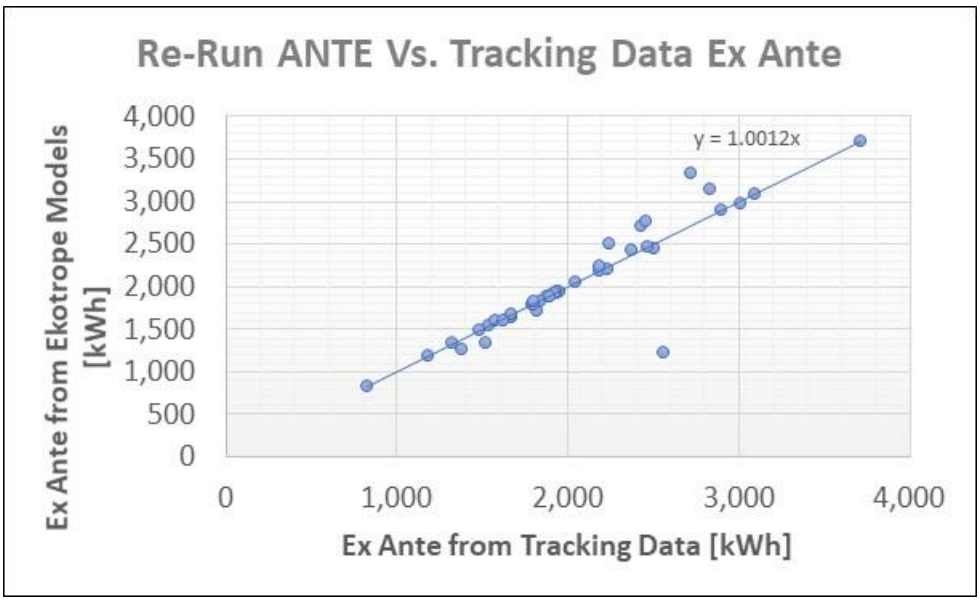
It was noted previously that the Ekotrope RATER software lacked a level of transparency necessary for evaluation and thus represented a 'black box' from which energy savings estimates could be derived. ADM therefore performed close review of the Ekotrope RATER software inputs/outputs in order to develop confidence in its results. This necessitated three parallel simulations for each sampled home:

- An *ex-ante simulation run* through the Ekotrope RATER software which was the model as received from the implementers. The evaluation team at ADM did this in an attempt to 're-produce' the ex-ante values and gain a better understanding about the internal consistency of the software as well as later comparisons between Ekotrope and REM/Rate.
- An *ex-post simulation* run through the Ekotrope RATER software which included our findings/changes to key model inputs.
- An *ex-post simulation* run through the REM/Rate software which included our findings/changes to key model inputs.

The purpose for these three parallel simulation runs was to track the internal consistency of Ekotrope RATER, and to facilitate use of REM/Rate (a known and trusted tool for new homes program verification) as a benchmark against Ekotrope RATER.

Our first step in this process was to compare the results from the *ex-ante simulation* run against the ex-ante values in the program tracking data. Since both were generated using the same software (e.g. Ekotrope RATER) with identical inputs, our expectation was that the numbers would be identical. However, it can be seen in Figure 3-22 that there exist some non-negligible differences between the two.

Figure 3-22: Comparison of Tracking Data to Re-Run Ex-Ante Models

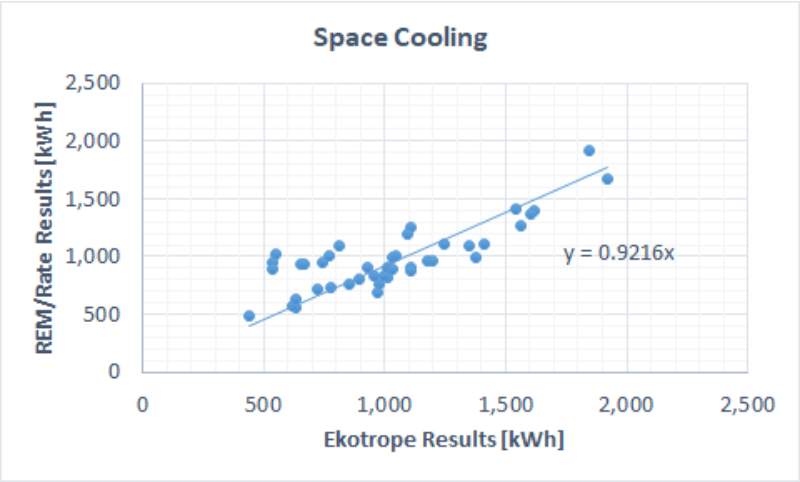


On average ADM observed that the program tracking data savings were slightly higher than the re-run Ekotrope RATER ex-ante model results. Furthermore, there was significant volatility in the observations which ranged from 18% lower to 109% higher than the re-run Ekotrope RATER ex-ante model results. Note that once sample weights were applied the overall trend was that the re-run ex-ante models net slightly higher savings estimates compared to the tracking data.

When following up with Ekotrope, ADM was told that the observed differences were generated due to differences in the software versions, but ADM was not provided with any additional information to substantiate why such differences should be expected to be accurate. In later in the conversations with Ekotrope, we discovered that when Ekotrope homes are exported to XML format some data is lost and the models are no longer consistent with the original – this is important due to the process that was established to facilitate transfer of the data files for the evaluation.

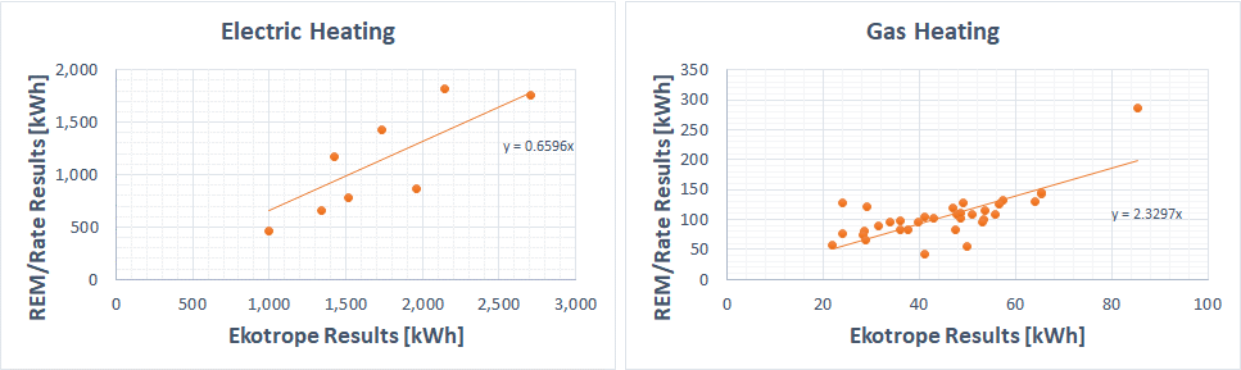
The second step of our review compared our ex-post simulation results from Ekotrope against the same from REM/Rate. Note that ADM utilized the currently available version of Ekotrope to perform this analysis as that was what was made available to us. Additionally, ADM performed additional verification to ensure that the model inputs between the two simulations were identical. Figure 3-23, Figure 3-24, and Figure 3-25 compare the results from Ekotrope RATER against REM/Rate in the areas of *Heating Savings*, *Cooling Savings*, and *Lights/Appliance Savings*.

Figure 3-23: Comparing Cooling Savings Between Ekotrope and REM/Rate



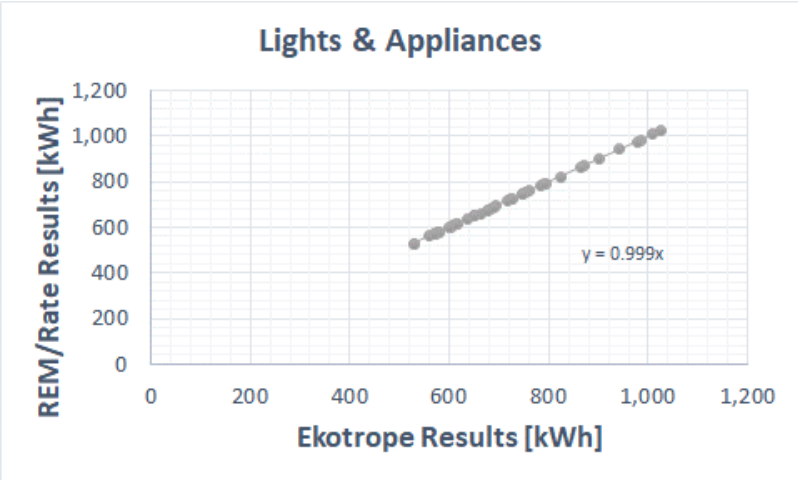
The cooling savings between the two follow a general alignment, though Ekotrope RATER estimates larger cooling savings than REM/Rate on average. There is more scatter than expected between REM/Rate and Ekotrope RATER. Note that it is our understanding that Ekotrope RATER uses a simple hourly simulation engine based on ASHRAE formulae and physical first principals. Therefore, it is expected that there should be some variance compared to REM/Rates seasonal mode.

Figure 3-24: Comparing Heating Savings Between Ekotrope and REM/Rate



The heating savings do not align well between the two simulation packages. Heating impacts for gas heated homes predicted by Ekotrope RATER are consistently much lower than those predicted by REM/Rate. However, for electrically heated homes the reverse is true. This is a significant departure from the results seen for the cooling end-use and illustrates some non-negligible differences between the software packages. ADM has asked Ekotrope to provide comparisons of their software's outputs against other industry standard hourly based simulation engines (e.g. DOE2 and EnergyPlus) as a benchmark as those results are expected to be a more consistent comparator.

Figure 3-25: Comparing Lights/Appliances Savings Between Ekotrope and REM/Rate



The lights and appliances results were faithfully reproduced (within less than 0.5%) between the two simulation packages which indicates that the two are using identical algorithms to quantify impacts for these aspects of the simulations. This is also the only aspect of the Ekotrope RATER simulation results that ADM confirmed to be reliable.[76]

Finally, ADM calculated two sets of energy savings (and therefore two sets of realization rates for each project). The first set compared the ex-post results against the tracking data savings. The second set compared the ex-post results against the 're-run' ex-ante models. These are compared in Table 3-102 and Table 3-103.

Table 3-102: Ex-Post Energy Savings Results Differences Across Software Platforms

Strata	Tracking Data Ex-Ante (kWh)	Ekotrope Ex-Ante Model (kWh)	Ekotrope Ex-Post Model (kWh)	REM/Rate Ex-Post Model (kWh)
Rater1	485,252	509,168	495,718	479,150
Rater2	439,628	436,618	436,504	422,440
Rater3	396,704	352,525	344,457	332,034
Rater4	372,152	384,044	399,863	377,381
Other	79,985	78,567	109,889	104,719
Totals	**1,773,721**	**1,760,922**	**1,786,431**	**1,715,723**

[76] This does not, by inference, indicate that the cooling and heating consumption algorithms are 'un-reliable' in Ekotrope. There remain too many unknowns regarding Ekotrope's heating and cooling algrithms to make definitive judgement at this time.

Table 3-103: Ex-Post Realization Rate Differences Across Software Platforms

Strata	Ekotrope Ex-Post vs. Tracking	Ekotrope Ex-Post vs. Ekotrope Ex-Ante	REM/Rate Ex-Post vs. Tracking	REM/Rate Ex-Post vs. Ekotrope Ex-Ante
Rater1	102%	97%	99%	94%
Rater2	99%	100%	96%	97%
Rater3	87%	98%	84%	94%
Rater4	107%	104%	101%	98%
Other	137%	140%	131%	133%
Totals	**101%**	**101%**	**97%**	**97%**

Note that the difference in results between REM/Rate and Ekotrope[77] show minimal discrepancy. The divergences that are present are expected to have been introduced by the process of exporting the original Ekotrope models as XML files and then re-importing them into Ekotrope once the files were handed off to the evaluation.

Based on ADMs comparisons between Ekotrope and REM/Rate, ADM elected to average the ex-post results between two software frameworks for use as the verified program results. However, (due to the lack of access to the software at the time of this evaluation) ADM is not confident that future updates to the Ekotrope software will maintain consistency with known benchmarks. Furthermore, some differences were observed between past versions of Ekotrope and the current version.

In summary, ADM found several factors relevant to the New Homes program in our review of the Ekotrope RATER software:

1) There exist potentially significant and unexplained differences in simulation results introduced by different versions of the simulation engine. It was found later in the evaluation that this may be induced to a large extent by the export/import process.
2) The current version of Ekotrope reliably calculated impacts from Lights and Appliances, but there exist significant differences in weather sensitive components.
3) Ekotrope has not demonstrated sufficient reliability or viability to be used for purposes of program evaluation. One of the significant variances was introduced through the export process required to facilitate data transfer for the evaluation. While Ekotrope had offered that with certain licensing they would copy files from the implementation account over to our account, the price requested by Ekotrope to do so exceeded the overall budgets for this evaluation and thereby rendered such use of their software (by the evaluation) untenable.

[77] Specifically, the version available during the time of this evaluation

Differences between Ex-Ante and Ex-Post simulation inputs

The impact analysis found that, for sampled homes, reported simulation models generally reflected the building characteristics verified during field verification visits, though there were some areas where ADM found consistent differences:

- **Saturation of LED lighting –** ADM found 17 homes with different saturations of installed efficient lighting then assumed in the ex-ante models. In most instances this factor led to slight increases in site energy savings and led to an overall slight increase in program level savings.
- **Furnace Auxiliary Energy Consumption Rating –** 28 sampled projects were found to have furnace Auxiliary Energy Consumption (EAE) Ratings less than assumed in the ex-ante models. This factor led to a slight decrease in site energy savings and an overall decrease in program level savings.
- **HVAC Equipment Efficiency –** During on-site visits ADM found 9 homes for which the assumed SEER ratings were different compared to what was assumed in the ex-ante models. Differences existed in both directions (e.g. some higher and some lower). The net effect was a slight decrease on program savings.
- **HVAC Equipment Capacity –** ADM found that the HVAC system capacity ratings differed from ex-ante assumptions on 18 of the sampled projects. Adjustments were made in both direction and the ultimate impact of this change was negligible.

As noted in the previous section, the above adjustments to the models resulted in minor impacts to the program savings compared to the issues identified in the Ekotrope RATER software. When compared to the ex-ante models (e.g. unchanged models with original ex-ante assumptions) run through the current version of Ekotrope RATER, the above changes result in the net impact of a 1.0% decrease in program savings.

3.5.2.2.3 New Homes NTG Estimation Results

Ten builder interviews were used to estimate NTG ratios for the New Homes program. NTG ratios (ranging from zero to one, zero for complete free ridership and one for no free ridership) were determined for each interviewed home builder. Average NTG ratios were weighted by the builder's verified savings contributions. The final component level NTG ratio was 80% for energy savings and 81% for demand savings.

Anecdotal evidence suggests that the magnitude of both participant and non-participant spillover is negligible. The program may have some market transformation effects, but no attempt was made to quantify these effects in terms of additional energy and demand impacts. Results from the builder interviews suggest that the new program design for New Homes has had a positive impact on free ridership levels.

3.5.3 Multiple Upgrades

3.5.3.1 EM&V Methodology

This section provides an overview of the gross and net impact evaluation of the Multiple Upgrades component of the Home Rebates program. Data collection included online/telephone surveys, on-site verification visits, in-depth interviews with program staff, and discussions with project auditors. Additional sources of data to inform the impact evaluation were a census of program tracking data from the program implementor's tracking and reporting system, along with project documentation. Program tracking data included customer contact information and descriptions of the measures installed, with file storage for submitted applications, test-in home photos and data, test-out photos and data, and contractor invoices for the work performed.

3.5.3.1.1 Sampling Plan

Table 3-104 summarizes the sample size for each primary data collection activity. The random sample for verification was designed to achieve ±10% relative precision or better at the 90% confidence interval.

Table 3-104: Sample Sizes for Data Collection Efforts – Multiple Upgrades

Data Collection Activity	Achieved Sample Size
Participant Surveys Completed	76
On-Site Verification Visits	24
In-Depth Interviews with Program Staff	2

Participant Surveys

For the calculation of sample size for survey completes, a coefficient of variation of 0.5 was assumed.[78] With this assumption, a minimum sample size of 68 participants was needed, as shown in the following formula. This minimum sample size of 68 was exceeded with 76 surveys completed.

Equation 3-3: Minimum Sample Size Formula for 90 Percent Confidence Level

$$n_0 = \left(\frac{Z * CV}{RP}\right)^2 = \left(\frac{1.645 * 0.5}{0.10}\right)^2 = 68$$

Where:

n_0 = minimum sample size

[78] The coefficient of variation, cv(y), is a measure of variation for the variable to be estimated. Its value depends on the mean and standard deviation of the distribution of values for the variable (i.e., cv(y) = sd(y)/mean(y)).

Z = Z-statistic value (1.645 for the 90% confidence level)

CV = Coefficient of Variation (assumed to be 0.5)

RP = Relative Precision (0.10)

On-site Verification Visits

The sample for on-site verification visits was designed to achieve ±10% relative precision or better at the 90% confidence interval. The reported savings values were placed in strata by the measure name, then a sub strata dependent on the size and span of the sample based on the expected energy savings. All measure strata had an outreach performed to schedule a site visit. Some of the measures with lower participation had every participant contacted but were not able to be scheduled. *Table 3-105* below lists the achieved sample design.

The sample design also included the measure for window and glass door replacement. The applications were submitted in the prior year when the measure was offered, but the installation was completed in the current year. Finally, the sample design included 516 projects with a LED omnidirectional lamp measure. Although, this measure was not offered through the website, it was available on special request.

Table 3-105: Sample Design Multiple Upgrades Site Visits

Strata	Measure	Upper Boundary	Lower Boundary	Population	Sampled	CV	kWh
Stratum 1	Air Sealing Package	5,037	400	75	10	0.76	64,265
Stratum 2	Air Sealing Package	400	0	168	6	0.46	31,048
Stratum 1	Insulation - Attic	5,536	1000	42	3	0.51	79,111
Stratum 2	Insulation - Attic	1,000	0	183	10	0.49	89,071
Stratum 1	Insulation – Knee Wall	1,349	200	27	1	0.64	14,332
Stratum 2	Insulation – Knee Wall	200	0	15	2	0.29	1,809
Stratum 1	Duct Replacement (Insulation)	567	140	21	1	0.46	4,157
Stratum 2	Duct Replacement (Insulation)	140	0	68	6	0.48	4,502
Stratum 1	Duct System Sealing	13,496	2000	145	6	0.31	30,457
Stratum 2	Duct System Sealing	2,000	0	494	21	0.53	877,390
Stratum 1	Heat Pump	5,571	0	40	3	0.52	70,944
Stratum 1	Central AC	3,689	2500	42	2	0.13	122,079
Stratum 2	Central AC	2,500	1300	214	7	0.19	376,068
Stratum 3	Central AC	1,300	0	279	5	0.27	252,976
Stratum 1	Window Improvement	709	0	29	5	0.17	12,440
Stratum 1	GSHP	7,581	0	2	0	1.41	7,592
Stratum 1	Radiant Barrier	340	0	1	0	0.00	339
Stratum 1	ECM heating fan	466	0	14	0	0.64	2,729
Stratum 1	9W Omni LED	700	0	516	0	0.55	126,996
Stratum 1	Insulation-Basement	27	0	1	0	0.00	26
Stratum 1	Insulation-Ext Wall	828	0	1	0	0.00	827
Total							**2,169,158**

3.5.3.1.2 Data Collection

Participant Surveys

For the Multiple Upgrades program, there were a total of 76 completed surveys. All Multiple Upgrades participants were pulled from the tracking data and included in the survey sample list. Due to the limited number of participants with valid email addresses in the tracking data, the survey had to be administered via online and telephone. Any participant with a valid email address was sent the online participation survey. A total of 326 participants were sent the online survey, which resulted in 64 survey completes. Any participant that did not have a valid email address was contacted via telephone call. A

total of 81 participants were called for the telephone survey, which resulted in 12 survey completes. Special care was taken so that no participants received both the online and telephone surveys.

On-site Verification Visits

On-site verification visits were scheduled, then visited by evaluation field staff, who verified the measure installation and operational characteristics. Photographs were taken during all on-site visits to document measure installation. For HVAC equipment, the type, capacity, efficiency ratings, and model numbers were recorded. For attic insulation, installation was visually verified, and measured when accessible. Heating and cooling system equipment types were noted and the approximate measurement area in square feet of insulation was recorded. For high efficiency windows/doors, the total count of new units was recorded along with heating and cooling system type. The findings from the on-site verification visits were compared to information in the program tracking database to verify that input to savings calculations were correctly recorded.

Program Staff Interviews

Program staff members from PSO and the implementation contractor (ICF) were interviewed to obtain the program administrator's perspective on program processes and operations.

3.5.3.1.3 Gross Impact Methodologies

The method used to calculate energy savings (kWh) and demand savings (kW) consisted of:

Program tracking data census. The tracking data was reviewed for a census of homes and measures. The data was verified for duplicate participation within the program and between programs.

Measure installation verification. In-service rates (ISR) were calculated by measure for a sample of program participants using data from on-site verification visits.

Reported savings review. Reported savings calculations were reviewed for all measures to determine the cause of savings discrepancies.

Standard for verification of savings. The data collected from the site visits along with program tracking data were used as inputs to the savings algorithms as listed in the Arkansas Technical Reference Manual, Version 7.0 (AR TRM 7.0) and the Oklahoma Deemed Savings Document (OKDSD).

A brief description of each measure calculation method is described in the sections below. Appendix F lists the measure-level algorithms and deemed savings values utilized for the energy and peak demand savings algorithms.

Air Sealing Package: AR TRM 7.0 was utilized to calculate energy and demand impacts of air sealing measures. Savings are calculated by multiplying the air infiltration reduction (CFM), with the energy savings factor corresponding to the climate zone and HVAC type. The air infiltration reduction estimate in cubic feet per minute (CFM at 50 Pascal) was obtained through blower door testing performed by the program contractor for each home serviced.

Duct Sealing: Savings were estimated by updating the inputs to the savings algorithm listed in the OKDSD for duct sealing. The pre- and post-installation duct leakage is measured by the contractor. The duct leakage reduction results are utilized to calculate measure savings. Existing or new HVAC unit capacity and efficiency data were obtained either from another measure installed within the project or from participation in another program. If existing unit efficiency is unknown the default value from OKDSD of 13 SEER is used.

Duct Replacement (Insulation): Savings were estimated by updating the savings algorithm inputs listed in the OKDSD for duct insulation. The climate zone specific deemed savings values were factored by the installed area where the duct supplies conditioned air. All tracking data within the Home Rebates program was considered to determine the number of HVAC systems in the home. The tracking data often listed total home square feet for the measure as opposed to the area affected by the duct replacement.

Attic Insulation: Savings were estimated by updating the savings algorithm inputs listed in the AR TRM 7.0 for attic insulation. The savings factor was climate zone specific, determined by the pre-insulation thickness R-value compared to the post-installation thickness R-value. As the AR TRM energy and demand savings factors are based on multiple starting insulation R-values, and just two final insulation R-values, an interpolation was completed for those values between R-38 and R-49. Finally, for the projects that exceeded the AR TRM table value sets for R-49, the extrapolation was not made, as the energy savings per R -value is diminishing.

Floor Insulation: Savings were estimated by updating the savings algorithm inputs listed in the OKDSD for floor insulation. The savings factor was climate zone specific, and HVAC equipment specific, then factored by the installed area. There was only one project completed for floor insulation.

Exterior Wall Insulation: Savings were estimated by updating the savings algorithm inputs listed in the ARM TRM 7.0 for wall insulation. The savings factor was climate zone specific, and HVAC equipment specific then factored by the installed surface area listed in the tracking data. There was only one project completed for exterior wall insulation.

Knee Wall Insulation: Savings were estimated by updating the savings algorithm inputs listed in the ARM TRM 7.0 for knee wall insulation. The savings factor was dependent

upon climate zone and HVAC equipment type. Additionally, savings are driven by the post-installation R-value-. The TRM table was modeled for a home starting at zero insulation going to a R-19 or R-30 value. The savings estimated considered the initial insulation R-value and adjusted the savings value. All of the project document test out pictures indicated an open cell or closed cell foam applied to attic vertical walls. The final R-value was interpolated for the R-values between R-19 and R-30. All the projects reached the R-19 value, and the projects exceeding R-30 were not extrapolated due to the diminishing heat transfer reduction.

Electronically Commutated (ECM) Furnace Fan Motor: Savings were estimated by updating the savings algorithm inputs listed in the OKDSD for ECM air handler motors. There was a mid-program change where the savings were no longer tracked. The verified savings are based only on those homes where the savings were also claimed in the tracking data. If the cooling system is also replaced along with the ECM, with incentives paid for the new cooling system based on the SEER, cooling season fan energy savings shall not be claimed under this measure. Those savings are captured in the air conditioner replacement measure based on graded SEER (which includes air handler fan performance).

Central Air Conditioners, Air Source Heat Pumps and Ground Source Heat Pumps: Savings were estimated by updating the savings algorithm inputs in the OKDSD, along with a baseline SEER modification to reflect federal guidelines[79]. OKDSD baseline SEER is 12.44, this was updated to 14 SEER in ex-post calculations.

ENERGY STAR® Windows and Doors: Savings were calculated for each weather zone in accordance with the OKDSD. Savings were based on the heating and cooling type of the home and the existing windowpane type. Savings were calculated by multiplying the corresponding savings value by the square footage of the installed window, including the frame and sash.

Radiant Barrier: Savings were taken from the saving algorithm in the OKDSD and were dependent upon weather zone, cooling/heating type, and the R-Value of the additional radiant barrier. The savings value was multiplied by the square footage of the ceiling area over the conditioned space which the radiant barrier was applied. There was only one project completed for radiant barrier.

Omni-directional LEDs: The savings were estimated by the difference in the wattage of the new 9W LED lamp and an EISA 2007 baseline of 43W from the OKDSD. A modification to the hours of use per year (960.61 HOU per year) was utilized by ADM. The modification of the hours of use was sourced from a benchmarking study performed in 2016.[80]

[79] Federal Standard, https://www.regulations.gov/document?D=EERE-2011-bt-ce-0077-0102
[80] ADM HOU Memo, 2016.

3.5.3.1.4 NTG Estimation

This section provides a summary of the method to score the responses from the online survey of participants for the measure-level free ridership score, project-level free ridership score, and spillover score. The survey results were weighted and extrapolated to the population of participants.

Measure-Level Free Ridership Scoring

For customers who completed projects that did not include HVAC measures, the free ridership score was based entirely on responses to questions in the participant survey. Program education and outreach efforts for HVAC measures may have influenced service providers' selling of efficient equipment in ways that are not apparent to customers. The assessment of free ridership for HVAC equipment also included a service provider influence component. The following paragraphs summarize the approach to assessing both the participant free ridership score and the service provider component.

Participant Free Ridership Score

The participant free ridership questions addressed several criteria to determine the likelihood that a customer is a free rider. If the respondent reported they had no financial ability to install the measure without the program, then the final participant free ridership score was equal to 0. In that case, no other consideration affected the score.

If the respondent reported they had the financial ability to install the measure without the program, then the final participant free ridership score was a function of three other factors: the respondent's prior plans to implement the project before learning of the program rebate, the reported likelihood of implementing the measure in the absence of the program, and the impact of the program on the timing of the project.

The first questions produced a Plans Score, with a value of 1 or 0, representing the existence of prior plans relating to the energy saving measures installed. Respondents who reported prior plans to implement measures that provided at least as much energy savings as those done through the program received a Plans Score of 1, while all others received a Plans Score of 0.

A separate set questions produced a Likelihood Score, ranging from 0 to 1, which represented the likelihood that the respondent would have installed the measures without the program. The average of the Plans Scores and the Likelihood Score produced the preliminary participant free ridership score, with a value ranging from 0 to 1.

Finally, the respondent's report of how the program affected the timing of the project produced a Timing Score, with a value ranging from 0 (the program moved the project forward by at least one year) to 1 (the program did not move the project forward). For each respondent the final participant free ridership score was the product of the preliminary participant free ridership score and the Timing Score.

Service Provider Free Ridership Score

The service provider free ridership score related to the service providers influence of their marketing and sales of energy efficient equipment on the participant, ranging in value from 0 (highest influence) to 1 (lowest influence). A second question assessed whether the program influenced the service provider's equipment recommendations.

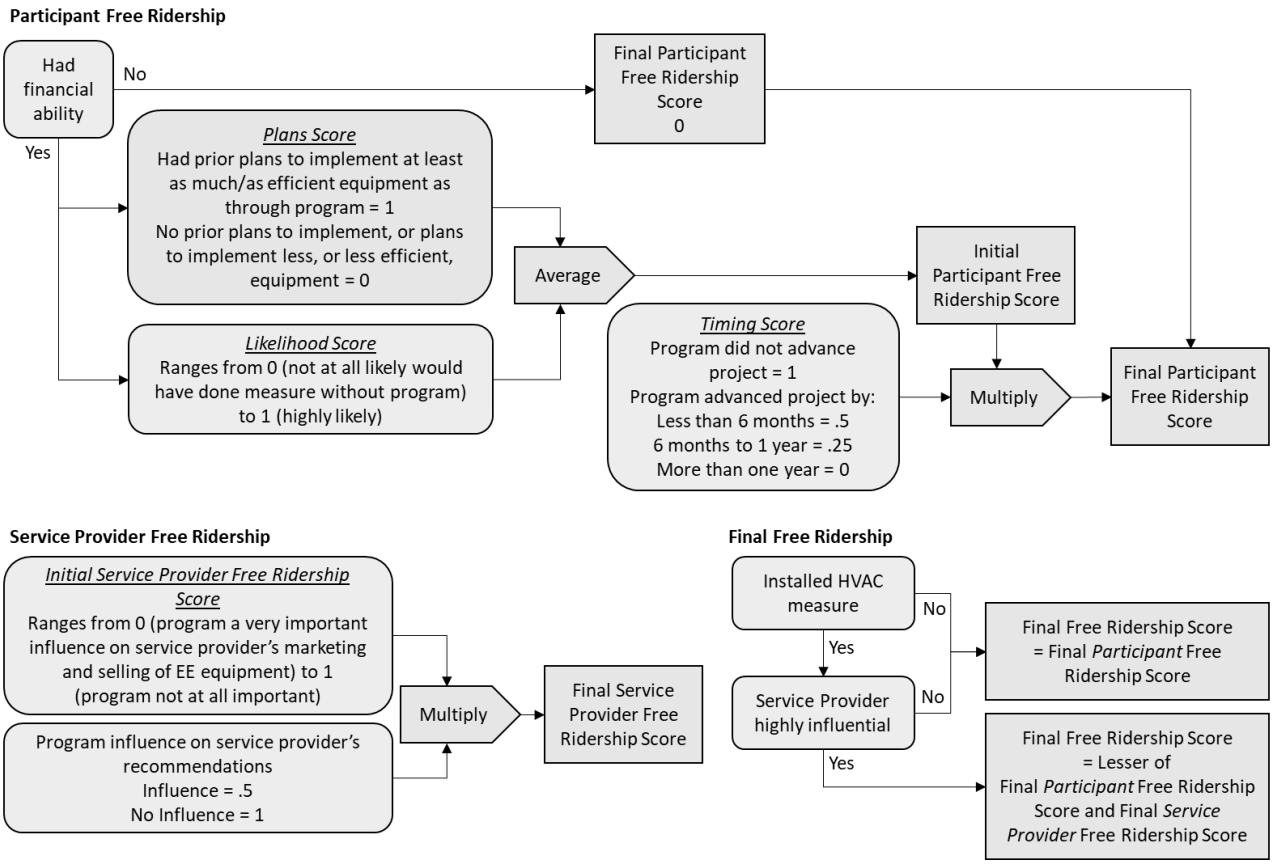
Final Free Ridership Score

The final participant free ridership score represented the final free ridership score in either of two cases: 1) The participant did not have HVAC equipment installed; or 2) the participant had HVAC equipment installed but did not receive any equipment information or recommendation from the service provider who installed it that the participant considered "very influential."

If, however, a participant installed HVAC equipment and reported that the service provider who installed the equipment gave information or a recommendation that was "very influential," then the final free ridership score was the lesser of two scores: 1) That participant's Final Participant Free Ridership Score; and 2) the service provider free ridership score. For any given participant, if that participant's service provider completed the service provider survey and provided a service provider free ridership score, then the evaluation team at ADM used *that* service provider's score as the service provider free ridership score for the participant; otherwise, the mean service provider free ridership score was calculated across all surveyed service providers.

Figure 3-26 illustrates the above process for generating the final free ridership score.

Figure 3-26: Free Ridership Flow Diagram



Project Level Free Ridership

For each respondent, a project level free ridership score was determined by weighting the measure-level free rider scores, over the project energy savings.

Survey responses about other energy-efficient measures installed recently were vetted against their participation in other projects, or programs, and the program influence on their purchase or installation of these measures. Spillover identified by the survey is vetted for influence by the program, then extrapolated to the population.

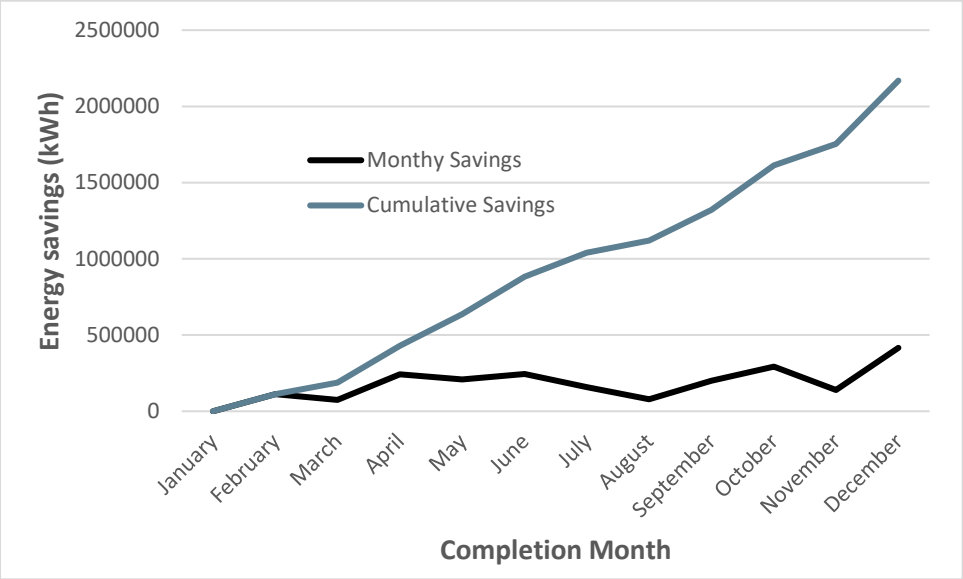
3.5.3.2 Impact Evaluation Findings

This section details the level of Multiple Upgrades activity for 2019, the reported and verified gross savings that resulted from that activity, and the NTG estimates applied to the gross savings to produce the net savings reported in Section 3.5.5.

3.5.3.2.1 Program Activity

The Multiple Upgrades part of Home Rebates in 2019 had 1,125 total projects installed as part of the program. Final energy savings were based on a total of 3,242 energy-savings measures. *Figure 3-27* below details the savings accumulated over the program year.

Figure 3-27: Cumulative Reported kWh Savings during the Program Year – Multiple Upgrades



Net Savings: Based on the impact evaluation results, the total verified net energy savings for the Multiple Upgrades program are 1,723,142 kWh, and the total verified net peak demand savings are 1,172 kW. A summary of Multiple Upgrades impact findings is shown in *Table 3-106*.

Table 3-106: Multiple Upgrades-Gross, Net Verified Energy & Demand Savings

Program	Gross Verified Energy (kWh)	Gross Verified Demand (kW)	NTG Ratio	Net Verified Energy (kWh)	Net Verified Demand (kW)
Multiple Upgrades	1,918,839	1,303.40	89.8%	1,723,142	1,172.13

3.5.3.2.2 Reported and Verified Gross Savings

The Multiple Rebates program's gross verified savings estimates resulted in an energy savings realization rate of 88.5% and demand reduction realization rate of 121.5%. The following presents the gross verified savings by measure, and the realization rates.

Table 3-107: Reported and Verified Gross Energy & Demand Savings

Measure	Reported Energy (kWh)	Gross Verified Energy (kWh)	RR_{kWh}	Reported Demand (kW)	Gross Verified Demand (kW)	RR_{kW}
9-watt Omnidirectional LED	126,996	135,360	107%	18.60	14.10	76%
Air Sealing Package	95,313	76,238	80%	49.29	44.14	90%
Central AC	751,123	539,025	72%	322.66	269.79	84%
Duct Replacement (Insulation)	8,658	12,582	-	0.00	180.66	-
Duct System Sealing	907,847	903,488	-	532.83	641.83	-
Duct Replacement & System Sealing*	916,505	916,070	100%	532.83	822.50	154%
Ground Source Heat Pump	7,592	14,847	196%	1.62	4.15	256%
Heat Pump	70,944	47,349	67%	17.76	14.46	81%
Heating System ECM Fan	2,729	2,729	100%	0.00	0.00	-
Insulation – Attic	168,183	160,885	96%	110.68	117.47	106%
Insulation – Floor	26	27	107%	-0.03	0.01	-23%
Insulation - Exterior Wall	827	827	100%	0.38	0.38	100%
Insulation - Knee Wall	16,141	14,567	90%	11.11	10.42	94%
Radiant Barrier	339	602	178%	0.27	.56	211%
Window/Door Improvement	12,440	10,312	83%	7.90	6.78	86%
Total	**2,169,158**	**1,918,839**	**88.5%**	**1,073.07**	**1,303.40**	**121.5%**

* Savings for duct replacement (insulation) and duct system sealing were combined to calculate realization rate due to all duct replacement savings being captured in the corresponding duct sealing measure in the tracking data.

The gross impact analysis consisted of verifying measure installation and checking the program tracking data to ensure that deemed savings algorithms were appropriately applied. ISRs for each measure type were developed based on the findings from the on-site visits. Findings from the on-site visits determined a 100% ISR for all measures in Multiple Upgrades for PY2019. A description of verified gross findings for each measure type is included below:

Omni-directional LEDs: Although not offered through the traditional application process, there were 516 projects that included measures for replacing omnidirectional lamps with efficient LED lamps. The realization rate is 107% for energy savings and 76% for demand savings. The hours of use were inputted into the savings algorithm based on previous residential metering of lighting. The savings will decrease after the baseline shift in the Tier 2 period, when it would be expected for the remaining useful life to finish, and the

federal guidelines for screw in omnidirectional lamps require 45 lumens per watt output, equivalent to a CFL type lamp.

Air Sealing (infiltration reduction): The measure had realization rates of 80% and 90% for energy and demand savings, respectively. Discrepancies between reported and verified gross savings is attributable to the ex-ante initially calculating saving with OKDSD and then migrating to AR TRM for later projects. ADM continued to utilize AR TRM deemed values for all infiltration reduction projects.

Central Air Conditioner: The realization rates of 72% for energy and 84% for demand savings are due to the baseline efficiency difference. The reported calculations used a SEER of 12.44 rather than the updated 2015 federal minimum value of 14 SEER.[81] The right sizing of the unit, reducing the capacity of new unit to less than the baseline unit, was considered when the tow capacities were similar (i.e., a 1-ton mini split replacing a 1.5-ton unit, but not a 1-ton unit replacing a 4-ton unit). ADM assumed that the contractor right sized the unit in the baseline condition.

Duct Replacement (Insulation) and Duct System Sealing: Savings for duct replacement and duct system sealing were combined due to all duct replacement demand savings being captured in the corresponding duct sealing measure in the tracking data. These two measures were the largest energy savings measure of the program with 916,070 kWh of verified energy savings and 822.50 kW of demand savings. The estimated savings for the combined duct replacement and duct system sealing measures had an overall realization rate of 100% and 154% for energy and demand savings, respectively. Although the tracking data's report field for the location of the replaced ducts showed crawlspace, project documentation with the test out photographs from the home energy audit indicated most were installed in the attic space. The AR TRM deemed savings factor for all weather zones is higher for the attic than a crawlspace installation. Although the duct system sealing measure kWh realization rate was 100%, there was a lot of variation in the realization rates among the projects. Potential differences between reported and verified gross savings is that reported calculations used baseline condition SEER and HSPF values in the savings calculations when a new central air conditioner unit or heat pump was installed. ADM determined if a new central air conditioner unit or heat pump was installed and used the SEER and HSPF of the installed unit in the savings calculations. Additionally, the kW realization rate is over 100% because the ex-ante potentially utilized a baseline SEER value of 13 for all sites, while ADM used the SEER value of the new unit when appropriate.

Ground Source Heat Pumps: Two homes installed ground source heat pumps resulting in realization rates of 196% for energy savings and 256% for demand savings. The AHRI certification document in the program tracking database was reviewed and used for the

[81] Federal Standard, https://www.regulations.gov/document?D=EERE-2011-bt-ce-0077-0102

inputs to the savings algorithm. There was an error in the tracking data for one of the two ground source heat pump projects, as the reported savings was only 12 kWh. This was likely due to a discrepancy in the reported capacity as it was reported as 60 BTU/hr (instead of 60,000 BTU/hr). The overall savings for GSHP is a small percentage of the Home Rebates program and has little impact.

Heat Pumps: The realization rate for new heat pumps was 67% for energy savings and 81% for demand savings are due to the baseline efficiency difference. The reported calculations used a SEER of 12.44 and HSPF of 7.7 rather than the updated 2015 federal minimum value of 14 SEER and 8.2 HSPF. Additionally, projects for “mini split” heat pump installation often replaced a traditional “window” air conditioner but had the baseline capacity of a larger unit in the home listed. In those cases, the baseline capacity was set equal to the new mini split, to only consider the mini split heat pump energy savings. However, the gross verified savings did include the “right sizing” for units that were similar in size, for example, a 1-ton heat pump replacing a 1.5-ton air conditioner.

Electronically Commutated (ECM) Furnace Fan Motor: The energy savings were equal for the expected and verified resulting in a 100% realization rate, with no demand savings as the motor efficiency is only realized during the heating months, as the high efficient motor savings are already included in air conditioning SEER values.

Attic Insulation: The measure had realization rates of 96% and 106% for energy and demand savings, respectively. Ex-post savings values were calculated using the AR TRM for attic insulation. The AR TRM provides deemed savings for post insulation value of R-38 and R-49. Savings were interpolated for installed insulation levels between R-38 and R-49. The program implementor provided additional data for the homes with post installation R values that initially did not appear to reach the required R-value. The pictures in the tracking data were verified by ADM for the installation depth. Of these, three were spray foam insulation, with the verified savings determined by the AR TRM measure for Roof Deck Insulation which recognizes the performance of spray foam insulation in reducing infiltration through the attic floor.

Floor Insulation: There was only a single project implemented for floor insulation. The realization rate for energy savings was 107% and -23% for demand savings. There is some uncertainty in the verified savings, as the tracking data indicated a larger installed area, but ADM estimated the square footage from the Test Out pictures for the application of spray foam insulation.

Exterior Wall Insulation: There was also only one project completed for wall insulation with a realized savings of 100% for both the energy and demand savings.

Knee Wall Insulation: The AR TRM based savings with the verified inputs for the savings algorithm indicated realization rates of 90% and 94% for energy and demand savings, respectively. The realization rate is driven by the ex-ante savings for 3 homes (or 7% of

knee wall insulation projects), which appear to be determined by the OKDSD deemed values, then migrated to the AR TRM method for later projects.

Radiant Barrier: There was just one home that had a radiant barrier installed. The realization rate was 178% energy savings. There is some uncertainty in the savings, as the installed area had the same value as an associated measure for wall insulation. The radiant barrier deemed savings are modeled for an attic. The impact is small to the program savings, with 339 kWh of expected savings. The verified savings estimate was based on the tracking data system data for installed size.

ENERGY STAR® Windows and Doors: The calculated savings were based on the installed area and the deemed savings values by climate zone and HVAC equipment, with realization rates of 83% for energy savings and 86% for the demand savings. The realization rate is less than 100% because the ex-ante savings used OKDSD deemed values while the ex-post calculation used AR TRM deemed values.

3.5.3.2.3 Multiple Upgrades NTG Estimation Results

Survey data from a total of 76 Multiple Upgrades participants were used to determine the NTG ratio for this program. Survey respondents were asked a series of questions aimed at determining the program influence on the purchase and installation decisions for each installed measure. The measure-level free ridership of each participant was weighted by the measure energy savings to determine the project-level free ridership score. This score was applied to the other measures where a survey response was not obtained.

The survey also included questions related to their retail purchase or contractor installation of similar products offered by the program. Although 12 responses provided specific details of the product, the savings were not considered spillover as some were gas saving measures, or their program influence score was not high enough to claim added savings in the NTG estimation.

The simple average free ridership score was 10.2%. The measure score was weighted and rolled up into the project level score and applied to the verified gross savings for the projects without a survey response. The sum of the verified net project savings over the total verified gross savings resulted in a NTG ratio of 89.8%.

3.5.4 Single Upgrade

3.5.4.1 EM&V Methodology

This section provides an overview of the gross and net impact evaluation of the Single Upgrade component of the Home Rebates program. The primary data collection activities for Single Upgrade consisted of a participant online/telephone survey, a separate sample of on-site verification visits, in-depth interviews with program staff, and discussions with project auditors. Additional data reviewed included a census of program tracking data

from Sightline database, SQL Server Reporting Services (SSRS) and, when necessary, project documentation obtained from VisionDSM. Program tracking data for Single Upgrade included customer contact information and descriptions of the measures installed.

The process evaluation for all program components is provided in Section 3.5.6.

3.5.4.1.1 Sampling Plan

Table 3-108 summarizes the sample size for each primary data collection activity. The random sample for verification was designed to achieve ±10% relative precision or better at the 90% confidence interval.

Table 3-108: Sample Sizes for Data Collection Efforts – Single Upgrade

Data Collection Activity	Achieved Sample Size
Participant Survey	136
On-Site Verification Visits	43
In-Depth Interviews with Program Staff	2

The sample size for the participant survey was determined by the minimum sample size algorithm with 90% precision and 10% relative precision constants, for a value of 68 which was exceeded with 136 surveys completed.

The sample for in-home inspections was designed to achieve ±10% relative precision or better at the 90% confidence interval. The reported savings values were aggregated by the measure name, then sub sampled dependent on the expected energy savings. Participants were contacted for every measure, but the ground source heat pump measure could not be visited. The completed sample design achieved 8.3% precision.

Table 3-109: Sample Design Single Upgrade

Stratum	Measure	Upper Boundary	Lower Boundary	Population	Sampled	CV	Reported Energy (kWh)
Stratum 1	Insulation – Attic	7,831	800	55	4	0.73	97,516
Stratum 2	Insulation – Attic	800	0	110	5	0.35	52,662
Stratum 1	Central AC	4,300	2000	171	6	0.17	415,181
Stratum 2	Central AC	2,000	1500	225	4	0.09	394,159
Stratum 3	Central AC	1,500	0	766	9	0.21	835,310
Stratum 1	Air Source Heat Pumps	9,281	0	119	5	0.46	444,081
Stratum 1	VSD Pool Pump - Year Round	3,736	2000	47	2	0.16	117,113
Stratum 2	VSD Pool Pump - Year Round	2,000	0	112	3	0.29	145,281
Stratum 3	VSD Pool Pump - Year Round	12,452	1100	85	6	0.70	152,779
Stratum 1	VSD Pool Pump - Summer Only	1,100	0	21	2	0.12	19,421
Stratum 1	Ground Source Heat Pumps	6,224	0	12	0	0.63	27,547
Total							**2,701,050**

3.5.4.1.2 Data Collection

Participant Surveys

For the Single Upgrade program, there were a total of 136 completed surveys. All Single Upgrade participants were pulled from the tracking data and included in the survey sample list. Due to the limited number of participants with valid email addresses in the tracking data, the survey had to be administered via online and telephone. Any participant with a valid email address was sent the online participation survey. A total of 691 participants were sent the online survey, which resulted in 113 survey completes. Any participant that did not have a valid email address was contacted via telephone call. A total of 373 participants were called for the telephone survey, which resulted in 23 survey completes. Special care was taken so that no participants received both the online and telephone surveys.

On-site Verification Visits

On-site verification visits were conducted for 43 participants. During the visits, ADM field staff verified measure installation and operational characteristics. For HVAC equipment, the type, capacity, efficiency ratings, and model numbers were recorded. For attic insulation, installation was visually verified, and pre- and post-insulation levels were

measured where possible. Heating and cooling system types were also recorded along with an approximate measurement of square feet of insulation installed. For high efficiency windows/doors, the total count of new units was recorded along with heating and cooling system type. Where possible, pre-existing window type (dual/single pane) was recorded. Pictures were taken during all on-site visits to document measure installation and characteristics. The findings from the on-site verification visits were compared to information in the program tracking database to verify that input to savings calculations were correctly recorded.

Program Staff Interviews

Program staff members from PSO and an implementation contractor (ICF) were interviewed to elicit the program administrator perspective on program processes and operations.

3.5.4.1.3 Gross Impact Methodologies

The method used to calculate energy (kWh) and demand impacts (kW) consisted of reviewing a census of program tracking data. The tracking data was reviewed for a census of homes and measures. ADM verified there were not any duplicate project data entry errors. ADM calculated in-service rates (ISR) by measure for a sample of program participants using data from onsite verification visits.

Reviewed Reported Savings Estimates for Each Measure

ADM reviewed reported savings calculations for all measures to provide an explanation of any savings discrepancies.

Calculated the verified Gross savings utilizing:

- Oklahoma Deemed Savings Document (OKDSD)
- Arkansas Technical Reference Manual 7.0 (AR TRM)

A brief description of each measure calculation methodology has been described in the Multiple Upgrades section above (see Section 3.5.3.1.3), except variable speed drive pool pumps. Appendix F includes the measure-level algorithms and deemed savings values utilized for the verified gross kWh and kW savings calculations.

Variable Speed Drive Pool Pumps: Savings were estimated with the algorithms in the OKDSD document. The savings algorithms inputs are dependent upon the horsepower of the motor, and the seasonal usage.

3.5.4.1.4 NTG Estimation

This section provides a summary of the method used to score survey responses for free ridership and spillover. The online survey sample and phone survey of program participants were asked a series of questions aimed at estimating program attribution and

identifying spillover measures. The attribution scoring system had three components: measure-level free ridership score, project-level free ridership score, and the spillover score. Each part is described individually below. Details of the questions used for free ridership and spillover estimation are listed in Section 3.5.8.

This NTG estimation method for the Single Upgrade component of the Home Rebates program is the same as that for the Multiple Upgrades component (Section 3.5.3.1.4), except in the Single Upgrade program, each participant was limited to two equipment upgrades so the free ridership assessment was similarly limited.

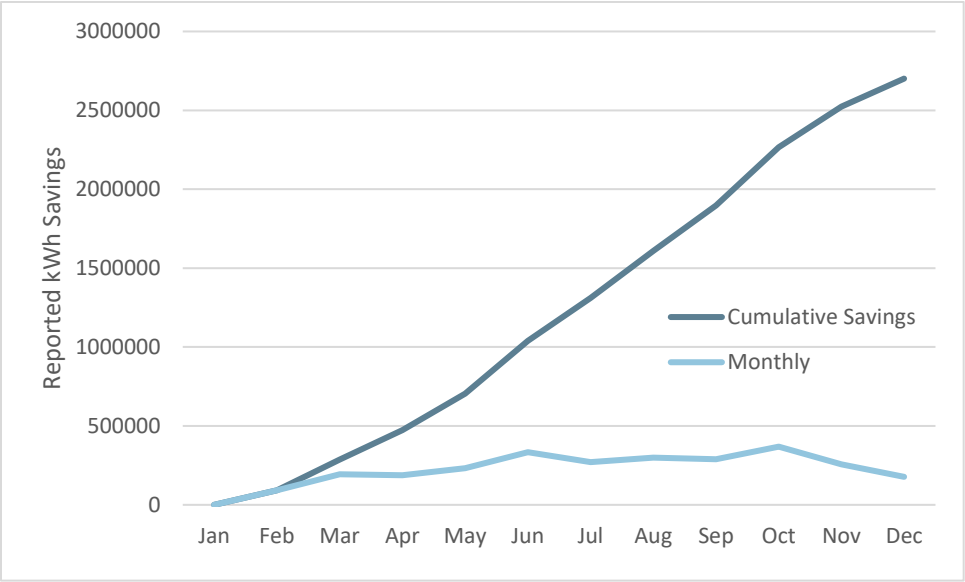
3.5.4.2 Impact Evaluation Findings for Single Upgrade

This section details the level of the Single Upgrade program activity for 2019, the reported and verified gross savings that resulted from that activity, and the NTG estimates that were applied to the gross savings to produce the net savings reported in Section 3.5.5.

3.5.4.2.1 Program Activity for Single Upgrade

The Single Upgrade portion of Home Rebates in 2019 had 1,639 total projects installed as part of the program. Final energy savings were based on a total of 1,726 energy-savings measures. Figure 3-28 lists the monthly energy savings along with the cumulative annual savings.

Figure 3-28: Cumulative Reported kWh Savings during the Program Year – Single Upgrade



Net Savings: Based on the impact evaluation results, the total verified net energy savings for the Single Upgrade program are 1,611,264 kWh, and the total verified net peak demand savings are 708.91 kW. A summary of Single Upgrade impact findings is shown in *Table 3-110*.

Table 3-110: Single Upgrade-Gross, Net Energy & Demand Savings

Program	Gross Verified Energy (kWh)	Gross Verified Demand(kW)	NTG Ratio	Net Verified Energy (kWh)	Net Verified Demand (kW)
Single Upgrade	1,611,264	708.91	82.5%	1,329,946	585.14

3.5.4.2.2 Single Upgrade Reported and Verified Gross Savings

The verified gross and reported savings by measure are shown in the following table. The savings estimates result in a gross annual energy realization rate of 60% and a peak demand reduction realization rate of 67%.

Table 3-111: Reported and Verified Gross Energy and Peak Demand Savings

Measure	Reported Energy (kWh)	Reported Demand (kW)	Gross Verified Energy (kWh)	Gross Verified Demand (kW)	RR_{kWh}	RR_{kW}
Heat Pumps	444,081	78.40	228,382	45.13	51%	58%
Central AC	1,644,650	781.94	743,447	457.87	45%	59%
Ground Source Heat Pumps	27,547	15.40	53,658	15.40	195%	100%
Attic-Ceiling Insulation	150,178	89.62	153,970	90.40	103%	101%
Pool Pumps	434,594	100.11	431,807	100.11	99%	100%
Total	**2,701,050**	**1,065.47**	**1,611,264**	**708.91**	**60%**	**67%**

The gross impact analysis consisted of verifying measure installation and reviewing the program tracking data to ensure the deemed savings algorithms were appropriately applied. ISRs for each measure type were developed based on the findings from the on-site visits. Findings from on-site visits determined a 100% ISR for all measures in Single Upgrade for PY2019. A description of verified findings for each measure type is included below:

Heat Pumps: The energy savings for heat pumps had a 51% realization rate and the demand savings rate of 58%. The reported calculations used a SEER of 12.44 and HSPF of 7.7 rather than the updated 2015 federal minimum value of 14 SEER and 8.2 HSPF.

Central Air Conditioner: The energy savings for central A/C units had a 45% realization rate for energy savings and 59% for demand savings. The reported calculations used a SEER of 12.44 rather than the updated 2015 federal minimum value of 14 SEER. The right sizing of the unit, reducing the capacity of new unit to less than the baseline unit, was considered when the tow capacities were similar (i.e., a 1-ton mini split replacing a 1.5-ton unit, but not a 1-ton unit replacing a 4-ton unit). ADM assumed that the contractor right sized the unit in the baseline condition.

Ground Source Heat Pump: The energy savings for ground source heat pump units had a 195% realization rate and the demand savings 100%. The baseline matched the federal guidelines of SEER 14, as the ground source heat pumps were replacing other types of HVAC equipment. The ex-post savings included both heating and cooling season savings, as the site visits showed the units would be used year-round.

Attic Insulation: The energy savings realization rate was 103% and the demand savings realization rate was 101%. The AR TRM based savings table are based on two final insulation values with many starting R-values. The extra savings between the R-38 and R-49 table values were interpolated. The extra inches of insulation that provide an R-value beyond the R-49 table were not included, as the heat transfer rate diminished with each extra R-value past R-49. The realization rate is over 100% because approximately 35% of homes had final insulation levels between R-38 and R-49. For these homes the ex-ante used the deemed values for R-38 while the ex-post used the interpolated values.

Variable Speed Drive Pool Pumps: ADM calculated savings for each home with a variable speed drive pool pump and determined the measure kWh realization rate to be 99%, and the kW realization rate to be 100% by applying the same OKDSD deemed savings table values. The verified savings for the year-round pool pumps included the same annual operating days as the tracking data algorithm, although the TRM lists longer operating days for the year-round pumps.

3.5.4.2.3 Single Upgrade NTG Estimation Results

Survey data from a total of 136 Single Upgrade participants were used to determine the NTG ratio for this program. Survey respondents were asked a series of questions aimed at determining the program influence on the purchase and installation decisions for each installed measure. Each respondent was assigned a free ridership score (ranging from 0 for no free ridership to 1 for complete free ridership) based on their responses for each measure they installed. The free ridership scores for all survey respondents were then weighted by kWh savings and averaged to determine the program-level free ridership rate. The simple average free ridership score was 17.4%. Contributing to that free ridership score was an average score of 17.7% for heat pumps, 16.9% for central air conditioners, 17.7% for ground source heat pumps, 16.9% for attic insulation, and 18.5% for variable speed drives on swimming pool pumps. The measure score was weighted and rolled up into the project level score and applied to the verified gross savings for the projects without a survey response. The sum of the verified net project savings over the total verified gross savings resulted in a NTG ratio of 82.5%.

Survey respondents were also asked a series of questions to determine if they had installed any additional, non-rebated, energy efficiency measures because of their participation in the program (spillover). Seventeen respondents said they had installed

additional measures, and that their participation in the program was influential in their decision to do so. There were 17 responses with measures identified by the participants. After comparing the premise account numbers with other projects within the Single Upgrade program and projects competed in the Multiple Upgrades program, the eligibility was reduced by half. Further vetting the responses identified gas appliances, lighting that may be incentivized in the retail channel, and products that could not be verified as energy efficient. The result was zero spillover savings attributed to the program from the sampled responses.

3.5.5 Home Rebates Impact Evaluation Findings

The component programs of the Home Rebates are listed below with the verified gross energy and demand savings in Table 3-112.

Table 3-112: Program Level Gross Energy and Demand Savings

Program	Reported Energy (kWh)	Reported Demand (kW)	Gross Verified Energy (kWh)	Gross Verified Demand (kW)
New Homes	1,773,721	582	1,751,077	822
Multiple Upgrades	2,169,158	1,073	1,918,839	1,303
Single Upgrade	2,701,050	1,065	1,611,264	709
Total	**6,737,964**	**2,723**	**5,180,243**	**2,867**

Table 3-113 and Table 3-114 summarize the verified net impacts of the complete Home Rebates program.

Table 3-113: Verified Gross and Net Energy Savings

Program	Free Ridership	Participant Spillover	NTG Ratio	Gross Verified Energy (kWh)	Net Verified Energy (kWh)
New Homes	20.0%	0%	80.0%	1,751,077	1,400,862
Multiple Upgrades	10.2%	0%	89.8%	1,918,839	1,723,142
Single Upgrade	17.4%	0%	82.5%	1,611,264	1,329,946
Total				**5,180,243**	**4,373,200**

Table 3-114: Verified Gross and Net Peak Demand Reduction

Program	Free Ridership	Participant Spillover	NTG Ratio	Gross Verified Demand (kW)	Net Verified Demand (kW)
New Homes	19.0%	0%	81.0%	582	666
Multiple Upgrades	10.2%	0%	89.8%	1,303	1,172
Single Upgrade	17.4%	0%	82.5%	709	585
Total				**2,867**	**2,450**

3.5.6 Process Evaluation Findings

The evaluation team at ADM performed a process evaluation that assessed program documentation and primary data collected from program stakeholders. The evaluation included participant surveys, completed interviews with program staff, reviewed program documentation, and analyzed the program tracking data. A portfolio level process evaluation memo was provided to PSO after the completion of the program year.

3.5.6.1 New Homes

The following summarizes the key findings of the process evaluation of the New Homes component:

- **New Homes experienced changes to its operations**. PSO changed the process of payments for New Homes' incentives. Payments now follow a two-week, rather than monthly, cycle. As a result of this change, service providers have finished project completion documentation faster than in previous cycles.
- **New Homes expected to meet goals.** This has been a high participation year, according to staff. There has also been an increase in the number of builders participating in the program. The year-end total was 879 homes completed, with two builders having built 205 and 194 homes, respectively. Staff believe the program will continue to thrive in the future as the new builders' return.
- **Innovation budget used for free HERs ratings to encourage participation from new builders.** This year PSO staff indicated they offered to copay with ICF (through its innovations budget) for a free assessment to raters who recruited new builders into the program.
- **House price, location, and interior features are most important to home buyers.** Homebuyer survey respondents rated various factors in their decision to buy their home on a scale ranging from "not at all important" to "extremely important." Survey respondents most frequently rated the house price (68%) as important to them, followed by location (63%), interior features (53%), and general appearance (47%).

- **Many homebuyers buy homes built to PSO program standards.** Builders stated that approximately 86% of their customers purchased a new home that was built to the PSO program standards. Fourteen percent of builders stated that none of their customers purchased a new home built to the PSO program standards. Nearly two-thirds of survey builders were unable to estimate how much more, on average, homes built to the PSO program standards would cost than other comparable homes. Those who provided an estimate indicated the cost difference would range from $2,000 to $7,500. Builder estimates of the percentage of home buyers in the current market who would choose not to pay for the additional process to qualify the home ranged from 15% to 80%.
- **New Homes appears to positively influences builder practices.** About three-quarters of builders indicated their specifications or building practices have changed since they began with the program and two-thirds indicated they had integrated new construction elements into their building standards. Those elements included: framing techniques, foam insulation, duct sealing, LED lighting, air sealing, insulation, and HERs ratings. Two-thirds of builders indicated it was a great or moderate advantage to have an independent HERs rating in selling a home.
- **High satisfaction among builders with the New Homes component.** More than two-thirds (78%) of the respondents were very satisfied with the PSO New Homes program. The same percentage of respondents were somewhat or very satisfied with their interactions with the New Homes program staff and more than three-quarter (80%) were somewhat or very satisfied with the program's paperwork and recording-keeping processes.

3.5.6.2 Single and Multiple Upgrades

The following summarizes key findings of the process evaluation of the Single & Multiple Upgrades components:

- **Program design changes in 2019**. There were some changes to the Multiple Upgrades' incentive amounts and measures:
  - **ECM Motors:** PSO decreased the bonus from $150 to $25 for ECM motors and will not be claiming any direct savings from the measure. ICF indicated no savings claims for ECM motors but allowed service providers to use the motor as a third measure to qualify for the program.
  - **HVAC**: PSO program manager indicated the offer shift for SEER 15 (MU) to SEER 16. The SEER 15 units are no longer the minimum for the program; instead SEER 16 units are now the baseline. PSO added tiers to the incentives for SEER 18 to 19.99, and an additional bonus was added for SEER 20+ (in previous program years it had been 18+).

- **Duct Insulation and Duct Sealing:** Program staff stated there was a change in how duct replacement and duct sealing incentives were calculated. Previously, the incentives were based on the number of returns and registers; now the incentives are based on tonnage of the air conditioning unit. This change helped standardize how duct sealing and replacements are counted.
- **Heat pumps:** The ground source heat pump incentive increased to $1,200 plus a $525 per ton.
- **Information about rebates is easier to find on the website**. According to PSO staff, the site is now more user-friendly. Staff stated they redesigned the website so that the measures are categorized and laid out in a way that is easier for customers to find.

- **Single Upgrade made changes to incented measures in PY2019**. PSO removed the ECM motor offering, which affected participation according to ICF. The program increased the ground source heat pump incentive from $600 to $800, adding $350 bonus per ton. Program staff stated they no longer offered $100 bonuses to use the mobile application for service providers. This bonus was used at the onset of the mobile app, but this is now a requirement. As a result, the mobile application has created less work for service providers. However, one staff member explained that not every contractor was willing or could adapt to the new technology.
- **Lower participation in Multiple Upgrades and Single Upgrade, but the Home Rebates program overall is expected to meet savings goals**. There has been low participation in the Multiple and Single Upgrade components of the Home Rebates program in PY2019 compared to prior program years. PSO believed this was due to a less warm summer. The Multiple Upgrades component had low participation in air sealing installations, as well. PSO created a separate program for multifamily because that segment is uniquely residential and commercial, and that change decreased overall involvement in the Home Rebates program by about 20%.
- **Multiple Upgrades reduced the number of third-party verifiers (TPV) and adjusted testing fees and requirements**. PSO reduced the number of TPVs to one sole provider (Precise Building Performance). According to ICF, the other provider was not meeting PSO's standards for service and professionalism. Test-in fees also increased from $125 to $150 per test. PSO indicated the Manual J was no longer a requirement. ICF stated the program improved how service providers tested homes because there is less documentation to complete compared to previous years.

- **Marketing and outreach efforts included gift cards and bonuses.** PSO indicated it did an eblast to market the Single Upgrade program in Bartlesville and Lawton. PSO offered a $25 Walmart gift card for participation in Single Upgrade. Single and Multiple Upgrades provided an additional $500 bonus for HVAC change-out to increase sales due to the low demand for this measure during the summer. According to staff, the offer will probably extend until November. PSO indicated it offered a free home energy check-up to past Single Upgrade participants in the Northern region of their service territory. PSO staff believe its monthly newsletters are helpful for marketing and outreach. PSO staff also stated they used Facebook and billboards to advertise the program in Lawton and Tulsa.
- **Communication between PSO and ICF remained consistent**. Meetings are still on a biweekly basis through the phone. PSO indicated there was an in-person meeting this program year. Although service providers have an accessible communication channel to PSO, the program manager indicated that the PSO website could be challenging to navigate and believes the website could improve (e.g., how and where information can be found online).
- **Program experienced changes in tracking and reporting**. PSO continues to use Vision for data management, and PSO still receives a monthly spreadsheet. PSO does receive an additional report regarding heat pumps. For the Multiple and Single Upgrade component, PSO is now using a mobile intake tool. The tool can be used on site and data is recorded in real time. One staff member also indicated that they created an additional reporting tool for heat pumps. ICF staff member stated they changed the format of their tracking and reporting to improve its understanding. The account manager indicated their clients are satisfied with the formatting changes.
- **Program experienced changes to quality assurance and quality control (QA/QC).** There has been an increased number of desk reviews for Single and Multiple Upgrade projects, and 10% to 15% of projects are verified out in the field. All rebates are processed in the Tulsa office and are verified before checks are sent out. If mistakes or flaws are found during the process, the processing team reaches out directly to those specific service providers to correct issues. Before and after photos are submitted and geotagged through the rebate app. The most significant change to the QA/QC process was the addition of the Power Rebates app for the Single Upgrade component of the Home Rebates program. Staff believes current procedures for ensuring quality control are adequate and did not anticipate any significant changes in the future.

The following summarizes planned program changes of the Single & Multiple Upgrades components:

- **Changes to Single Upgrade for PY2020**. Program staff indicated HVAC measures will move to a midstream program for Single Upgrade next year. The program staff have secured the distributors and are looking to roll out early during PY2020. Staff believes the change will expand the program to more rural areas. The only measures that will be available through Single Upgrade will be pool pumps and attic insulation. The implementor, ICF noted they foresee some issues in quality assurance that may arise because of this change, such as contractors buying measures at an earlier time to save money.

3.5.7 Conclusions and Recommendations

The following recommendations are offered for continued improvement of the New Homes component:

- **Collaborate with the National Association of Realtors or the Residential Real Estate Council chapter in Oklahoma to appeal more to realtors about Green Appraisal courses**. These two organizations focus on providing continuing education for realtors. More Oklahoma realtors could benefit from knowing that energy-efficient "green" measures can improve building appraisal and produce a higher return on property investment. This would increase awareness about these courses and their importance.
- **Have all involved parties agree upon an energy modeling software before the start of the program year.** This will help avoid differences in savings calculations that can be attributed to software type or software versions.
- **Have all involved parties agree upon a baseline home before the start of the program year**. This will help avoid differences in savings calculations that can be attributed to baseline home variations.

The following recommendations are offered for continued improvement of the Multiple Upgrades component:

- **Consider creating educational/instructional how-to videos for customers.** Home improvement how-to videos can be advertised through a digital newsletter or other print ads such as bill inserts. Videos should highlight or emphasize the importance of a contractor's expertise and the need for energy efficiency home audits. Promoting contractor and customer relationships may increase home projects and maintain high-quality standards that PSO promises its customers.

- **Consider developing a system to automate communication between service providers and the Third-Party Verifier (Precise Building Performance).** Service providers mentioned that job completion, and thus paperwork submission, can sometimes be delayed when test-out assessments do not pass. They are not usually informed when this occurs. A system to automate communication between the service providers and the third-party verifier can help to alleviate some of the frustrations of not knowing whether job completion paperwork can be submitted, or if it is to be delayed due to a specific reason.

The following recommendations are offered for continued improvement of the Single Upgrades component:

- **Consider creating educational/instructional how-to videos for customers.** Home improvement how-to videos can be advertised through a digital newsletter or other print ads such as bill inserts. Videos should highlight or emphasize the importance of a contractor's expertise and the need for energy efficiency home audits. Promoting contractor and customer relationships may increase home projects and maintain high-quality standards that PSO promises its customers.
- **Assess the critical touchpoints for the Single Upgrades component**. Explore where customers might experience a negative interaction during their time in the program and create processes that will help PSO staff navigate through the challenges.

3.5.8 Multiple Upgrades/ Single Upgrade Net-To-Gross Questions

Questions relating to the assessment of net-to-gross (NTG) address both free ridership and spillover. Both the participant survey and service provider survey include questions relating to program participation and free ridership. For customers who completed projects that did not include HVAC measures, the free ridership score is based entirely on responses to questions in the participant survey. For customers who completed projects that included HVAC measures and who reported that equipment information or a recommendation from their service provider was highly influential in their decision to implement the HVAC measures, the assessment of free ridership includes information from the service provider survey. This is because program education and outreach efforts for HVAC measures may influence service providers' selling of efficient equipment in ways that are not apparent to customers.

The following subsections describe the questions from the participant and service provider surveys that the evaluation team at ADM used to assess free ridership and spillover, as described in Section 3.5.3.1.4 of this report.

3.5.8.1 Participant Free Ridership Questions

The participant free ridership (PFR) questions addressed the following criteria to determine the likelihood that a customer is a free rider:

- Financial ability to install the energy efficiency measures without program support
- Prior plans regarding installation of the energy efficiency measures
- Likelihood of implementing the measures in the absence of the program
- The program's impact on the timing of measure implementation

3.5.8.1.1 Financial Ability

Financial ability was assessed with the following question:

> PFR1: Would you have been able to make the financial investment to complete the [MEASURE] project if the rebate was not available?

Respondents who indicated that they were not able to afford the efficiency measure without the financial support provided by the program were deemed to not be free riders. For all others, a free ridership score was assigned based on a combination of their reported prior plans to implement the measure, the reported likelihood they would have installed one without the program, and the reported effect of the program on the likely timing of the installation (as described in following subsections).

3.5.8.1.2 Prior Plans

The presence of plans prior to involvement with the program was assessed through the following questions:

> PFR2: Before learning about the [program] rebate, did you have plans to purchase or install the [measure] that you received a rebate for?
>
> PFR3: Did you [install/complete] [a more efficient/more] [measure] than you would have if you had not received a rebate through the [program]?

For measures other than duct sealing and knee wall insulation, if FR2 = Yes and FR3 = No, then Plans = 1, otherwise Plans = 0.

3.5.8.1.3 Likelihood of Implementing the Measure in the Absence of the Program

The respondents' stated likelihood of implementing the measure in the absence of the program was assessed through the following three questions:

> PFR6: Using a scale where 1 means not at all likely and 5 means very likely, how likely is it that you would have [INSTALLED/COMPLETED] the same [MEASURE] if the rebate was not available?
>
> PFR7: Using a scale from 1 to 5 where 1 means "not at all likely" and 5 means "very likely," how likely would you have been to complete the following upgrades if you had not learned of the program from ["Online Ad" "Bill insert" " PSO website" "Print Ad" "PSO monthly e-newsletter"]?
>
> PFR8: [IF MULTIPLE UPGRADES OR RESPONDENT HAD AN ASSESSMENT] Using a scale where 1 means not at all likely and 5 means very likely, how likely is it that you would have [INSTALLED/COMPLETED] the same [MEASURE] if it was not recommended [through the home energy assessment/by your service provider]?

Based on the responses to the likelihood question, the following point values were assigned to each of the responses:

> 1 (Not at all likely) = 0
>
> 2 = .25
>
> 3 = .5
>
> 4 = .75
>
> 5 (Very likely) = 1

The Likelihood score was based on the lowest rating provided on questions FR6 through FR8.

3.5.8.1.4 Program Impact on Timing

The program effect on the timing was assessed with the following two questions:

> PFR8: Did you [INSTALL/COMPLETE] the [MEASURE] sooner than you would have if the [PROGRAM] rebate had not been available?
>
> PFR9: When might you have installed/completed the same [MEASURE] if you had not participated in the [PROGRAM]? Would you say …

The responses to these questions produced a Timing score in a manner consistent with the AR TRM definition of a free rider as someone who would have implemented a program measure within one year of when it was installed through a program. If FR8 = No, meaning the respondent did not install the measure sooner because of the program, the Timing score = 1, and the preliminary free ridership score is not changed. If FR8 = Yes, the Timing score ranges from .5 to 0, depending on how much the project was advanced in time because of the program:

> If PFR9 indicates the program advanced the timing of the project by less than six months (i.e., without the program, the respondent would have installed the measure within 6 months of when it was installed), the Timing score is .5.
>
> If PFR9 indicates the program advanced the timing of the project by 6 months to one year, the Timing score is .25.
>
> If PFR9 indicates the program advanced the timing of the project by more than one year, the Timing score is 0.

3.5.8.2 Participant Questions to Assess Service Provider Influence on HVAC Installation

The participant survey asked participants:

> PFR10: Did the service provider that you worked with provide you with information or a recommendation to [INSTALL/COMPLETE] the energy efficient [MEASURE]?
>
> PFR11: On a scale where 1 means “not at all influential and 5 means “very influential,” how influential was the information or recommendation provided by this service provider in your decision to [INSTALL/COMPLETE] the [MEASURE]?

A “Yes” response to PFR10 and rating of 5 for PFR11 indicates service provider influence.

3.5.8.3 Service Provider Free Ridership Questions

The service provider survey included two service providers free ridership (SPFR) questions:

> SPFR1: On a scale of 1 to 5 where 1 is “not at all important” and 5 is “very important,” how important was the [PROGRAM], including the incentive and

information provided through the program, in influencing your level of marketing and selling of energy efficient products to PSO customers during [YEAR]?

SPFR2: Thinking about the projects that you completed as part of the PROGRAM in [YEAR], did the availability of incentives from the program influence the type, quantity, or efficiency level of the items that you recommended to customers? In other words, would you have made different recommendations if the program were not available?

The responses to SPFR1 were scored as following (where higher values indicated higher free ridership):

1 (Not at all important) = 1

2 = .75

3 = .5

4 = .25

5 (Very important) = 0

If the service provider answered "Yes" to question SPFR2, the score from SPFR1 is reduced by 50%.

3.5.8.4 Spillover Questions

Spillover (SO) is defined as energy efficiency measures that respondents report installing in their home without receiving additional incentives but that were installed based on program influence. Potential spillover respondents were identified using the question below:

SO1: "Following your participation in the PSO's Multiple Upgrades Service, did you install any additional energy efficiency upgrades in your home for which you did not receive a rebate or financial incentive?"

Customers who responded "No" to this question were determined to not be potential spillover candidates. If a respondent indicated that they have installed additional energy efficiency measures, they were then asked:

SO2: "Did your participation in PSO's Multiple Upgrades program influence your decision to install the additional energy efficient upgrades in your home?"

Customers who responded "Yes, Strongly Influenced" or "Yes, Somewhat Influenced" were considered potential spillover candidates and were asked to identify the additional measures they have installed. The measures identified were then checked to ensure they had not received a corresponding PSO rebate through any program and that they represent measures with the potential to save energy. All measures that passed through this screening process were assigned a savings value based on the deemed savings

documents. Verified spillover savings for a given customer were then divided by the project-level reported savings for that customer. The resulting percentage is the total spillover score for that participant.

3.6 Education Program

3.6.1 Program Overview

The PSO Education Program has operated continuously since 2010 but has only claimed savings since 2016. The Education Program was formerly composed of three subprograms, which consisted of Residential, Non-residential, and Schools components. PSO discontinued the Residential and Non-residential components in 2018. Therefore, the program year 2019 (PY2019) evaluation exclusively focuses on the Schools component. Table 3-115 summarizes PY2019 performance metrics for the Schools component.

Table 3-115: Performance Metrics – Education Program

Metric	PY2019
Number of Customers	14,820
Budgeted Expenditures	$1,144,000
Actual Expenditures	$873,910
Energy Impacts (kWh)	
Projected Energy Savings	4,394,641
Reported Energy Savings	3,679,492
Gross Verified Energy Savings	3,507,610
Net Verified Energy Savings	3,507,610
Peak Demand Impacts (kW)	
Projected Peak Demand Savings	516.84
Reported Peak Demand Savings	687.17
Gross Verified Peak Demand Savings	674.94
Net Verified Peak Demand Savings	674.94
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	2.10
Utility Cost Test Ratio	2.18

The Education Program, known by teachers, students, and parents as the PSO Super Power Saver! Program, provides teachers, parents, and students with educational materials and energy-efficient products for use in their homes. Teachers enrolled in the program educate their fifth-grade students about electricity and the benefits of saving energy in their homes.

The PSO Super Power Saver! webpage[82] includes resources for teachers, students, and parents that offer a range of information from energy efficiency information to installation instructions for the measures provided in the kits. The kits are sent home with the students, who then seek out the help of their parents with the installation of the included measures. Students then complete an included post-program survey and return it to the teachers.

The effective use of compelling stories creates student engagement throughout which illustrated characters such as C.A.D.E. (the Champion and Defender of Energy) participate in energy-saving adventures. Students learn about energy-saving habits and ways to be more energy-efficient at home. Students then return home with their Super Power Saver! Kit (Table 3-116 lists measures included in the kit and verified energy savings and demand reduction per kit), which encourages them to install the measures from the kit at home. Students who are eager to learn more can find “Cool Links” on the Super Power Saver! website that includes resources and games marketed towards children such as the Department of Energy Kids and Energy Information Administration (EIA) Kids.

The implementer developed a curriculum for the program that spans five days and meets the Oklahoma Academic State Standards. This curriculum allows teachers to easily integrate the program into their existing curriculum at no cost to the school district, teacher, and students. The ready-made curriculum includes documentation explicitly outlining each Oklahoma Academic Standard supported through the program in each of three areas (language arts, mathematics, and science).

Teachers have the option of accessing many additional resources via the PSO Super Power Saver! Website. These additional resources enrich the students’ experience in the program by learning about energy efficiency throughout other organizations such as ENERGY STAR®. It also offers the opportunity to participate in additional activities to engage students beyond the provided program materials.

A quiz assesses the students’ knowledge about energy efficiency and conservation before and after participating in the program. Surveys accompany the quizzes. The Home Check-Up Survey collects information about the home; impact calculations utilize this information, which includes the type of heating fuel and air conditioning. The Home Activities Survey collects information about measure installation; impact calculations utilize this information known as installation rates (ISR). Teachers are eligible for a 50 dollar gift card when 80% of their student surveys are completed and returned.

[82] https://www.pso-education.com/

Table 3-116: Summary of Kit Content and Verified Energy Savings and Demand Reduction

Kit Contents	Quantity	Verified kWh Savings Per Measure	Per measure kW Reduction	Verified Aggregate kWh Savings	Per Kit kW Reduction
ENERGY STAR® LED	4	18.36	0.001936	73.45	0.007745
Advanced Power Strip	1	91.94	0.010570	91.94	0.010570
FilterTone® Alarm	1	50.07	0.027227	50.07	0.027227
Digital Thermometer	1	0.00	0.000000	0.00	0.000000
LED Night Light	1	21.22	0.000000	21.22	0.000000
Total				**236.68**	**0.045542**

Some of the available program literature for parents was developed in English and Spanish and add to the program's penetration and efficacy. A "parent pack" was included in the kit that includes a bilingual "Quick Start Guide" to help parents with product installation and other energy-savings tips. Furthermore, a bilingual informational bulletin was included to help parents understand what they need to do to participate. Parents also have the option to visit the Super Power Saver! website for installation instructions and other energy-saving information. The "Save More" information is a direct link to PSO's Power Forward with PSO website[83] and includes available rebates, resources for the home, and other tips.

3.6.2 EM&V Methodologies

This section provides a brief overview of the data collection activities, gross impact calculation methodologies, net-to-gross estimation, and process evaluation activities that ADM employed in the evaluation of the Education Program.

3.6.2.1 Data Collection

The primary data collection for the evaluation is the tracking data, which documents the number of kits distributed to students. The tracking data review consisted of screening for duplicate entries, unexpected number of kits per teacher, and the correct climate zone characterization for the FilterTone® alarms. Secondary data collection consisted of student self-reported survey results from surveys included in the kit. The teachers gather the surveys and return them to the implementer. The implementer encourages teachers to instruct their students to complete the surveys with the help of their parents. ADM reviewed the student survey results to calculate ISR.

[83] https://powerforwardwithpso.com/

ADM conducted two in-depth interviews with program staff to gain insight into the process evaluation. ADM completed interviews in October 2019 with the PSO Program Coordinator, who managed the program and the implementation Program Manager. Table 3-117 summarizes the data collection activities and purpose.

Table 3-117: Data Collection and Sample Size Effort by Survey

Data Collection Activity	Data Use	Achieved Sample Size
Program Tracking Data	Impact/Process	14,820
Student Survey (Return by Mail)	ISR/Process	2,438
Implementation Staff Interviews	Process	2

3.6.2.2 Reported Savings Calculations Review

ADM reviewed reported savings sources and calculations for all measures to explain any savings discrepancies. Table 3-118 below shows the sources used by ADM and the implementer.

Table 3-118: Source of Measure Savings Algorithms

Measure	Verified Savings Reference Source	Reported Savings Reference Source
Advanced Power Strip	Arkansas TRM v.7.0	Oklahoma Deemed Savings Document
LED Night Light	2016 Pennsylvania TRM	2016 Pennsylvania TRM
FilterTone® Alarm	2016 Pennsylvania TRM	2016 Pennsylvania TRM
ENERGY STAR® LED	Arkansas TRM v.7.0	Oklahoma Deemed Savings Document

The source for measure level ISR was the program year 2017 (PY2017) ex-post evaluation. The source for the equivalent full load hours (EFLH) for the FilterTone alarms calculation was the PY2016 – PY2018 Demand Portfolio Model.

3.6.2.3 Gross Impact Methodologies

The general methodology used to calculate energy-savings (kWh) and demand impacts (kW) consisted of:

- **Reviewed a census of program tracking data:** ADM reviewed the tracking data for a census of kits. ADM verified there were not any duplicate project data entry errors.
- **Calculated verified savings:** The sources for deemed savings algorithms are the 2016 Pennsylvania Technical Reference Manual and Arkansas Technical Reference Manual v7 (AK TRM).

- **Determined measure installation:** ADM calculated the ISR for ENERGY STAR® LEDs, FilterTone® alarms, LED night lights, and the digital thermometer using data collected from a sample of program participants in the student surveys and used the ISR for APS from PSO's PY2019 – PY2021 Demand Portfolio Model.

ENERGY STAR® LEDs

The algorithm used to determine energy-savings and demand reduction for ENERGY STAR® LEDs is in Appendix F, Section F.1.5.1.

The AR TRM stipulated value for hours of use for omnidirectional lamps is 792.6 hours for a lamp. ADM used 960 hours based on the 2016 Energy Savings Products Memo. ADM determined total gross energy and demand savings for each measure in the program; total gross energy and demand savings are a product of the number of measures verified as installed and the deemed savings per measure.

Advanced Power Strips

The algorithm used to determine energy-savings and demand reduction for advanced power strips in residential applications is in Appendix F, Section F.1.5.2. An ISR of 50% was used for the advanced power strips, as documented in PSO's PY2019 – PY2021 Demand Portfolio Model filed on June 29, 2018.

FilterTone® Alarm

The algorithm used to determine energy-savings and demand reduction for FilterTone® Alarms is in Appendix F, Section F.1.5.3. The student survey informed the ISR calculation.

LED Night Light

The algorithm used to determine energy-savings for LED Night Lights is in Appendix F, Section F.1.5.4. The student survey informed the ISR calculation.

Digital Thermometer

PSO did not claim energy-savings or demand reduction for the digital thermometers distributed in the Education Program kits.

3.6.3 Net-to-Gross Estimation

The Education Program has a net-to-gross (NTG) of 100%. The fifth-grade students and parents of the students do not have the option to opt-out of the program. The teachers decide whether or not to participate. It is therefore not reasonable to assume that a parent or student was a free rider when they received the kit.

3.6.4 Impact Evaluation Findings

Table 3-119 report the verified energy-savings (kWh) of the 2019 Education Program by measure.

Table 3-119: Gross Energy-savings (kWh) Summary by Measure for PY2019

Measure	Number of measures in Kit	ISR	Reported Energy (kWh) Savings	Verified Energy (kWh) Savings	Realization Rate	Ex-Post Lifetime Energy-savings (kWh)
Advanced Power Strip	14,820	50.0%	1,127,566	1,362,573	120.8%	13,625,731
LED Night Light	14,820	80.7%	311,618	314,411	100.9%	2,515,290
FilterTone® Alarm	14,820	41.7%	1,122,157	742,083	66.1%	10,389,158
ENERGY STAR® LED	59,280	58.0%	1,118,151	1,088,543	97.4%	9,636,812
Total			**3,679,492**	**3,507,610**	**95.3%**	**36,166,990**

Table 3-120 reports the demand reduction (kW) of the 2019 Education Program by measure.

Table 3-120: Gross Demand Reduction (kW) Summary by Measure for PY2019

Measure	Number of measures in Kit	ISR	Reported Demand (kW) Reduction	Verified Demand (kW) Reduction	Realization Rate
Advanced Power Strip	14,820	50.0%	131.50	156.64	119.1%
LED Night Light	14,820	80.7%	0.00	0	-
FilterTone® Alarm	14,820	41.7%	405.67	403.51	99.5%
ENERGY STAR® LED	59,280	58.0%	150.00	114.78	76.5%
Total			**687.17**	**674.94**	**98.2%**

Overall, the realization rate for energy-savings and demand reduction was 95.3% and 98.2%, respectively. However, there was high variability between measures in realization rates. A portion of the differences between reported and verified savings for the advanced power strips and ENERGY STAR® LEDs are due to the differences in sources used to determine the measure level savings. Detailed descriptions of differences in the savings calculations are in the measure level findings below.

3.6.4.1 Advanced Power Strip

ADM calculated the deemed savings values for an average advanced power strip installed in the Education Program and determined the total program level kWh and kW impacts as 1,362,573 kWh and 156.64 kW, respectively. The program level realization rates for kWh and kW were 120.8% and 119.1%, respectively.

ADM used the student survey to determine the percentage of the controlled system type, which was then applied to the energy-savings and demand reductions to create weighted average savings and demand reduction for advanced power strips. Table 3-121 illustrates the differences in deemed savings calculations.

Table 3-121: Differences Between OKDSD and AR TRM v7.0 for Advanced Power Strips

Oklahoma Deemed Savings Document			Arkansas TRM v.7.0		
System Type	**kWh**	**kW**	**System Type**	**kWh**	**kW**
Home Entertainment System	141	0.018	Home Entertainment System	252.2	0.03
Home Office	84	0.009	Home Office	82.5	0.008
Other Devices	75	0.009	Average APS	167.4	0.019

Finally, ADM used a 50%[84] ISR for advanced power strips, whereas the implementer used the ISR of 75.92%, which ADM reported in the PY2017 evaluation. Therefore, a combination of the different savings algorithm sources and ISR resulted in a higher realization rate.

3.6.4.2 LED Night Light

ADM calculated the deemed savings values for LED night lights installed in the Education Program and determined the total program level kWh impacts as 314,411 kWh. The program level realization rates for energy-savings was 100.9%. The differences in energy-savings for the LED night lights are due to the difference between ISR used in the calculations.

3.6.4.3 FilterTone® Alarm

ADM calculated the program level kWh and kW impacts for FilterTone® Alarms to be 742,083 kWh and 403.51 kW, respectively. The program level realization rates for kWh and kW were 66.1% and 99.5%, respectively. The differences in savings calculation was the value of EFLH used in the algorithm and the ISR.

3.6.4.4 ENERGY STAR® LED

ADM calculated the deemed savings values for ENERGY STAR® LEDs installed in the Education Program and determined the total program level kWh and kW impacts as 1,088,543 kWh and 114.78 kW, respectively. The program level realization rates for kWh

[84] This value was used in PSO's PY2019 to PY2021 Demand Portfolio Model. ADM believes this is a reasonable value based on student surveys that indicate that 75.8% of APS were installed, and 57.4% of students responded they "work[ed] with their family on this program". Because the APS is more technical to install, it is expected that help from a family member would be required for correct installation. When the ISR is weighted by the percentage of students who worked with their families the result is 43.5%.

and kW were 97.4% and 76.5%, respectively. The differences in savings calculations between ADM and the implementer were due to the deemed savings algorithm source and ISRs.

3.6.5 Process Evaluation Findings

ADM's process evaluation activities included student and teacher surveys and interviews with the PSO Program manager and implementer. ADM provided a process evaluation memo to PSO after the completion of the 2019 program year. The following summarizes the key finding from the process evaluation of the Education program.

- **The Education Program has high participation and acceptance rates.** Through the years, the implementer staff have formed relationships with teachers who utilize the program materials. Many teachers find the materials to be beneficial and complementary to their curriculum according to staff.
- **The program continues to strive for energy efficiency awareness in Oklahoma.** Staff indicated the program continues to be an active channel of interaction among future ratepayers and underserved areas. The program may empower students to share information with their families on the importance of energy conservation.
- **Statistically significant differences in student test scores indicate an increase in knowledge of energy efficiency**. Pre- and post-test score analysis suggests that the program was effective in increasing knowledge of energy efficiency among the students. Further analysis of individual questions revealed a statistically significant difference in pre and post score averages improved for each question.
- **Many of the teachers who responded to the surveys have participated in the past (81%).** Most have participated for more than three years (72%). Ninety-seven percent of teachers stated the educational materials were clearly written and well organized. The respondents also indicated the curriculum was a useful learning tool (91%), and 63% stated that the work and effort they had to invest in teaching the curriculum did not add to their overall workload.
- **The instructors perceived high levels of engagement from their students (83%).** The instructors perceived better comprehension of energy efficiency from them (90%). Student test score analysis indicates a significant improvement of knowledge regarding energy efficiency.
- **Program kit distribution goal not met in PY2019.** Staff indicated the program was expected to achieve goals set for this year of distributing 16,000 school kits. However, they distributed 14,820 by the end of the program year. This was due to

the change from one shipping enterprise system to another when the implementer was acquired.

- **There were a few changes made to Education Program during 2019**. The program only offered school kits for PY2019. The implementer was acquired by a different company. The teacher and student workbooks were updated with references and dates relative to the program year. There are plans to change the dimensions of kits for next year and PSO may consider changing other measures in the following years if measures are no longer cost-effective (e.g., LED bulbs).

3.6.6 Conclusions and Recommendations

The following summarizes the key findings of the impact evaluation of the Education Program:

- **The Education Program did not reach the projected portfolio goals in energy-savings, demand reductions, and distributed kits.** The program achieved 3,507,610 kWh savings (95.3% realization rate) and 674.94 kW reduction (98.2% realization rate). While 14,820 kits were distributed to teachers this program year; the program did not reach its goal to distribute 16,000 kits. The goal was not met due to the implementer's acquisition by a parent company and the technical difficulties with integrating an enterprise shipping system with the implementer's existing shipping system. Integrating systems took approximately one month and therefore delayed the shipment of kits by a month.
- **The program level realization rate was 95.3%.** There was high variability in the realization rate between measures due to different sources of savings algorithms, ISR, and EFLH.
- **ISRs were relatively unchanged from the previous program year, apart from the advanced power strips.** ISRs for PY2019 measures were within ±2% of the PY2018 ISR.
- **Changes made to Education Program staff and operations during 2019.** Despite changes in personnel and program scope, staff reported a smooth transition in operations.

ADM offers the following recommendations for continued improvement of the Education Program.

- **Explore the use of digital resources in the kits and educational material.** While the available content is extensive, six teachers expressed their desire for more digital content. Consider creating a "virtual field trip" with up-to-date video footage of an energy efficient school. Create digital content that students can learn about during instruction time and engage with at home.

- **Explore additional training opportunities for teachers on how to effectively deliver curriculum materials.** The training would include information on how students can work with their parents with the kit materials. Training should include instructions the importance of completing the Home Activities Survey, installing the kit items, and motivating further energy efficiency behavioral changes.

3.7 Behavioral Modification Program

3.7.1 Program Overview

The Behavioral Modification Program provides energy usage reports to residential customers. The program was designed to generate greater awareness of energy use and ways to manage energy use through energy efficiency education in the form of an energy report. The energy report provides customers with energy saving behaviors and compares their current energy use to previous years as well as energy use in similar homes. It is expected that through this education, customers will adopt energy conservation tips that will lead to more efficient energy use in their homes. Customers could choose to opt out if the customer no longer wanted to receive the emailed energy reports. In addition to receiving a report that encourages saving energy, participants were also encouraged to go to an online portal where they could input more specific information to receive tips addressing their specific energy use.

In developing the program, a pool of potential participants was identified that had emails associated with their accounts. If any participant had a month of usage that exceeded 5,000 kWh or was below 100 kWh, they were excluded from the pool of eligible participants. Implementers also filtered the pool of potential participants for single family homes. The program also focused on identifying single family homes within that pool of potential participants using a third-party data set. Lastly, participants were randomized into treatment and control groups and the equivalency of their pre-program year data was verified

PY2019 was the first year that the current implementor executed the program. In PY2017 and PY2018 the program was implemented by a different team. The first group of participants (wave 1) began receiving reports on October 25, 2017. A second wave (wave 2) commenced on May 22, 2018. These participants continued to receive energy reports in 2019. An additional wave was added on March 20, 2019.

For PY2019, reports to wave 1 were delivered via email, wave 2 were delivered via email and mail, and wave 3 were delivered via mail and email, when emails were available. A total of six paper energy reports were mailed to treatment participants in March, May, June, July, September, and November 2019. Emailed reports were sent every month except for February 2019, for a total of eleven emailed reports for wave 1 and wave 2, while wave 3 participants with available emails received ten reports, due to the March 2019 start date.

Table 3-122 shows the performance metrics achieved by the program.

Table 3-122: Performance Metrics – Behavioral Modification Program

Metric	PY2019
Number of Customers	166,937
Budgeted Expenditures	$1,288,750
Actual Expenditures	$1,116,829
Energy Impacts (kWh)	
Projected Energy Savings	18,900,000
Reported Energy Savings	15,638,415
Gross Verified Energy Savings	8,475,928
Net Verified Energy Savings	8,475,928
Peak Demand Impacts (kW)	
Projected Peak Demand Savings	3,436.4
Reported Peak Demand Savings	1,785.2
Gross Verified Peak Demand Savings	967.6
Net Verified Peak Demand Savings	967.6
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	0.45
Utility Cost Test Ratio	0.43

PSO's Behavioral program serviced 166,937 households during the 2019 program year. Table 3-123 shows the savings (kWh) per wave for PY2019.

Table 3-123: Verified Energy Savings per Wave

Wave	Number of Treatment Customers	Daily kWh Savings per Customer	Average Annual kWh Savings per Customer	Verified Gross kWh Savings	Verified Net kWh Savings
Wave 1	82,484	0.10	36.5	3,010,666	3,010,666
Wave 2	36,521	0.20	73.0	2,666,033	2,666,033
Wave 3	47,932	0.16	58.4	2,799,229	2,799,229
Total	**166,937**	**0.14**	**50.8**	**8,475,928**	**8,475,928**

3.7.2 EM&V Methodologies

This section provides a brief overview of the data collection activities, gross and net impact calculation methodologies, and process evaluation activities that ADM employed in the evaluation of the Behavioral Modification program.

To determine annual kWh savings and kW reduction, ADM performed an analysis of the billing data for participants in the program using panel regression modeling. The data

cleaning steps and methodology for the panel regression approach are presented in the following section.

3.7.2.1 Data Collection

ADM incorporated several types of data into the preparation of the dataset that was used in the regression analysis outlined in this section:

- Pre-program year and 2019 raw monthly billing data for all treatment and control group participants
- Regional temperature obtained from the National Oceanic and Atmospheric Administration (NOAA) for Tulsa International Airport in Tulsa, OK
- Participant information, which included the account number
- Date each treatment participant received their first energy report
- A dataset compiled by ADM of participants in PSO's other residential programs used to control for cross-program participation
- Treatment and control participant surveys to determine LED purchasing patterns and customer satisfaction
- In-depth interviews with program staff to support the process evaluation

3.7.2.2 Survey Sampling Plan

For the calculation of sample size for survey completes, a coefficient of variation of 0.5 was assumed.[85] With this assumption, a minimum sample size of 68 participants was required, as shown in the Equation 3-4 below.

[85] The coefficient of variation, cv(y), is a measure of variation for the variable to be estimated. Its value depends on the mean and standard deviation of the distribution of values for the variable (i.e., cv(y) = sd(y)/mean(y)). Where y is the average savings per participants. Without data to use as a basis for a higher value, it is typical to apply a CV of 0.5 in residential program evaluations.

Equation 3-4: Minimum Sample Size Formula for 90 Percent Confidence Level

$$n_0 = \left(\frac{Z*CV}{RP}\right)^2 = \left(\frac{1.645*0.5}{0.10}\right)^2 = 68$$

Where:

n_0	= minimum sample size
Z	= Z-statistic value (1.645 for the 90% confidence level)
CV	= Coefficient of Variation (assumed to be 0.5)
RP	= Relative Precision (0.10)

3.7.2.3 Survey Procedure

The objective of the participant group member survey was to assess participants' overall satisfaction with the program, perceptions of the reports, actions taken to reduce energy consumption, household characteristics, and quantify lighting purchases. The objective of the control group survey was to assess program uplift, or the difference in energy savings actions/purchases taken by those that receive reports and those that do not.

ADM selected a target sample of 150 per wave (over double the minimum) completed online surveys.

Table 3-124: Summary of Survey Targets and Responses

Wave	Treatment Group		Control Group	
	Number of Customers Targeted	Number of Completed Surveys	Number of Customers Targeted	Number of Completed Surveys
Wave1	1,723	150	2,326	162
Wave 2	1,751	150	2,563	157
Wave 3	1,729	150	2,326	152
Total	**5,203**	**450**	**7,215**	**471**

3.7.2.4 Preparation of Data

ADM performed the following steps to prepare the dataset that was utilized to determine the verified energy savings for the Behavioral Modification Program.

1. Verified that participants were sent energy reports during 2019
2. Calendarized the billing data provided by PSO
3. Cleaned the data for duplicate bills and string characters in the monthly consumption column
4. Removed billing months with negative consumption on their monthly bill

5. Removed billing months with consumption less than 100 kWh or greater than 10,000 kWh
6. Removed billing months with number of billing days less than 25 or greater than 35
7. Removed customers that did not have pre-program and program year data
8. Determined the appropriate pre-treatment time frame for all participants in the program
   - For wave 1, participants started the program on October 25, 2017, the pre-treatment period was January 1, 2016 – December 31, 2016. Due to previous energy efficiency activities that PSO performed for this group before the start of the Behavioral program, ADM found that this is a more representative pre-treatment period
   - For wave 2, participants who started the program on May 22, 2018, the pre-treatment period was May 22, 2017 – May 21, 2018
   - For wave 3, participants who started the program on March 20, 2019, the pre-treatment period is March 20, 2018 – March 19, 2019

3.7.2.5 Cross Participation and Uplift

Cross participants are considered any participant that also participated in PSO's other residential energy efficiency programs during the program year. These programs included the down-stream measures for Energy Savings Products, Home Rebates, Home Weatherization, and Power Hours. ADM compared the cross participation among the treatment and control groups using a two-sample t-test and removed all treatment and control participants from the panel regression model that participated in programs that had a statistically significant difference (p value < 0.10).

Because the participants in the upstream lighting program are unknown, ADM used a different approach to avoid the double counting of savings. Program uplift is the increased participation in other energy efficiency programs due to participation in the Behavioral Modification program. This is calculated by surveying both treatment and control participants in the Behavioral modification program for their lighting purchasing habits. ADM determined whether there was a statistically significant difference in LED purchases between the treatment and control groups using a two-sample t test.

3.7.2.6 Methodology for Regression Approach

ADM utilized the mixed effects panel regression model specified in Equation 3-5 to determine daily average electricity savings for treatment group members.

Equation 3-5: Mixed Effects Panel Regression Model

$$AEC_{i,t} = \alpha_i \text{Customer}_\text{i} + \beta_1 CDD_{i,t} + \beta_2 HDD_{i,t} + \beta_3 Post_{i,t} + \beta_4 Post_{i,t} * Treat_{i,t} + \beta_5 Post_{i,t} * CDD_{i,t} + \beta_6 Post_{i,t} * HDD_{i,t} + E_{i,t}$$

Where the subscript i denotes individual customers and t = 1. $T_{(i)}$ serves as a time index, where $T_{(i)}$ is the number of bills available for customer i. The model is defined as "mixed effects" because the model decomposes its parameters into fixed-effects (i.e. HDD, CDD, Post, Treat, and its various interactions) and random effects (i.e. the individual customer's base usage). A fixed effect is assumed to be constant and independent of the sample, while random effects are assumed to be sources of variation (other than natural measurement error) that are uncorrelated with the fixed effects. The variables included in the regression model are specified in Table 3-125.

The program implementer provided ADM with a dataset that included the participation start date for each treatment group member and their corresponding control group. The first billing period after the beginning of treatment is considered the "deadband period". Observations that occur in the deadband period are not included in the mixed effects panel regression as they contain a mix of pre-treatment and post-treatment data. For the treatment and control group members, the post period begins in the first billing period following the deadband period. The post variable is defined as a 0 in the billing periods prior to the beginning of treatment and a 1 for billing periods following the deadband period.

Heating degree day (HDD) and cooling degree day (CDD) were used in the model to control for energy demand based on outside temperature. HDD is defined as the monthly average difference between 65 degrees (the outside temperature at which it is assumed that a building needs no heating) and the actual outside air temperature. CDD is defined as the monthly average difference between the actual outside air temperature and 65 degrees (the outside temperature at which it is assumed that a building needs no cooling). A minimum value of 0 is used for both HDD and CDD.

Table 3-125: Description of Variables Used in the Regression Model

Variable	Variable Description
Average Electricity Consumption ($AEC_{i,t}$)	Average daily use of electricity for period t for a customer (determined by dividing total usage in a period by number of days in that period)
Customer	A panel of dummy variables that is a 1 for customer i or a 0 if not
Cooling Degree Days (CDD)	The mean cooling degree days per day during the billing period.
Heating Degree Days (HDD)	The mean heating degree days per day during the billing period.
Post	Post is a dummy variable that is 0 if the monthly period is before the customer received their first energy report and 1 if not
Treatment	Treatment is a dummy variable that is 0 if the customer is a member of the control group and a 1 if not
E_t	E_t is the error term

Table 3-126 describes the coefficients that were determined by using the mixed effects panel model shown in Equation 3-5.

Table 3-126: Description of the Coefficients Estimated by the Regression Model

Coefficient	Coefficient Description
α_i	α_i is a coefficient that represents the grand mean (mean of the unique customer specific intercepts). The customer specific intercepts control for any customer specific differences.
β_1	β_1 is a coefficient that adjusts for the main effect of cooling.
β_2	β_2 is a coefficient that adjusts for the main effect of heating.
β_3	β_3 is a coefficient the main effect of time, i.e., whether an observation falls in the pre-period or post-period.
β_4	β_4 is a coefficient that represents the interactive effect of whether an observation falls in the post-period and the treatment effect. This coefficient represents savings attributable to the program.
β_5	β_5 is a coefficient that adjusts for the interactive effect between the post-period and cooling.
β_6	β_6 is a coefficient that adjusts for the interactive effect between the post-period and cooling.

3.7.2.7 Calculation of kWh Savings

The average daily kWh savings value for the post period treatment groups is coefficient β_4 in the regression model. To determine per participant annualized savings, the kWh savings value is multiplied by 365. The verified kWh savings for the program was determined by multiplying the annualized kWh savings by the number of participants that were in the treatment group.

3.7.2.8 Calculation of kW Peak Reduction

The kW peak reduction was determined by dividing the kWh annual savings by the number of hours in the year (8,760).

3.7.2.9 Net-to-Gross Estimation

The Behavioral Modification Program was administered using a randomized control trial (RCT) design, allocating participants to either the treatment or control group randomly. As a result, free riders are equally likely to be distributed in both the treatment and control group. The NTG ratio is assumed to be 1, because the RCT design minimizes selection bias and the only assumed difference between the treatment and control groups is the receipt of energy reports.

3.7.3 Impact Evaluation Findings

The following section reports the findings for PY2019 kWh savings and kW peak reduction.

3.7.3.1 Data Review

ADM calculated the average daily pre-treatment consumption for both the treatment and control groups for participants with valid billing data. This step was performed to ensure that the average daily pre-treatment consumption was similar for both the treatment and control groups. The results are reported in Table 3-127.

Table 3-127: Pre-Treatment Average Daily Consumption

Wave	Treatment Group		Control Group		t test p value
	Number of Customers	Average Daily Pre-Treatment kWh	Number of Customers	Average Daily Pre-Treatment kWh	
Wave 1	82,484	42.49	18,807	42.54	0.46
Wave 2	36,521	47.89	15,630	47.89	0.98
Wave 3	47,932	36.00	23,962	35.96	0.39

3.7.3.2 Cross Participation

ADM determined whether there was a difference in participation in PSO's other residential energy efficiency programs by comparing participation in treatment and controls groups using a two-sample t test. Of these, ADM determined that the only program for which there was a statistically significant difference (p value < 0.10) in participation between the treatment and control groups was the Home Weatherization program. Therefore, these cross participants were removed from the panel regression model data.

Table 3-128: Cross Participation with the Weatherization Program

Home Weatherization Program	Control Group		Treatment Group		t-test p-value
	n	%	n	%	
Wave 1	87	0.46%	509	0.62%	0.01
Wave 2	59	0.38%	179	0.49%	0.05
Wave 3	92	0.38%	237	0.49%	0.04

Since the participants of the Energy Savings Products' (ESP) upstream lighting program are unknown, ADM surveyed Behavioral Program treatment and control participants to understand their lighting purchases. To determine program uplift on upstream LED purchases due to the Behavioral Modification program, ADM performed a two-sample t-test on the treatment and control survey data results regarding lighting purchases. The results are provided in Table 3-129. The results of the t-test show that no significant program uplift in LED purchases due to the Behavioral Modification program. Waves were also tested individually and no statistically significant difference in LED purchases between Treatment and Control participants by wave were identified (results not shown).

Table 3-129: Cross Participation with ESP's Upstream Lighting Program

Control Group		Treatment Group		t test p value
Mean Number of LEDs Purchased	n	Mean Number of LEDs Purchased	n	
10.2	337	8.2	285	0.60

3.7.3.3 Data Cleaning

Table 3-130 shows the data cleaning steps ADM took and the number of accounts left after each step to determine the data to be used in the model. The steps and rational for removing participants were based on whether they were cross-participants in other residential PSO programs, if there was no active billing data in the program year, billing records were abnormal or outliers, or participants had insufficient data to include in the panel regression analysis. A description of the data cleaning steps is provided in Section 3.7.2.4.

Table 3-130: Number of Accounts After Each Data Cleaning Step

Cleaning Step	Wave 1		Wave 2		Wave 3	
	Control Group	Treatment Group	Control Group	Treatment Group	Control Group	Treatment Group
Participant list	24,000	104,999	17,830	40,170	25,000	50,000
Participants not active PSO customers in the program year removed	18,807	82,484	15,630	36,521	23,962	47,932
Cross participants removed	18,697	81,884	15,561	36,298	23,854	47,657
Outliers removed	18,578	81,272	15,412	35,949	22,705	45,262
Accounts with insufficient data removed	18,174	79,561	15,212	35,548	22,552	44,988
Number of accounts in final model:	**18,174**	**79,561**	**15,212**	**35,548**	**22,552**	**44,988**

3.7.3.4 Calculated Energy Savings (kWh)

Table 3-131 provides the results of the mixed-effects panel regression model.

Table 3-131: Results of Mixed Effect Panel Regression Modeling

Wave	Post x Treat Coefficient	Std. Error	T-Statistic	P-Value	R-Squared
Wave 1	-0.10	0.05	-2.09	0.04	0.71
Wave 2	-0.20	0.07	-2.78	0.01	0.74
Wave 3	-0.16	0.04	-3.67	0.00	0.61

3.7.3.5 Total Energy Savings (kWh)

The kWh savings by wave are reported in Table 3-132 below.

Table 3-132 kWh Savings, by Wave

Wave	Number of Treatment Customers	Daily kWh Savings per Customer	Average Annual kWh Savings per Customer	Verified Gross kWh Savings	Verified Net kWh Savings
Wave 1	82,484	0.10	36.5	3,010,666	3,010,666
Wave 2	36,521	0.20	73.0	2,666,033	2,666,033
Wave 3	47,932	0.16	58.4	2,799,229	2,799,229
Total	**166,937**	**0.14**	**50.8**	**8,475,928**	**8,475,928**

3.7.3.6 Total Peak Reduction (kW)

The results by wave are reported in Table 3-133.

Table 3-133: kW Peak Reduction, by Wave

Wave	Number of Treatment Customers	Verified Net kW Peak Reduction
Wave 1	82,484	343.68
Wave 2	36,521	304.34
Wave 3	47,932	319.55
Total	**166,937**	**967.57**

3.7.3.7 Verified Gross Impacts

Verified and reported energy savings (kWh) and peak demand reduction (kW) in Table 3-134.

Table 3-134: Reported and Verified kWh and Peak Demand kW

Reported Energy Savings (kWh)	Reported Peak Demand Savings (kW)	Verified Gross Energy Savings (kWh)	Verified Gross Peak Demand Savings (kW)	kWh Realization Rate	kW Realization Rate
15,638,415	1,785.2	8,475,928	967.57	54%	54%

3.7.4 Process Evaluation Findings

ADM's process evaluation activities included participant surveys, an interview with the PSO Program manager, and an interview with the implementer. ADM provided a process evaluation memo to PSO in December of 2019. The following summarizes the key findings from the process evaluation of the Behavioral Modification program.

The PSO Behavioral Program had a new implementer and underwent several changes beginning in 2019: adoption of mailed paper reports and a more regular schedule of report delivery; addition of Smart Energy Rewards; and reduced cross-promotion of other PSO programs.

Information from the treatment and control group surveys identified areas of potential program impact:

- Survey respondents largely found the energy report information on their home's energy use to be accurate and information in the report to be valuable Additionally, respondents generally were satisfied with most aspects of the energy report and reported an increase in knowledge about energy efficiency since receiving the information.

- Consistent with the generally positive attitudes toward the energy reports, satisfaction with PSO among program participants generally increased or remained the same since receiving them.
- Based both on participant self-reports and comparisons between participant and controls, the energy reports appear to induce respondents to take more actions to reduce their energy use – most commonly, things that involved day-to-day activities or relatively little effort, like turning off lights when leaving the room, cleaning or replacing air filters, and running the clothes washer with a full load. Exceptions were that relatively few respondents reported taking shorter showers, lowering the water heater temperature, unplugging electronics or kitchen appliances when not in use, and adjusting the refrigerator temperature – all things that should not involve much effort.

Despite the changes mentioned above and the positive attitudes toward the program and evidence of program impacts on some behavior, the program was not expected to meet savings goals for 2019. Findings primarily from the participant survey shed light on the lack of program impact:

- While most participants found the report information on their home's energy use to be accurate, some believe the information to be inaccurate and comparisons with other homes to be questionable. Many of those concerned about inaccuracy of the comparisons cited ways in which their homes were not comparable to average homes in their areas.
- While about one-third of participants reported they had purchased or installed energy efficient equipment or appliances in 2019, most commonly installing LEDs, treatment participants were *not* more likely than control participants to report installing such items. As was the case with energy-saving activities, the most common items installed were those that are used frequently and/or involve little cost or effort.
- While the addition of Energy Rewards was part of an effort to increase engagement through "behaviorally informed" best practices, both awareness of and participation in the Energy Rewards addition were low. Most surveyed participants reported not having noticed information on it in their report.
- While paper may reach a market segment who are not highly digitally engaged, evidence suggests that the program may not have as much impact on those who prefer them as it does on more digitally engaged customers. Those who prefer the mailed reports were less likely to use My Energy Advisor, which was positively related to several program success indices. They also tended to find the information contained in the report less easy to understand, compared to other participants. These findings point to a need to identify participants who prefer

mailed information and seek a way to improve their experience, including by making the information in the report easier to understand.

In addition to the above, ADM observes that reduced cross-promotion of other PSO programs may not be the best strategy. Anecdotal evidence from the current evaluation indicates that some participants indicated frustration that they were advised to install energy efficient equipment and appliances but were not aware of the existence of PSO rebate programs to help them do that.

3.7.5 Conclusions and Recommendations

The following conclusions were developed from the evaluation findings.

- The final verified net kWh savings and verified net kW savings are 8,475,928 kWh and 967.57 kW, respectively.
- While savings goals were not met in PY2019, the program generated more savings per participant for wave 2 as compared to program year 2018. Additionally, wave 3 generated higher savings in its first year than either waves 1 or 2.

The following recommendations are offered for improvement of the Behavioral Program.

- **PSO and the implementer should develop evidence-based messaging** to induce participants to take additional energy-saving actions that do not require significant effort or expense, such as reducing water heater temperatures, unplugging electronics or kitchen appliances when not in use, and adjusting refrigerator temperatures.
- **The implementer should make information on Smart Energy Rewards more prominent** in the report to increase awareness of and participation in it.
- **The implementer should seek a way to improve the experience of participants who prefer mailed information**, such as by making the information in report easier to understand.
- **PSO should consider re-emphasizing My Energy Advisor.** Logging onto My Energy Advisor was related to several indices of program success.
- **PSO and the implementer should consider re-introducing cross-promotion of other programs** to ensure that participants are fully equipped to act on report recommendations to install energy efficient equipment.

3.8 Conservation Voltage Reduction (CVR) Program

Under contract with Public Service Company of Oklahoma (PSO), ADM Associates, Inc. (ADM) is performing measurement and verification (M&V) activities to confirm the energy savings (kWh) and demand reductions (kW) being realized through the demand programs that PSO implemented in PY2019. This document is the Evaluation Report for the PY2019 Conservation Voltage Reduction (CVR) Program.

3.8.1 CVR Program Overview

PSO's Conservation Voltage Reduction (CVR) program uses a system of devices, controls, software, and communications equipment to manage reactive power flow and lower voltage level for implemented distribution circuits. Under ANSI Standard C84.1 Electric Power Systems and Equipment, a utility system is to deliver electricity to end-users at a voltage within the range of 120 ± 5% volts (i.e., 114 – 126). With the usual system design, customers close to a substation receive voltages closer to 126 volts and customers farther from the substation receive lower voltages. Because most electric devices are designed to operate most efficiently at 115 volts, any "excess" voltage is typically wasted, usually in the form of heat.[86] PSO's CVR program uses a software program called "Yukon", a control system from Eaton that monitors the voltage and power factor along the distribution circuit and lowers the voltage profile within an acceptable bandwidth. The tighter voltage regulation provided by CVR technology allows end-use devices to potentially operate more efficiently without any action on the part of consumers. Consumers receive a lower but still acceptable voltage and use less energy to accomplish the same tasks.

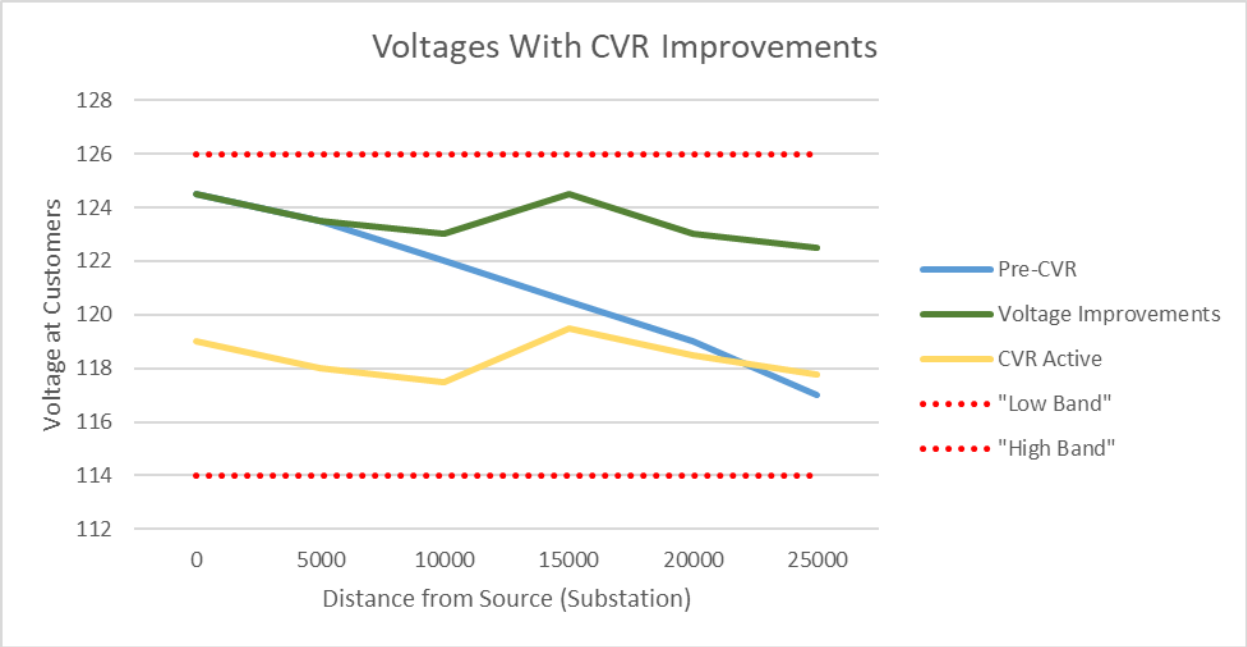
PSO approached the implementation of CVR in a holistic, system-wide manner, to fully optimize the energy efficiency potential. PSO considered the following three system configurations and decided on full implementation of these configurations.

- Typical distribution configuration: This configuration utilizes existing equipment in its current state to assist with distribution operation. It does not include any update to equipment or settings.
- Distribution equipment location optimization: This configuration includes new optimized locations with new equipment and settings for capacitor banks and regulators, which allow the system to operate more efficiently.
- Networked distribution equipment settings optimized: The final stage includes optimized locations for the equipment, along with end of line sensors that monitor the voltage. All of the equipment is now communicating with a backend system (Yukon) and a fully implemented CVR system.

[86] https://www.tdworld.com/grid-opt-smart-grid/cvr-here-stay

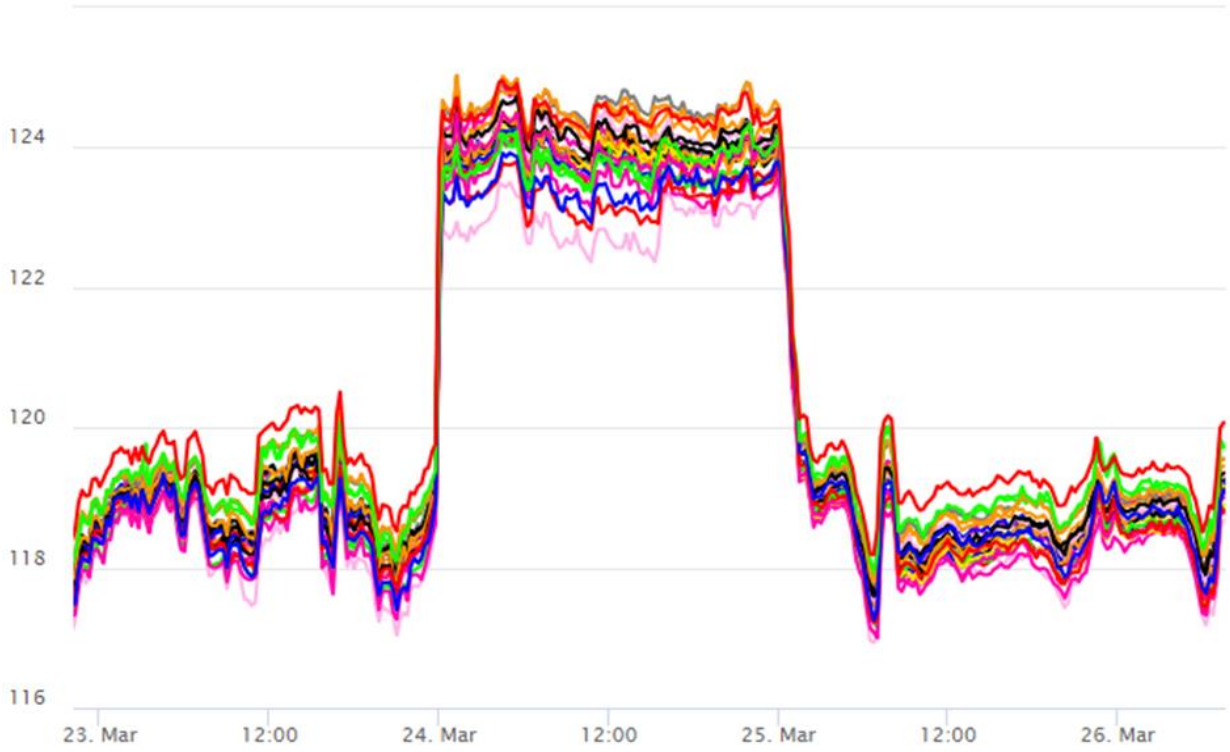
The inclusion of systematic upgrades results in a more consistent delivery of voltage to customers. As shown in Figure 3-29, blue represents voltage of a typical distribution system configuration, green represents a typical distribution system with equipment locations and settings optimized, and yellow represents the lowered voltage with typical CVR enabled (hardware and software). Keeping the system below 120V provides an efficient voltage for customers and reduced load demand from the utility and reduced usage from the customer.

Figure 3-29: Various Voltage Profiles with Modifications



A tighter distribution of voltages is evident in PSO's implementation of optimizing networked distribution equipment. As shown in Figure 3-30, CVR is enabled on March 23rd, disabled on March 24th, and enabled on March 25th. Each colored line represents a piece of equipment along the feeder providing a unique voltage reading. The tighter the distribution, the tighter bandwidth that PSO is operating at along the entire circuit. A larger distribution of voltages would likely indicate the system could not reduce voltage drop further through the utilization of system upgrades such as a capacitor bank, thus resulting in additional energy losses. When CVR is enabled, there is a significantly lower voltage with a tighter spread between the voltage points, compared to when CVR is disabled.

Figure 3-30: Example PSO Circuit with CVR and Upgrades during Evaluation Testing



In order to support CVR at this level of configuration, PSO had electrical engineers design, model, and coordinate the installation of equipment. Once the equipment was installed, the engineers worked with numerous departments to implement a communication network and install Eaton's Yukon software to get CVR active and online. PSO followed a bid process to select Eaton's Yukon software based on price, features, and operational standards.

The PY2019 CVR program M&V evaluation consisted of 4 substations and 15 circuits (See Table 3-135). PSO's CVR deployment included upgrades inside the substation, as well as on the distribution system. Inside the substation included installing a new RTU, as well as new relaying or metering equipment to provide all the necessary information for the CVR system to function properly. The distribution system required the installment of voltage regulators, capacitor banks, end of line monitors, and repeaters. Once the construction was complete, all devices underwent a commissioning period of field testing. After field testing was completed and Yukon was programmed, CVR was put into service.

Table 3-135: CVR Deployment Timeline

Substation	Construction Start Date	Construction Complete Date	In Service Date
Henryetta	May-2018	Dec-2018	12/26/2018
North Mingo	July-2018	Dec-2018	12/26/2018
Okemah	Apr-2018	May-2018	9/1/2018
Tulsa North 138	Aug-2018	Dec-2018	12/26/2018

The additional equipment installed, by substation, is listed in Table 3-136.

Table 3-136: System Equipment Upgrades

Substation	Capacitors	Regulators	End of Line Devices
Henryetta	14	12	13
North Mingo	12	5	5
Okemah	11	9	15
Tulsa North 138	13	7	13

Gross kWh reported energy savings were projected to be 9,754,550 kWh. ADM's verified savings estimates for CVR are 10,439,497 kWh, resulting in an 107.0% realization rate for gross energy savings. The estimated peak demand reduction is 2,063.86 kW. Table 3-137 provides reported and verified program performance metrics.

Table 3-137: PY2019 CVR Program Overview

Metric	PY2019
Budgeted Expenditures	$641,321
Actual Expenditures	$801,114
Energy Impacts (kWh)	
Projected Gross Energy Savings	8,161,998
Gross Verified Energy Savings	10,439,497
Peak Demand Impacts (kW)	
Projected Gross Peak Demand Savings	1,773
Gross Verified Peak Demand Savings	2,064
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	1.35
Utility Cost Test Ratio	1.43

PSO implemented the program using Eaton's Yukon Integrated Volt/VAR Control (IVVC) automation software.[87] Voltage levels were controlled independently for each of the three phases for all evaluated circuits.

3.8.2 CVR EM&V Methodologies

For the PY2019 CVR Program, ADM estimated typical year annual energy savings (kWh) resulting from the implementation of CVR for the first year of each circuit. This section provides a description of the data collection, data cleaning, and regression analysis methodologies that ADM employed in the evaluation of the Conservation Voltage Reduction program.

3.8.2.1 Data Collection

ADM provided a schedule of events to either deactivate CVR or conduct a transition test on the evaluated circuits on certain days prior to the operation of the technology. The schedule was balanced in terms of days where CVR was either on, off, or had transition tests conducted such that ADM would be able to maximize operational time but still have enough "off" and "transition test" period data to achieve a statistically significant counterfactual baseline for the evaluation methodologies employed in this analysis. In addition, timeseries voltage and power consumption data at minute intervals was provided to ADM by PSO every month for the evaluated circuits reflecting the substation

[87] Eaton Integrated Volt/VAR Control
https://www.eaton.com/content/dam/eaton/products/utility-and-grid-solutions/grid-automation-systems/volt-var-management/volt-var-management-software/integrated-volt-var-control-br910005en.pdf
https://www.eaton.com/FTC/buildings/KnowledgeCenter/WhitePaper2/index.htm

operating schedule recommended by ADM. Upon delivery of this data ADM conducted a review to verify that the "off" events and transition tests were responding as expected such that it could be incorporated into the final analysis of savings. ADM alerted PSO to any abnormalities or departures from steady state operation that would interfere with the accurate evaluation of savings.

3.8.2.2 Data Cleaning

ADM performed an extensive review of data which involved both algorithmic and graphical detection of abnormalities. This involves any sudden voltage or consumption spikes, repeating values, or other unusual behaviors not characteristic of typical substation data. Data identified as capable of biasing the regression analysis was necessarily removed as even small abnormalities can alter results when trying to identify a relatively small effect (less than a 5% change in consumption) due to operation of CVR mode. A Mahalanobis algorithm was applied which identified data points whose consumption was a group outlier relative to its weather conditions. A value of .9 was used as the Chi Squared Distribution quantile cutoff for outliers; this had the effect of removing approximately 10% of data points in addition to those removed through graphical review. The minute interval time series data is aggregated to hourly intervals to reduce noise associated with smaller time intervals.

3.8.2.3 On / Off Regression Analysis

The on/off regression analysis for CVR is the accepted industry standard for evaluation of voltage control technologies.[88] It involves running a regression of the form:

$$kWh = a_o \times Mode + a_1 \times WeatherVar + a_2 \times HourOfTheDay + a_3 \times DayType$$

Where the coefficient a_0 gives the estimated savings found by virtue of operating in CVR mode, and the rest of the terms control for primary consumption effects. Separate regressions are run for the cooling season dataset (May through October) and the heating season dataset (November through April). Weekday and weekend effects are accounted for using a variable in the regression.

For the most accurate results, the data that is input into the regression consists of an approximately equal number of data points where CVR was on and off under like conditions. Since the schedule ADM provided to PSO consisted of approximately one day per week where CVR was off to maximize operational time, this meant filtering down to days adjacent to any days where CVR was off to maximize the likelihood of capturing like conditions. The appropriately matching "on" day was selected from a set of one to two

[88] Conservation Voltage Reduction/Volt VAR Optimization EM&V Practices https://www.energystar.gov/sites/default/files/asset/document/Volt%20Var%20and%20CVR%20EMV%20Best%20Practice%2006-01-17clean%20-%20508%20PASSED.PDF

days before and after each “off” data point by finding the most closely matching temperature value to the given “off” data point.

The final estimate of savings for each circuit and phase in the evaluation pool was developed by taking the CVR factor for each circuit and phase from the analysis and multiplying it by the percent change in voltage of the voltage profile that best reflects both the average baseline and average operational voltages for that circuit.

Where available, ADM uses voltages from circuit regulators. We will take a weighted mean across the line voltage regulators (where the weights are determined by the load for each regulator section) in both their off and on conditions. Regulator voltages represent operating conditions accurately in cases where the substation is operated on a load tap change (LTC) system. LTC’s have limited functionality due to operating in a “gang” related manner: if one phase is raised, all three must be raised and vice versa. This creates a limit in the system’s ability to lower voltage both due to load imbalances between phases and from geographic limitations. For imbalanced phases, the minimum achievable voltage on one phase limits the change in voltage on the other phases (i.e. Phase B with an operational midline around 120 volts will not be able to achieve lower voltages if Phase A is already at its’ lower limit). Geographic limitations exist in systems that include a large variety of conductor sizing and load locations. This mainly applies to rural areas where there may be three feeders on one transformer, but each feeder has a very different distribution of load. Regulator stations provide the ability to isolate voltages along the line for providing a more accurate representation of the system voltage profiles.

Where regulator voltage and kilowatt-hour data are not available, ADM uses the operational voltages from the feeder head. In this method, the baseline condition is determined to be the pre-installation operational voltages from the feeder head. Applying the pre-installation voltages helps account for the efficiency improvements made by new equipment (capacitor banks, regulator stations, etc.) that otherwise would not be detected in the “off” condition after the new equipment installation.

CVR factors along with the adjusted voltage profiles are applied to full year consumption as determined by AMI data from PSO. Typical year annual energy savings are determined for the first year in which CVR has been implemented.

3.8.2.4 Transition Test Analysis

The transition test analysis involved determining the effect on consumption for each test and then averaging the effect across all tests for each circuit and phase to develop a reasonable estimate of savings. For each approximately 10-minute long transition test, the consumption and voltage were averaged across the transition test portion and the time periods approximately 10 minutes prior and following the test. The estimated daily savings for each date (which can consist of 2-4 individual transition tests) is then calculated using a weighted average where the weights are the average consumption

conditions at the time of each test. These values are then averaged across the entire season of transition tests to develop an estimate for daily average savings. From this, a CVR factor can be developed which can be used to estimate savings due to different changes in voltages. In equation form it looks like this:

$$CVR\ Factor = \frac{\%\Delta\ Energy\ Consumption}{\%\Delta\ Voltage}$$

Because the voltage step change implemented in each transition test does not reach the true baseline voltage, final savings estimates are developed by applying the voltage profile used in the on/off testing analysis.

3.8.2.5 Coincident Peak Demand Reduction (kW)

The gross verified peak demand reduction (kW) is calculated by multiplying the identified percent consumption reduction for each circuit and phase by the total consumption during the system-wide peak consumption hour. The system peak consumption time in 2019 was 5 PM on August 19th.

3.8.3 CVR Impact Evaluation Findings

The evaluation for CVR includes an impact evaluation in order to determine the gross verified typical year annual energy savings (kWh) and gross verified typical year coincident peak demand reduction (kW). These results are presented from the industry standard evaluation method utilizing CVR system “OFF” days to develop CVR Factors (as described in Section 3.8.2). As additional improvements were made to each electrical circuit, baseline voltage condition was derived from the full year before CVR installation.

3.8.3.1 Gross Verified Annual Energy Savings (kWh)

The gross verified annual energy savings (kWh) for PY2019 are 10,439,497 kWh. This represents an overall percent savings of 2.68% relative to the evaluated circuit loads. Table 3-138 and Table 3-139 below show the summary of a typical year’s gross verified annual energy savings separated by season (Cooling versus Heating) due to operation of CVR on each circuit. Note that Okemah heating season savings are not claimed in this report as they were claimed in the 2018 program year.

Table 3-138: PY2019 CVR Cooling Season Gross Verified Energy Savings (kWh)

Substation	Circuit	Percent Savings	Cooling Season Energy Savings (kWh)	Cooling Season Energy Consumption (kWh)
Henryetta	06931	3.77%	595,311	15,787,290
	06932	2.26%	335,778	14,867,641
	06933	2.16%	1,115,573	51,711,236
	06934	3.22%	411,474	12,766,110
Okemah	07431	4.69%	577,468	12,314,862
	07432	5.85%	581,769	9,951,274
	07433	2.95%	160,685	5,451,385
Tulsa North 138	H1	2.64%	180,122	6,815,788
	H2	2.34%	286,629	12,236,615
	H3	2.78%	164,523	5,912,699
	H4	2.56%	204,298	7,995,868
	H5	2.57%	248,720	9,663,796
North Mingo	U2	1.67%	181,128	10,839,966
	U4	1.45%	255,476	17,656,251
	U6	2.40%	677,697	28,190,553
Total / Average		**2.69%**	**5,976,649**	**222,161,334**

Table 3-139: PY2019 CVR Heating Season Gross Verified Energy Savings (kWh)

Substation	Circuit	Percent Savings	Heating Season Energy Savings (kWh)	Heating Season Energy Consumption (kWh)
Henryetta	06931	3.10%	404,175	13,043,382
	06932	2.66%	322,272	12,138,301
	06933	2.59%	1,249,936	48,219,824
	06934	2.93%	341,135	11,637,699
Tulsa North 138	H1	2.62%	150,706	5,746,684
	H2	2.32%	256,633	11,040,516
	H3	2.76%	107,481	3,892,494
	H4	2.54%	183,043	7,219,251
	H5	2.55%	217,670	8,522,594

Substation	Circuit	Percent Savings	Heating Season Energy Savings (kWh)	Heating Season Energy Consumption (kWh)
North Mingo	U2	1.89%	148,033	7,836,987
	U4	2.63%	431,576	16,382,705
	U6	2.91%	650,187	22,340,237
Total / Average		**2.66%**	**4,462,848**	**168,020,674**

Extrapolation of CVR factors was applied to circuits in which CVR came online in 2019 but sufficient evaluation testing was not able to be collected. CVR factors were extrapolated from circuits within the same substation when applicable. In cases where no circuits in a substation achieved sufficient evaluation testing for a given season, an estimate was calculated by applying an average ratio adjustment to that substations other season CVR factor. In any cases where neither season for a given substation had significant enough testing data, the program year average across all substations that do was applied. Circuit savings and characteristics split by phase are shown in Section 3.8.5.

3.8.3.1 Gross Verified Coincident Peak Demand Reduction (kW)

The gross verified coincident peak demand reduction (kW) for PY2019 is 2,063.86 kW. This represents 116.4% of the projected peak demand reduction. Results per circuit are shown in Table 3-140.

Table 3-140: PY2019 CVR Gross Verified Peak Demand Reduction (kW)

Substation	Circuit	Peak Demand Reduction (kW)
Henryetta	06931	298.09
	06932	145.57
	06933	263.97
	06934	233.47
Okemah	07431	258.28
	07432	241.65
	07433	44.66
Tulsa North 138	H1	52.21
	H2	85.99
	H3	8.15
	H4	64.94
	H5	63.85

Substation	Circuit	Peak Demand Reduction (kW)
North Mingo	U2	54.84
	U4	66.81
	U6	181.38
Total		**2,063.86**

3.8.3.1 Evaluation Methodology Comparison

Results between the industry standard on/off regression methodology and the transition test approach are compared in Table 3-141. Only circuits where testing data was available under both methodologies were included in this comparison and therefore results are distinct from the savings presented above. Analysis shows that the projected annual savings (with seasons combined) agree within 9.96% of one another between the two methodologies. Transition test annual savings results are shown in

Table 3-142 and Table 3-143.

Table 3-141: CVR Methodology Summary Comparison

Season	Methodology	Daily Average Savings	Percent Savings	CVR Factor	Projected Annual Savings
Cooling	On / Off	89,235	2.71%	0.62	16,419,153
	Transition Test	72,039	2.22%	0.53	13,255,168
Heating	On / Off	65,634	2.90%	0.63	11,879,835
	Transition Test	66,650	3.18%	0.72	12,063,657

Table 3-142: PY2019 CVR Cooling Season Transition Test Savings Summary

Substation	Circuit	Percent Savings	Cooling Season Energy Savings (kWh)	Cooling Season Energy Consumption (kWh)
Henryetta	06931	3.10%	495,786	16,001,570
	06932	1.65%	221,488	13,393,282
	06933	2.00%	1,019,341	50,848,949
	06934	4.14%	628,521	15,199,403
Okemah	07431	4.29%	366,913	8,550,206
North Mingo	U2	1.10%	96,273	8,728,445
	U4	1.24%	216,890	17,463,493

Substation	Circuit	Percent Savings	Cooling Season Energy Savings (kWh)	Cooling Season Energy Consumption (kWh)
	U6	0.22%	61,248	27,567,981
81st & Garnett	XB1	3.83%	421,569	11,006,971
	XB2	2.61%	463,715	17,794,709
	XB3	2.61%	400,034	15,326,937
	XB4	2.74%	240,778	8,785,425
	XB5	2.35%	563,521	23,929,518
	XB6	2.48%	264,251	10,668,779
	XB9	2.13%	472,486	22,144,555
	XB11	0.53%	47,271	8,923,440
	XB13	-0.50%	(134,649)	26,955,672
East 121st	XK1	2.00%	501,897	25,150,164
	XK3	2.37%	572,240	24,187,792
	XK5	3.23%	542,179	16,791,092
77th & Memorial	ZM1	2.54%	584,057	22,967,550
	ZM2	2.18%	462,143	21,217,838
	ZM3	1.42%	332,034	23,343,359
	ZM4	3.47%	389,647	11,213,976
	ZM5	3.01%	575,712	19,136,426
	ZM6	4.41%	473,220	10,739,894
Bixby 111th	ZX1	1.78%	324,596	18,248,702
	ZX2	2.70%	731,923	27,094,658
	ZX3	1.01%	208,542	20,614,001
	ZX4	3.63%	504,904	13,903,516
	ZX5	3.40%	641,308	18,837,159
	ZX6	2.61%	565,331	21,650,843
Total / Average		**2.22%**	**13,255,168**	**598,386,305**

Table 3-143: PY2019 CVR Heating Season Transition Test Savings Summary

Substation	Circuit	Percent Savings	Heating Season Energy Savings (kWh)	Heating Season Energy Consumption (kWh)
Henryetta	06933	2.52%	512,354	20,366,427
Okemah	07431	5.61%	404,098	7,198,450
	07432	8.11%	519,462	6,401,647

Substation	Circuit	Percent Savings	Heating Season Energy Savings (kWh)	Heating Season Energy Consumption (kWh)
	07433	3.35%	114,446	3,413,295
North Mingo	U2	3.05%	139,582	4,571,000
	U4	1.51%	269,189	17,859,689
	U6	1.06%	238,625	22,486,368
81st & Garnett	XB1	2.74%	179,262	6,545,211
	XB2	2.26%	317,799	14,090,936
	XB3	3.87%	356,675	9,209,043
	XB4	0.72%	50,637	7,004,956
	XB5	3.62%	684,230	18,903,882
	XB6	5.22%	357,629	6,855,812
	XB9	2.58%	348,266	13,521,050
	XB11	3.17%	151,427	4,778,552
	XB13	2.25%	424,046	18,875,615
East 121st	XK1	2.95%	449,126	15,241,531
	XK3	3.21%	532,297	16,589,320
	XK5	3.78%	384,606	10,182,041
77th & Memorial	ZM1	3.91%	610,807	15,603,611
	ZM2	3.09%	409,586	13,261,322
	ZM3	4.15%	725,688	17,487,548
	ZM4	2.79%	235,003	8,427,304
	ZM5	5.28%	824,415	15,607,925
	ZM6	5.42%	520,635	9,598,831
Bixby 111th	ZX1	2.88%	308,314	10,698,167
	ZX2	3.60%	546,465	15,189,213
	ZX3	2.21%	325,725	14,752,248
	ZX4	3.20%	326,940	10,231,352
	ZX5	3.94%	451,863	11,464,455
	ZX6	2.57%	344,462	13,398,623
Total / Average		**3.18%**	**12,063,657**	**379,815,424**

Circuit savings and characteristics split by phase for the transition test methodology evaluation are shown in Section 3.8.6.

3.8.4 Conclusions and Recommendations

PY2019 was the second full year of evaluation for the PSO CVR program. Evaluation testing was completed using both system off days and transition tests. Comparison of the CVR factors between the two methodologies in the first program year at the circuit level showed a moderate degree of agreement with the total program level savings agreeing within nearly 1% of one another. The same analysis for this program year found a percent difference of approximately 10.5%. In both cases the transition test methodology had lower savings estimates. ADM will continue to evaluate the effectiveness of the transition test analysis methodology and advise PSO on the optimal course of action.

Circuits in which evaluation testing was completed for both the cooling and heating season do not require further evaluation testing (off days or transition tests) going forward. CVR factors and the reduction in consumption due to CVR were similar in PY2018 and PY2019. CVR implementation on any new circuits will undergo the same evaluation testing.

There are several factors that may have affected the estimation of annual energy savings and the annual energy savings realization rate for PY2019. These include:

- Adequate evaluation testing across heating and cooling season, and ability to use an industry standard evaluation methodology approach with the actual efficient condition.
- The voltage profiles applied to the found CVR factors.
- End use energy demand variation (including customer class distribution and line density) and external influences such as electrical equipment upgrades by end users and changes in usage patterns.

The overall average reduction in distributed energy due to CVR across the evaluated circuits is 2.68% with an average CVR factor around 0.66. The previous year's evaluation identified a 3.01% energy consumption reduction with a .64 CVR factor. As CVR factors between years are comparable, it is likely that the source of the difference in the percent energy reduction is the achieved voltage difference among circuits. Circuit level (for each phase) CVR factors and results can be seen in Section 3.8.5 and Section 3.8.6. Cells within the tables are italicized and footnoted to indicate where average CVR factors were extrapolated in order to estimate typical year energy savings.

3.8.5 Detailed Circuit Level ON/OFF Results

Table 3-144: Okemah Substation Savings by Phase

Substation	Season	Circuit	Phase	Baseline OFF Voltage	ON Voltage	Daily Avg kWh Savings	Daily Average Consumption	Percent Savings	CVR Factor
Okemah	Cooling	07431	A	126.10	118.42	1,188	22,310	5.33%	0.87
			B	126.18	118.10	1,175	22,310	5.27%	0.82
			C	126.45	119.83	775	22,310	3.47%	0.66
		Total / Average		**126.24**	**118.78**	**3,138**	**66,929**	**4.69%**	**0.79**
		07432	A	126.10	119.12	856	18,028	4.75%	0.86
			B	126.18	118.27	1,401	18,028	7.77%	1.24
			C	126.45	118.99	904	18,028	5.01%	0.85
		Total / Average		**126.24**	**118.79**	**3,162**	**54,083**	**5.85%**	**0.99**
		07433	A	126.10	119.07	285	9,876	2.89%	0.52
			B	126.18	119.79	137	9,876	1.39%	0.27
			C	126.45	119.16	451	9,876	4.56%	0.79
		Total / Average		**126.24**	**119.34**	**873**	**29,627**	**2.95%**	**0.54**
	Total / Average			**126.24**	**118.97**	**7,173**	**150,639**	**4.76%**	**0.83**

Table 3-145: Henryetta Substation Savings by Phase

Substation	Season	Circuit	Phase	Baseline OFF Voltage	ON Voltage	Daily Avg kWh Savings	Daily Average Consumption	Percent Savings	CVR Factor
Henryetta	Cooling	06931	A	124.59	119.54	867	28,600	3.03%	0.75
			B	124.59	119.54	1,178	28,600	4.12%	1.02
			C	124.59	119.54	1,190	28,600	4.16%	1.03
		Total / Average		**124.59**	**119.54**	**3,235**	**85,800**	**3.77%**	**0.93**
		06932	A	124.53	120.20	459	26,934	1.70%	0.49
			B	124.53	120.20	682	26,934	2.53%	0.73
			C	124.53	120.20	684	26,934	2.54%	0.73
		Total / Average		**124.53**	**120.20**	**1,825**	**80,802**	**2.26%**	**0.65**
		06933	A	124.05	119.81	2,172	93,680	2.32%	0.68
			B	123.71	119.58	2,246	93,680	2.40%	0.72
			C	124.22	119.99	1,645	93,680	1.76%	0.52
		Total / Average		**123.99**	**119.79**	**6,063**	**281,039**	**2.16%**	**0.64**

Substation	Season	Circuit	Phase	Baseline OFF Voltage	ON Voltage	Daily Avg kWh Savings	Daily Average Consumption	Percent Savings	CVR Factor
		06934	A	124.53	119.76	896	23,127	3.87%	1.01
			B	124.53	119.76	606	23,127	2.62%	0.68
			C	124.53	119.76	734	23,127	3.17%	0.83
		Total / Average		**124.53**	**119.76**	**2,236**	**69,381**	**3.22%**	**0.84**
	Total / Average			**124.41**	**119.82**	**13,359**	**517,023**	**2.58%**	**0.70**
	Heating[89]	06931	A	124.59	119.54	744	24,021	3.10%	*0.76*
			B	124.59	119.54	744	24,021	3.10%	*0.76*
			C	124.59	119.54	744	24,021	3.10%	*0.76*
		Total / Average		**124.59**	**119.54**	**2,233**	**72,063**	**3.10%**	***0.76***
		06932	A	124.53	120.20	594	22,354	2.66%	*0.76*
			B	124.53	120.20	594	22,354	2.66%	*0.76*
			C	124.53	120.20	594	22,354	2.66%	*0.76*
		Total / Average		**124.53**	**120.20**	**1,781**	**67,062**	**2.66%**	***0.76***
		06933	A	124.05	119.81	2,325	88,803	2.62%	*0.76*
			B	123.71	119.58	2,267	88,803	2.55%	*0.76*
			C	124.22	119.99	2,314	88,803	2.61%	*0.76*
		Total / Average		**123.99**	**119.79**	**6,906**	**266,408**	**2.59%**	***0.76***
		06934	A	124.53	119.76	628	21,432	2.93%	*0.76*
			B	124.53	119.76	628	21,432	2.93%	*0.76*
			C	124.53	119.76	628	21,432	2.93%	*0.76*
		Total / Average		**124.53**	**119.76**	**1,885**	**64,297**	**2.93%**	***0.76***
	Total / Average			**124.41**	**119.82**	**12,804**	**469,830**	**2.73%**	***0.74***
Total / Average				**124.41**	**119.82**	**26,163**	**986,853**	**2.65%**	**0.72**

[89] Extrapolated CVR Factors

Table 3-146: Tulsa North 138 Substation Savings by Phase

Substation	Season	Circuit	Phase	Baseline OFF Voltage	ON Voltage	Daily Avg kWh Savings	Daily Average Consumption	Percent Savings	CVR Factor
Tulsa North 138[90]	Cooling	H1	A	124.36	119.11	326	12,347	2.64%	*0.63*
			B	124.36	119.11	326	12,347	2.64%	*0.63*
			C	124.36	119.11	326	12,347	2.64%	*0.63*
		Total / Average		**124.36**	**119.11**	**979**	**37,042**	**2.64%**	***0.63***
		H2	A	124.58	119.91	519	22,168	2.34%	*0.63*
			B	124.58	119.91	519	22,168	2.34%	*0.63*
			C	124.58	119.91	519	22,168	2.34%	*0.63*
		Total / Average		**124.58**	**119.91**	**1,558**	**66,503**	**2.34%**	***0.63***
		H3	A	124.47	118.93	298	10,711	2.78%	*0.63*
			B	124.47	119.36	298	10,711	2.78%	*0.63*
			C	124.47	119.36	298	10,711	2.78%	*0.63*
		Total / Average		**124.47**	**119.22**	**894**	**32,134**	**2.78%**	***0.66***
		H4	A	124.44	119.36	370	14,485	2.56%	*0.63*
			B	124.44	119.36	370	14,485	2.56%	*0.63*
			C	124.44	119.36	370	14,485	2.56%	*0.63*
		Total / Average		**124.44**	**119.36**	**1,110**	**43,456**	**2.56%**	***0.63***
		H5	A	124.71	119.58	451	17,507	2.57%	*0.63*
			B	124.71	119.58	451	17,507	2.57%	*0.63*
			C	124.71	119.58	451	17,507	2.57%	*0.63*
		Total / Average		**124.71**	**119.58**	**1,352**	**52,521**	**2.57%**	***0.63***
	Total / Average			**124.51**	**119.44**	**5,893**	**231,656**	**2.54%**	***0.62***
	Heating	H1	A	124.36	119.11	278	10,583	2.62%	*0.62*
			B	124.36	119.11	278	10,583	2.62%	*0.62*
			C	124.36	119.11	278	10,583	2.62%	*0.62*
		Total / Average		**124.36**	**119.11**	**833**	**31,750**	**2.62%**	***0.62***
		H2	A	124.58	119.91	473	20,332	2.32%	*0.62*
			B	124.58	119.91	473	20,332	2.32%	*0.62*
			C	124.58	119.91	473	20,332	2.32%	*0.62*
		Total / Average		**124.58**	**119.91**	**1,418**	**60,997**	**2.32%**	***0.62***
		H3	A	124.47	118.93	198	7,168	2.76%	*0.62*

[90] Extrapolated CVR Factors

Substation	Season	Circuit	Phase	Baseline OFF Voltage	ON Voltage	Daily Avg kWh Savings	Daily Average Consumption	Percent Savings	CVR Factor
			B	124.47	118.93	198	7,168	2.76%	*0.62*
			C	124.47	118.93	198	7,168	2.76%	*0.62*
		Total / Average		**124.47**	**118.93**	**594**	**21,505**	**2.76%**	***0.62***
		H4	A	124.44	119.36	337	13,295	2.54%	*0.62*
			B	124.44	119.36	337	13,295	2.54%	*0.62*
			C	124.44	119.36	337	13,295	2.54%	*0.62*
		Total / Average		**124.44**	**119.36**	**1,011**	**39,885**	**2.54%**	***0.62***
		H5	A	124.71	119.58	401	15,695	2.55%	*0.62*
			B	124.71	119.58	401	15,695	2.55%	*0.62*
			C	124.71	119.58	401	15,695	2.55%	*0.62*
		Total / Average		**124.71**	**119.58**	**1,203**	**47,086**	**2.55%**	***0.62***
	Total / Average			**124.51**	**119.38**	**5,058**	**201,224**	**2.51%**	***0.61***
Total / Average				**124.51**	**119.41**	**10,951**	**432,880**	**2.53%**	***0.62***

Table 3-147: North Mingo Substation Savings by Phase

Substation	Season	Circuit	Phase	Baseline OFF Voltage	ON Voltage	Daily Avg kWh Savings	Daily Average Consumption	Percent Savings	CVR Factor
North Mingo	Cooling	U2	A	124.56	119.67	264	19,638	1.34%	0.34
			B	124.56	119.67	328	19,638	1.67%	*0.43*[91]
			C	124.56	119.67	392	19,638	2.00%	0.51
		Total / Average		**124.56**	**119.67**	**984**	**58,913**	**1.67%**	**0.43**
		U4	A	125.16	121.04	361	31,986	1.13%	0.34
			B	126.13	121.30	436	31,986	1.85%	0.51
			C	125.83	121.29	591	31,986	2.83%	0.64
		Total / Average		**125.71**	**121.21**	**1,388**	**95,958**	**1.45%**	**0.40**
		U6	A	124.65	119.16	1,445	51,070	2.83%	0.64
			B	124.65	119.16	1,757	51,070	3.44%	0.78
			C	124.65	119.16	481	51,070	0.94%	0.21
		Total / Average		**124.65**	**119.16**	**3,683**	**153,210**	**2.40%**	**0.55**
	Total / Average			**124.97**	**120.01**	**6,056**	**308,080**	**1.97%**	**0.50**

[91] Extrapolated CVR Factor

Substation	Season	Circuit	Phase	Baseline OFF Voltage	ON Voltage	Daily Avg kWh Savings	Daily Average Consumption	Percent Savings	CVR Factor
	Heating	U2	A	124.56	119.67	165	14,433	1.14%	0.29
			B	124.56	119.67	273	14,433	1.89%	*0.48*[92]
			C	124.56	119.67	380	14,433	2.63%	0.67
		Total / Average		**124.56**	**119.67**	**818**	**43,298**	**1.89%**	**0.48**
		U4	A	125.16	121.04	593	30,171	1.97%	0.60
			B	126.13	121.30	892	30,171	2.96%	0.77
			C	125.83	121.29	900	30,171	2.98%	0.83
		Total / Average		**125.71**	**121.21**	**2,384**	**90,512**	**2.63%**	**0.74**
		U6	A	124.65	119.16	1,317	41,142	3.20%	0.73
			B	124.65	119.16	1,455	41,142	3.54%	0.80
			C	124.65	119.16	820	41,142	1.99%	0.45
		Total / Average		**124.65**	**119.16**	**3,592**	**123,427**	**2.91%**	**0.66**
	Total / Average			**124.97**	**120.01**	**6,794**	**257,237**	**2.64%**	**0.67**
Total / Average				**124.97**	**120.01**	**12,850**	**565,317**	**2.27%**	**0.57**

3.8.6 Detailed Circuit Transition Test Results

Table 3-148: Henryetta Substation Transition Test Savings by Phase

Substation	Season	Circuit	Phase	Baseline OFF Voltage	ON Voltage	Daily Avg kWh Savings	Daily Average Consumption	Percent Savings	CVR Factor
Henryetta	Cooling	06931	A	124.59	119.54	573	30,171	1.90%	0.47
			B	124.59	119.54	897	26,559	3.38%	0.83
			C	124.59	119.54	1,224	30,235	4.05%	1.00
		Total / Average		**124.59**	**119.54**	**2,694**	**86,965**	**3.10%**	**0.76**
		06932	A	124.53	120.20	744	25,054	2.97%	0.86
			B	124.53	120.20	360	25,341	1.42%	0.41
			C	124.53	120.20	100	22,394	0.45%	0.13
		Total / Average		**124.53**	**120.20**	**1,204**	**72,790**	**1.65%**	**0.48**
		06933	A	124.05	119.81	1,831	90,910	2.01%	0.59

[92] Extrapolated CVR Factor

Substation	Season	Circuit	Phase	Baseline OFF Voltage	ON Voltage	Daily Avg kWh Savings	Daily Average Consumption	Percent Savings	CVR Factor
			B	123.71	119.58	1,956	93,826	2.08%	0.62
			C	124.22	119.99	1,754	91,617	1.91%	0.56
		Total / Average		**123.99**	**119.79**	**5,540**	**276,353**	**2.00%**	**0.59**
		06934	A	124.53	119.76	1,347	30,218	4.46%	1.16
			B	124.53	119.76	886	27,113	3.27%	0.85
			C	124.53	119.76	1,183	25,275	4.68%	1.22
		Total / Average		**124.53**	**119.76**	**3,416**	**82,605**	**4.14%**	**1.08**
	Total / Average			**124.41**	**119.82**	**12,854**	**518,713**	**2.48%**	**0.67**
	Heating	06933	A	124.05	119.81	943	37,117	2.54%	0.74
			B	123.71	119.58	1,020	38,109	2.68%	0.80
			C	124.22	119.99	867	37,295	2.32%	0.68
		Total / Average		**123.99**	**119.79**	**2,831**	**112,522**	**2.52%**	**0.74**
	Total / Average			**123.99**	**119.79**	**2,831**	**112,522**	**2.52%**	**0.74**
Total / Average				**124.33**	**119.82**	**15,685**	**631,235**	**2.48%**	**0.69**

Table 3-149: Okemah Substation Transition Test Savings by Phase

Substation	Season	Circuit	Phase	Baseline OFF Voltage	ON Voltage	Daily Avg kWh Savings	Daily Average Consumption	Percent Savings	CVR Factor
Okemah	Cooling	07431	A	126.10	118.42	819	16,716	4.90%	0.80
			B	126.18	118.10	674	14,260	4.72%	0.74
			C	126.45	119.83	501	15,492	3.24%	0.62
		Total / Average		**126.24**	**118.78**	**1,994**	**46,469**	**4.29%**	**0.73**
	Total / Average			**126.24**	**118.78**	**1,994**	**46,469**	**4.29%**	**0.73**
	Heating	07431	A	126.10	118.42	1,029	14,817	6.95%	1.14
			B	126.18	118.10	592	11,868	4.99%	0.78
			C	126.45	119.83	611	13,085	4.67%	0.89
		Total / Average		**126.24**	**118.78**	**2,233**	**39,770**	**5.61%**	**0.95**
		07432	A	126.10	119.12	1,079	12,823	8.41%	1.52
			B	126.18	118.27	707	9,287	7.61%	1.21
			C	126.45	118.99	1,084	13,258	8.18%	1.39
		Total / Average		**126.24**	**118.79**	**2,870**	**35,368**	**8.11%**	**1.38**

Substation	Season	Circuit	Phase	Baseline OFF Voltage	ON Voltage	Daily Avg kWh Savings	Daily Average Consumption	Percent Savings	CVR Factor
		07433	A	126.10	119.07	242	5,817	4.15%	0.75
			B	126.18	119.79	153	6,763	2.26%	0.45
			C	126.45	119.16	238	6,278	3.79%	0.66
		Total / Average		**126.24**	**119.34**	**632**	**18,858**	**3.35%**	**0.61**
	Total / Average			**126.24**	**118.97**	**5,735**	**93,997**	**6.10%**	**1.06**
Total / Average				**126.24**	**118.92**	**7,729**	**140,465**	**5.50%**	**0.95**

Table 3-150: North Mingo Substation Transition Test Savings by Phase

Substation	Season	Circuit	Phase	Baseline OFF Voltage	ON Voltage	Daily Avg kWh Savings	Daily Average Consumption	Percent Savings	CVR Factor
North Mingo	Cooling	U2	A	124.56	119.67	141	15,738	0.90%	0.23
			B	124.56	119.67	174	15,812	1.10%	0.28
			C	124.56	119.67	207	15,887	1.31%	0.33
		Total / Average		**124.56**	**119.67**	**523**	**47,437**	**1.10%**	**0.28**
		U4	A	125.16	121.04	268	31,447	0.85%	0.26
			B	126.13	121.30	490	32,298	1.52%	0.40
			C	125.83	121.29	421	31,165	1.35%	0.37
		Total / Average		**125.71**	**121.21**	**1,179**	**94,910**	**1.24%**	**0.35**
		U6	A	124.65	119.16	119	49,643	0.24%	0.05
			B	124.65	119.16	108	50,009	0.22%	0.05
			C	124.65	119.16	106	50,174	0.21%	0.05
		Total / Average		**124.65**	**119.16**	**333**	**149,826**	**0.22%**	**0.05**
	Total / Average			**124.97**	**120.01**	**2,035**	**292,173**	**0.70%**	**0.18**
	Heating	U2	A	124.56	119.67	225	8,243	2.74%	0.70
			B	124.56	119.67	257	8,418	3.05%	0.78
			C	124.56	119.67	289	8,593	3.36%	0.86
		Total / Average		**124.56**	**119.67**	**771**	**25,254**	**3.05%**	**0.78**
		U4	A	125.16	121.04	333	32,485	1.02%	0.31
			B	126.13	121.30	584	33,407	1.75%	0.46
			C	125.83	121.29	571	32,780	1.74%	0.48
		Total / Average		**125.71**	**121.21**	**1,487**	**98,672**	**1.51%**	**0.42**

Substation	Season	Circuit	Phase	Baseline OFF Voltage	ON Voltage	Daily Avg kWh Savings	Daily Average Consumption	Percent Savings	CVR Factor
		U6	A	124.65	119.16	401	41,184	0.97%	0.22
			B	124.65	119.16	520	41,468	1.25%	0.28
			C	124.65	119.16	398	41,582	0.96%	0.22
		Total / Average		**124.65**	**119.16**	**1,318**	**124,234**	**1.06%**	**0.24**
	Total / Average			**124.97**	**120.01**	**3,577**	**248,161**	**1.44%**	**0.36**
Total / Average				**124.97**	**120.01**	**5,612**	**540,334**	**1.04%**	**0.26**

Table 3-151: 81st & Garnett XB Substation Transition Test Savings by Phase

Substation	Season	Circuit	Phase	Baseline OFF Voltage	ON Voltage	Daily Avg kWh Savings	Daily Average Consumption	Percent Savings	CVR Factor
81st & Garnett	Cooling	XB1	A	124.52	118.91	643	19,476	3.30%	0.73
			B	124.45	118.86	991	18,813	5.27%	1.17
			C	124.05	118.88	657	21,531	3.05%	0.73
		Total / Average		**124.34**	**118.88**	**2,291**	**59,820**	**3.83%**	**0.87**
		XB2	A	124.58	118.81	714	27,863	2.56%	0.55
			B	123.85	118.96	908	36,138	2.51%	0.64
			C	124.81	119.09	898	32,709	2.75%	0.60
		Total / Average		**124.41**	**118.95**	**2,520**	**96,710**	**2.61%**	**0.59**
		XB3	A	124.52	118.91	367	28,391	1.29%	0.29
			B	124.45	118.89	900	25,897	3.48%	0.78
			C	124.05	118.88	907	29,010	3.13%	0.75
		Total / Average		**124.34**	**118.89**	**2,174**	**83,299**	**2.61%**	**0.60**
		XB4	A	124.58	118.78	448	16,687	2.68%	0.58
			B	123.85	118.95	443	16,565	2.68%	0.68
			C	124.81	119.07	418	14,494	2.88%	0.63
		Total / Average		**124.41**	**118.94**	**1,309**	**47,747**	**2.74%**	**0.62**
		XB5	A	124.52	118.92	763	39,648	1.92%	0.43
			B	124.45	118.88	1,434	46,566	3.08%	0.69
			C	124.05	118.88	865	43,837	1.97%	0.47
		Total / Average		**124.34**	**118.89**	**3,063**	**130,052**	**2.35%**	**0.54**
		XB6	A	124.58	118.86	453	20,821	2.17%	0.47

Substation	Season	Circuit	Phase	Baseline OFF Voltage	ON Voltage	Daily Avg kWh Savings	Daily Average Consumption	Percent Savings	CVR Factor
			B	123.85	118.98	385	18,291	2.11%	0.54
			C	124.81	119.12	599	18,870	3.17%	0.70
		Total / Average		**124.41**	**118.99**	**1,436**	**57,982**	**2.48%**	**0.57**
	Total / Average			**124.38**	**118.92**	**12,793**	**475,611**	**2.69%**	**0.61**
	Heating	XB1	A	124.52	118.91	301	11,606	2.59%	0.57
			B	124.45	118.86	264	11,664	2.26%	0.50
			C	124.05	118.88	425	12,892	3.30%	0.79
		Total / Average		**124.34**	**118.88**	**990**	**36,161**	**2.74%**	**0.62**
		XB2	A	124.58	118.81	454	21,874	2.08%	0.45
			B	123.85	118.96	859	30,111	2.85%	0.72
			C	124.81	119.09	442	25,865	1.71%	0.37
		Total / Average		**124.41**	**118.95**	**1,756**	**77,850**	**2.26%**	**0.51**
		XB3	A	124.52	118.91	704	17,087	4.12%	0.91
			B	124.45	118.89	520	15,924	3.27%	0.73
			C	124.05	118.88	747	17,868	4.18%	1.00
		Total / Average		**124.34**	**118.89**	**1,971**	**50,879**	**3.87%**	**0.88**
		XB4	A	124.58	118.78	85	13,463	0.63%	0.14
			B	123.85	118.95	106	13,639	0.78%	0.20
			C	124.81	119.07	89	11,600	0.76%	0.17
		Total / Average		**124.41**	**118.94**	**280**	**38,701**	**0.72%**	**0.16**
		XB5	A	124.52	118.92	1,120	31,219	3.59%	0.80
			B	124.45	118.88	1,376	35,130	3.92%	0.88
			C	124.05	118.88	1,284	38,092	3.37%	0.81
		Total / Average		**124.34**	**118.89**	**3,780**	**104,441**	**3.62%**	**0.83**
		XB6	A	124.58	118.86	897	14,223	6.30%	1.37
			B	123.85	118.98	595	12,955	4.59%	1.17
			C	124.81	119.12	484	10,699	4.52%	0.99
		Total / Average		**124.41**	**118.99**	**1,976**	**37,877**	**5.22%**	**1.20**
	Total / Average			**124.38**	**118.92**	**10,753**	**345,911**	**3.11%**	**0.71**
Total / Average				**124.38**	**118.92**	**23,545**	**821,521**	**2.87%**	**0.65**

Table 3-152: 81st & Garnett Substation Transition Test Savings by Phase

Substation	Season	Circuit	Phase	Baseline OFF Voltage	ON Voltage	Daily Avg kWh Savings	Daily Average Consumption	Percent Savings	CVR Factor
81st & Garnett	Cooling	XB9	A	124.75	119.63	584	40,839	1.43%	0.35
			B	125.14	119.80	957	39,411	2.43%	0.57
			C	125.53	119.92	1,027	40,101	2.56%	0.57
		Total / Average		**125.14**	**119.78**	**2,568**	**120,351**	**2.13%**	**0.50**
		XB11	A	124.75	119.65	-124	18,865	-0.66%	-0.16
			B	125.14	119.80	313	17,017	1.84%	0.43
			C	125.53	119.95	68	12,615	0.54%	0.12
		Total / Average		**125.14**	**119.80**	**257**	**48,497**	**0.53%**	**0.12**
		XB13	A	124.75	119.65	-234	50,241	-0.47%	-0.11
			B	125.14	119.81	-3	45,801	-0.01%	0.00
			C	125.53	119.96	-495	50,456	-0.98%	-0.22
		Total / Average		**125.14**	**119.80**	**-732**	**146,498**	**-0.50%**	**-0.12**
	Total / Average			**125.14**	**119.79**	**2,093**	**315,346**	**0.66%**	**0.16**
	Heating	XB9	A	124.75	119.63	588	26,098	2.25%	0.55
			B	125.14	119.80	611	24,113	2.54%	0.59
			C	125.53	119.92	725	24,490	2.96%	0.66
		Total / Average		**125.14**	**119.78**	**1,924**	**74,702**	**2.58%**	**0.60**
		XB11	A	124.75	119.65	286	10,316	2.77%	0.68
			B	125.14	119.80	265	8,947	2.97%	0.70
			C	125.53	119.95	285	7,138	4.00%	0.90
		Total / Average		**125.14**	**119.80**	**837**	**26,401**	**3.17%**	**0.74**
		XB13	A	124.75	119.65	588	35,542	1.65%	0.40
			B	125.14	119.81	760	31,639	2.40%	0.56
			C	125.53	119.96	994	37,105	2.68%	0.60
		Total / Average		**125.14**	**119.80**	**2,343**	**104,285**	**2.25%**	**0.53**
	Total / Average			**125.14**	**119.79**	**5,104**	**205,388**	**2.48%**	**0.58**
Total / Average				**125.14**	**119.79**	**7,197**	**520,734**	**1.38%**	**0.32**

Table 3-153: East 121st Street Substation Transition Test Savings by Phase

Substation	Season	Circuit	Phase	Baseline OFF Voltage	ON Voltage	Daily Avg kWh Savings	Daily Average Consumption	Percent Savings	CVR Factor
East 121st	Cooling	XK1	A	125.64	120.40	982	48,956	2.01%	0.48
			B	125.54	120.50	933	44,843	2.08%	0.52
			C	125.12	120.49	813	42,887	1.89%	0.51
		Total / Average		**125.43**	**120.46**	**2,728**	**136,686**	**2.00%**	**0.50**
		XK3	A	125.64	120.39	1,028	39,672	2.59%	0.62
			B	125.54	120.50	1,343	47,915	2.80%	0.70
			C	125.05	120.43	740	43,868	1.69%	0.46
		Total / Average		**125.41**	**120.44**	**3,110**	**131,455**	**2.37%**	**0.60**
		XK5	A	125.62	120.37	956	29,572	3.23%	0.77
			B	125.55	120.50	1,097	31,224	3.51%	0.87
			C	125.04	120.43	894	30,460	2.94%	0.80
		Total / Average		**125.40**	**120.43**	**2,947**	**91,256**	**3.23%**	**0.82**
	Total / Average			**125.41**	**120.45**	**8,784**	**359,397**	**2.44%**	**0.62**
	Heating	XK1	A	125.64	120.40	886	28,275	3.13%	0.75
			B	125.54	120.50	783	28,687	2.73%	0.68
			C	125.12	120.49	813	27,246	2.98%	0.81
		Total / Average		**125.43**	**120.46**	**2,481**	**84,207**	**2.95%**	**0.74**
		XK3	A	125.64	120.39	913	27,372	3.34%	0.80
			B	125.54	120.50	1,095	34,394	3.18%	0.79
			C	125.05	120.43	933	29,888	3.12%	0.85
		Total / Average		**125.41**	**120.44**	**2,941**	**91,654**	**3.21%**	**0.81**
		XK5	A	125.62	120.37	674	18,028	3.74%	0.89
			B	125.55	120.50	657	19,173	3.43%	0.85
			C	125.04	120.43	794	19,053	4.17%	1.13
		Total / Average		**125.40**	**120.43**	**2,125**	**56,254**	**3.78%**	**0.95**
	Total / Average			**125.41**	**120.45**	**7,547**	**232,115**	**3.25%**	**0.82**
Total / Average				**125.41**	**120.45**	**16,331**	**591,512**	**2.76%**	**0.70**

Table 3-154: 77th & Memorial Substation Transition Test Savings by Phase

Substation	Season	Circuit	Phase	Baseline OFF Voltage	ON Voltage	Daily Avg kWh Savings	Daily Average Consumption	Percent Savings	CVR Factor
77th & Memorial	Cooling	ZM1	A	125.33	119.46	1,038	42,950	2.42%	0.52
			B	126.31	119.59	1,475	43,975	3.35%	0.63
			C	125.85	119.76	661	37,899	1.74%	0.36
		Total / Average		**125.83**	**119.60**	**3,174**	**124,824**	**2.54%**	**0.51**
		ZM2	A	125.66	118.76	1,117	39,983	2.79%	0.51
			B	126.33	119.12	703	36,303	1.94%	0.34
			C	126.07	119.12	691	39,028	1.77%	0.32
		Total / Average		**126.02**	**119.00**	**2,512**	**115,314**	**2.18%**	**0.39**
		ZM3	A	125.33	119.43	428	39,823	1.08%	0.23
			B	126.31	119.68	1,027	47,243	2.17%	0.41
			C	125.85	119.85	349	39,800	0.88%	0.18
		Total / Average		**125.83**	**119.65**	**1,805**	**126,866**	**1.42%**	**0.29**
		ZM4	A	125.66	118.78	726	18,965	3.83%	0.70
			B	126.33	119.04	825	20,279	4.07%	0.70
			C	126.07	119.08	566	21,701	2.61%	0.47
		Total / Average		**126.02**	**118.97**	**2,118**	**60,946**	**3.47%**	**0.62**
		ZM5	A	125.33	119.36	884	33,189	2.66%	0.56
			B	126.31	119.60	1,001	32,029	3.12%	0.59
			C	125.85	119.78	1,244	38,784	3.21%	0.66
		Total / Average		**125.83**	**119.58**	**3,129**	**104,002**	**3.01%**	**0.61**
		ZM6	A	125.66	118.68	864	23,220	3.72%	0.67
			B	126.33	118.97	1,115	15,532	7.18%	1.23
			C	126.07	119.01	593	19,617	3.02%	0.54
		Total / Average		**126.02**	**118.89**	**2,572**	**58,369**	**4.41%**	**0.78**
	Total / Average			**125.93**	**119.28**	**15,309**	**590,321**	**2.59%**	**0.49**
	Heating	ZM1	A	125.33	119.46	1,334	29,986	4.45%	0.95
			B	126.31	119.59	1,008	28,704	3.51%	0.66
			C	125.85	119.76	1,032	27,518	3.75%	0.78
		Total / Average		**125.83**	**119.60**	**3,375**	**86,208**	**3.91%**	**0.79**
		ZM2	A	125.66	118.76	463	25,169	1.84%	0.34
			B	126.33	119.12	720	23,215	3.10%	0.54
			C	126.07	119.12	1,080	24,883	4.34%	0.79

Substation	Season	Circuit	Phase	Baseline OFF Voltage	ON Voltage	Daily Avg kWh Savings	Daily Average Consumption	Percent Savings	CVR Factor
		Total / Average		**126.02**	**119.00**	**2,263**	**73,267**	**3.09%**	**0.55**
		ZM3	A	125.33	119.43	1,307	28,899	4.52%	0.96
			B	126.31	119.68	1,838	36,621	5.02%	0.96
			C	125.85	119.85	864	31,097	2.78%	0.58
		Total / Average		**125.83**	**119.65**	**4,009**	**96,616**	**4.15%**	**0.85**
		ZM4	A	125.66	118.78	316	15,103	2.09%	0.38
			B	126.33	119.04	596	15,543	3.83%	0.66
			C	126.07	119.08	387	15,914	2.43%	0.44
		Total / Average		**126.02**	**118.97**	**1,298**	**46,560**	**2.79%**	**0.50**
		ZM5	A	125.33	119.36	1,981	29,624	6.69%	1.40
			B	126.31	119.60	1,327	25,540	5.19%	0.98
			C	125.85	119.78	1,247	31,068	4.01%	0.83
		Total / Average		**125.83**	**119.58**	**4,555**	**86,232**	**5.28%**	**1.06**
		ZM6	A	125.66	118.68	1,281	20,772	6.17%	1.11
			B	126.33	118.97	728	15,040	4.84%	0.83
			C	126.07	119.01	867	17,221	5.03%	0.90
		Total / Average		**126.02**	**118.89**	**2,876**	**53,032**	**5.42%**	**0.96**
	Total / Average			**125.93**	**119.28**	**18,376**	**441,915**	**4.16%**	**0.79**
Total / Average				**125.93**	**119.28**	**33,685**	**1,032,235**	**3.26%**	**0.62**

Table 3-155: Bixby 111th Substation Transition Test Savings by Phase

Substation	Season	Circuit	Phase	Baseline OFF Voltage	ON Voltage	Daily Avg kWh Savings	Daily Average Consumption	Percent Savings	CVR Factor
Bixby 111th	Cooling	ZX1	A	125.13	119.63	542	31,124	1.74%	0.40
			B	125.63	119.88	574	33,377	1.72%	0.38
			C	125.04	119.93	648	34,676	1.87%	0.46
		Total / Average		**125.26**	**119.81**	**1,764**	**99,178**	**1.78%**	**0.41**
		ZX2	A	125.71	119.40	1,172	48,612	2.41%	0.48
			B	126.12	119.60	2,310	48,220	4.79%	0.93
			C	125.88	119.73	496	50,422	0.98%	0.20
		Total / Average		**125.90**	**119.58**	**3,978**	**147,254**	**2.70%**	**0.54**

Substation	Season	Circuit	Phase	Baseline OFF Voltage	ON Voltage	Daily Avg kWh Savings	Daily Average Consumption	Percent Savings	CVR Factor
		ZX3	A	125.13	119.58	344	39,968	0.86%	0.19
			B	125.63	119.81	441	36,561	1.21%	0.26
			C	125.04	119.88	348	35,503	0.98%	0.24
		Total / Average		**125.26**	**119.76**	**1,133**	**112,033**	**1.01%**	**0.23**
		ZX4	A	125.71	119.38	544	19,505	2.79%	0.55
			B	126.12	119.55	1,188	26,838	4.42%	0.85
			C	125.88	119.67	1,012	29,220	3.46%	0.70
		Total / Average		**125.90**	**119.53**	**2,744**	**75,563**	**3.63%**	**0.72**
		ZX5	A	125.13	118.91	1,512	30,610	4.94%	0.99
			B	125.63	119.26	993	31,038	3.20%	0.63
			C	125.04	119.07	980	40,729	2.41%	0.50
		Total / Average		**125.26**	**119.08**	**3,485**	**102,376**	**3.40%**	**0.69**
		ZX6	A	125.71	119.38	677	39,523	1.71%	0.34
			B	126.12	119.58	1,204	43,427	2.77%	0.53
			C	125.88	119.72	1,191	34,717	3.43%	0.70
		Total / Average		**125.90**	**119.56**	**3,072**	**117,668**	**2.61%**	**0.52**
	Total / Average			**125.58**	**119.55**	**16,177**	**654,070**	**2.47%**	**0.51**
	Heating	ZX1	A	125.13	119.63	241	18,587	1.29%	0.29
			B	125.63	119.88	641	20,134	3.18%	0.70
			C	125.04	119.93	822	20,385	4.03%	0.99
		Total / Average		**125.26**	**119.81**	**1,703**	**59,106**	**2.88%**	**0.66**
		ZX2	A	125.71	119.40	1,164	28,957	4.02%	0.80
			B	126.12	119.60	973	27,124	3.59%	0.69
			C	125.88	119.73	882	27,838	3.17%	0.65
		Total / Average		**125.90**	**119.58**	**3,019**	**83,918**	**3.60%**	**0.72**
		ZX3	A	125.13	119.58	326	27,745	1.17%	0.26
			B	125.63	119.81	746	26,116	2.86%	0.62
			C	125.04	119.88	728	27,643	2.63%	0.64
		Total / Average		**125.26**	**119.76**	**1,800**	**81,504**	**2.21%**	**0.50**
		ZX4	A	125.71	119.38	522	15,591	3.35%	0.66
			B	126.12	119.55	649	20,641	3.14%	0.60
			C	125.88	119.67	635	20,295	3.13%	0.63
		Total / Average		**125.90**	**119.53**	**1,806**	**56,527**	**3.20%**	**0.63**

Substation	Season	Circuit	Phase	Baseline OFF Voltage	ON Voltage	Daily Avg kWh Savings	Daily Average Consumption	Percent Savings	CVR Factor
		ZX5	A	125.13	118.91	842	19,367	4.35%	0.87
			B	125.63	119.26	704	19,083	3.69%	0.73
			C	125.04	119.07	951	24,889	3.82%	0.80
		Total / Average		**125.26**	**119.08**	**2,496**	**63,340**	**3.94%**	**0.80**
		ZX6	A	125.71	119.38	622	24,927	2.50%	0.50
			B	126.12	119.58	869	26,959	3.22%	0.62
			C	125.88	119.72	412	22,139	1.86%	0.38
		Total / Average		**125.90**	**119.56**	**1,903**	**74,026**	**2.57%**	**0.51**
	Total / Average			**125.58**	**119.55**	**12,728**	**418,420**	**3.04%**	**0.63**
Total / Average				**125.58**	**119.55**	**28,905**	**1,072,490**	**2.70%**	**0.56**

4 Demand Response Programs

PSO's demand response (DR) portfolio in 2019 consisted of two programs, one that targeted residential customers and one that targeted commercial and industrial customers. Program-level annual savings are summarized in Table 4-1. PSO did not report annual energy savings for the Business DR program. This program's sole aim is to provide load reduction capabilities during times of high demand. However, because of participants' voluntary load reductions during event days, there are energy savings associated with the program. These energy savings are not persistent in the same way that the installation of energy-efficient equipment provides energy savings for the life of the equipment; rather energy savings from the Business DR program only occur during event days.

Table 4-1: Annual Energy Savings – Demand Response Programs

Program	Gross Annual Energy Savings (MWh)				Net Impacts	
	Projected	Reported	Verified	Gross Realization Rate	NTG Ratio	Net Annual Energy Savings (MWh)
Power Hours	2,047	1,460	2,377	163%	85%	2,024
Business Demand Response	128	0	545	-	100%	545
Demand Response Totals	**2,175**	**1,460**	**2,922**	**200%**	**88%**	**2,569**

Program-level peak demand reduction is summarized in Table 4-2.

Table 4-2: Peak Demand Reduction – Demand Response Programs

Program	Gross Peak Demand Reduction (MW)				Net Impacts	
	Projected	Reported	Verified	Gross Realization Rate	NTG Ratio	Net Peak Demand Reduction (MW)
Power Hours	15.27	16.07	12.26	76%	100%	12.26
Business Demand Response	51	69.89	51.41	74%	100%	51.41
Demand Response Totals	**66.27**	**83.96**	**63.66**	**74%**	**100%**	**63.66**

4.1 Power Hours Program

4.1.1 Program Overview

The Power Hours program provided ways to reduce energy usage of residential customers during peak demand periods by offering customers the option of participating in direct load control (DLC) events and time-of-day (TOD) usage rates. DLC events reduce energy usage when demand is highest by communicating with registered Wi-Fi enabled thermostats installed in the homes of participants. TOD rates offer lower rates for electricity during periods when there is less demand for electricity. This empowers participants to choose lower cost times to perform routine tasks such as clothes drying and running the dishwasher, which shifts energy usage away from high energy demand times.

Table 4-3 shows the performance metrics achieved by the program. Over 2 GWh of energy was saved by this program as a result of the smart thermostat incentives and DLC events. These measures also resulted in a peak demand reduction of over 12,000 kW.

Table 4-3: Performance Metrics – Power Hours Program

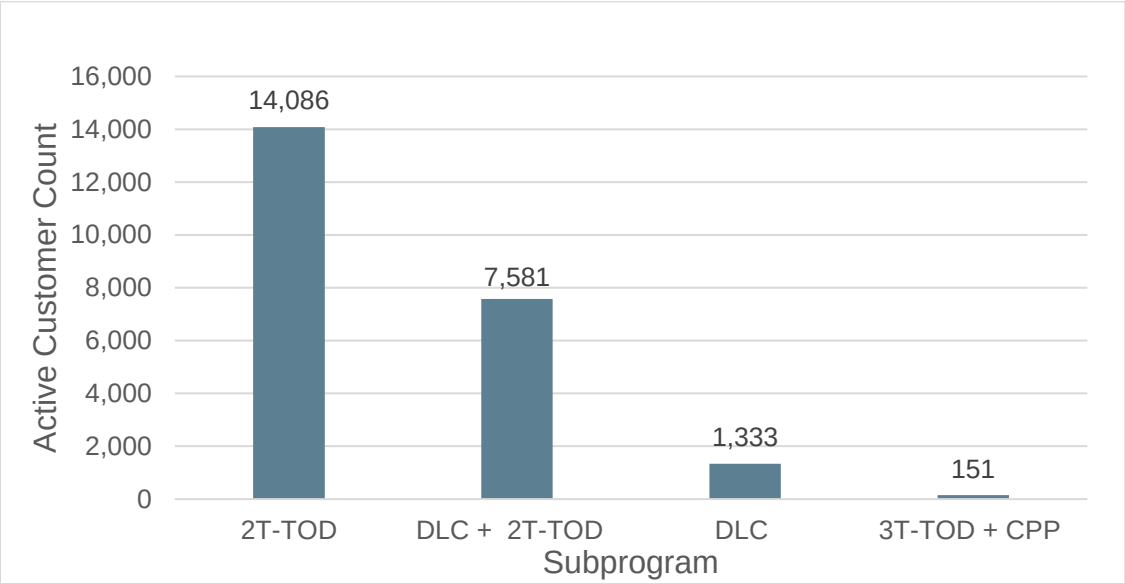
Metric	PY2019
Number of Customers	23,151
Budgeted Expenditures	$2,292,669
Actual Expenditures	$1,952,166
Energy Impacts (kWh)	
Projected Energy Savings	2,046,870
Reported Energy Savings	1,460,148
Gross Verified Energy Savings	2,377,419
Net Verified Energy Savings	2,024,453
Peak Demand Impacts (kW)	
Projected Peak Demand Savings	16,074
Reported Peak Demand Savings	14,037
Gross Verified Peak Demand Savings	**12,258.06**
Net Verified Peak Demand Savings	**12,258.06**
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	1.82
Utility Cost Test Ratio	1.47

All PSO residential customers with an Advanced Metering Infrastructure (AMI) installed are eligible to participate in the program. Households participating in DLC events are also required to have central air conditioning, Wi-Fi service, and have at least one program-

eligible, Wi-Fi enabled thermostat installed. All customers that participate in the Power Hours program are eligible to receive rebates for the full cost of up to two of Wi-Fi enabled thermostats per home, even if they do not participate in DLC events.

Program year 2019 (PY2019) was the fourth year PSO administered the program. At the end of PY2019 there were 23,151 active participants, with 3,463 new customers joining the program in 2019. The program has four subprograms, which are detailed in the following sections. Figure 4-1 shows the number of active customers participating in each subprogram.

Figure 4-1: Subprogram Active Customer Counts



4.1.1.1 Direct Load Control

The Direct Load Control (DLC) subprogram allows customers to participate in DLC events. Households participating in DLC events are required to have central air conditioning, Wi-Fi service, and have at least one program-eligible, Wi-Fi enabled thermostat installed. These thermostats are registered with PSO, allowing them to receive a load curtailment signal. There are two load curtailment strategies used for DLC events: temperature offset and duty-cycling.

- The temperature offset option changes participants' thermostat setpoint at the beginning of the event period. Setpoints can be increased by up to four degrees. Once the event period is over, the thermostats' setpoints are returned to the setpoint before the event occurred.
- The duty-cycling strategy changes the duration in which an air conditioner (A/C) compressor was on or off during the event time period. All duty-cycling events this year used a 50% cycling ratio with a 60-minute cycling period; meaning the A/C

compressor was shut off for 30 minutes, then turned back on for the next 30 minutes. This pattern repeats until the event is over.

Ten DLC events occurred in 2019 during the months of July and August. Nine events used the temperature offset strategy, while one event used the duty-cycling strategy.

Participants can override the DLC curtailment if they do not wish to participate in an event. Participants can override (or opt-out of) the curtailment either by using the Honeywell "Total Connect Comfort" app or by manually changing the setpoint on the thermostat. For 2019, all customers in the subprogram received a credit of $2.50 for each event they fully participated in.

4.1.1.2 Two-Tier Time of Day Pricing

Two-Tier Time of Day Pricing (2T-TOD) is a rate schedule available to individual residential customers in this subprogram. For 2019, the rate was broken into two tiers, with each tier having a unique electricity pricing.

- For non-holiday weekdays for June through October, two different rates are charged depending on the time of day. From 2 PM to 7 PM a higher cost tier was in effect, charged at a rate of 14.100₵/kWh. For all other hours during those months, a lower cost tier was in effect, charged at a rate 2.895₵/kWh.
- For all other times, a low-cost declining block rate schedule applies for all hours of all days, with the price in this period the same as in the standard tariff. Rates were as follows: 4.3220₵/kWh for first 475 kWh, 2.865₵/kWh for the next 775 kWh, and 1.921₵/kWh for all additional kWh.

4.1.1.3 Direct Load Control and Two-Tier Time of Day Pricing

Customers can participate in DLC events as well as the 2T-TOD rate schedule. Customers who do this are considered a part of a separate subprogram called Direct Load Control and Two-Tier Time of Day Pricing (DLC + 2T-TOD). All eligibility requirements of the DLC and 2T-TOD subprograms apply to this subprogram as well.

4.1.1.4 Three-Tier Time of Day Plus Critical Peak Pricing

The final subprogram offered to residential customers is the Three Tier Time of Day pricing plus Critical Peak Pricing (3T-TOD + CPP). Unlike the 2T-TOD subprogram, customers participating in this subprogram are not eligible to participate in the DLC subprogram. Participating customers are expected to remain in the subprogram for a minimum of one year. If a customer terminates service under this schedule, the customer is not eligible to receive service under it again for a period of one year from the termination date.

The rate schedule for this subprogram is referred to as the Variable Peak Pricing Residential Service Tariff (VPPRS) rate schedule. The tariff included a "hold harmless"

provision for customers during their first year in the subprogram. This guarantees that a customer does not pay more under the tariff than they would under the standard residential rates.

This rate tariff charges different rates for electricity during the billing months of June through October. For 2019, the rates were as follows:

- A rate of 2.3340₵/kWh was applied for all hours on weekends and holidays and for non-holiday weekdays from 11 p.m. to 10 a.m.
- A rate of 3.850₵/kWh was applied to hours from 10 a.m. to 2 p.m. and from 7 p.m. to 11 p.m. on non-holiday weekdays.
- A rate of 14.10₵/kWh was applied to hours from 2 p.m. to 7 p.m. on non-holiday weekdays.
- A rate of .75₵/kWh is typically applied during hours when PSO called a critical peak event. This had no effect in PY2019, however, as no critical peak events were called.

4.1.2 EM&V Methodologies

The impact of the Power Hours program was measured in two parts. The first was measuring energy savings (kWh) and peak reduction (kW) during DLC events. The second was the annual energy savings (kWh) and peak reduction (kW) from the smart thermostat incentives. Annual energy savings methodologies are provided in Appendix F of this report.

4.1.2.1 Direct Load Control Events

The impact of DLC events was analyzed using 15-minute interval Advanced Metering Infrastructure (AMI) consumption data provided by PSO. The statistical program R was used to process and analyze the data. Various high-level data processing steps were applied to the data before it was analyzed. These steps included:

- Validating that the files were not corrupt and of a consistent size.
- Extracting and transferring data from these files.
- Updating PSO with remaining data needs (i.e., if files were missing or corrupted).

After the necessary files were validated, the data was cleaned and prepared for analysis. This included:

- Parsing timestamps and converting them to Central Standard Time (CST).
- Multiplying 15-minute consumption values by 4 to convert the units from kWh to kW.
- Performing data completeness checks on all data.

- Aggregating 15-minute consumption data to 30-minute consumption data. This was done to better match available weather data and to improve statistical model effectiveness.

Local temperature and humidity data were retrieved from the National Oceanic and Atmospheric Administration (NOAA). Temperature values were converted to cooling degree days (CDD). This was done because CDD values can quantify how power consumption relates to the weather more effectively than temperature values. Equation 4-1 shows how temperature is converted to CDD.

Equation 4-1: Temperature to CDD Conversion

$$CDD_t = \begin{cases} 0 & if\ temp_t < cddbase \\ (temp_t - cddbase)\ /\ 48 & if\ temp_t \geq cddbase \end{cases}$$

Where:

$temp_t$ = temperature at time t
$cddbase$ = determined CDD base temperature

In order to calculate the most accurate CDD values, the optimal CDD base temperature for the evaluated population was determined. Intuitively, the CDD base temperature can be thought of as the coolest temperature in which energy usage begins increasing due to the operation of A/C units. The optimal CDD base temperature for the participant population was determined by running several possible CDD base temperature values through the following process.

- Temperature values were converted to CDD using the hypothetical CDD base.
- A linear regression model was fit to predict energy usage during the months of May through August, using only the CDD values.
- The model is scored by calculating the root mean squared error of its predictions.

The CDD base temperature that produced the model with the smallest root mean squared error score was the value chosen. In PY2019, the optimal CDD base temperature for the participant population was determined to be 69°.

Hourly precipitation data was retrieved from the Iowa State University Iowa Environmental Mesonet[93]. All weather data was retrieved for three locations: Tulsa, Lawton, and Bartlesville. Each household was matched with weather data from the location it was nearest to geographically.

Once the necessary data was processed, the devices that participated in the DLC events were identified. Two Power Hours subprograms included a direct load control component: DLC and DLC + 2T-TOD. Tracking data for these subprograms, provided by PSO, was

[93] Iowa Environmental Mesonet, available at: https://mesonet.agron.iastate.edu/

used to identify which devices were available to participate in each event. An available device is defined as a device registered with PSO as part of either the DLC or DLC + 2T-TOD subprogram. An available device could become unavailable only if the customer in possession of the device decided to permanently opt out of the subprogram.

Because customers can manually override the DLC curtailment signal or various technical failures may occur, not every available device participated in the events. Thus, devices that were non-responsive to the called events needed to be identified so that the calculation of energy savings included only devices that actually participated in the event.

A device is considered a non-responsive device (NRD) if it does not respond to the curtailment signal sent by PSO. NRDs were identified using a combination of three tests. A device is considered non-responding for an event day only if all three tests identify the device as non-responding. These three tests are run on every available device for every event date.

Test 1 and 2 analyze the cumulative sum (CSUM) change in energy usage of each device to check for a significant change in energy usage before and during an event. To do this, the cumulative sum of each site's energy usage is calculated (Equation 4-2).

Equation 4-2: Cumulative Sum Function

$$x = (i_1, i_2, i_3, \dots, i_{48})$$

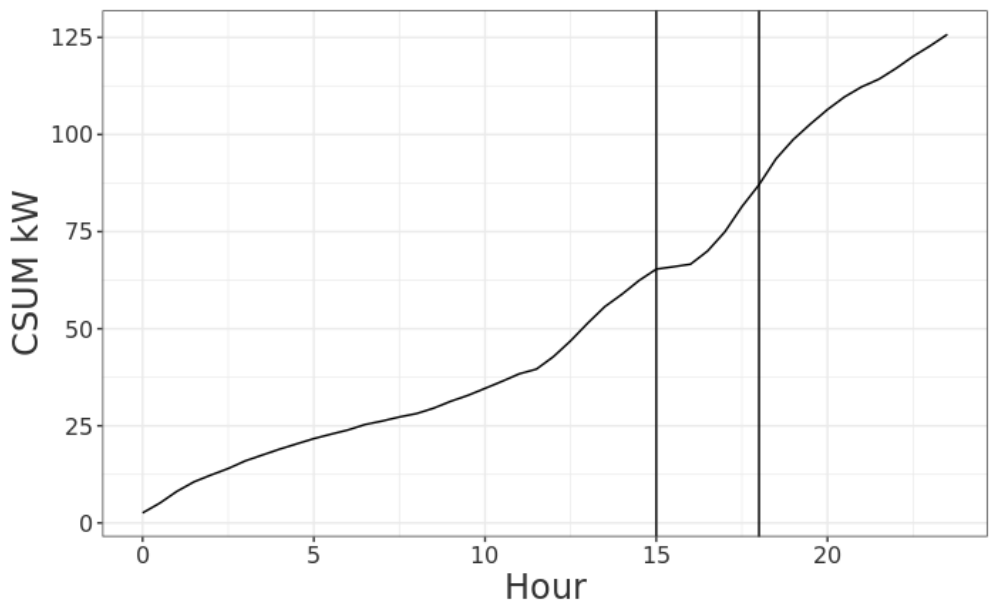
$$CSUM(x) = (i_1, i_1 + i_2,\ i_1 + i_2, + i_3, \dots, i_1 + \dots + i_{48})$$

Where:

x	= a vector of kW measures taken at 30-minute intervals,
$i_1 : i_{48}$	= the 24-hour interval from 12am to 12am the following day.

This creates a "running total" of power used throughout the day. This provided a way to quantify how the rate of energy consumption changed throughout the day. Figure 4-2 shows an example of the CSUM curve for one responding device during the event date August 20. The vertical lines represent the start and end of the event period.

Figure 4-2: Example of Site-level CSUM Changes



To quantify how the rate of energy usage changed once the event started, a slope ratio was calculated for the CSUM curve of each device on each event day (Equation 4-3).

Equation 4-3: Slope Ratio Calculation

$$SlopeRatio = s_{event}/s_{pre.event}$$

Where:

s_{event} = slope of the CSUM curve during the event

$s_{pre.event}$ = slope of the CSUM curve three hours prior to the start of the event

For Test 1, if the slope ratio was greater than or equal to 1 the device was identified as non-responding.

Equation 4-4: NRD Test 1

$$NRD_{T1} = SlopeRatio_{event} \geq 1$$

Where:

$SlopeRatio_{event}$ = Slope ratio of the CSUM curve

For Test 2 an expected (or site-normal) CSUM curve was created for each site using the average kW usage of the previous seven non-event weekdays. Next, the slope ratio was calculated for the actual CSUM curve and the site-normal CSUM curve. If the slope ratio for the actual curve was greater than or equal to the slope ratio for the site-normal curve, the device was considered non-responding.

Equation 4-5: NRD Test 2

$$NRD_{T2} = SlopeRatio_{event} \geq SlopeRatio_{site.normal}$$

Where:

$SlopeRatio_{event}$ = Slope ratio of the CSUM curve
$SlopeRatio_{site-normal}$ = Slope ratio of the site-normal CSUM curve

Finally, Test 3 tested for a 10% reduction in kW usage. For each device, the kW one hour before the event started and the kW one hour after the event started were tested for a drop greater than 10% (Equation 4-6). The value of 10% was used because it is the average value found from an extensive review of drop percentages found in similar programs.

Equation 4-6: NRD Test 3

$$NRD_{T3} = T1_{kWh} \leq T2_{kWh}$$

Where:

$PreHr_{kW}$ = kW measured one hour before the event start
$EventHr_{kW}$ = kW measured one hour after the event start
$T1_{kWh}$ = $PreHr_{kWh} - EventHr_{kWh}$
$T2_{kWh}$ = $PreHr_{kWh} * 10\%$

Next, baseline energy usage curves were developed. These were used to estimate what energy usage would have been during an event day had the event not occurred. For each event, an average baseline was developed using AMI data from all responding devices during non-event, non-holiday weekdays that had similar weather to that of the event day being analyzed.

The kmeans clustering algorithm was used to identify similar weather days to each event day. Average daily temperature and humidity was calculated for every non-holiday weekday from May to September. Then the kmeans clustering algorithm was applied to the daily weather data. This split every day into one of three clusters (or similar groups) of dates. Any non-event day that was placed into the same cluster as the event day was used to calculate that event's baseline. Two events (July 10 and August 21) had a significant amount of precipitation before/during the event. In order to ensure the baseline curves for these two dates were able to account for this, data from the three hottest non-event, non-holiday weekdays in which it rained was used in addition to the data from the event days' weather cluster.

Once it was determined what data would be used to calculate each event's baseline curve, a linear regression model was calculated using that data (Equation 4-7).

Equation 4-7: Baseline Energy Usage Curve Regression Model

$$kW_t = CDD_t + CDD_{t-2} + t + Percipitation_t$$

Where:

t	= the 30-minute interval for which kW usage is being predicted
CDD_t	= cooling degree days at time t
CDD_{t-2}	= cooling degree days two hours before t
$Precipitation_t$	= inches of precipitation at time t

Finally, to ensure the baseline curves were as accurate as possible, a normalizing factor was calculated and applied to the baseline curve of each event day (Equation 4-8).

Equation 4-8: Normalization Factor Calculation

$$nf = kW_{actual.hour=es-2} \,/\, kW_{baseline.hour=es-2}$$

Where:

$kW_{actual.hour=es-2}$	= kW measured two hours before the event
$kW_{baseline.hour=es-2}$	= kW predicted by the baseline two hours before the event

Once the baseline curve was determined, demand reduction could be calculated. Demand reduction represented the average decrease in energy usage that occurred for the average event participant during a given time interval. Demand reduction was calculated for the event period and the snapback period. The event period is the time from when the event starts to when the event ends. The snapback period is the time from when the event ends to two hours after the event ends. The snapback period represents the time when all devices are resuming normal function and, as a result, typically have a small spike in energy usage before returning to normal. Equation 4-9 shows the formula used for calculating demand reduction.

Equation 4-9: Demand Reduction Calculation

$$kW_t^{reduction} = kW_t^{baseline} - kW_t^{actual}$$

Where:

t	= the 30-minute interval for which demand reduction is being calculated
$kW_t^{baseline}$	= kW demand predicted by the baseline at time t
kW_t^{actual}	= kW demand measured at time t

Demand reduction was then used to calculate average energy savings for each event. This was done by converting the demand reduction measures from kW to kWh and summing all those kWh values up.

Equation 4-10: DLC Event Energy Savings (kWh) Calculation

$$kWh_{saved} = \sum_{t \in EventPeriod} \left(\frac{kW_t^{reduction}}{2}\right)$$

Where:

t = the 30-minute interval for which energy savings is being calculated
$EventPeriod$ = all time intervals from event start to two hours after the event end
$kW_t^{reduction}$ = demand reduction calculated at time t

Peak reduction was also calculated for each event. This measure represented the maximum drop in energy usage that occurred for the average event participant. Peak reduction was calculated by finding the maximum difference between the event's baseline curve and the actual measured usage.

Equation 4-11: DLC Verified Peak Reduction (kW) Calculation

$$kW_{reduced} = mean_{\,t \in FirstHour}\,(kW_t^{reduction})$$

Where:

t = the 30-minute interval for which energy savings is being calculated
$FirstHour$ = all time intervals from event start to one hour after event start
$kW_t^{reduction}$ = demand reduction calculated at time t

4.1.2.2 Smart Thermostat Incentives

The use of smart thermostats leads to an annual reduction in energy use. This reduction is due to occupancy sensors, sophisticated setpoint algorithms, advanced scheduling options, remote programming capability, and available information that optimizes energy use. Savings were calculated for customers that joined the program in PY2019 and received a rebate on the purchase of at least one smart thermostat. A thermostat model was considered smart if it met all the requirements for a smart thermostat listed in the Arkansas Technical Reference Manual (AR TRM)[94] or it the thermostat model was listed as an EnergyStar® certified smart thermostat at any point in PY2019.[95] Table 4-4 lists every thermostat model incentivized by the program, as well as which of those models qualify as a smart thermostat.

[94] Arkansas Technical Reference Manual, version 7.0 volume 1: See Section 2.1.12
[95] Accessible via: https://www.energystar.gov/products/certified-products/detail/set

Table 4-4: Thermostat Models Incentivized by the Program

Thermostat Model	Qualifies as Smart
Honeywell Wi-Fi 7-Day Programmable Touchscreen Thermostat	No
Honeywell Wi-Fi VisionPRO	Yes
Honeywell Wi-Fi 9000	Yes
Honeywell Lyric Round	Yes
Honeywell Lyric T5/T6	Yes
Honeywell Home T9	Yes
ecobee3	Yes
ecobee3 lite	Yes
ecobee4	Yes
ecobee5 Pro with Voice Control	Yes

Energy efficiency savings were calculated as deemed value for each new participant, based on the savings offered for smart thermostats listed in the AR TRM.

New customers who received a new thermostat and participated in the DLC events (customers in the DLC or DLC + 2T-TOD programs) had their savings calculated as part of the DLC event impact analysis. The remaining customers were eligible for peak reduction savings of 0.26 kW per device. This number was estimated in 2017 by ADM after analyzing 7,618 customers participating in the 2T-TOD subprogram. This number was determined to be representative of the subprogram in 2019 as well. This estimate will be reviewed annually to ensure it is still an accurate estimate of savings for this customer group.

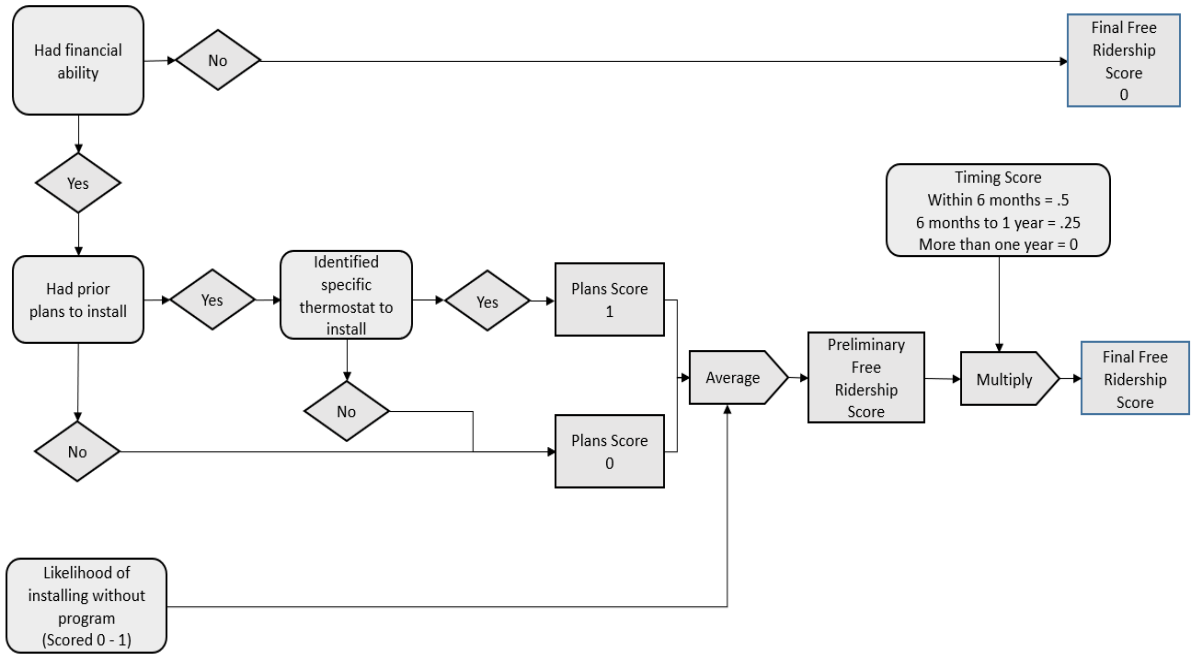
4.1.3 Net-to-Gross Estimation

A net-to-gross ratio was calculated to take into consideration the effect of free ridership on energy savings. Free ridership is the estimated proportion of participants that would have participated in the energy saving behavior incentivized by the program regardless of whether or not the program existed. A net-to-gross ratio was only calculated and applied to savings resulting from smart thermostat incentives. Demand response programs are not likely to have net-to-gross effects because customers are unlikely to curtail load in absence of the program. For this reason, a net-to-gross ratio of 100% was assumed for all savings resulting from demand response events.

Information collected from a sample of participant decision makers was used to estimate the net savings resulting from the rebated smart thermostats. This program was not expected to generate significant spillover effects; therefore, the evaluators did not assess spillover.

Decision makers were asked a series of questions on their financial ability to implement the measure without program incentives, plans to implement the project before learning of the program, the likelihood of implementing the measure in the absence of the program, and the impact of the program on the timing of the project to assess free ridership. Each respondent was then assigned a free ridership score based on a consistent free ridership scoring algorithm. The free ridership scoring algorithm for the surveys is shown in Figure 4-3.For the survey, responses were not weighted. That is, each response had equal weight in estimating the average free ridership level for the program.

Figure 4-3: Free Ridership Scoring for Smart Thermostats Based on Survey Responses



4.1.4 Impact Evaluation Findings

The methods described in the EM&V Methodologies section were used to determine the impacts on customer energy use for the various subprograms of the Power Hours program. Those findings are presented and discussed in this section.

4.1.4.1 Direct Load Control Event Impact

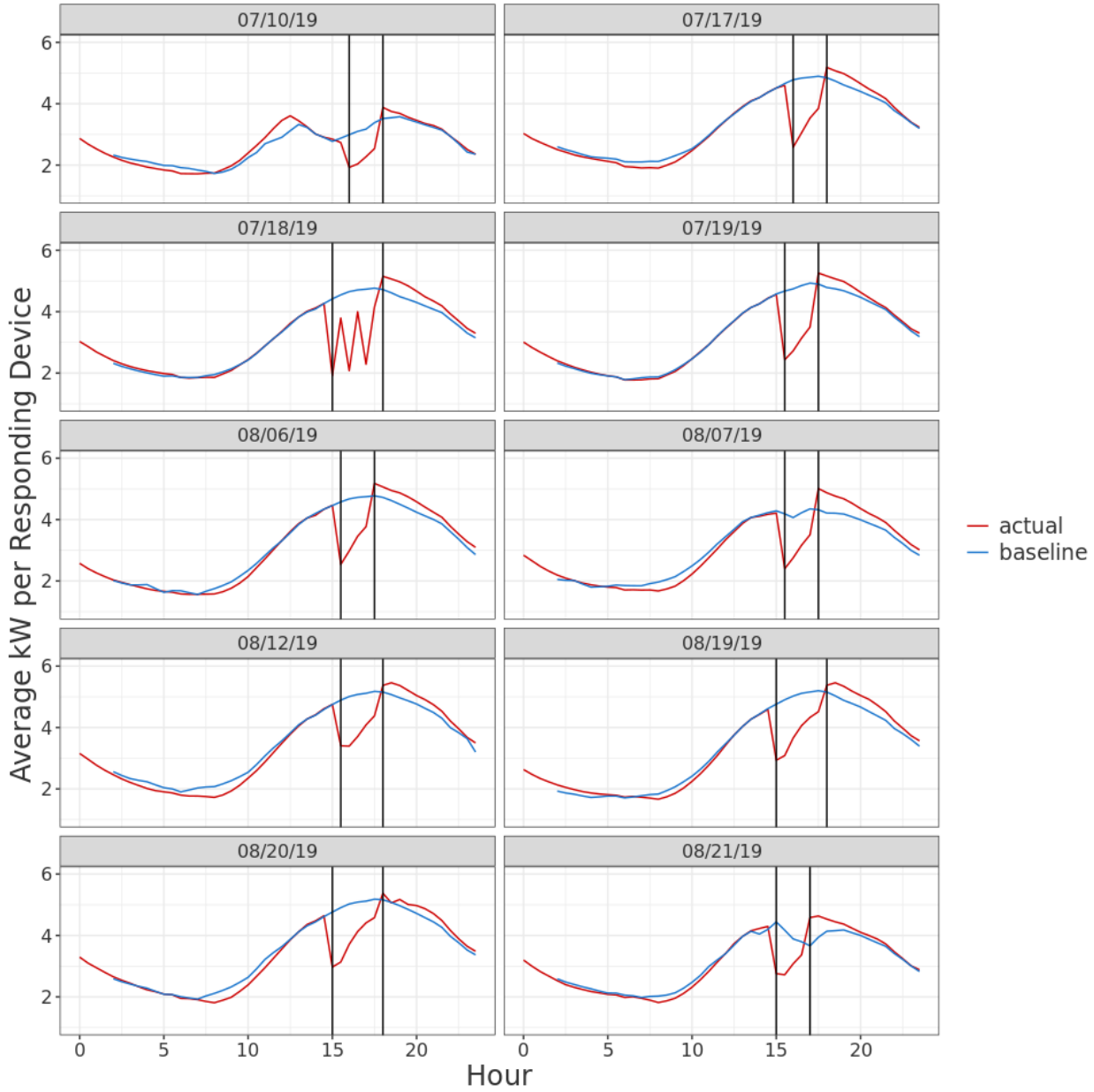
In 2019, ten Direct Load Control (DLC) events were called in the months of July and August. These events are summarized in Table 4-5. July 18 was the only event date where the duty-cycling strategy was used.

Table 4-5: Summary of Events

Date	Event Start Hour	Event End Hour	Duration (Hours)	Curtailment Strategy
07/10/2019	16	18	2	Temperature Offset
07/17/2019	16	18	2	Temperature Offset
07/18/2019	15	18	3	Duty-Cycling
07/19/2019	15.5	17.5	2	Temperature Offset
08/06/2019	15.5	17.5	2	Temperature Offset
08/07/2019	15.5	17.5	2	Temperature Offset
08/12/2019	15.5	18	2.5	Temperature Offset
08/19/2019	15	18	3	Temperature Offset
08/20/2019	15	18	3	Temperature Offset
08/21/2019	15	17	2	Temperature Offset

Baseline curves were developed for each event day. These were used to estimate what energy usage would have been during an event day had the event not occurred. The baseline curves used for the demand reduction calculations are shown in Figure 4-4. Vertical lines represent the start and end time of each event.

Figure 4-4: Actual vs. Baseline Energy Usage per Responding Device



Non-responsive device identification was performed on all available devices using the methods discussed in the EM&V Methodologies section. Any device that was identified as an NRD (non-responsive device) for an event was removed from the analysis. The response rate for an event is defined as the percentage of available devices that were not identified as an NRD. Table 4-6 shows the response rates for each event.

Table 4-6: Active and responsive Device Counts per Event

Date	Available Devices	Responsive Devices	Response Rate
07/10/2019	8,034	6,615	82.34%
07/17/2019	8,036	6,896	85.81%
07/18/2019	8,035	7,037	87.58%
07/19/2019	8,035	6,897	85.84%
08/06/2019	8,054	7,056	87.61%
08/07/2019	8,055	7,195	89.32%
08/12/2019	8,060	6,974	86.53%
08/19/2019	8,062	7,164	88.86%
08/20/2019	8,061	7,134	88.50%
08/21/2019	8,062	7,399	91.78%

Demand reduction was calculated by comparing the kW usage predicted by the baseline curve to the actual kW usage during the event. Results included demand reduction from the event period and the snapback period. The event period is the time from when the event starts to when the event ends. The snapback period is the time from when the event ends to two hours after the event ends.

Demand reduction was calculated in 30-minute increments, shown in Table 4-7. Each column represents the average kW reduction per responding device during the specified time interval. Time intervals during the snapback period are identified by the grey cells.

Table 4-7: Demand Reduction (kW) per 30-Minute Interval

Date	15	15.5	16	16.5	17	17.5	18	18.5	19	19.5
07/10/2019			1.06	1.06	0.90	0.85	-0.36	-0.20	-0.11	-0.07
07/17/2019			2.20	1.78	1.33	1.05	-0.34	-0.33	-0.37	-0.32
07/18/2019	2.50	0.75	2.57	0.71	2.44	0.61	-0.43	-0.45	-0.48	-0.44
07/19/2019		2.24	2.02	1.71	1.43	-0.36	-0.37	-0.32	-0.30	
08/06/2019		2.04	1.70	1.27	0.97	-0.40	-0.34	-0.33	-0.37	
08/07/2019		1.79	1.31	1.06	0.85	-0.69	-0.66	-0.56	-0.50	
08/12/2019		1.48	1.61	1.37	1.03	0.80	-0.22	-0.39	-0.40	-0.34
08/19/2019	1.82	1.82	1.37	1.05	0.83	0.68	-0.22	-0.43	-0.46	-0.40
08/20/2019	1.79	1.77	1.31	0.96	0.71	0.60	-0.21	0.02	-0.20	-0.16
08/21/2019	1.68	1.45	0.81	0.43	-0.92	-0.69	-0.39	-0.29		

Average energy savings per responding device was calculated for each event, using the demand reduction results above. This was done by converting the average kW demand

reduction for each time interval to kWh and summing the kWh values together. Total energy savings for each event was then calculated by multiplying the average energy savings per responding device by the number of responding devices for that event. Table 4-8 shows average savings per device and total savings for each event.

Table 4-8: Energy Savings (kWh) per Event

Date	Responsive Devices	Savings During Event Hours (kWh)	Savings During Snapback Hours (kWh)	Average Energy Savings (kWh)	Total Energy Savings (kWh)
07/10/2019	6,615	1.94	-0.37	1.56	10,335.41
07/17/2019	6,896	3.18	-0.68	2.50	17,248.19
07/18/2019	7,037	4.80	-0.90	3.90	27,416.93
07/19/2019	6,897	3.70	-0.68	3.02	20,840.82
08/06/2019	7,056	2.99	-0.72	2.27	15,986.38
08/07/2019	7,195	2.50	-1.20	1.30	9,345.02
08/12/2019	6,974	3.15	-0.67	2.48	17,301.65
08/19/2019	7,164	3.79	-0.75	3.03	21,728.07
08/20/2019	7,134	3.57	-0.28	3.29	23,483.28
08/21/2019	7,399	2.19	-1.15	1.04	7,696.91
Total					**171,383**

Lastly, peak reduction per device was calculated for each event. Verified peak reduction represents the average demand reduction during the first hour of the event, while max peak reduction represents the maximum demand reduction that occurred at any point during event. Peak reductions for each event are shown in Table 4-9.

Table 4-9: Program-Level Peak Reduction (kW) per Event

Date	Responsive Devices	Peak Reduction per Device (kW)	Peak Reduction per Event (kW)
07/10/2019	6,615	1.06	7,032.99
07/17/2019	6,896	1.99	13,730.52
07/18/2019	7,037	1.63	11,449.78
07/19/2019	6,897	2.13	14,677.71
08/06/2019	7,056	1.87	13,171.32
08/07/2019	7,195	1.55	11,155.56
08/12/2019	6,974	1.55	10,807.15
08/19/2019	7,164	1.82	13,047.92
08/20/2019	7,134	1.78	12,706.22
08/21/2019	7,399	1.57	11,600.84
Total			**11,938.00**

Verified peak reduction was calculated by taking the average peak reduction per event. Max peak reduction was calculated by finding the maximum peak reduction per event. Potential max peak reduction represents the max peak reduction possible if each event had reached the max response rate from the year (91.78%), max number of available devices (8,062), and maximum peak reduction per device (2.13 kW). The results are shown in Table 4-10.

Table 4-10: Total Peak Reduction

Verified Peak Reduction (kW)	Max Peak Reduction (kW)	Potential Max Peak Reduction (kW)
11,938.00	14,677.71	15,746.03

4.1.4.2 Smart Thermostat Rebates Impact

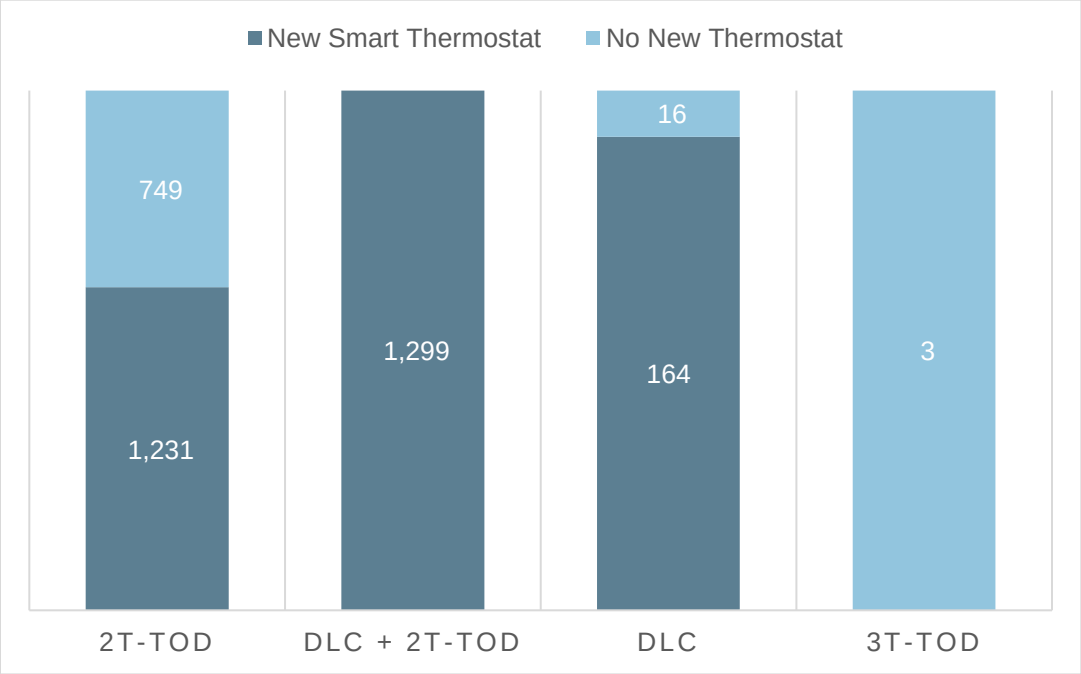
The annual savings for the Power Hours program was calculated based on the savings associated with the smart thermostat program incentive. Savings from smart thermostats came from improved real-time information about HVAC usage and cost, improved user interfaces, and algorithm optimization (such as occupancy detection and prediction).

Savings were calculated for customers that joined the program in PY2019 and received a rebate on the purchase of at least one smart thermostat. A thermostat model was considered smart if it met all the requirements for a smart thermostat listed in the AR TRM. In PY2019, 2,694 new customers purchased a smart thermostat using rebates from the program.

Not all participants who enrolled in the program received an incentivized smart thermostat. Figure 4-5 shows the proportion of new participants that did and did not

purchase a smart thermostat, broken up by subprogram. This was because they either signed up for the TOD subprogram, in which a smart thermostat is not required, or they already had an Ecobee thermostat which allows them to participate in DLC events.

Figure 4-5: New Participant Thermostat Installation by Subprogram



Information collected from a sample of participants was used to estimate the net savings resulting from the free or rebated smart thermostats. This program offering does not generate significant spillover effects; therefore, evaluators did not assess spillover for this program. Residents were asked a series of questions on their financial ability to implement the measure without program incentives, plans to implement the project before learning of the program, the likelihood of implementing the measure in the absence of the program, and the impact of the program on the timing of the project to assess free ridership. The net-to-gross ratio was found to be 84%.

Table 4-11: Thermostat Incentive Energy Savings

New Customers that Purchased Smart Thermostats	Gross Energy Savings (kWh)	Net-to-Gross Ratio	Net Energy Savings (kWh)
2,694	2,206,036	84%	1,853,070

These customers were also eligible for peak reduction savings. Customers who received a new thermostat and participated in the DLC events (customers in the DLC or DLC + 2T-TOD programs) had their savings calculated as part of the DLC event impact analysis (see Section 4.1.4.1). The remaining customers received peak reduction savings of 0.26 kW per device. This number was estimated in 2017 by ADM as the average peak reduction for customers in the 2T-TOD subprogram.

Table 4-12: Thermostat Incentive Peak Reduction

New 2T-TOD Customers that Purchased Smart Thermostats	Verified Peak Reduction per Device (kW)	Total Verified Peak Reduction (kW)
1,231	0.26	320.06

4.1.4.3 Total Verified Demand Reduction (kW)

Total verified demand reduction was calculated by adding the verified demand reduction from the DLC events and the smart thermostat incentives. The results are shown in Table 4-13.

Table 4-13: Total Verified Peak Reduction

Source	Total Verified Peak Reduction (kW)
DLC Events	11,938.00
Thermostat Incentives	320.06
Total	**12,258.06**

4.1.4.4 Total Net Energy Savings (kWh)

Total net energy savings was calculated by adding up the total energy savings of each DLC event and the net annual energy savings from smart thermostat incentives. The results are shown in Table 4-14.

Table 4-14: Total Net Energy Savings

Source	Total Energy Savings (kWh)
DLC Events	171,383
Thermostat Incentives	1,853,070
Total	**2,024,453**

4.1.5 Process Evaluation Findings

ADM's process evaluation activities included participant surveys and an interview with the PSO Program manager. ADM provided a portfolio level process evaluation memo to PSO after the completion of the 2019 program year. The following summarizes the key finding from the process evaluation of the Power Hours program.

- **Power Hours program staff met their savings goals.** The program surpassed PSO's projections for savings (kWh) but fell short of their peak demand reduction (kW) projections. The program also met PSO's goal to obtain over 3,000 new participants.

- **Opt-out rates remain low for events.** The rate of customers who opt out of events is approximately 15% per event. Staff stated most people opt-out of events or the program because they find their house is too uncomfortable during events. Thirty-one percent of survey participants stated they overrode the thermostat during a peak event. The most commonly given reason for overriding the event was that the home felt too uncomfortable (91%). Overall, the $2.50 per event incentive had a modest effect on decisions to not opt out of an event. Eighteen percent of participants stated the incentive prevented them from opting out of an event to a great degree and 30% said that it did not prevent them from opting out at all.
- **Unenrollment from the program is relatively high for demand response program.** PSO staff provided ADM with Power Hours Program Tracker data. According to PSO staff, there are over 23,867 active program participants and program staff estimated there have been approximately 8,000 who have unenrolled over the past five years.
- **Educating customers is key to marketing and assisting with technical difficulties.** PSO staff indicated educating customers about the program is a major focus when marketing the program. Focus groups have been used in the past with their messaging campaigns. The program did experience some technical difficulties with customers connectivity issues and developed educational resources for these customers. Staff also developed an email campaign to target those customers to alert them they were not participating in the events. Survey findings showed that Power Hours program participants primarily learned about the program through three main channels: emails from PSO (47%), inserts in their utility bills (29%), and from PSO's website (31%).
- **Saving on utility bills is main reason for customer participation.** Seventy-eight percent of respondents stated that cost savings were extremely important to them, 76% thought that getting lower electricity rates were extremely important, and 62% reported that earning bill credits to be of great importance.
- **Power Hours influences customers' installation of smart thermostats.** Forty percent of respondents indicated that they would not have been willing to make the financial investment in a smart thermostat without the program and 55% of respondents did not have plans to purchase the thermostat prior to learning of the program. Twenty-one percent of respondents would have not been at all likely to install the thermostat without the program and 15% would not have been at all likely to install the thermostat without the opportunity to earn bill credits.
- **Few participants are aware or engage with the Honeywell "Total Connect Comfort" app.** Twenty-eight percent of survey respondents indicated they used the application to check for notification of peak events. The most commonly given reason for not using the notification feature is that the respondents were not aware

of the service. Most respondents (61%) reported that they became aware of the event by observing a change in how their home felt.

- **Quality of participant's experiences with customer care agents varied.** Among the customers who contacted the Power Hours customer care agent with questions about the program (n = 26), 42% were either dissatisfied or very dissatisfied with how long it took the agent to address their questions and 50% were dissatisfied or very dissatisfied with how thoroughly the agent addressed their questions or concerns. A similar share reported that they were either satisfied or very satisfied with these aspects of their experience with the customer care agent.
- **Overall satisfaction with most participants planning to participate next program year.** For customers participating in the DLC component, satisfaction with their smart thermostat was high, with 79% who reported they were satisfied with it and 44% were satisfied with the bill credits they received. Most participants (75%) are likely to continue participating in the DLC component of the program another year.
- **No major changes anticipated for the PY2020.** Program staff did indicate if changes were to occur, they would be contingent on end-of-year program participant survey results.

4.1.6 Conclusions and Recommendations

The following summarizes the key findings from the evaluation of the Power Hours Program:

- **The verified net kWh savings for PY2019 is 2,024,453 kWh, and the verified peak kW reduction is 12,258.06 kW.**
- **Opt-out rates remain low for events.** The rate of customers who opt out of events is approximately 15% per event.
- **Unenrollment from the program is relatively high for demand response program.** There are over 23,000 active program participants and program staff estimated there have been approximately 8,000 who have unenrolled over the past five years. PSO has communicated that the high unenrollment rate is due to participants moving out.
- **Overall satisfaction with most participants planning to participate next program year.** For customers participating in the DLC component, 79% reported they were satisfied with it. A majority (75%) of participants are likely to continue participating in the DLC component of the program another year.

The following recommendations are offered for continued improvement of the Power Hours program:

- **Continue to refine the education system to help customers better understand the Power Hours program.** There was some indication that customers' expectations of energy savings were not aligned with the program. Customers may benefit from additional visuals to help them understand what is realistic when it comes to participating in Power Hours. The program could also explore creating additional incentives for ongoing participation.
- **Continue the campaign to assist customers who are not enrolled or otherwise participating in events.** At the time of the interview, PSO staff discussed their efforts in 2019 to re-engage program participants who were not participating in events or those whose thermostats were not connected. If there are opportunities to streamline the processes to assist customers, they should be explored and deployed when possible. PSO staff has stated that they are continuing to work towards this, most recently by rolling out a series of educational videos to help customers better understand the program.
- **Consider removing any thermostat models that don't qualify as smart thermostats from the program's selection of incentivized thermostats.** The use of smart thermostats leads to an annual reduction in energy use. Annual energy efficiency savings will be fully realized if, going forward, PSO only incentivized smart thermostats. Currently the Honeywell Wi-Fi 7-Day Programmable Touchscreen Thermostat is the only thermostat model in the program that does not meet the requirements to be considered a smart thermostat.
- **Work with ADM to develop a codified set of QA/QC procedures for the program.** At the time of the interview, PSO staff indicated there were not official quality assurance or quality control procedures for Power Hours. As the program matures, it will be critical to develop and adopt codified QA/QC practices.
- **Work with ADM to provide tracking data regularly.** ADM and PSO should work together to streamline the transfer of participant data. Data should include participant name, address, zip code, phone number, email, program start date, program end date, thermostat type, thermostat model number, and ex-ante savings and peak reduction.

4.2 Peak Performers Program

4.2.1 Peak Performers Overview

The Business Demand Response program, also referred to as Peak Performers, is a demand response (DR) program for commercial and industrial customers in the PSO service territory. Non-residential PSO customers who are enrolled in the program voluntarily reduce their electricity load during load reduction events. Participants are paid incentives based on the average electricity usage reduction over the course of all events and can opt-out of any event. Incentives are set at $32 per average kW reduction over all event hours and participants receive a 5% payment bonus if they participate in all reduction events throughout the year (three events in 2019). There is no direct penalty for opting out of specific event days. PSO calls no more than three peak events per week, no more than four per month, and no more than 12 per year. The program is active during summer months, when average demand typically approaches designated capacity thresholds.

During the summer of 2019, a total of 1,844 premise account numbers representing 232 customers, participated in three DR events. The events lasted from 2 PM - 6 PM on 8/7/2019 and 8/12/2019 and from 3 PM - 6 PM on 8/20/2019.

ADM's evaluation developed verified demand reduction estimates that were lower than reported values. The kW realization rate was 74%. Both reported and verified peak demand reduction represent the average kW reduction for each customer over all 11 event hours (three event days, four hours for two events, and three hours for one event), summed across participants.

Table 4-15 Performance Metrics – Peak Performers

Metric	PY2019
Number of Customers	232
Premise Account Numbers	1,844
Budgeted Expenditures	$3,237,576
Actual Expenditures	$2,721,470
Energy Impacts (kWh)	
Projected Energy Savings	127,500
Reported Energy Savings	0
Gross Verified Energy Savings	544,736
Net Verified Energy Savings	544,736
Peak Demand Impacts (kW)	
Projected Peak Demand Savings	54,983
Reported Peak Demand Savings	69,885
Gross Verified Peak Demand Savings	51,406
Net Verified Peak Demand Savings	51,406
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	8.13
Utility Cost Test Ratio	2.90

4.2.2 Impact Evaluation

The section below covers ADM's impact evaluation methodology and results for the 2019 Peak Performers Program.

4.2.2.1 PSO Methodology for Estimating Customer Baselines

For the purposes of financial settlement with Peak Performer participants, PSO uses a "top 3-of-10 baseline days" methodology to estimate participants' baseline load, or the demand that participants would have used had no Peak Performer event been called. Reported program impacts were calculated based on this baseline estimation methodology. For each premise, one applies the following algorithm:

1. For an event day *D*, *D(h)* is the participant's actual electric demand at hour h on *D*.
2. Starting with the day before *D*, the eligible baseline days are the most recent 10 non-weekend, non-holiday, non-Peak Event days.
3. For each of the eligible baseline days, the average midday electric demand during the hours corresponding to the peak event (usually 2 PM – 6 PM but can

be any two to four-hour period between 1 PM and 7 PM) is calculated. The eligible baseline days are ranked in descending order of this average peak time demand.

4. The hourly loads are averaged for the top three days identified in the previous step. This is the unadjusted baseline, *B(h)*.
5. If, on average, the ratio of *B(h)/D(h)*, between 10 AM and 12 PM, is less than 1 (that is, the baseline is too low), *B(h)* is multiplied by the reciprocal of that ratio so that the baseline and event loads match prior to the event. The most *B(h)* can be adjusted upward is 30%; no downward adjustments are made.

Reported demand reduction and payments made to Peak Performers participants depend on the difference, B(h)-D(h).

PSO provided hourly interval data for all the facilities involved in the Peak Performers program. PSO staff also provided internal audits for all the events, which are produced by a database script that implements the 3-of-10 baseline. ADM used these audits and interval data to independently verify that the baseline loads reported by PSO were calculated according to the algorithm described above.

4.2.2.2 ADM Baseline Methodology

In the case of evaluating demand reduction impacts associated with the Peak Performers program baselines or counterfactuals should represent what participants' usage would have been if the event had not occurred. In 2019, ADM employed multiple baseline methodologies and selected the best fitting models for each premise number (i.e., models that produced load profiles which best represented each participant's usage in absence of the program as determined by objective statistical test). These methodologies included the following models:

Table 4-16: Peak Performers Baseline Models

Model Name	Description
3 of 10 Unadjusted	Model described in Section 4.2.2.1 without the adjustment described in step 5.
3 of 10 Scalar Adjusted	Model described in Section 4.2.2.1 but allows for a ±30% day of adjustment.
3 of 10 Additive Adjusted	Model described in Section 4.2.2.1 but allows an adjustment of the actual demand difference in kW between *B(h)* and *D(h)* described in Section 4.2.2.1.
3 of 10 Weather Sensitive	The 3 of 10 unadjusted model with a weather sensitivity adjustment based on temperature's impact on energy usage for each premise from June to September.
5 of 10 Unadjusted	Model described in Section 4.2.2.1, but with 5 baseline days selected and without the adjustment described in step 5.
5 of 10 Scalar Adjusted	Model described in Section 4.2.2.1, but with 5 baseline days selected and allows for a ±30% adjustment.
5 of 10 Additive Adjusted	Model described in Section 4.2.2.1, but with 5 baseline days selected and allows an adjustment of the actual demand difference in kW between *B(h)* and *D(h)* described in the section.
5 of 10 Weather Sensitive	The 5 of 10 unadjusted model with a weather sensitivity adjustment based on temperature's impact on energy usage for each premise from June through September.
7 of 10 Unadjusted	Model described in Section 4.2.2.1, but with 7 baseline days selected and without the adjustment described in step 5.
7 of 10 Scalar Adjusted	Model described in Section 4.2.2.1, but with 7 baseline days selected and allows for a ±30% adjustment.
7 of 10 Additive Adjusted	Model described in Section 4.2.2.1, but with 7 baseline days selected and allows an adjustment of the actual demand difference in kW between *B(h)* and *D(h)* described in the section.
7 of 10 Weather Sensitive	The 7 of 10 unadjusted model with a weather sensitivity adjustment based on temperature's impact on energy usage for each premise from June through September.
9 of 10 Unadjusted	Model described in Section 4.2.2.1, but with 9 baseline days selected and without the adjustment described in step 5.
9 of 10 Scalar Adjusted	Model described in Section 4.2.2.1, but with 9 baseline days selected and allows for a ±30% adjustment.
9 of 10 Additive Adjusted	Model described in Section 4.2.2.1, but with 9 baseline days selected and allows an adjustment of the actual demand difference in kW between *B(h)* and *D(h)* described in the section.
9 of 10 Weather Sensitive	The 9 of 10 unadjusted model with a weather sensitivity adjustment based on temperature's impact on energy usage for each premise from June through September.

ADM identified candidate baseline “best fits” using residual root mean squared error (RRMSE) scores from the five highest usage weekdays over the program year (8/19/2019, 8/21/2019, 8/26/2019, 9/4/2019, 9/9/2019) during typical demand response hours for each premise number. The days chosen as high usage days serve as a good proxy for event days. They will be referred to as proxy event days.

It has been ADM’s experience that baseline estimation methodologies often produce generally consistent results, but in some cases, these estimations can produce divergent results. To minimize calculation bias, we combined results as a weighted average of the best three models for each premise number. The weights were the inverse squares of the model RRMSEs. For example, if the three best fitting models have RRMSEs of 5%, 11%, and 52% respectively, their relative weights will be 79%, 20%, and 1% respectively.

4.2.2.3 Baseline Methodology for Small Sites

All models with less than or equal to 450 kW reported reduction were compared to the proxy event days using RRMSE with the three best fitting models being selected and weighted in the way described in the previous section.

4.2.2.4 Baseline Methodology for Large Sites

For the twenty sites with the largest kW reductions in the program (greater than 450 kW reported reduction), ADM chose to modify the models considered for RRMSE testing based on premise level information such as business type and pre-event energy usage. Weather sensitive models were dropped if a premise’s energy usage was determined to not be weather dependent. Adjusted models were dropped if the premise showed an abnormal dip or spike pre-event. The modified selection of models was then compared to the proxy event days using RRMSE with the three best fitting models selected and weighted in the way described in the previous section. The table below shows the action taken regarding models for all twenty sites.

Table 4-17: Large Site Model Selection

Premise Name	Reported kW	Weather Dependent Energy Usage?	Abnormal Pre-Event Usage?	What Models were Added/Removed
P	6,379	No	Yes	Drop weather models and drop adjusted models
Q	5,449	No	Yes	Drop weather models and drop adjusted models
R	3,508	No	Yes	Drop weather models and drop adjusted models
N	3,340	No	Yes	Drop weather models and drop adjusted models
I	3,141	No	Yes	Drop weather models and drop adjusted models
K	3,062	No	Yes	Drop weather models and drop adjusted models
T	1,735	No	Yes	Drop weather models and drop adjusted models
J	1,509	No	No	Drop weather models
H	1,342	Yes	Yes	Drop adjusted models
F	1,170	No	No	Drop weather models
Z	975	No	No	Drop weather models
E	915	No	No	Drop weather models
AA	771	Yes	No	No Change
O	748	No	No	Drop weather models
AB	642	No	No	Drop weather models
S	642	No	No	Drop weather models
AC	607	No	No	Drop weather models
AD	499	No	No	Drop weather models
AE	489	No	Yes	Drop weather models and drop adjusted models
B	465	No	Yes	Drop weather models and drop adjusted models

4.2.2.5 Review of Program Interval Data

ADM reviewed program interval data found on the PSO's SQL Server Reporting Services (SSRS) for both completeness and accuracy.

4.2.2.6 Net-to-Gross Methodology

Demand response programs are not likely to have net-to-gross effects because customers are unlikely to curtail load in absence of the program. A net-to-gross ratio of 100% was assumed for this program.

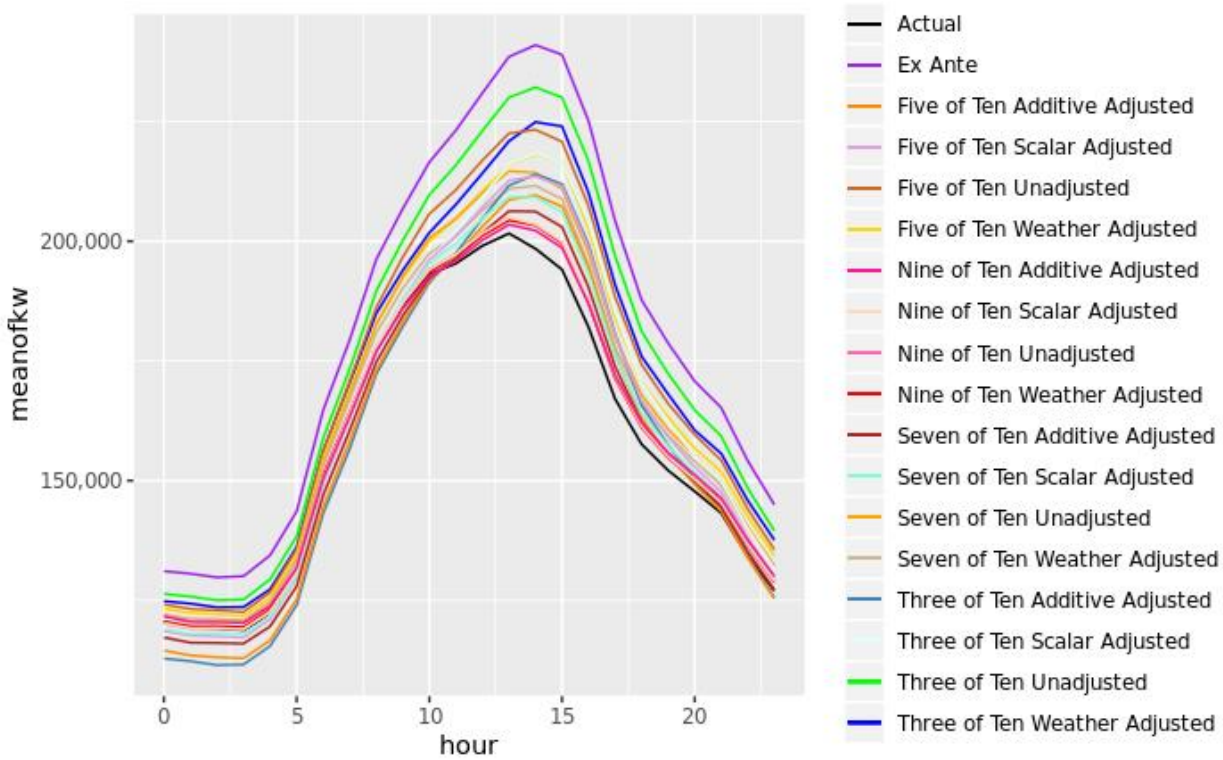
4.2.3 Impact Evaluation Results

This section presents the results of ADM's impact evaluation of the Peak Performers Program

4.2.3.1 Program-Level Graphs

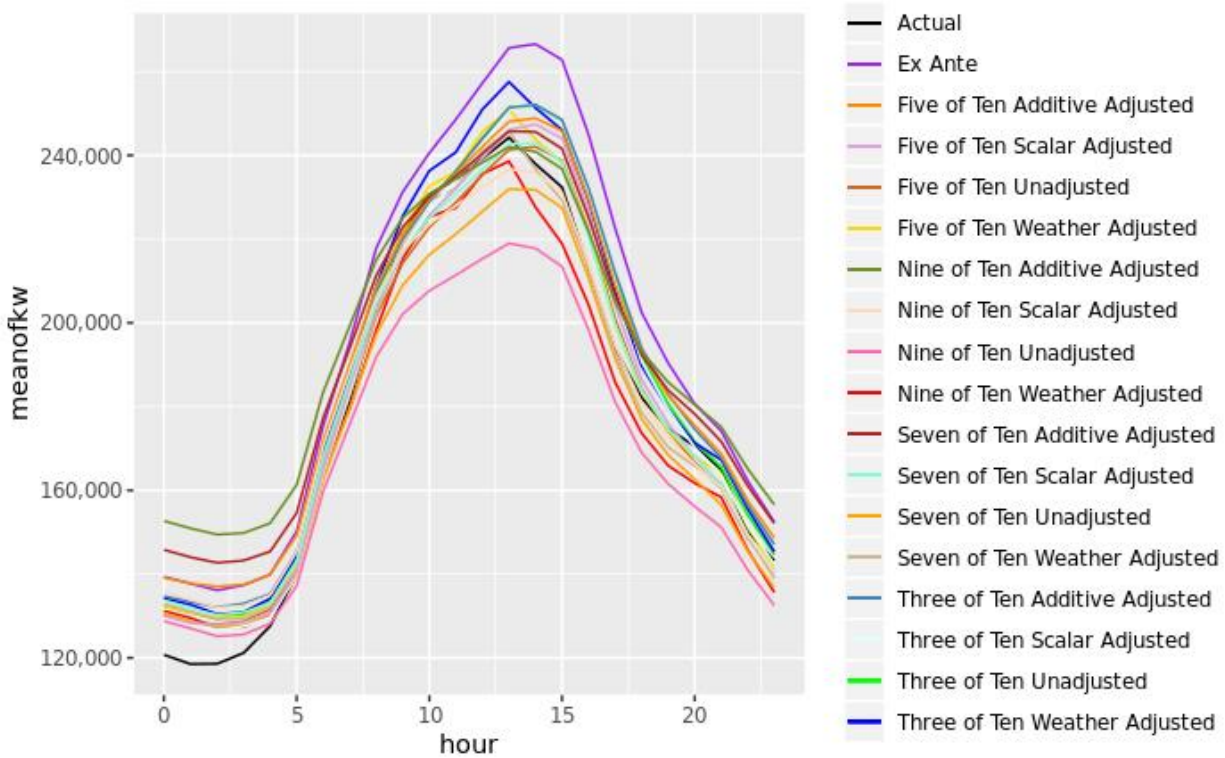
The graph below presents the aggregated results of each model averaged for each premise account for all non-event, non-holiday June through August weekdays.

Figure 4-6: Average Weekday Usage for All Models



The nine of ten models appear to perform the best compared to the average summer day while the reported (ex-ante) model appears to overestimate more than other models. This is useful information; however, how models perform when compared to high usage non-event days is more important as the intention of event days is to reduce demand during the highest usage periods of the year. Figure 4-7 presents similar aggregated results as Figure 4-6, but for the proxy event days (8/19/2019, 8/21/2019, 8/26/2019, 9/4/2019, 9/9/2019).

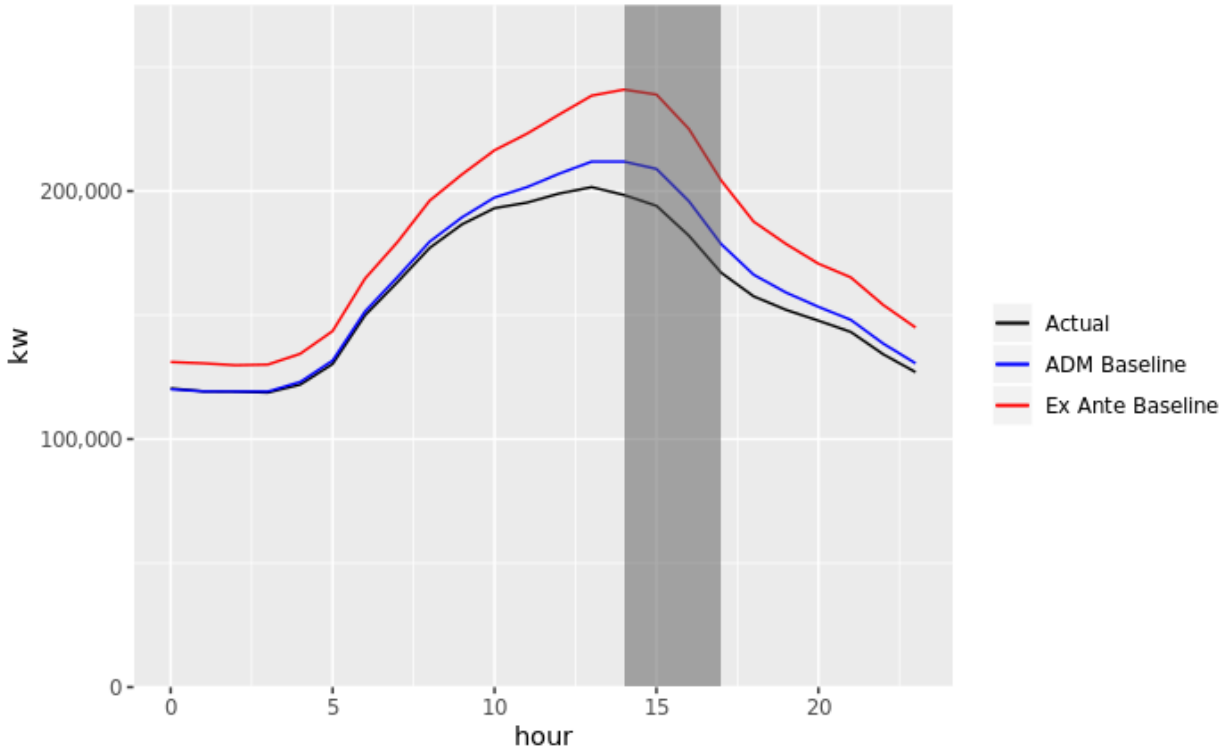
Figure 4-7: Five Highest Weekday Usage for All Models



On these days, which serve as a good substitute for event days, several ADM models fit the actual usage well, while the reported model overestimates savings by the largest amount.

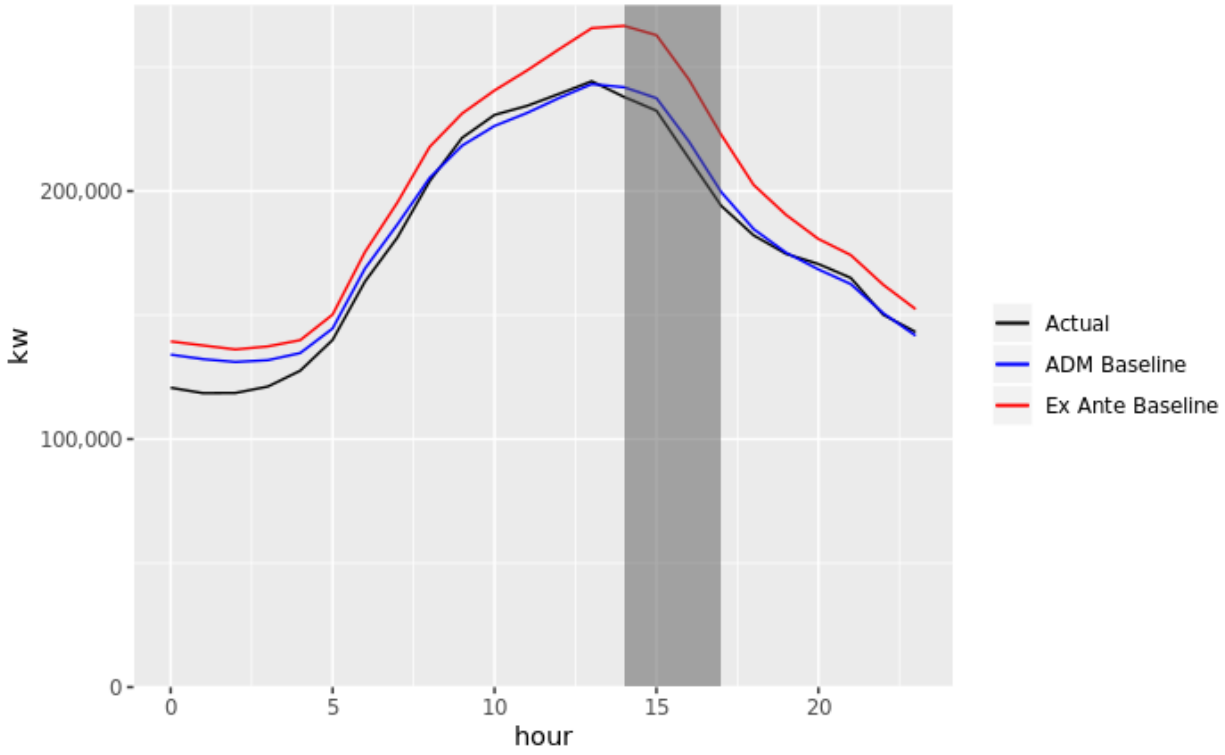
Figure 4-8, below, presents the aggregated results of actual usage, reported modeled usage, and verified modeled usage for all non-event, non-holiday June through September weekdays.

Figure 4-8: Average Actual, Reported, Verified Weekday Usage



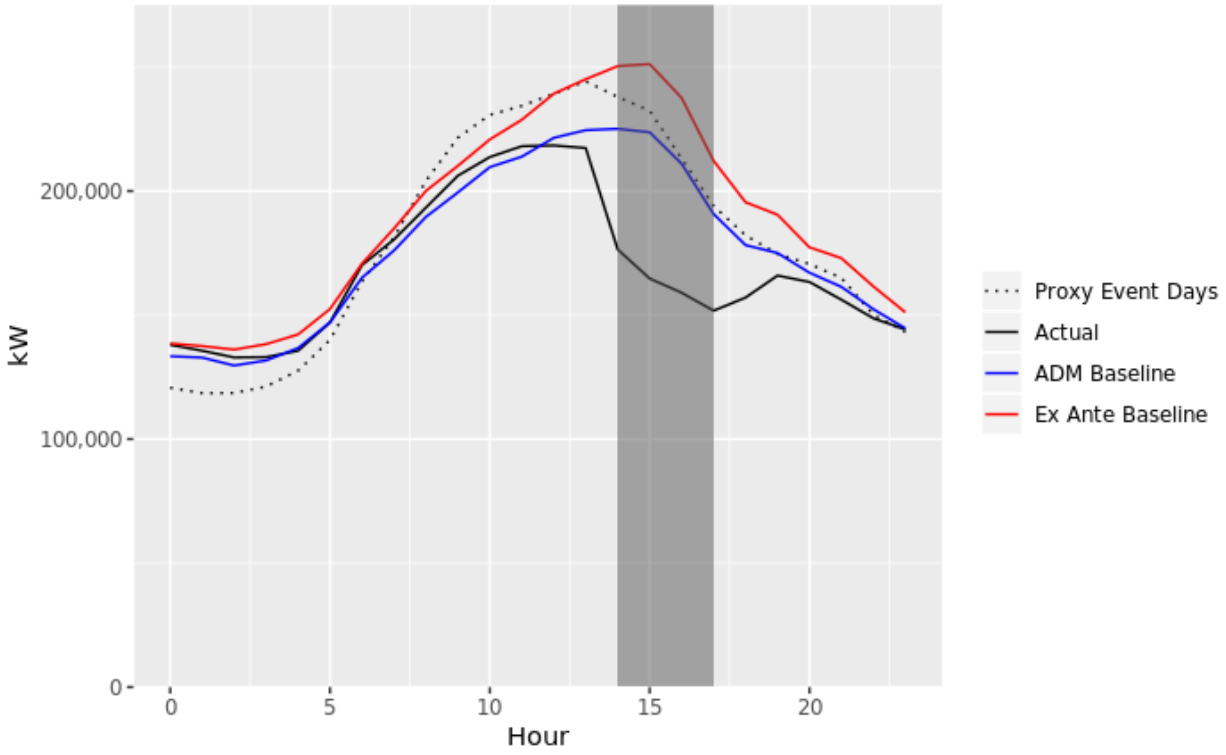
For the average summer non-event day, ADM's baseline performs better than the reported model, but would appear to overestimate energy usage. However, as noted previously, comparing the models to high-usage, non-event days, rather than an average of all non-event days, can provide a more relevant proxy. Below, in Figure 4-9, the aggregated results of actual usage, reported modeled usage, and verified modeled usage are presented for only the proxy event days during the typical event period. This comparison shows that ADM's baseline may overestimate energy usage slightly, but overall provides a good fit for actual usage.

Figure 4-9: Five Highest Usage Days Average Actual, Reported, Verified Weekday Usage



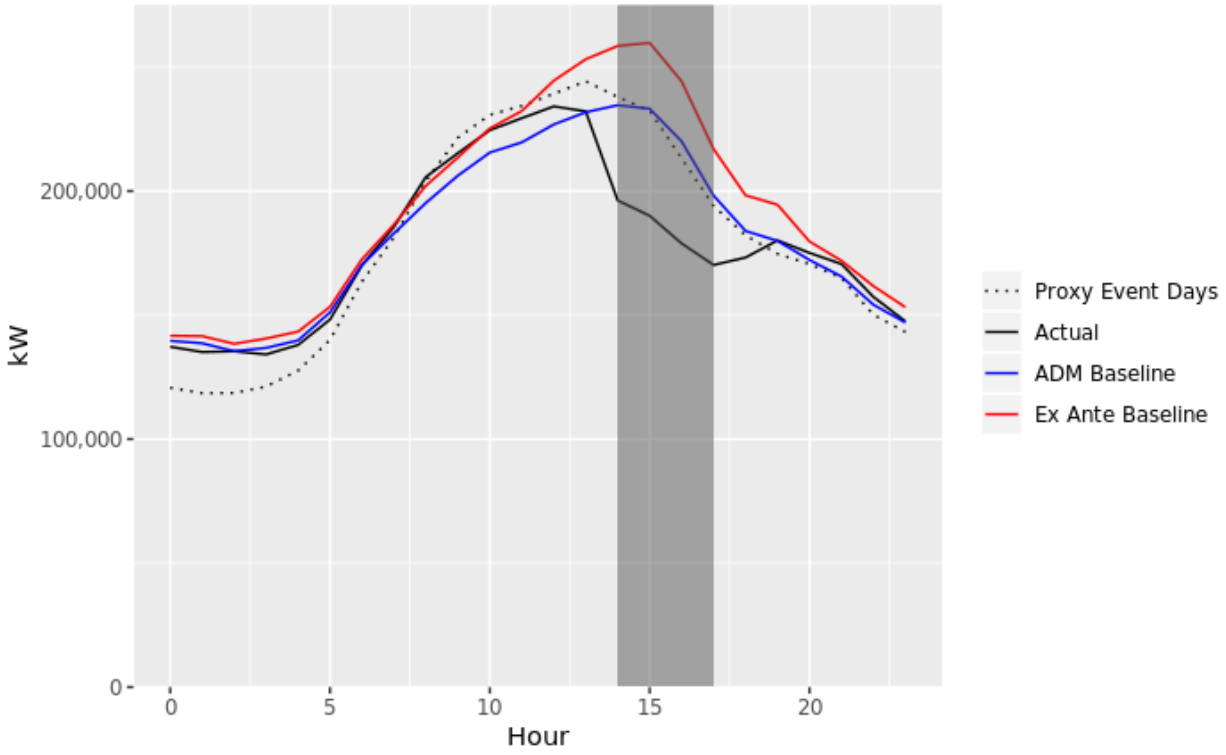
The following figures compare actual, reported, and verified usage for each of the three DR events that were called in 2019. The following graph presents aggregated results of actual usage, reported modeled usage, and verified modeled usage for event one on 8/7/2019.

Figure 4-10: Actual, Reported, and Verified Usage for Event 1, 8/7/2019



For event one, the ADM model fits the actual event day usage well during non-event periods. It also mirrors the proxy event day usage during the event. Figure 4-11 presents aggregated results of actual usage, reported modeled usage, and verified modeled usage for event two on 8/12/2019.

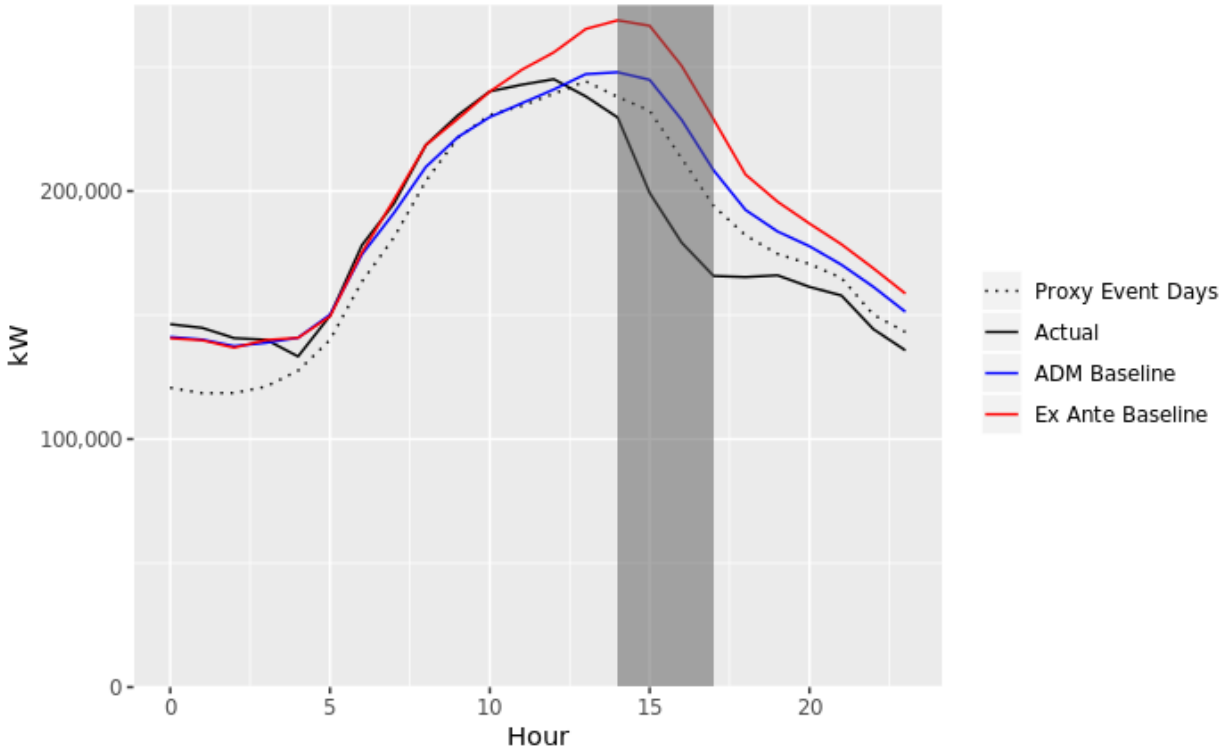
Figure 4-11: Actual, Reported, Verified Usage for Event 2, 8/12/2019



During event two, the ADM model fits the actual event day usage fairly well during non-event periods; however, the ADM baseline does not follow an increase in usage at around 7 AM. After 10 AM, some of this usage could be due to participants “ramping-in” to an event by precooling their facility. The ADM baseline does, however, follow proxy event day usage closely during the event period.

Figure 4-12 presents aggregated results of actual usage, reported modeled usage, and verified modeled usage for event three on 8/20/2019.

Figure 4-12: Actual, Reported, Verified Usage for Event 3, 8/20/2019



For event three, the ADM model fits the actual event day usage fairly well during non-event periods; however, the ADM baseline does not follow an increase in usage at around 7 AM. After 10 AM, some of this usage could be due to participants "ramping-in" to an event by precooling their facility. The ADM baseline does, however, follow proxy event day usage relatively closely during the event period and may perhaps overestimate counterfactual usage.

4.2.3.2 Peak Performers Peak Demand Reductions

Demand response event impacts were estimated by comparing the event day demand curves to the estimated baseline demand curves; the difference between the two is the estimated peak demand reduction. As described in Section 4.2.2.1, ADM used hourly interval data to recreate the baseline estimations used to determine reported impacts. The process was then repeated, this time using ADM's baseline methodology described in Section 4.2.2.2 and represented by "ADM Adjusted Baseline" in the graphs in the previous section. Below are ADM's peak demand reduction estimates for 2019.

Table 4-18: Peak Demand Reduction – Peak Performers

Program	Gross Peak Demand Reduction (MW)				Net Impacts	
	Projected	Reported	Verified	Gross Realization Rate	NTG Ratio	Net Peak Demand Reduction (MW)
Peak Performers	54.98	69.89	51.41	74%	100%	51.41

4.2.3.3 Peak Performers Annual Energy Savings

The Business Demand Response program is designed primarily as a resource for procuring peak demand savings during periods of high demand. As such, the program does not report annual kWh savings. However, the program does generate energy impacts during and surrounding called events. These impacts are not lasting, in the sense that kWh savings from a lighting retrofit might last the lifetime of the installed lighting fixtures. When a peak demand event is called – usually between hours to a full day before the actual event period – participants have several options. They might decrease electric energy usage immediately in anticipation of the upcoming event, or they might increase usage for the remaining pre-event hours in anticipation of future usage reduction. Additionally, the post-event hours are of interest because it may take several hours for facilities to restore electric energy usage to pre-event operation levels. Facilities might also increase electric energy usage immediately after the conclusion of an event to make up for previously reduced usage.

ADM chose to use the full event day to evaluate kWh savings for 2019 to capture before, during, and after event energy usage behavior. Verified kWh savings presented below represent the net difference in energy consumption (between the estimated baseline and the observed usage) summed over the event days (72 total hours). It is possible that some facilities shifted event related load outside of the event day due to their reduction; however, given the post-event survey findings from past program years, investigating the entire event day appears to be sufficient.

The following table presents ADM's annual energy savings estimates for 2019.

Table 4-19 Annual Energy Savings – Peak Performers

Program	Gross Annual Energy Savings (MWh)				Net Impacts	
	Projected	Reported	Verified	Gross Realization Rate	NTG Ratio	Net Annual Energy Savings (MWh)
Peak Performers	134.97	0.00	544.74	N/A	100%	544.74

4.2.4 Process Evaluation Findings

ADM's process evaluation activities included participant surveys and an interview with the PSO Program manager. ADM provided a portfolio level process evaluation memo to PSO after the completion of the 2019 program year. The following summarizes the key finding from the process evaluation of the Peak Performers program.

- **No substantial changes to program design or delivery in PY2019**. Program staff indicated the design and implementation of Peak Performers did not change in PY2019.
- **Event notifications are sent through Vision**. PSO staff stated this year they began sending event notification to participants through Vision, which worked well for the program. Peak Performers participants should receive notification up to four hours prior to when an event begins through either email or text messages or both. For two of the three events called this year, program staff were able to send a notification a day ahead. PSO indicated this can be beneficial for certain types of business who need to prepare to partially or fully shut down for an event. Next year, a new version of Vision will be implemented, and staff indicated notification may be more customized.
- **Peak Performers met its demand reduction goals for 2019.** At the time of the interview, program staff believed the program would achieve the reductions goal for the year. There was a total of three events called in PY2019, all of which occurred in August. Staff indicated the number of events this program year was consistent with prior years and the criteria for calling events has not changed from previous years (i.e., events were planned when the system load capacity was expected to be at 92%).
- **PSO staff is satisfied with Peak Performers.** The program has been operating for seven years and has continued to generate reliable load reductions of approximately 40 to 50 megawatts through participants voluntary load shedding actions. In addition to incentive payments that can range from $30 to $600,000, three appreciation luncheons were held in November in Tulsa, Lawton, and McCallister to recognize participants' efforts.
- **Varied approaches were used to market the Peak Performers program to encourage broad awareness of the offer, but individual approaches tend to be most effective.** The approaches used to market the program included LinkedIn and Facebook campaigns in the spring and early summer, as well as information sent through Questline. The program also provides YouTube videos to educate potential participants about the program and its benefits. Staff observed that that the social media campaigns generated interest but few of the interested customers enrolled, and that overall, account representatives speaking with customers was

the most effective recruitment approach. Additionally, program staff noted that school districts are often reluctant to enroll, and program staff has found that word-of-mouth referral from other school district staff is most effective at encouraging their participation. At this time, about one-third of the program participants are schools and staff commented that "*Schools are not only stewards of our children but also stewards of our facilities and our environment.*"

- **Seventeen new participants enrolled in PY2019.** Staff stated that most of the new participants are small businesses. Most participants are organizations that rolled over their participation from the prior cycle. Staff indicated that some organizations have stopped participating but that they do not track the attrition rate closely.
- **No major changes to data management.** No major changes to tracking and reporting data were reported, and staff indicated they continue to utilize Vision for data management. Peak Performer participants are now presented with preliminary results from events but are also informed that there may be changes once all primary data has been finalized in Vision and staff has had time to finalize the demand reduction and payment calculation.
- **No planned changes to Peak Performers for 2020.** PSO program staff indicated there have been small adjustments over the years and they are satisfied with where the program is today. There were not anticipated changes to program design or delivery in 2020.
- **Eight accounts were erroneously enrolled twice resulting in duplication of kW savings and incentive.** The error accounted for 0.1% of the incentive payment made in this program year.
- **Most participants (94%) reported that they were very likely to participate in the program during 2020.** No respondents indicated that they were somewhat unlikely or very unlikely to participate in the next program year.
- **All participants were satisfied (75%) or very satisfied (25%) with the program overall.** All respondents also reported that they were satisfied with their interactions with PSO staff (5% "satisfied" and 95% "very satisfied"). In addition, participants expressed a high level of satisfaction with the application process (19% "satisfied" and 77% "very satisfied"). Lastly, 81% of respondents reported that they recommended the program to someone else, suggesting that the program continues to spread by word of mouth among PSO customers.

4.2.5 Conclusions and Recommendations

The following summarizes the key findings of the evaluation of the Peak Performers Program.

- **Staff load reduction expectations were met.** The final verified net kW savings and verified net kWh savings are 51,406 kW and 544,736 kWh, respectively.
- **Participant satisfaction remains high.** All participants reported that they were satisfied with the program overall. Most participants were satisfied with every rated facet of it. The program continues to be an earnings opportunity for customers that operates well for most of them.
- **Participation levels remain steady with small gains in the number of participants.** Most of the program participants continued their participation from prior years with a limited number of new participants (17) during PY2019. Most new participants are the result of individual contacts such as through customer service representatives or peers who participate in the program rather than more mass-marketing campaigns. Importantly, the program has maintained a high level of geographic equity as demonstrated by the similarity in the location of program participants and the number of businesses served by PSO.
- **Awareness of incentive payment information on the website was relatively low, but nearly all participants received the email communications about the payments.** Less than half of the respondents were aware of the incentive payment information on the website, but 92% were aware that it was provided by email.

The following recommendations are offered for continued improvement of the Peak Performers program.

- **Continue low cost mass marketing despite limited evidence of effectiveness in generating new participants.** Staff should continue to keep informing customers of the program so that that they are aware of the service and the opportunity to participate. By focusing on low cost methods such as social media, the benefits of customer awareness of the program (i.e., a full understanding of the services available to customers) can be realized even if it does not directly lead to new participants.
- **Implement a check for duplicates in the incentive payment system.** The duplicated incentives paid were very small (0.1%), but steps that prevent duplication of payments should be put in place to prevent the issue in future program years.

Appendix A. Glossary

Cash Inducement Costs: Refers to customer and service provider rebate/incentive costs incurred by PSO in the implementation of a program.

Coincidence Factor (CF): For energy efficiency measures, the CF represents the fraction of connected load reduction that occurs during the peak demand period.

Deemed Savings: A savings estimate for relatively homogeneous measures. Generally, an assumed average savings across many rebated units is applied to each individual unit installed.

Effective Useful Life (EUL): The number of years (or hours) that an energy-efficient technology is estimated to function. Also, referred to as "measure life."

EM&V Administrative Costs: EM&V administrative costs include all costs associated with evaluation, measurement and verification of reported energy and demand impacts resulting from the implementation of a program.

Reported: Refers to estimates of energy savings and peak demand reduction developed before program evaluation. Equivalent to "reported impacts" or also "ex-ante."

Verified: Refers to estimates of energy savings and peak demand reductions developed from program evaluation. Equivalent to "verified impacts" or also "ex-post."

Free-ridership: Percentage of participants who would have implemented the same energy-efficiency measures in a similar timeframe even in the absence of the program.

Gross Impacts: Changes in energy consumption/demand that result directly from program-promoted actions regardless of the extent or nature of program influence on these actions.

Impact Evaluation: Impact evaluation is the verification and estimation of gross and net impacts resulting from the implementation of one or more energy-efficiency or demand response programs.

Measure: An energy-efficiency "measure" refers to any action taken to increase energy efficiency, whether through changes in equipment, control strategies, or behavior.

Net Savings: The portion of gross savings that is directly attributable to the actions of an energy-efficiency or demand response program.

Net-to-Gross Ratio (NTGR): A factor representing net program savings divided by gross program savings that is applied to gross program impacts to convert them into net program impacts. Generally calculated as 1 – (free-ridership %) + (Spillover %).

Non-Cash Inducement Costs: Non-cash inducement costs include third party implementation costs and advertising costs incurred by PSO in the implementation of a program. PSO earns no incentives on advertising costs.

Non-Energy Benefits: Non-energy benefits refer to any benefits PSO customers may experience due to their participation in PSO programs beyond energy savings. Examples include improved comfort, aesthetic enhancements, better indoor air quality, improved security, better employee productivity, etc.

Non-EM&V Administrative Costs: Non-EM&V administrative costs include PSO staff labor costs and overhead costs associated with implementing a program.

Oklahoma Deemed Savings Documents (OKDSD): Refers to the Oklahoma Deemed Savings, Installation & Efficiency Standards, and associated work papers for small commercial and residential energy efficiency measures. These documents were originally submitted to the OCC as part of Cause No. PUD 201800073. In 2013, the documents were updated to reflect more recent and applicable baseline conditions.

Participant Cost Test (PCT): The PCT examines the cost and benefits from the perspective of the customer installing the energy efficiency measure. Costs include incremental costs of purchasing and installing the efficient equipment, above the cost of standard equipment. Benefits include customer bill savings, incentives received from the utility, and any applicable tax credits.

Peak Demand: For the purposes of this report peak demand refers to the average metered demand during the peak period, defined as 2PM to 9 PM during the summer months, June through September, excluding weekends and holidays. Note that for the Business Demand Response program, peak demand reduction is calculated as the average reduction during event hours.

Process Evaluation: A systematic assessment of an energy efficiency program for documenting program operations at the time of examination and identifying potential improvements that can be made to increase the programs efficacy or effectiveness.

Projected, Reported, and Verified Savings: Projected impacts refer to the energy savings and peak demand reduction forecasts submitted to the OCC as part of PSO's 2019 – 2021 portfolio filing on June 29, 2018.[96] Reported impacts refer to energy savings and peak demand reduction estimates based on actual program participation in PY2019, before program evaluation activities. Finally, verified impacts refer to energy savings and demand reduction estimates for PY2019 developed through independent program evaluation, measurement, and verification (EM&V).

[96] Cause No. PUD 201800073.

Ratepayer Impact Measure (RIM): The RIM examines the impact of energy efficiency programs on utility rates. Reduced energy sales can lower revenues and put upward pressure on retail rates as the remaining fixed costs are spread over fewer kWh. Costs include overhead and incentive payments and the cost of lost revenue due to reduced sales. Benefits include cost savings associated with not delivering energy to customers. These “avoided costs” include generation, transmission, and distribution costs.

Realization Rate: The ratio of verified impacts to reported impacts.

Societal Cost Test (SCT): The SCT includes the same costs and benefits as the TRC but uses a lower discount rate to reflect the overall benefit to society over the long term.

Spillover: Energy and/or demand savings caused by a program, but for which the utility did not have to provide cash inducements.

Total Resource Cost Test (TRC): The TRC measures the net benefits of the energy efficiency program for the region as a whole. Costs included in the TRC are incremental costs of purchasing and installing the efficient equipment, above the cost of standard equipment and overhead cost associated with implementing the program. Benefits include cost savings associated with not delivering energy to customers. These “avoided costs” include generation, transmission, and distribution costs.

Utility Cost Test (UCT): The UCT examines the costs and benefits of the energy efficiency program from the perspective of the utility company. Costs include overhead (administration, marketing, EM&V) and incentive costs. Benefits include cost savings associated with not delivering energy to customers. These “avoided costs” include generation, transmission, and distribution costs. This test is also often referred to as the Program Administrator Cost Test (PACT).

Appendix B. Portfolio Cost-Effectiveness

This appendix provides an overview of each programs' participation, verified reduction in peak load, verified kWh savings, annual admin costs, total program costs, as well as a summary of the cost effectiveness analysis.

B.1 Cost Effectiveness Summary

This appendix covers all verified electricity and peak demand savings, and associated program costs incurred in the implementation of PSO's 2019 energy efficiency and demand response portfolio from January 1, 2019 through December 31, 2019.

The cost-effectiveness of PSO's 2019 programs was calculated based on reported total spending, verified energy savings, and verified demand reduction for each of the energy efficiency and demand response programs. All spending estimates were provided by PSO. The methods used to calculate cost-effectiveness are informed by the California Standard Practice Manual.[97]

The demand reduction (kW) and energy savings (kWh) presented throughout this appendix represent net savings at the generator by applying program level net-to-gross (NTG) ratios and adjusting for line losses. Program level NTG ratios for the 2019 programs were estimated by ADM as part of the portfolio impact evaluation. Verified savings estimates at the meter were adjusted to account for line losses using a line loss adjustment factor of 1.0586. For gas savings estimates, a 1.014 gas loss factor was included.

To calculate the cost-effectiveness of each program, measure lives were assigned on a measure-by-measure basis. When available, measure life values came from the Oklahoma Deemed Savings Documents (OKDSD). When not available in the OKDSD, measure life values came from the Arkansas TRM.[98] Additionally, assumptions regarding incremental/full measure costs were necessary. These costs were taken directly from the portfolio plan or project specific invoices, avoided energy, capacity, transmission/distribution, and CO_2 costs used to calculate cost-effectiveness were provided by PSO and are found in Section B.4 of this appendix. Residential and commercial rates used to estimate certain cost-effectiveness tests were also provided by PSO.

[97] California Standard Practice Manuel: Economic Analysis of Demand Side Management Programs, October 2001. Available at: http://www.cpuc.ca.gov/uploadedFiles/CPUC_Public_Website/Content/Utilities_and_Industries/Energy_-_Electricity_and_Natural_Gas/CPUC_STANDARD_PRACTICE_MANUAL.pdf

[98] http://www.apscservices.info/EEInfo/TRM6.pdf

Table B-1 lists each program included in this analysis, along with the projected savings estimates and projected budget. Impacts show in Table B-1 are net-at-generator, reflecting the NTG projections and line losses.

Table B-2 lists each program included in this analysis, along with the final verified savings estimates, total expenditures, Utility Cost Test (UCT)[99] results, and Total Resource Cost Test (TRC) results. Impacts shown in Table B-2 are net-at-generator, reflecting NTG assumptions and line losses as described above. Results from the UCT and TRC are focused on in this summary for the following reasons:

- The TRC and UCT results are a direct input to the shared savings component of the Demand Side Management Cost Recovery Rider (DSM Rider) as described in Oklahoma Administrative Code (OAC) 165:35-41-8(a).[100]
- Oklahoma Administrative Code (OAC) 165:35-41-2 lists the goals of energy efficiency and demand response programs as (1) minimize the long-term cost of utility service, and (2) avoid or delay the need for new generation, transmission, and distribution investment. The TRC test best reflects these goals, as it looks at benefits and costs from the perspective of all utility customers in the utility's service territory (participants and non-participants).

In addition to UCT and TRC results, results from the Ratepayer Impact Measure (RIM), Participant Cost Test (PCT) and Societal Cost Test (SCT) are included in the body of this appendix.

Based on verified program impacts and spending during PY2019, PSO's overall portfolio is cost-effective based on both the UCT and TRC.

[99] The UCT is also referred to as the Program Administrator Cost Test (PACT).
[100] http://www.occeweb.com/rules/CH35finalrules111819.pdf.

Table B-1: Projected by Program, 2019 (Impacts are Net, at Generator)

Program	Projected Peak Demand Reduction (kW)	Projected Annual Energy Savings (kWh)	Annual Gas Savings (Therms)	Total Program Expenditures
Business Rebates	7,482	40,552,667	(207,358)	$11,191,794
Multi-Family	281	1,515,779	12,290	$973,599
Home Weatherization	1,252	2,565,307	174,719	$3,568,107
Energy Saving Products	2,918	23,594,258	(221,559)	$3,295,840
Home Rebates	2,525	6,553,028	287,888	$7,424,826
Education	420	3,510,710	(12,064)	$1,144,000
Behavioral	3,705	20,007,540	438,048	$1,288,750
Conservation Voltage Reduction	1,911	8,640,291	-	$641,321
Total – EE Programs	**20,494**	**106,939,579**	**471,964**	**29,528,237**
Power Hours	16,464	1,625,112	128,745	$2,292,669
Business Demand Response	54,983	134,972	-	$3,237,576
Total – DR Programs	**71,447**	**1,760,084**	**128,745**	**5,530,245**
Total – R&D Programs	**211**	**125,722**	**-**	**306,031**
Total	**92,152**	**108,825,384**	**600,709**	**35,364,514**

Table B-2: Cost-Effectiveness by Program, 2019 (Impacts are Verified Net)

Program	Peak Demand Reduction (kW at Meter)	Peak Demand Reduction (kW at Generator)	Energy Savings (kWh at Meter)	Energy Savings (kWh at Generator)	Total Program Expenditures	TRC (b/c ratio)	UCT (b/c ratio)
Business Rebates	10,158	10,791	62,116,604	65,983,221	$10,788,034	2.58	4.30
Multi-Family	964	1,024	3,604,011	3,828,352	$951,182	3.04	3.41
Home Weatherization	2,072	2,201	3,743,243	3,976,252	$3,659,104	2.25	1.55
Energy Saving Products	5,807	6,168	36,428,573	38,696,169	$3,613,293	7.10	7.16
Home Rebates	2,452	2,604	4,373,200	4,645,422	$7,008,892	1.24	1.11
Education	675	717	3,507,610	3,725,951	$873,910	2.10	2.18
Behavioral	968	1,028	8,475,928	9,003,535	$1,116,829	0.45	0.43
Conservation Voltage Reduction	2,064	2,192	10,439,497	11,089,332	$801,114	1.35	1.43
Total – EE Programs	**25,159**	**26,725**	**132,688,667**	**140,948,234**	**28,812,360**	**2.44**	**3.07**
Power Hours	12,258	13,021	2,024,453	2,150,471	$1,952,166	1.82	1.47
Business Demand	51,406	55,761	544,737	590,885	$2,721,470	8.13	2.90
Total – DR Programs	**63,664**	**68,782**	**2,569,190**	**2,741,356**	**4,673,636**	**8.13**	**2.90**
Total – R&D Programs	**0**	**-**	0	**-**	**1,568**	**-**	**-**
Total	**88,823**	**95,507**	**135,257,857**	**143,689,589**	**33,487,563**	**2.58**	**3.06**

B.2 Energy Efficiency Programs

PSO's energy efficiency portfolio in 2019 consisted of eight programs with a verified net peak demand reduction of 26,725 kW and verified net annual energy savings of 140,948,234 kWh (including line-loss estimates of 5.86%). Total spending in 2019 equaled $28,812,360. Table B-3 provides a summary of program participation and verified net impacts for each of the energy-efficiency programs. Table B-4 provides a summary of program costs in 2019.

Table B-3: Energy-Efficiency Programs – Verified Impacts (Net, at Generator)

Program	Number of Participants in 2019	Verified Peak Demand Reduction (kW)	Verified Annual Energy Savings (kWh)	Gas Savings (Therms)
Business Rebates	1,192	10,791	65,983,221	0
Multi-Family	105	1,024	3,828,352	8,004
Home Weatherization	2,048	2,201	3,976,252	435,915
Energy Saving Products	1,528,871	6,168	38,696,169	0
Home Rebates	3,643	2,604	4,645,422	253,344
Education	14,820	717	3,725,951	-230
Behavioral	166,937	1,028	9,003,535	0
Conservation Voltage Reduction	12,828[101]	2,192	11,089,332	0
Total – EE Programs	**1,730,444**	**26,725**	**140,948,234**	**697,034**

Table B-4: Energy-Efficiency Programs – Reported Costs

Program	Annual Non-EM&V Admin Costs ($)[102]	Annual EM&V Admin Costs ($)	Annual Cash Inducement Costs ($)[103]	Annual Non-Cash Inducement Costs ($)[104]
Business Rebates	$348,862	$317,072	$6,527,767	$3,594,333
Multi-Family	$7,827	$20,510	$703,272	$219,574
Home Weatherization	$101,098	$103,400	$3,260,805	$193,801
Energy Saving Products	$158,564	$201,332	$2,404,318	$849,079
Home Rebates	$193,736	$217,869	$4,475,056	$2,122,230
Education	$65,719	$54,043	$719,189	$34,959
Behavioral	$33,299	$91,682	$49,849	$941,999
Conservation Voltage Reduction	$13,326	$110,597	$0	$677,191
Total – EE Programs	**$922,431**	**$1,116,505**	**$18,140,257**	**$8,633,166**

[101] Represents the number of customers on the service lines that had CVR implemented in 2019.
[102] Non-EM&V Admin Costs include PSO staff labor costs and overhead costs.
[103] Cash inducement costs refer to customer rebate costs.
[104] Non-cash inducement costs include third party implementation costs.

Table B-5 shows the measures with measure life and associated programs. The measure life for Business Rebates are calculated as a weighted average based on kWh savings. The programs for Behavioral Modification, Business Demand Response, and Conservation Voltage Reduction each have a Tier 1 EUL of one year.

Table B-5*: Measure Life*

Measure	Measure life		Business Rebates	Multi-Family	Home Weatherization	Energy Saving Products	Homes Rebates	Education	Power Hours
	Tier 1	Tier 2							
9-watt Omnidirectional LED	4	16			X		X		
Air Sealing Package	11	0		X	X		X		
Central AC	19	0					X		
Duct Replacement	20	0					X		
Duct System Sealing	18	0		X			X		
Ground Source Heat Pump Bonus	25	0					X		
Heat Pump	16	0		X			X		
Heating System ECM-type Blower Fan	18	0					X		
Insulation - Attic	20	0		X	X		X		
Insulation - Basement/Enclosed Crawlspace	20	0					X		
Insulation - Exterior Wall	20	0					X		
Insulation - Knee walls/Vertical Attic Wall	20	0					X		
Radiant Barrier	25	0					X		
Window and Glass Door Improvement	20	0					X		
Air Sealing Package	10	0			X				
Water Heater Jacket	7	0			X				
Water Heater Pipe Insulation	13	0			X				
Advanced Power Strip	10	0				X		X	

Measure	Measure life		Business Rebates	Multi-Family	Home Weatherization	Energy Saving Products	Homes Rebates	Education	Power Hours
	Tier 1	Tier 2							
LED Night Light	8	0						X	
FilterTone® Furnace Filter Alarm	14	0						X	
9-watt LED	4	15						X	
Variable Speed Drive Pool Pump	10	0		X			X		
Irrigation Drip System	13	0	X						
Custom Compressed Air	15	0	X						
New Construction Indoor	14.5	0	X						
Oil and Gas - VFD	10.5	0	X						
Dishwasher	14	0	X						
Indoor Fixture Retrofit	15.5	0	X						
Custom HVAC	14.5	0	X						
Indoor Fixture Retrofit	13	0	X						
Indoor Fixture Retrofit	15	0	X						
Custom HVAC	15	0	X						
DLC Events	1	0							X
Smart Thermostat Incentive	11	0							X
New Homes	20	0					X		
Duct Replacement	18	0		X					
Faucet Aerator	10	0		X					
Low Flow Shower Head	10	0		X					
Windows	20	0		X					
Residential Lighting	4	15		X					
HID	16	0		X					

Measure	Measure life		Business Rebates	Multi-Family	Home Weatherization	Energy Saving Products	Homes Rebates	Education	Power Hours
	Tier 1	Tier 2							
Fluorescent	9	0		X					
LED Screw In	4	15		X					
Air Filters	1	0				X			
Bathroom Ventilation Fans	12	0				X			
Clothes Dryers	13	0				X			
Clothes Washers	14	0				X			
Electric Vehicle Chargers	10	0				X			
Heat Pump Water Heaters	10	0				X			
Refrigerators	17	0				X			
Room Air Conditioners	10.5	0				X			
Room Air Purifiers	9	0				X			
Water Dispensers	10	0				X			
Weatherization Measures	15	0				X			
Lighting - Directional LED Retail	20	0				X			
Lighting - Omni-directional LED - Retail	4	16				X			
Lighting - Omni-directional LED - DG	4	16				X			
Lighting - Omni-directional LED - FB	4	16				X			

In the tables that follow, total costs and benefits, and cost-effectiveness test results are provided for each energy efficiency program in the PY2019 portfolio.

B.2.1 Business Rebates Program

Table B-6: Business Rebates Benefit/Cost Tests

Metric	Utility Cost Test	Total Resource Cost Test	Ratepayer Impact Measure	Societal Cost Test	Participant Cost Test
Benefit/Cost Ratio	**4.30**	**2.58**	**0.76**	**2.96**	**3.45**
Net Benefits ($000s)	34,940.04	30,446.37	(14,428.33)	37,776.30	37,234.26
Total Benefits ($000s)	45,543.55	49,749.16	45,543.55	57,079.09	52,461.57
Total Costs ($000s)	10,603.51	19,302.79	59,971.88	19,302.79	15,227.31

B.2.2 Multi-Family Program

Table B-7: Multi-Family Benefit/Cost Tests

Metric	Utility Cost Test	Total Resource Cost Test	Ratepayer Impact Measure	Societal Cost Test	Participant Cost Test
Benefit/Cost Ratio	**3.41**	**3.04**	**0.66**	**3.89**	**5.88**
Net Benefits ($000s)	2,287.07	2,008.69	(1,669.40)	2,850.05	3,627.18
Total Benefits ($000s)	3,234.59	2,995.42	3,234.59	3,836.78	4,370.96
Total Costs ($000s)	947.53	986.74	4,903.99	986.74	743.79

B.2.3 Home Weatherization Program

Table B-8: Home Weatherization Benefit/Cost Tests

Metric	Utility Cost Test	Total Resource Cost Test	Ratepayer Impact Measure	Societal Cost test	Participant Cost Test
Benefit/Cost Ratio	**1.55**	**2.25**	**0.70**	**2.70**	**3.32**
Net Benefits ($000s)	2,017.31	4,582.64	(2,488.21)	6,238.08	7,559.56
Total Benefits ($000s)	5,676.41	8,241.75	5,676.41	9,897.18	10,820.36
Total Costs ($000s)	3,659.10	3,659.10	8,164.63	3,659.10	3,260.81

B.2.4 Energy Saving Products Program

Table B-9: Energy Saving Products Benefit/Cost Tests

Metric	Utility Cost Test	Total Resource Cost Test	Ratepayer Impact Measure	Societal Cost test	Participant Cost Test
Benefit/Cost Ratio	**7.16**	**7.10**	**0.61**	**11.56**	**23.45**
Net Benefits ($000s)	18,794.28	13,212.68	(14,195.58)	22,868.00	31,905.41
Total Benefits ($000s)	21,845.00	15,378.24	21,845.00	25,033.57	33,326.47
Total Costs ($000s)	3,050.72	2,165.57	36,040.59	2,165.57	1,421.06

B.2.5 Home Rebates Program

Table B-10: Home Rebates Benefit/Cost Test

Metric	Utility Cost Test	Total Resource Cost Test	Ratepayer Impact Measure	Societal Cost test	Participant Cost Test
Benefit/Cost Ratio	**1.11**	**1.24**	**0.59**	**1.50**	**2.30**
Net Benefits ($000s)	698.44	1,690.01	(4,916.49)	3,562.32	6,450.47
Total Benefits ($000s)	6,969.94	8,785.54	6,969.94	10,657.85	11,405.28
Total Costs ($000s)	6,271.50	7,095.53	11,886.43	7,095.53	4,954.81

B.2.6 Education Program

Table B-11: Education Benefit/Cost Test

Metric	Utility Cost Test	Total Resource Cost Test	Ratepayer Impact Measure	Societal Cost test	Participant Cost Test
Benefit/Cost Ratio	**2.18**	**2.10**	**0.54**	**2.64**	**4.44**
Net Benefits ($000s)	1,167.02	1,086.32	(1,827.62)	1,619.23	2,869.10
Total Benefits ($000s)	2,154.82	2,074.12	2,154.82	2,607.04	3,702.19
Total Costs ($000s)	987.81	987.81	3,982.44	987.81	833.09

B.2.7 Behavioral Program

Table B-12: Behavioral Benefit/Cost Test

Metric	Utility Cost Test	Total Resource Cost Test	Ratepayer Impact Measure	Societal Cost test	Participant Cost Test
Benefit/Cost Ratio	**0.43**	**0.45**	**0.24**	**0.45**	**-**
Net Benefits ($000s)	(631.36)	(581.51)	(1,510.13)	(581.51)	983.32
Total Benefits ($000s)	485.47	485.47	485.47	485.47	983.32
Total Costs ($000s)	1,116.83	1,066.98	1,995.60	1,066.98	-

B.2.8 Conservation Voltage Reduction

Table B-13: CVR Benefit/Cost Test

Metric	Utility Cost Test	Total Resource Cost Test	Ratepayer Impact Measure	Societal Cost test	Participant Cost Test
Benefit/Cost Ratio	**1.43**	**1.35**	**0.55**	**1.35**	**30.15**
Net Benefits ($000s)	219.42	190.28	(607.47)	190.28	849.22
Total Benefits ($000s)	730.22	730.22	730.22	730.22	878.36
Total Costs ($000s)	510.81	539.94	1,337.69	539.94	29.14

B.3 Demand Response Programs

PSO's demand response portfolio in 2019 consisted of two demand response programs with a verified net energy savings of 2,741,356 kWh and a verified net peak demand reduction of 68,782 kW.[105] Total spending in 2019 equaled $4,673,636. Table B-14 provides a summary of program participation and verified net impacts for the 2019 demand response portfolio. Table B-15 provides a summary of 2019 program costs.

Table B-14: Demand Response Programs – Verified Impacts (Net, at Generator)

Program	Number of Participants in 2019	Verified Peak Demand Reduction (kW)	Verified Annual Energy Savings (kWh)	Gas Savings (Therms)
Power Hours	23,151	13,021	2,150,471	0
Business Demand Response	232	55,761	590,885	0
Total – DR Programs	**23,383**	**68,782**	**2,741,356**	**0**

Table B-15: Demand Response Programs – Reported Costs

Program	Annual Non-EM&V Admin Costs ($)	Annual EM&V Admin Costs ($)	Annual Cash Inducement Costs ($)	Annual Non-Cash Inducement Costs ($)
Power Hours	$250,301	$87,489	$480,312	$1,134,064
Business Demand Response	$133,787	$55,546	$2,333,926	$198,211
Total – DR Programs	**$384,088**	**$143,035**	**$2,814,238**	**$1,332,275**

In the table that follows, total costs and benefits, and full cost-effectiveness test results are provided for the Business Demand Response program.

[105] The verified peak demand reduction shown here for the demand response programs includes an adjustment for line-losses (7.81%).

B.3.1 Power Hours Program

Table B-16: Power Hours Benefit/Cost Test

Metric	Utility Cost Test	Total Resource Cost Test	Ratepayer Impact Measure	Societal Cost test	Participant Cost Test
Benefit/Cost Ratio	**1.47**	**1.82**	**0.81**	**1.91**	**6.72**
Net Benefits ($000s)	969.67	1,405.89	(714.13)	1,554.68	1,941.22
Total Benefits ($000s)	3,017.09	3,120.07	3,017.09	3,268.87	2,280.66
Total Costs ($000s)	2,047.43	1,714.19	3,731.22	1,714.19	339.44

B.3.2 Business Demand Response Program

Table B-17: Business Demand Response Benefit/Cost Test

Metric	Utility Cost Test	Total Resource Cost Test	Ratepayer Impact Measure	Societal Cost test	Participant Cost Test
Benefit/Cost Ratio	**2.90**	**8.13**	**2.85**	**8.13**	**4.08**
Net Benefits ($000s)	5,169.70	6,920.15	5,126.56	6,920.15	1,796.28
Total Benefits ($000s)	7,891.17	7,891.17	7,891.17	7,891.17	2,379.76
Total Costs ($000s)	2,721.47	971.03	2,764.62	971.03	583.48

B.4 Avoided Costs

The avoided costs in the table below were developed for energy, capacity, T&D, and CO2 during the portfolio design process (PUD 201800073) and utilized for the TRC, UCT SCT & PCT tests. The values used to calculate avoided costs for the RIM test values were scaled fuel cost factors + embedded cost rate (ECR).[106]

[106]https://psoklahoma.com/global/utilities/lib/docs/ratesandtariffs/Oklahoma/PSO%20Riders%20Jan%202019.pdf

Table B-18: Avoided Costs from PSO Portfolio Plan

Year	SPP - Energy	SPP Capacity		T&D Costs	CO2	Natural Gas
	$/MWh	$/MW-day	$/kW-yr	$/kW-yr	($/metric tonne)	($/Mcf)
2019	$49.17	$401.73	$146.63	$18.08	$0.00	$5.34
2020	$51.25	$410.97	$150.01	$18.35	$0.00	$5.37
2021	$54.12	$420.02	$153.31	$18.63	$1.26	$5.40
2022	$62.48	$429.68	$156.83	$18.91	$15.10	$5.43
2023	$64.07	$439.13	$160.28	$19.19	$15.29	$5.46
2024	$66.39	$448.79	$163.81	$19.48	$15.49	$5.49
2025	$68.59	$458.66	$167.41	$19.77	$15.69	$5.52
2026	$69.91	$468.75	$171.10	$20.07	$15.90	$5.69
2027	$72.18	$479.07	$174.86	$20.37	$16.10	$5.86
2028	$74.00	$489.13	$178.53	$20.67	$16.31	$6.03
2029	$75.92	$499.40	$182.28	$20.98	$16.52	$6.20
2030	$78.07	$509.89	$186.11	$21.30	$16.74	$6.37
2031	$80.38	$520.59	$190.02	$21.53	$16.96	$6.54
2032	$83.77	$531.53	$194.01	$21.82	$17.18	$6.71
2033	$85.54	$542.69	$198.08	$22.11	$17.40	$6.88
2034	$81.01	$554.08	$202.24	$22.39	$17.62	$7.05
2035	$83.93	$565.72	$206.49	$22.68	$17.86	$7.22
2036	$85.22	$578.11	$211.01	$22.97	$18.09	$7.40
2037	$86.54	$590.77	$215.63	$23.26	$18.33	$7.57
2038	$87.89	$603.71	$220.35	$23.55	$18.58	$7.74
2039	$89.26	$616.93	$225.18	$23.83	$18.83	$7.91
2040	$90.66	$630.44	$230.11	$24.12	$19.08	$8.08
2041	$92.09	$644.25	$235.15	$24.41	$19.33	$8.25
2042	$93.56	$658.36	$240.30	$24.70	$19.59	$8.44
2043	$95.05	$672.78	$245.56	$24.99	$19.83	$8.62
2044	$97.14	$687.58	$250.97	$25.54	$20.26	$8.81
2045	$99.28	$702.71	$256.49	$26.10	$20.71	$9.00

Appendix C. Identification of Program Implementers

Table C-1 identifies program implementation contractors and associated contact information by 2019 program.

Table C-1: Program Implementer Identification

Program(s)	Implementation Contractor	Contact	Contact Title	Contact Address	Contact Phone	Contact Email
Business Rebates	ICF International	Janine Pittman	Program Manager	907 S. Detroit Ave. Suite 505 Tulsa, OK 74120	405-714-3437	Janine.Pittman@icfi.com
Multi-Family	ICF International	Jason Fisher	Technical Specialist	907 S Detroit Ave. Suite 505, Tulsa, OK 74120	918-519-0214	Jason.Fisher@icf.com
Home Weatherization	Titan ES, LLC	Bradley Cockings	President	9700 S. Pole Road, Tulsa, OK 73160	405-632-1700	bcockings@titanes.us
	Revitalize T-Town	Jennifer Barcus - Schafer	Chief Executive Officer	14 E 7th St, Tulsa, OK 74119	918-742-6241	jennifer@revitalizettown.org
	Ki Bois Community Action Foundation	Michael Knapp	Weatherization Director	200 SE A Street Stigler, Oklahoma 74462	918-967-3325	michael.knapp@kibois.org
Energy Saving Products	CLEAResult	Karen Miller	Program Manager	146 Chestnut Street, Springfield, MA 01103	413-426-7888	karen.miller@clearesult.com
Home Rebates	ICF International	Andrea Palmer	Program Manager	907 S. Detroit Ave. Suite 505 Tulsa, OK 74120	918-348-0503	Andera.palmer@icf.com
Education	Resource Action Programs	Lee Moran	Senior Program Manager	976 United Circle, Sparks, NV 89431	888-438-9473	lmoran@resourceaction.com

Program(s)	Implementation Contractor	Contact	Contact Title	Contact Address	Contact Phone	Contact Email
Power Hours	Honeywell	Amanda Richards	Program Manager	300 S Tryon St Suite 500, Charlotte, NC 28202	1-800-633-3991	amanda.richards@honeywell.com
Business Demand Response	PSO	Nonette Surbaugh	EE & Consumer Program Coordinator	212 E. 6th St. Tulsa, OK 74119	918-599-2101	nonettes@aep.com
CVR	PSO	Tyler H Devereux	Customer Design Manager	212 E. 6th St. Tulsa, OK 74119	918-599-2488	thdevereux@aep.com
Program Marketing Services	Cubic Creative	Billy Kulkin	President and Managing Partner	1643 S. Boston Ave, Tulsa, OK 74119	918-587-7888	billy@cubiccreative.com

Appendix D. Training and Customer Outreach

During 2019, PSO conducted several service provider recruitment and training events. Additionally, PSO sponsored various customer outreach events and stakeholder presentations. Table D-1 summarizes the in-store retail lighting promotional events. Table D-2 summarizes service provider recruitment and training events, customer outreach events, and other non-lighting promotion events throughout PY2019.

Table D-1: Summary of In-Store Retail Lighting Promotional Events

Date	Event Name	Location	Training/Education Type	Number of Attendees
1/14/2019	Sams Club	Tulsa	Contractor	51-60
1/17/2019	Walmart	Broken Arrow	Contractor	21-30
1/17/2019	Sams Club	Lawton	Contractor	11-20
1/20/2019	Walmart	Owasso	Contractor	31-40
1/23/2019	Lowes	Tulsa	Contractor	41-50
1/31/2019	Sams Club	Lawton	Contractor	11-20
2/9/2019	Lowes	Bartlesville	Contractor	51-60
2/15/2019	Lowes	Tulsa	Contractor	51-60
2/16/2019	Lowes	Tulsa	Contractor	71-80
2/22/2019	Sams Club	Lawton	Contractor	21-30
2/23/2019	Lowes	Tulsa	Contractor	41-50
2/23/2019	Walmart	Lawton	Contractor	31-40
3/8/2019	Sams Club	Lawton	Contractor	21-30
3/16/2019	Home Depot	Tulsa	Contractor	31-40
3/17/2019	Walmart	Broken Arrow	Contractor	31-40
3/22/2019	Walmart	Lawton	Contractor	21-30
3/29/2019	Home Depot	Tulsa	Contractor	61-70
3/30/2019	Home Depot	Tulsa	Contractor	71-80
3/30/2019	Walmart	Lawton	Contractor	21-30
4/6/2019	Walmart	Elk City	Contractor	21-30
4/13/2019	Lowes	Bartlesville	Contractor	41-50
4/13/2019	Walmart	Hobart	Contractor	21-30
4/20/2019	Sams Club	Tulsa	Contractor	61-70
4/26/2019	Home Depot	Tulsa	Contractor	41-50
4/27/2019	Home Depot	Owasso	Contractor	41-50
4/27/2019	Sams Club	Tulsa	Contractor	71-80
5/4/2019	Walmart	Owasso	Contractor	41-50
5/4/2019	Walmart	Hobart	Contractor	21-30
5/11/2019	Lowes	Grove	Contractor	41-50
5/11/2019	Home Depot	Tulsa	Contractor	61-70

Date	Event Name	Location	Training/Education Type	Number of Attendees
5/17/2019	Sams Club	Lawton	Contractor	21-30
5/18/2019	Walmart	Lawton	Contractor	21-30
5/24/2019	Lowes	Tulsa	Contractor	71-80
5/25/2019	Sams Club	Tulsa	Contractor	61-70
6/1/2019	Lowes	Owasso	Contractor	41-50
6/8/2019	Walmart	Elk City	Contractor	21-30
6/29/2019	Home Depot	Tulsa	Contractor	71-80
6/29/2019	Walmart	Vinita	Contractor	21-30
6/29/2019	Walmart	Lawton	Contractor	21-30
6/30/2019	Home Depot	Tulsa	Contractor	41-50
7/2/2019	Walmart	Broken Arrow	Contractor	31-40
7/13/2019	Ace Hardware	Broken Arrow	Contractor	21-30
7/13/2019	Walmart	Hobart	Contractor	21-30
7/15/2019	Walmart	Owasso	Contractor	21-30
7/27/2019	Walmart	Broken Arrow	Contractor	31-40
7/27/2019	Sams Club	Lawton	Contractor	21-30
7/27/2019	Home Depot	Tulsa	Contractor	61-70
7/28/2019	Lowes	Tulsa	Contractor	31-40
8/17/2019	Home Depot	Owasso	Contractor	31-40
8/17/2019	Walmart	Lawton	Contractor	21-30
8/23/2019	Sams Club	Lawton	Contractor	21-30
8/24/2019	Walmart	Broken Arrow	Contractor	31-40
8/24/2019	Walmart	Elk City	Contractor	21-30
8/24/2019	Sams Club	Tulsa	Contractor	21-30
8/25/2019	Lowes	Tulsa	Contractor	61-70
9/7/2019	Lowes	Broken Arrow	Contractor	41-50
9/7/2019	Walmart	Hobart	Contractor	21-30
9/14/2019	Walmart	Coweta	Contractor	31-40
9/21/2019	Sams Club	Lawton	Contractor	31-40
9/28/2019	Home Depot	Tulsa	Contractor	61-70
9/29/2019	Home Depot	Tulsa	Contractor	51-60
10/19/2019	Walmart	Elk City	Contractor	21-30
10/19/2019	Lowes	Grove	Contractor	21-30
10/20/2019	Home Depot	Owasso	Contractor	41-50
10/26/2019	Sams Club	Lawton	Contractor	21-30
10/26/2019	Home Depot	Tulsa	Contractor	71-80
10/27/2019	Home Depot	Tulsa	Contractor	51-60
11/2/2019	Walmart	Hobart	Contractor	21-30
11/9/2019	Lowes	Bartlesville	Contractor	41-50

Date	Event Name	Location	Training/Education Type	Number of Attendees
11/9/2019	Walmart	Lawton	Contractor	21-30
11/10/2019	Lowes	Owasso	Contractor	41-50
11/23/2019	Lowes	Tulsa	Contractor	61-70
11/30/2019	Home Depot	Tulsa	Contractor	71-80
12/7/2019	Home Depot	Tulsa	Contractor	31-40
12/7/2019	Lowes	Tulsa	Contractor	61-70
12/13/2019	Walmart	Elk City	Contractor	21-30
12/14/2019	Lowes	Tulsa	Contractor	31-40
12/14/2019	Sams Club	Lawton	Contractor	21-30
12/14/2019	Home Depot	Tulsa	Contractor	61-70

Table D-2: Service Provider Recruitment & Training Events, Customer Outreach Events, and Other Non-Lighting Promotional Events

Date	Event Name	Location	Training/Education Type	Number of Attendees
1/8/2019	Jenks East Intermediate	Tulsa	Contractor	21-30
1/30/2019	Apache Hotel	Lawton	Contractor	61-70
1/31/2019	Stoney Creek Hotel	Broken Arrow	Contractor	100+
2/4/2019	Prairie Fire	Elk City	Contractor	11-20
2/5/2019	Petes Place	Krebs	Contractor	11-20
2/7/2019	Roma Italian	Hugo	Contractor	0-10
2/8/2019	Tulsa General Office	Tulsa	Other	0-10
2/8/2019	Grove Civic Center	Grove	Contractor	100+
2/13/2019	HBA	Tulsa	Contractor	21-30
2/21/2019	Salas Urban	Lawton	Contractor	0-10
3/7/2019	Jay SC	Jay	Contractor	21-30
3/20/2019	Lawton SC	Lawton	Other	11-20
3/28/2019	Seniot Citizen Nutrition Center	McAlester	Contractor	11-20
4/1/2019	Lawton SC	Lawton	Other	11-20
4/3/2019	Center for Creative Living	Lawton	Contractor	31-40
4/22/2019	Tulsa General Office	Tulsa	Other	21-30
4/23/2019	Tulsa General Office	Tulsa	Other	21-30
4/24/2019	Tulsa General Office	Tulsa	Other	11-20
4/24/2019	Mazzios	Tulsa	Contractor	21-30
4/25/2019	Tulsa General Office	Tulsa	Other	21-30
4/26/2019	Tulsa General Office	Tulsa	Other	21-30
4/29/2019	Tulsa General Office	Tulsa	Other	0-10
5/9/2019	University of Tulsa, Allen Chapman Student Union	Tulsa	Contractor	71-80
5/11/2019	Grove Main Street	Grove	Contractor	100+

Date	Event Name	Location	Training/Education Type	Number of Attendees
5/30/2019	Tulsa General Office	Tulsa	Other	0-10
6/11/2019	Clinton SC	Clinton	Other	11-20
6/12/2019	Hobart SC	Hobart	Other	21-30
6/26/2019	Okmulgee SC	Okmulgee	Other	11-20
7/3/2019	Tulsa General Office	Tulsa	Other	0-10
7/17/2019	Clinton Senior Center	Clinton	Contractor	31-40
7/24/2019	Tulsa General Office	Tulsa	Other	11-20
8/3/2019	Tulsa Tech Center Peoria Campus	Tulsa	Contractor	81-90
8/8/2019	Lawton SC	Lawton	Other	31-40
8/16/2019	Okmulgee SC	Okmulgee	Other	0-10
8/22/2019	Cox Convention Center	Oklahoma City	Contractor	100+
8/23/2019	Weatherford SC	Tipton	Other	0-10
8/23/2019	Cox Convention Center	Oklahoma City	Contractor	100+
8/24/2019	Cox Convention Center	Oklahoma City	Contractor	100+
8/29/2019	TU Campus	Tulsa	Contractor	71-80
9/5/2019	McCurtain County Fair Grounds	Idabel	Contractor	81-90
9/5/2019	Guthrie Green	Tulsa	Contractor	51-60
9/6/2019	Choctaw County Fair	Hugo	Contractor	81-90
9/12/2019	Pushmataha County Fair	Antlers	Contractor	31-40
9/14/2019	TU Campus	Tulsa	Contractor	11-20
9/18/2019	Cox Convention Center	Tulsa	Contractor	100+
9/19/2019	Cox Convention Center	Tulsa	Contractor	100+
9/21/2019	Riverwalk	Jenks	Contractor	41-50
9/21/2019	BOK Center	Tulsa	Contractor	11-20
9/25/2019	Hugo SC	Hugo	Other	0-10
9/26/2019	Tulsa Fair Grounds	Tulsa	Contractor	100+
9/28/2019	Stillwater, OK	Stillwater	Contractor	0-10
10/8/2019	BOK Center	Tulsa	Contractor	11-20
10/15/2019	Tulsa General Office	Tulsa	Other	11-20
10/17/2019	Blanchard Chamber	Blanchard	Contractor	21-30
10/17/2019	Guthrie Green	Tulsa	Contractor	100+
10/19/2019	OSU Stadium	Stillwater	Contractor	11-20
10/24/2019	Renaissance Tulsa Hotel & Convention Center	Tulsa	Contractor	100+
10/25/2019	Bartlesville SC	Bartlesville	Other	21-30
10/26/2019	The Rose District	Broken Arrow	Contractor	100+
10/26/2019	Washington Irving Memorial Park	Bixby	Contractor	71-80
10/29/2019	Northeastern State University	Tulsa	Contractor	100+
11/1/2019	Tulsa General Office	Tulsa	Other	0-10
11/2/2019	OSU Stadium	Stillwater	Contractor	0-10

Date	Event Name	Location	Training/Education Type	Number of Attendees
11/6/2019	Tulsa Alsuma SC	Tulsa	Other	21-30
11/8/2019	TU Campus	Tulsa	Contractor	0-10
11/9/2019	Adair Main Street	Adair	Contractor	21-30
11/13/2019	Tulsa General Office	Tulsa	Other	11-20
11/13/2019	New Vinita SC	Vinita	Other	11-20
11/13/2019	Osage Hotel & Casino	Tulsa	Contractor	100+
11/14/2019	Bartlesville SC	Bartlesville	Other	0-10
11/14/2019	Osage Hotel & Casino	Tulsa	Contractor	100+
11/15/2019	Apache Casino Resort	Lawton	Contractor	91-100
11/15/2019	Rogers State University	Claremore	Contractor	100+
11/15/2019	Apache Casino & Hotel	Lawton	Contractor	100+
11/16/2019	OSU Stadium	Stillwater	Contractor	0-10
11/19/2019	Bartlesville SC	Bartlesville	Other	11-20
11/23/2019	TU Campus	Tulsa	Contractor	0-10
11/30/2019	OSU Stadium	Stillwater	Contractor	0-10
12/5/2019	Tulsa General Office	Tulsa	Other	0-10
12/19/2019	Okmulgee SC	Okmulgee	Other	11-20

Appendix E. Marketing Synopsis

The following pages of this appendix provide examples of marketing materials used to promote PSO's Demand Side Management portfolio in 2019.

2019 PROGRAM MARKETING OVERVIEW

PSO's marketing strategies for Power Forward with PSO continue to evolve in attracting, engaging and educating customers on energy efficiency. Multichannel marketing strategies are utilized to increase opportunities for customer awareness and engagement. PSO's centralized marketing function ensures strategic planning and execution across all energy efficiency programs, delivering a consistent message and experience for customers regardless of program. Additionally, in 2019 marketing initiatives focused on generated customer leads, which directly contributed to kWh savings for various programs.

2019 PROGRAM MARKETING GOALS

ACHIEVE ENERGY-SAVING GOALS	IMPROVE CUSTOMER ENGAGEMENT	EDUCATE + ENTERTAIN
• Work with program implementers to improve marketing effectiveness • Optimize marketing tactics to deliver greater ROI • Create opportunities for lead generation	• Utilize segmentation data for targeted marketing • Remove barriers for engagement and participation • Interact with customers in the space they prefer	• Simplify and streamline communications • Be transparent about the benefits of energy efficiency • Have a bolder voice to earn customers' attention

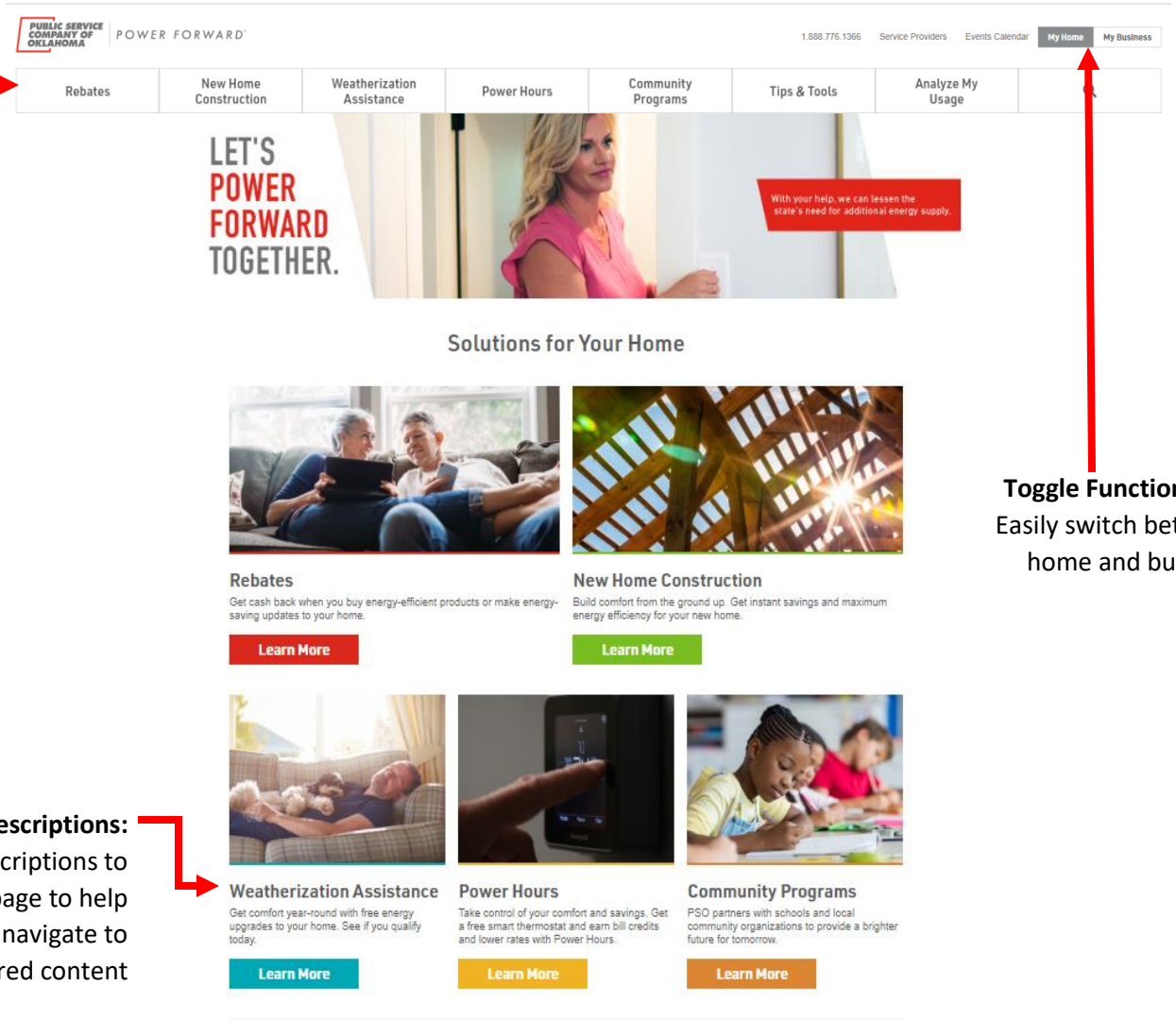
STRATEGIES + TACTICS:

- Harness feedback from customers, industry experts and partners to improve the clarity, effectiveness and follow-up efforts for EE program marketing.
- Utilize paid media to deliver targeted messages to customers.
- Develop content to support paid media and digital channels.
- Utilize e-blasts to promote program participation.
- Optimize Power Forward with PSO digital channels.
- Create opportunities for education, innovation and engagement.

WEBSITE OPTIMIZATIONS

In 2019, PSO launched a new look and feel for the Power Forward with PSO website, which is the central location for all program information. The website was optimized to more clearly communicate rebate and program offerings, and provide customers with opportunities to request more information about specific programs.

Streamlined navigation: primary navigation dedicated to individual programs

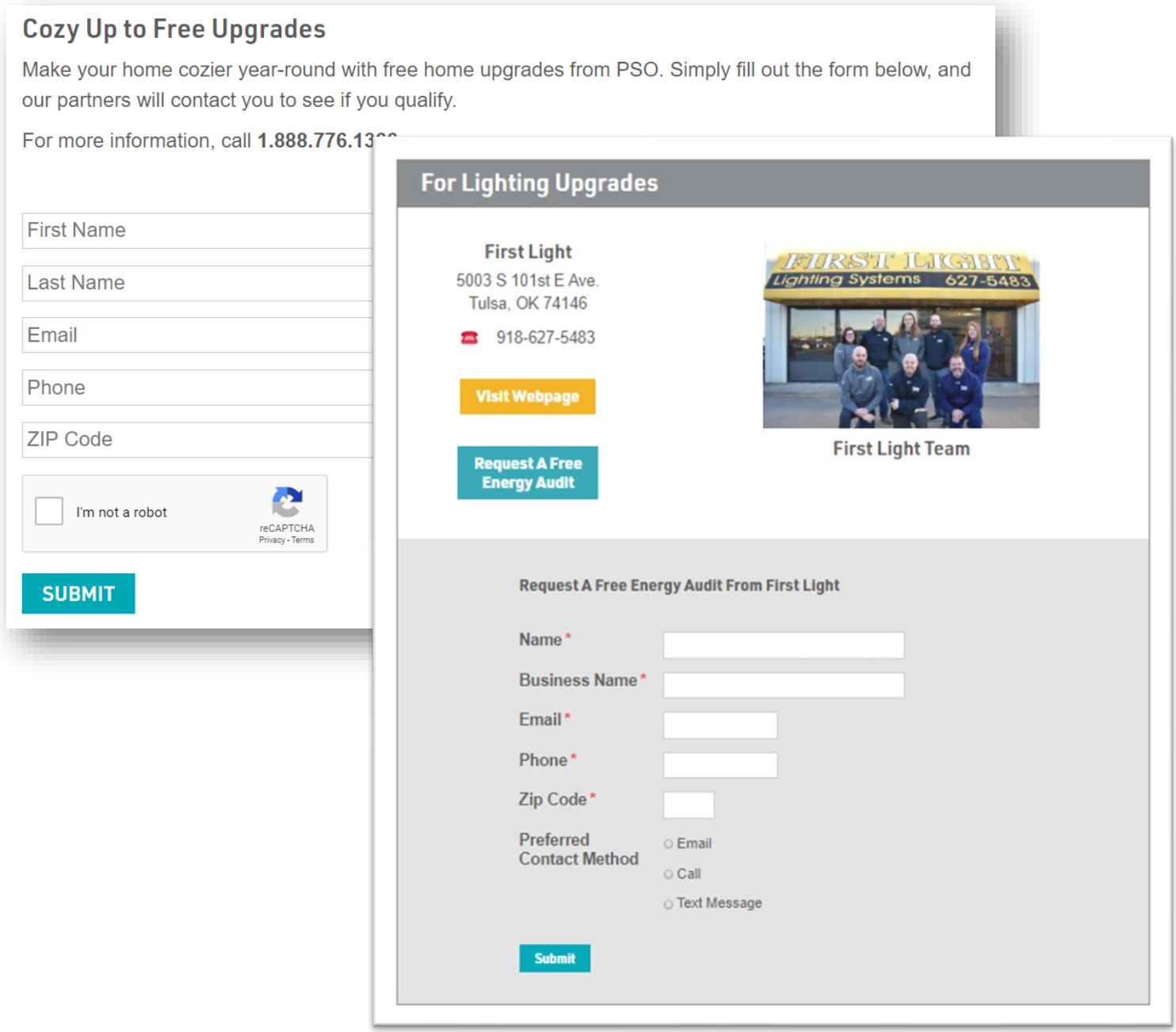


Toggle Functionality: Easily switch between home and business

Program Descriptions: Added descriptions to homepage to help customers navigate to desired content

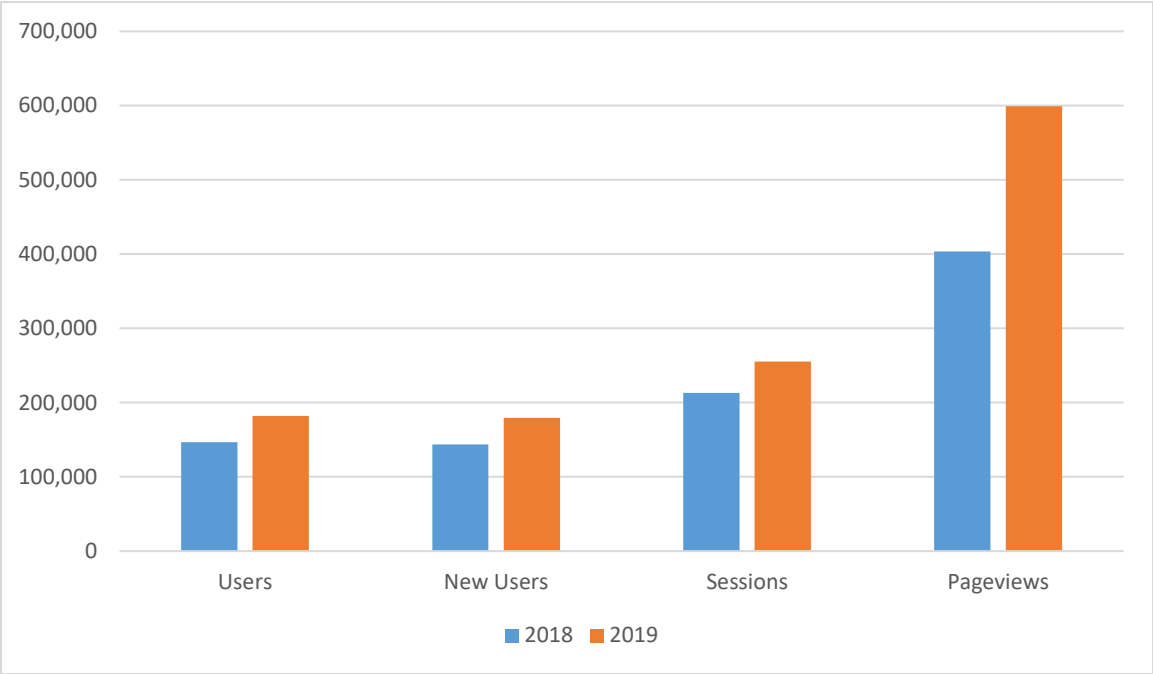
continued on next page

Lead Capture:
Integrated lead capture forms for Small Business, Home Weatherization and Energy Coaching

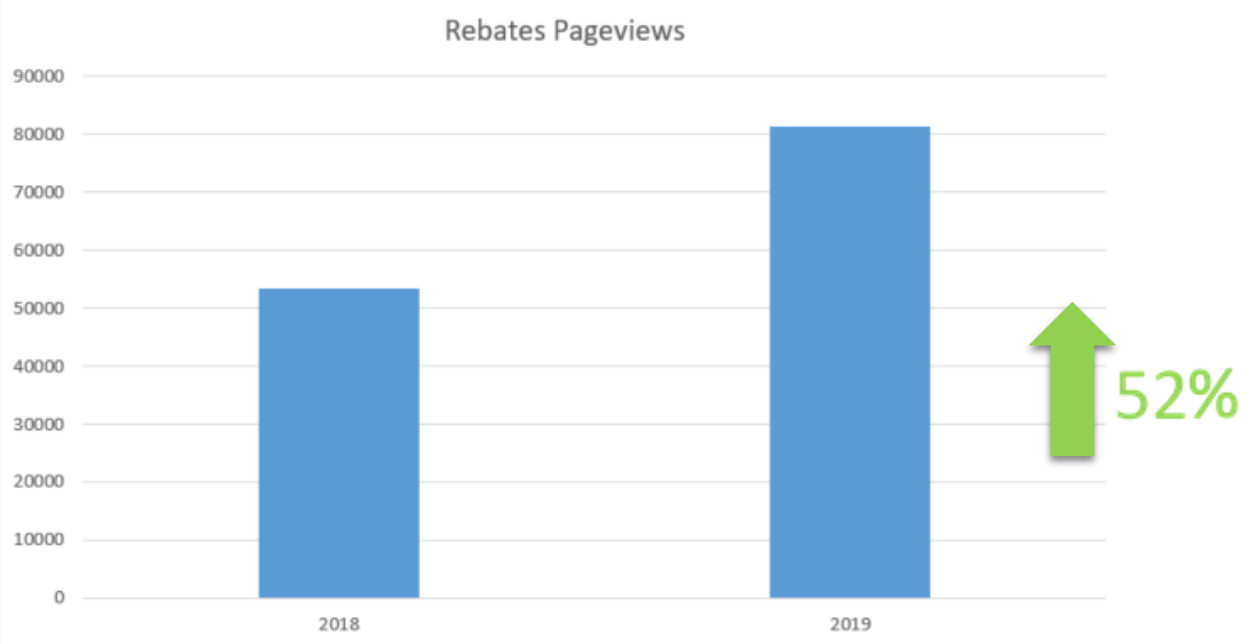


In 2019, more than **2,700** customers submitted their information using the forms.

OVERALL WEBSITE PERFORMANCE



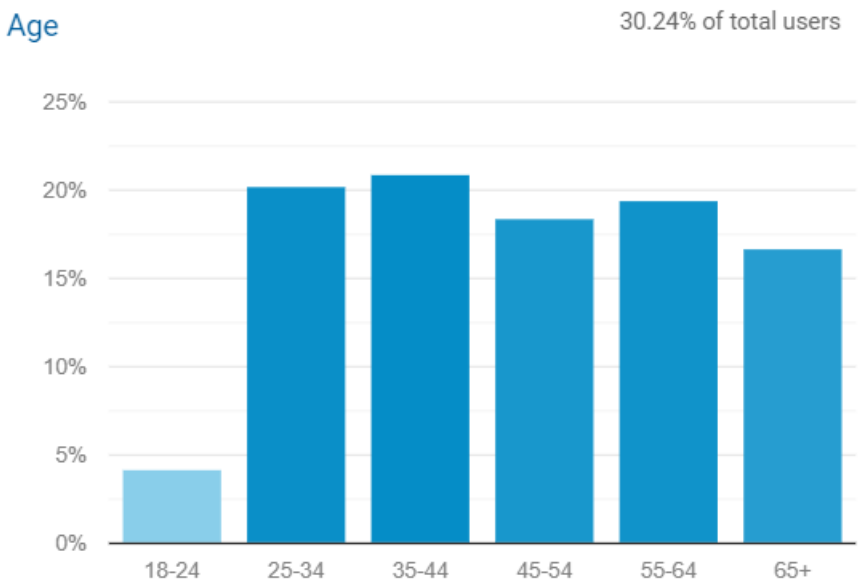
182,234	179,429	255,458	599,177
Users	New Users	Sessions	Pageviews
↑ 24.14%	↑ 24.7%	↑ 19.88%	↑ 48.55%



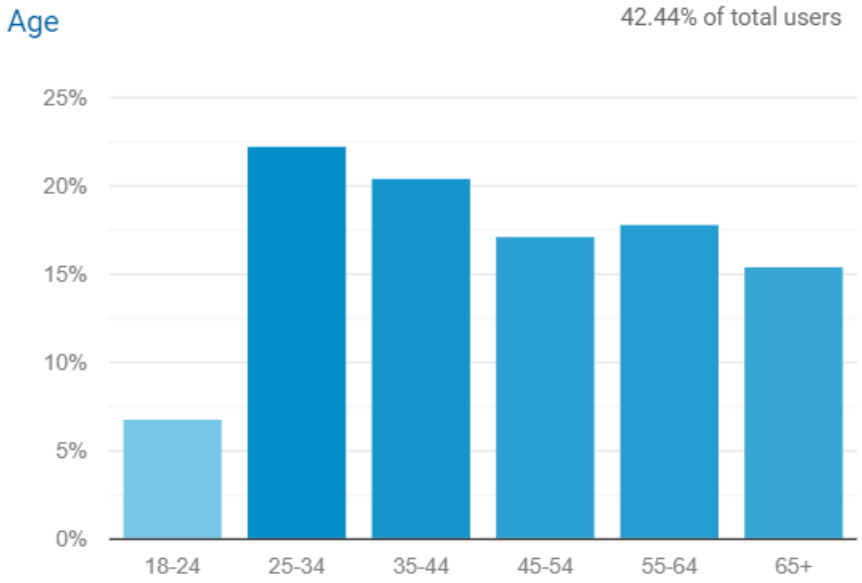
SITE VISITORS: BY AGE

Website visitors by age remained consistent from 2018 to 2019, with only a marginal increase in visitors from the 35-44 age group.

2019

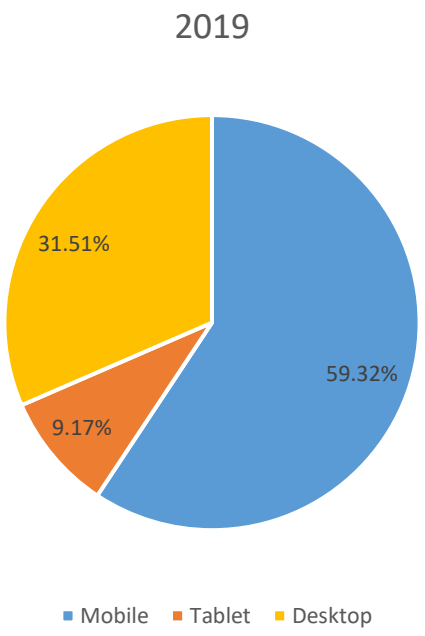


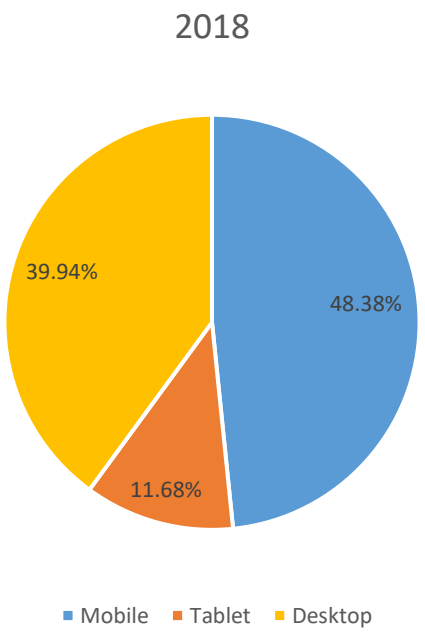
2018



SITE VISITORS: BY DEVICE

There continues to be a gradual increase in traffic from mobile devices over desktop computers. The website enhancements completed in 2019 have improved the user experience for mobile visitors, and any future upgrades will focus on mobile-first design.





WEBSITE EVENTS

After the website redesign, event tracking was adjusted to capture the most relevant website actions. Changes to event tracking were finalized in August 2019. The data below represents the top events according to the modified event tracking.

EVENT TYPE	# OF EVENTS
Find a Retailer/Provider – Home Rebates	3,894
Weatherization Form	910
Power Hours Sign Up	1,612
Find a Builder	64
Submit an Application – Business Rebates	984
Peak Performers Enrollment	278
Small Business Energy Audit	133
Schedule a Consultation – Business	40
Small Business Energy Consult	17
Agriculture Consult	9

WEBSITE ENGAGEMENT

The following pages have the most engagement – determined by total pageviews and time spent on page.

PAGE DESCRIPTION	PAGEVIEWS
Homepage - Residential	100,932
Rebates – Residential	91,164
Homepage – Business	48,312
Tips & Tools	35,560
Why Energy Efficiency Matters	31,254
Weatherization Assistance	20,807

PAID SEARCH RESULTS

Paid search is being utilized to capture customers at the bottom of the sales funnel. In 2019, we refined search keywords to increase media effectiveness and reduce spend in order to support additional upper funnel marketing tactics, which focus on moving customers from awareness to consideration.

PAID SEARCH IMPRESSIONS	
Residential	226,707
Commercial	15,862

Top Search Terms: LED lighting, PSO Energy, New Home Construction, Energy Star Rebate, Energy Saving Rebates, T12 Lighting, Farm & Agriculture Equipment, Business Rebates, Lighting Rebates

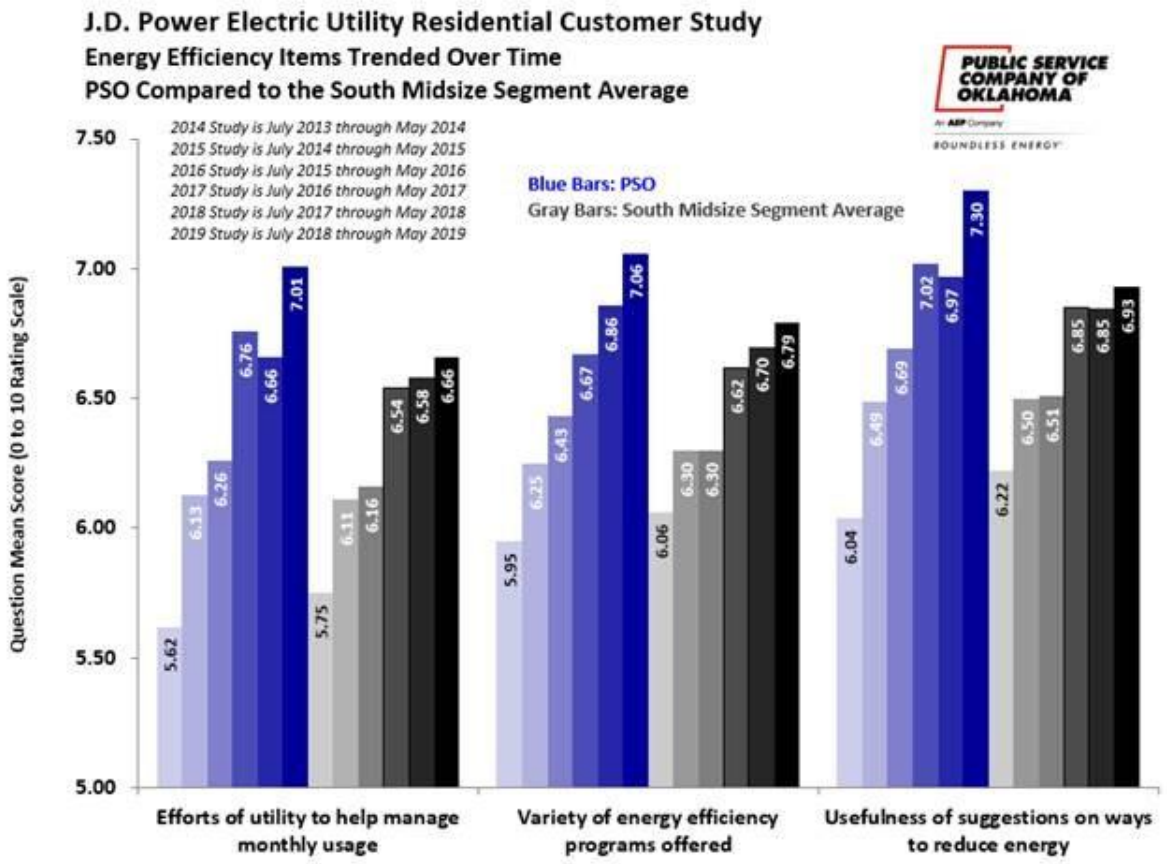
WEB TRAFFIC – SOCIAL

Social continues to be a strong driver of traffic to the website. In 2019, we added Pinterest into the media mix in order to diversify and reach customers across a variety of platforms where content is consumed. Pinterest has shown to perform well above benchmark; therefore, we will continue to develop content for this channel in 2020.

SOCIAL WEB REFERRALS	
Users	6,190
Sessions	6,841
Conversions	2

TOP REFERRAL CHANNELS	USERS
Facebook	3,651
Pinterest	3,098
LinkedIn	29

J.D. POWER SCORES

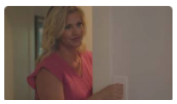
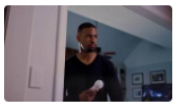


VIDEOS

In 2019, we shifted our video marketing strategy from a single vendor (YouTube) to multiple vendors (programmatic, AARP, etc) in order to reach a wider customer base. By diversifying the video ad placements, we were able to test the effectiveness of vendors among differing customer segments. As a result of the decreased YouTube ad spend, the YouTube video views have decreased year over year.

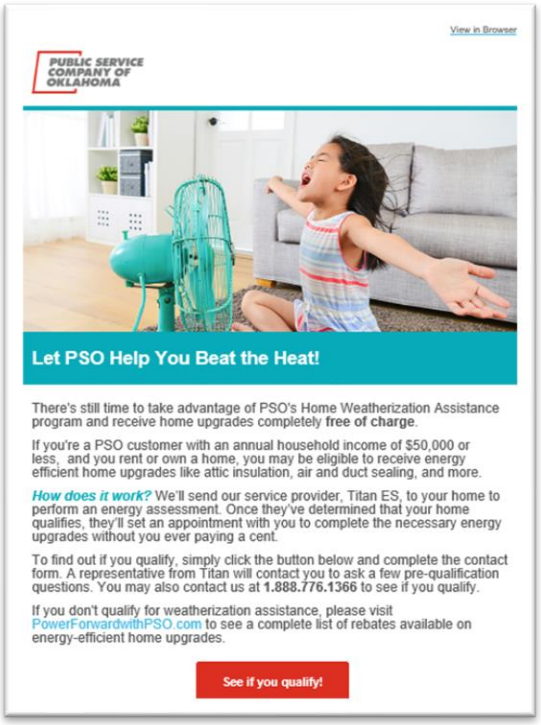
YouTube Channel Performance			
Video Type	Impressions	Views	Clicks
Residential	385,292	180,273	585
Commercial	539,394	244,948	677

Top Performing YouTube Content

	Video	Average view duration	Views
1	 Make Small Energy-Saving Changes | Be a Peak Performer | Power Forward ... May 20, 2019	0:14 (93.1%)	165,690
2	 More Rebates. More Savings. More Power to You! | PSO Rebates | Power For... Sep 20, 2017	0:14 (90.6%)	59,684
3	 Energy Efficiency | Power Forward with PSO Aug 22, 2019	0:30 (97.2%)	47,076
4	 Shopping for Light Bulbs? Look for Kelvins! May 4, 2017	0:30 (97.0%)	27,586
5	 Save the Watts | Power Forward with PSO Oct 31, 2019	0:15 (94.3%)	27,533

EMAIL MARKETING

PSO utilized email marketing to send communications regarding rebates and programs to various customer segments. Program participation data was utilized to ensure the right customers were targeted with relevant messaging. Emails included clear call to action buttons to improve customer engagement.



View in Browser

PUBLIC SERVICE COMPANY OF OKLAHOMA

Let PSO Help You Beat the Heat!

There's still time to take advantage of PSO's Home Weatherization Assistance program and receive home upgrades completely **free of charge**.

If you're a PSO customer with an annual household income of $50,000 or less, and you rent or own a home, you may be eligible to receive energy efficient home upgrades like attic insulation, air and duct sealing, and more.

How does it work? We'll send our service provider, Titan ES, to your home to perform an energy assessment. Once they've determined that your home qualifies, they'll set an appointment with you to complete the necessary energy upgrades without you ever paying a cent.

To find out if you qualify, simply click the button below and complete the contact form. A representative from Titan will contact you to ask a few pre-qualification questions. You may also contact us at **1.888.776.1366** to see if you qualify.

If you don't qualify for weatherization assistance, please visit PowerForwardwithPSO.com to see a complete list of rebates available on energy-efficient home upgrades.

See if you qualify!

PUBLIC SERVICE COMPANY OF OKLAHOMA

MORE WAYS TO SAVE

Colleague,

Thank you for participating in PSO's Small Business Energy Solutions. You've taken the first step toward energy efficiency, but did you know PSO offers other services to help you save energy?

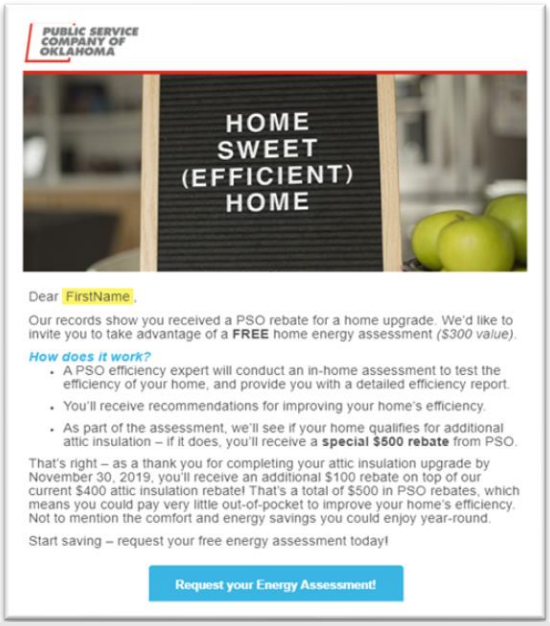
Earn cash incentives for your business with **PSO's Peak Performers** program. Simply reduce or shift electricity use during designated peak demand days. Participation is completely voluntary - no risk, only rewards!

Become a Peak Performer!

Take a closer look at your business' energy usage with **My Energy Advisor**. You can track your usage, set goals to reduce utility bills, and find rebates to help you save even more.

Customize Your Profile!

We appreciate your participation and look forward to helping you with additional energy saving solutions for your business.



PUBLIC SERVICE COMPANY OF OKLAHOMA

HOME SWEET (EFFICIENT) HOME

Dear FirstName,

Our records show you received a PSO rebate for a home upgrade. We'd like to invite you to take advantage of a **FREE** home energy assessment *($300 value)*.

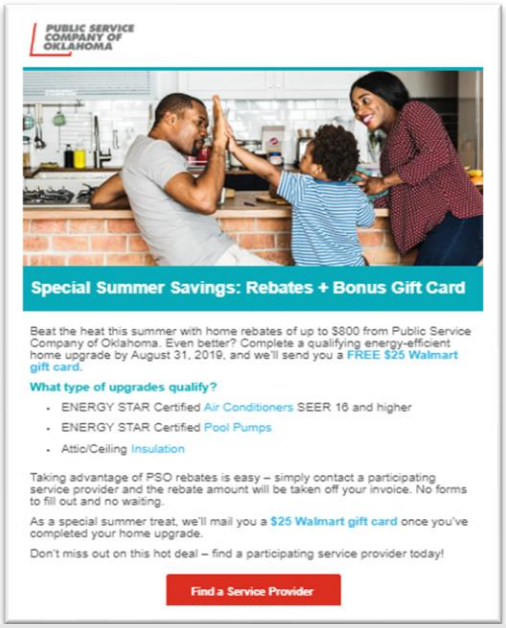
How does it work?

- A PSO efficiency expert will conduct an in-home assessment to test the efficiency of your home, and provide you with a detailed efficiency report.
- You'll receive recommendations for improving your home's efficiency.
- As part of the assessment, we'll see if your home qualifies for additional attic insulation – if it does, you'll receive a **special $500 rebate** from PSO.

That's right – as a thank you for completing your attic insulation upgrade by November 30, 2019, you'll receive an additional $100 rebate on top of our current $400 attic insulation rebate! That's a total of $500 in PSO rebates, which means you could pay very little out-of-pocket to improve your home's efficiency. Not to mention the comfort and energy savings you could enjoy year-round.

Start saving – request your free energy assessment today!

Request your Energy Assessment!



PUBLIC SERVICE COMPANY OF OKLAHOMA

Special Summer Savings: Rebates + Bonus Gift Card

Beat the heat this summer with home rebates of up to $800 from Public Service Company of Oklahoma. Even better? Complete a qualifying energy-efficient home upgrade by August 31, 2019, and we'll send you a **FREE $25 Walmart gift card**.

What type of upgrades qualify?

- ENERGY STAR Certified Air Conditioners SEER 16 and higher
- ENERGY STAR Certified Pool Pumps
- Attic/Ceiling Insulation

Taking advantage of PSO rebates is easy – simply contact a participating service provider and the rebate amount will be taken off your invoice. No forms to fill out and no waiting.

As a special summer treat, we'll mail you a **$25 Walmart gift card** once you've completed your home upgrade.

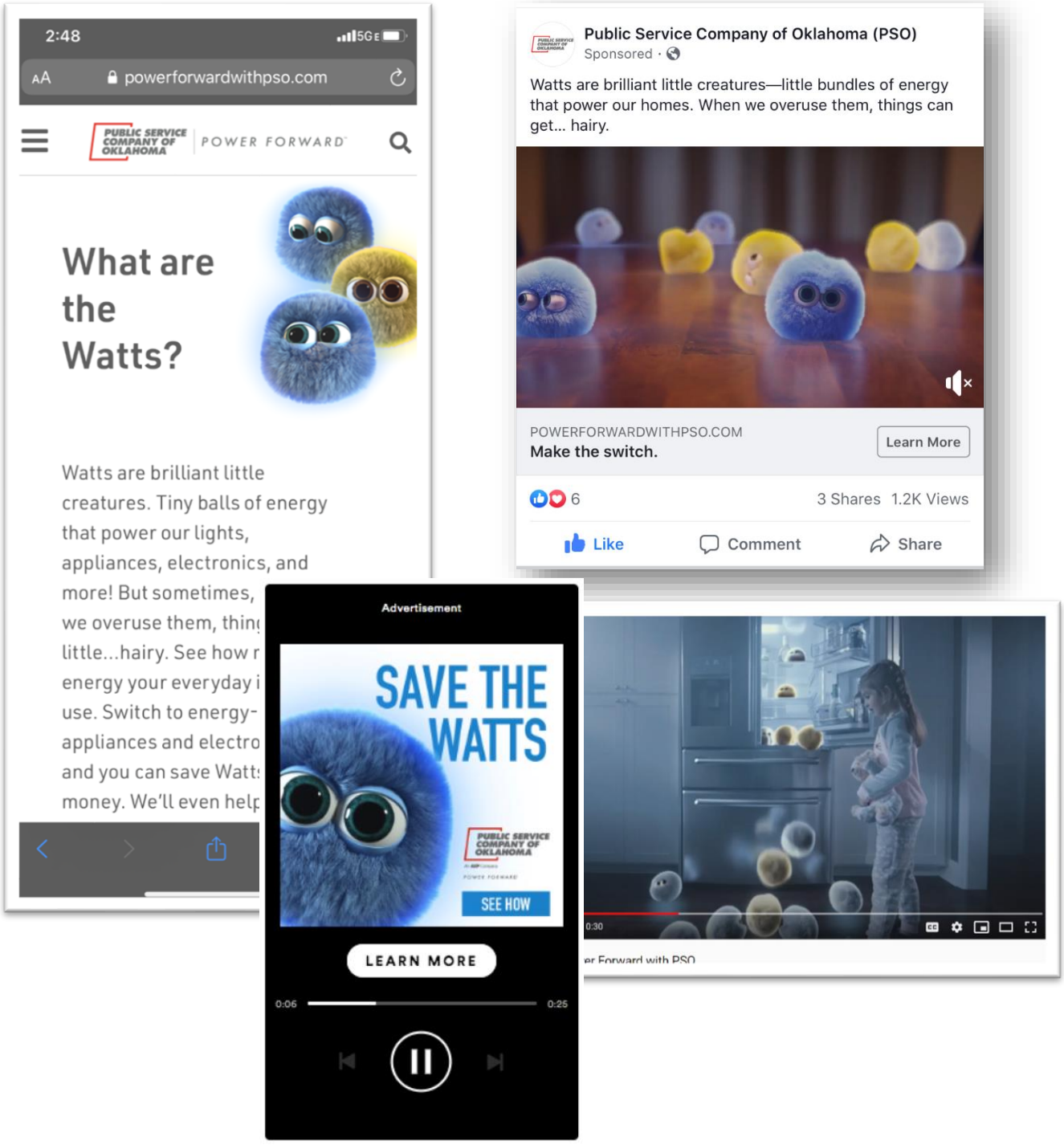
Don't miss out on this hot deal – find a participating service provider today!

Find a Service Provider

Emails resulted in 2,800 Weatherization requests & 100+ Small Business audit requests.

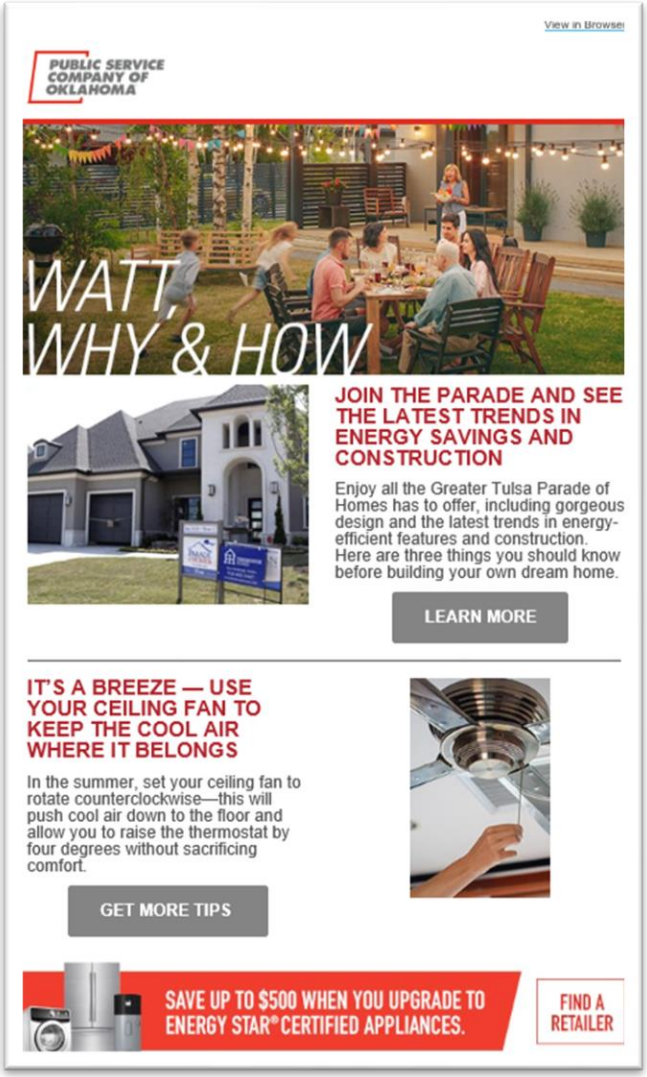
CREATIVE EXAMPLES | WATTS

PSO continues to utilize videos and blogs to provide energy-saving tips and educational content. In 2019, PSO launched the “Watts” video series, which focused primarily on educating customers about how inefficient equipment in their homes is wasting electricity.



RESIDENTIAL NEWSLETTER:

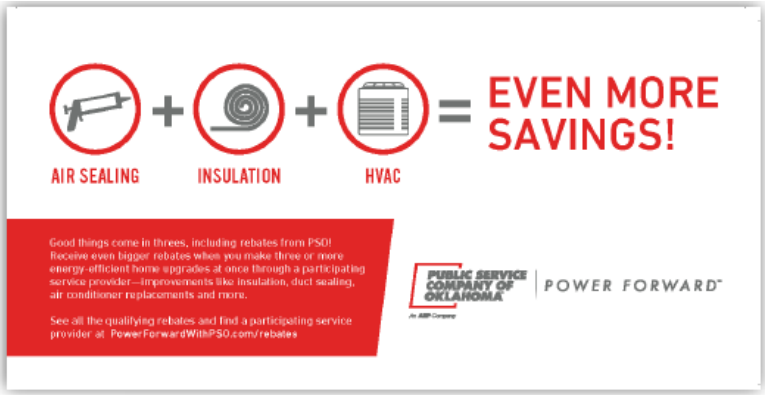
Sent to approximately 300,000 customers monthly. Content highlights energy-saving blog content, tips and available rebates. Customers are encouraged to visit the Power Forward with PSO website.

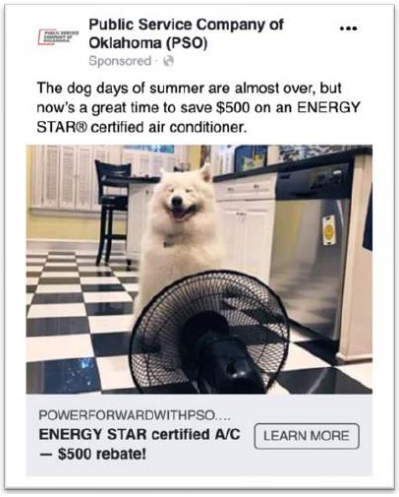


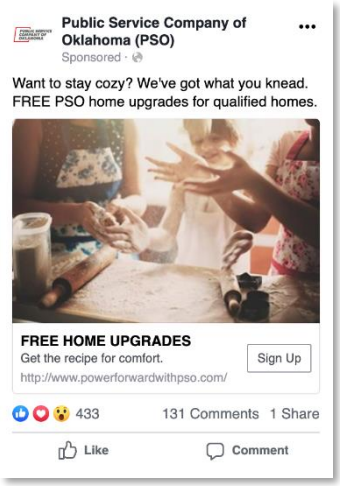
Clicks from the newsletter account for **30% increase** in monthly website traffic.

CREATIVE EXAMPLES | ENERGY STAR

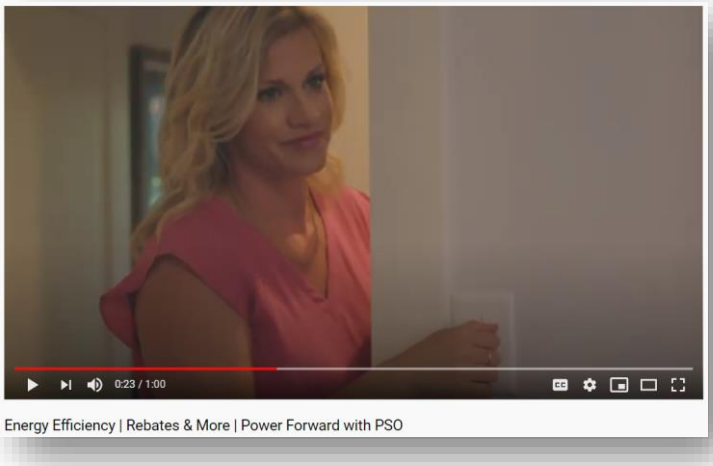
CREATIVE EXAMPLES | RESIDENTIAL PROGRAMS

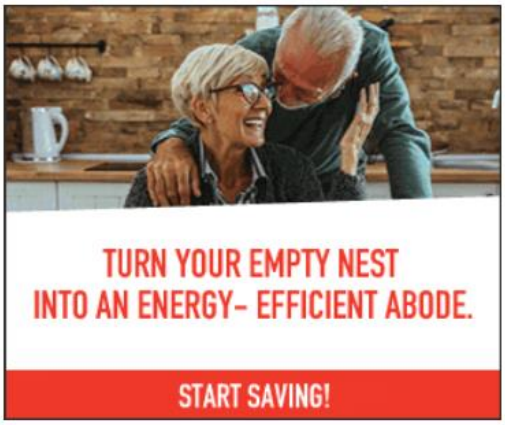


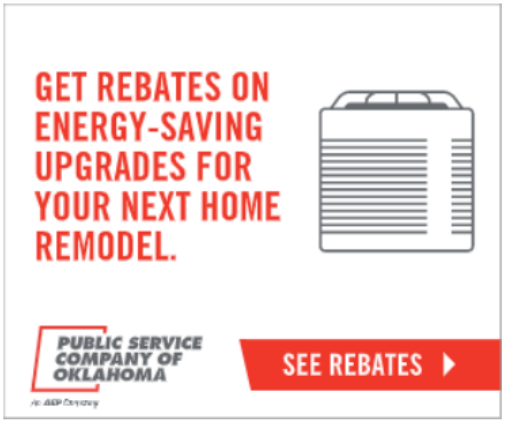




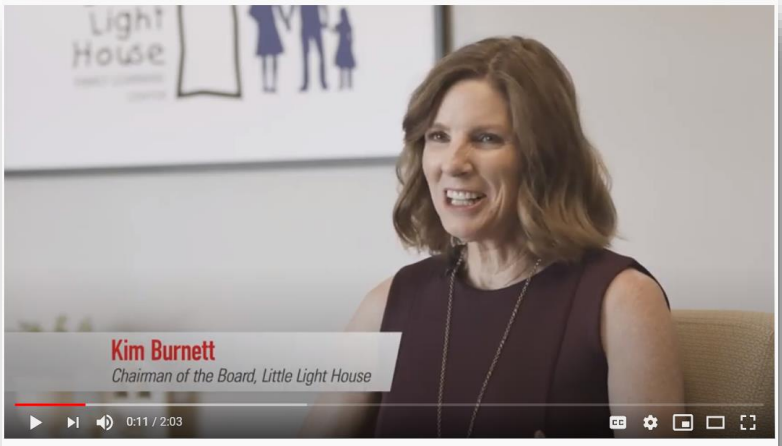
CREATIVE EXAMPLES | RESIDENTIAL PROGRAMS





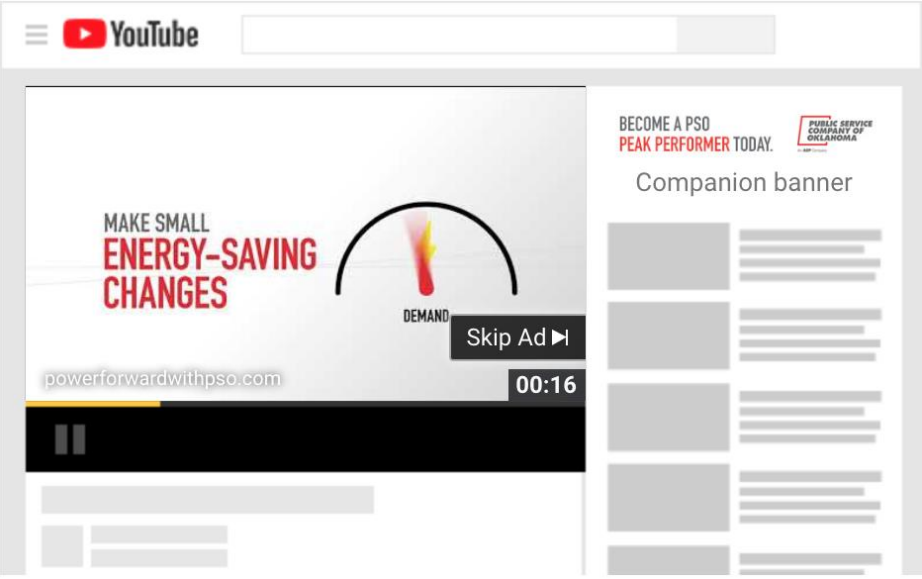


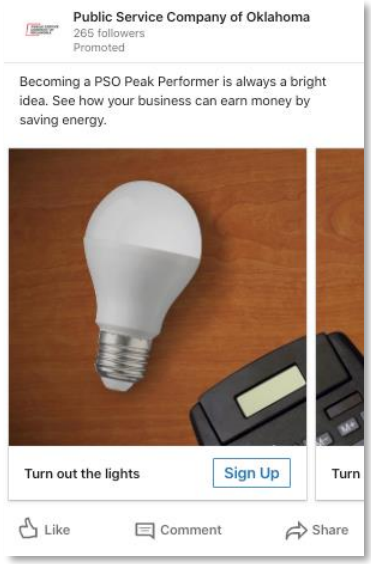
CREATIVE EXAMPLES | COMMERCIAL



Little Light House | Energy-Efficiency Rebates | Power Forward with PSO

CREATIVE EXAMPLES | COMMERCIAL





COMMUNITY ENGAGEMENT:

PSO participates in a variety of community events, including tradeshows, lighting demonstrations, program presentations, seminars and more. Community events are used to help educate customers on rebate and program offerings.

- 159 Training Events, including 33 internal presentations & 75+ retailer lighting promotions
- 35+ local promotional events

Appendix F. OKDSD, AR, & IL TRM Deemed Savings and Algorithms

F.1 Energy Efficiency Programs

F.1.1 Business Rebates Program

ADM's approach to project level savings analysis depends largely on the types of measures installed. Whenever possible, deemed savings and prescribed algorithms from the Arkansas Technical Reference Manual v7.0[107] (AR TRM) will be used to determine verified gross savings. Care will be taken to assure any assumptions are reasonable and current, and that there are no errors in the algorithms. Additionally, where engineering calculations from the AR TRM are applicable to measures installed through the Business Rebates program, those algorithms may also be used. Care will be taken to ensure that weather conditions and other factors that may vary from Arkansas to Oklahoma will be considered when applying these algorithms. The following discussion describes, in general, ADM's plan for analyzing savings from different measure types:

F.1.1.1 Analyzing Savings from Lighting Measures

Lighting measures may include retrofits of existing fixtures, lamps and/or ballasts with energy efficient fixtures, lamps and/or ballasts. These types of measures reduce demand, but operating hours for fixtures are generally the same pre- and post-retrofit. Also examined are any proposed lighting control strategies that might include the addition of energy conserving control technologies, such as motion sensors or day-lighting controls. These measures typically involve a reduction in hours of operation and/or lower current passing through the fixtures. New construction lighting projects are also included in the Business Rebates program, which requires calculating savings in comparison to applicable building codes instead of pre-retrofit conditions.

ADM analyzes the savings from lighting measures using data for new/retrofitted fixtures on (1) wattages before and after retrofit and (2) hours of operation before and after the retrofit. Fixture wattages are generally taken from a table of standard wattages or cut sheets when feasible, with corrections made for non-operating fixtures. Prescriptive algorithms for calculating energy savings and demand reductions from the AR TRM or other relevant program sources will be used. Additionally, HVAC interactive effects will be accounted for using partially deemed algorithms from the AR TRM dependent upon heating and cooling systems serving areas where lighting systems are installed.

[107] Arkansas Technical Reference Manual, version 7.0 volume 1: EM&V Protocols, *prepared by* The Independent Evaluation Monitor, *approved in Docket* 10-100-R, August 31, 2017.

F.1.1.2 Analyzing Savings from HVAC Measures

For the analysis of non-prescriptive HVAC and control measures, ADM developed estimates of the savings through simulations with energy analysis models (e.g., DOE-2, eQuest). Before making the analytical runs for each sample site with these measures, a Model Calibration Run was prepared. Calibration is based on actual billed usage during actual weather conditions. Once the analysis model had been calibrated for a particular facility, there were three steps in the procedure for calculating estimates of energy savings for HVAC measures installed or to be installed at the facility. First, an analysis of energy use was performed at a facility under the assumption that the energy efficiency measures were not installed. Second, energy use was analyzed at the facility with all conditions the same but with the energy efficiency measures now installed. Third, the results were compared of the analyses from the preceding steps to determine the energy savings attributable to the energy efficiency measure. The compared analysis runs were normalized to a typical meteorological weather year (TMY3). ADM used monitoring data to verify set points and operating characters and to calibrate the simulations, as necessary.

F.1.1.3 Analyzing Savings from Motor and VFDs

Estimates of energy savings from the use of non-prescriptive high efficiency motors or VFDs are derived through an "after-only" analysis. With this method, energy use is measured for the high efficiency motor or VFD and after it has been installed. ADM (1) made one-time measurements of voltage, current, and power factor of the VFD/motor and (2) use ACR loggers to conduct continuous measurements of amps or watts over a period of time in order to obtain the data needed on operating schedules. The data thus collected was then used in estimating what energy use would have been for the motor application if the high efficiency motor or VFD had not been installed. ADM field staff participate in annual safety training to ensure that safety best practices are used.

F.1.1.4 Analyzing Savings from Process Improvements

Analysis of savings from process improvements (including air compressors, process machines, etc.) is inherently project specific. Because of the specificity of such processes, analyzing the processes through simulations is generally not feasible. Rather, engineering analysis of the process affected by the improvements is relied on. Major factors in the engineering analysis of process savings are operating schedules and load factors. ADM developed the information on these factors through short-term monitoring of the affected equipment, be it pumps, heaters, compressors, etc. The monitoring was done after the process change, and the data gathered on operating hours and load factors were used in the engineering analysis to define “before” conditions for the analysis of savings.

F.1.1.5 Retro-commissioning and Enhanced O&M

As is the case for custom measures, the methods used to verify project gross energy impacts were dependent on the specifics of each site and the availability of data. However, the gross savings analysis for each site were more involved based on the additional data and documentation that was included in the savings calculations.

Methods included the range of International Performance Measurement & Verification Protocols, as shown in Table F-1 below. An emphasis was placed on Option D (Building simulation) for commercial facilities and Options B (pre/post monitoring) & C (Billing analysis) for industrial facilities. Often, multiple approaches are used to minimize uncertainty in the verified energy savings estimates. The preceding descriptions of typical gross savings estimation methods by measure type were used for retro-commissioning projects as well.

Table F-1: International Performance Measurement & Verification Protocols – M&V Options

M&V Option	How Savings Are Calculated
Partially Measure Retrofit Isolation	Engineering calculations using short term or continuous post-retrofit measurements and stipulations.
Retrofit Isolation	Engineering calculations using short term or continuous measurements.
Whole Facility	Analysis of whole facility utility meter or sub-meter data using techniques from simple comparison to regression analysis.
Calibrated Simulation	Energy use simulation, calibrated with hourly or monthly utility billing data and/or end-use metering.

F.1.2 Home Weatherization Program

This section includes the measure level algorithms and deemed savings values utilized for the verified kWh and kW savings calculations.

F.1.2.1 Infiltration Reduction (AR TRM)

Savings were calculated by multiplying the air infiltration reduction (CFM) with the energy savings factor corresponding to the climate zone / HVAC type. The air infiltration reduction estimate in CFM was obtained through blower door testing performed by the program contractor for each home serviced. Only homes with electric cooling systems are eligible

for the measure (central AC or room AC). The algorithms for energy savings listed in the AR TRM are:

Equation F-12: Annual Energy Savings

$$kWh_{Savings} = CFM\ X\ ESF$$

Equation F-13: Peak Demand Savings

$$kW_{Savings} = CFM\ X\ DSF$$

Where:

CFM	= Air infiltration reduction in Cubic Feet per Minute at 50 Pascal
ESF	= The energy savings value corresponding to the climate zone and heating and cooling type in the following table
DSF	= The demand savings value corresponding to the climate zone and heating and cooling type in the following table

Table F-2: Infiltration Control Deemed Savings Values

Infiltration Control Deemed Savings				
Impact per CFM50 Reduction				
Equipment Type	kWh Savings (ESF)	kW Savings (DSF)	Therm Savings (GSF)	Peak Therms (GPSF)
Zone 9				
Electric AC with Gas Heat	0.166	0.000098	0.095	0.002529
Gas Heat Only (no AC)	0.073	NA	0.099	0.002529
Elec. AC with Resistance Heat	2.344	0.000098	NA	NA
Heat Pump	1.099	0.000098	NA	NA
Zone 8				
Electric AC with Gas Heat	0.188	0.00014	0.0825	0.002325
Gas Heat Only (no AC)	0.062	NA	0.0863	0.002325
Elec. AC with Resistance Heat	2.079	0.00014	NA	NA
Heat Pump	0.942	0.00014	NA	NA
Zone 7				
Electric AC with Gas Heat	0.19	0.00016	0.0707	0.002181
Gas Heat Only (no AC)	0.053	NA	0.0747	0.002181
Elec. AC with Resistance Heat	1.812	0.00016	NA	NA
Heat Pump	0.818	0.00016	NA	NA
Zone 6				
Electric AC with Gas Heat	0.255	0.00017	0.0604	0.001812
Gas Heat Only (no AC)	0.046	NA	0.0639	0.001812
Elec. AC with Resistance Heat	1.641	0.00017	NA	NA
Heat Pump	0.756	0.00017	NA	NA

F.1.2.2 Duct Sealing

ADM utilized the Oklahoma Deemed Savings Document (OKDSD) in conjunction with the duct leakage reduction results in order to calculated measure savings. ADM modified to the default SEER value used in the algorithm. The default SEER value is 13, but ADM utilized a value of 11.5 SEER because the measure is being implemented in qualified income homes which tend to be older. The 11.5 SEER value is the average of U.S. DOE minimum allowed SEER for air conditioners from 1992-2006 (10 SEER) and after January 23, 2006 (13 SEER). The algorithms for cooling and energy saving listed in the OKDSD for duct sealing are as follows:

Equation F-14: Cooling Savings

$$kWH_{savings,C} = \frac{(DL_{pre} - DL_{\boldsymbol{post}})X\ EFLH_C\ X\ (h_{out}\rho_{out} - h_{in}\rho_{in})\ X\ 60}{1000\ X\ SEER}$$

Where:

DL_{pre} = Pre-improvement duct leakage at 25 Pa (ft3/min)
DL_{post} = Post-improvement duct leakage at 25 Pa (ft3/min)
$EFLH_c$ = Equivalent full load cooling hours, from Table F-3
h = Outdoor/Indoor seasonal specific enthalpy (Btu/lb), from Table F-4
ρ_{out} = Density of outdoor air (lb/ft3) from Table F-5
ρ_{in} = Density of conditioned air at 75°F (lb/ft3) = 0.0756
60 = Constant to convert from minutes to hours
1,000 = Constant to convert from W to kW
SEER = Seasonal Energy Efficiency Ratio of existing system (Btu/W·hr) = 11.5[108]

Table F-3: Equivalent Full-Load Hours for Cooling by Weather Zone for Duct Sealing

Weather Zone	$EFLH_c$
Zone 6: El Dorado, AR [11]	1,738
Zone 7: Lawton, OK [12]	1,681
Zone 8a: Oklahoma City, OK	1,436
Zone 8b: Tulsa, OK	1,486
Zone 9: Fayetteville, AR [13]	1,305

[108] Average of US DOE minimum allowed SEER for new air conditioners from 1992-2006 (10 SEER) and after January 23,2006 (13 SEER).

Table F-4: Seasonal Specific Enthalpy by Weather Zone for Duct Sealing

Weather Zone	h_{out} (BTU/lb)	h_{in} (BTU/lb)
Zone 6: El Dorado, AR 11	40	30
Zone 7: Lawton, OK 12	39	29
Zone 8a: Oklahoma City, OK	39	29
Zone 8b: Tulsa, OK	39	29
Zone 9: Fayetteville, AR 13	39	30

Table F-5: Outdoor Air Density by Weather Zone for Duct Sealing

Weather Zone	Temp. (°F) 16	ρout (lb/ft3)
Zone 6: El Dorado, AR	96	0.0739
Zone 7: Lawton, OK	99	0.0738
Zone 8a: Oklahoma City, OK	97	0.0739
Zone 8b: Tulsa, OK	98	0.0738
Zone 9: Fayetteville, AR	94	0.0741

The algorithms for heating (heat pump) and energy saving listed in the OKDSD for duct sealing are as follows:

Equation F-15: Heating Savings (Heat Pump)

$$kWH_{savings,C} = \frac{\left(DL_{pre} - DL_{\boldsymbol{post}}\right) X\ 60\ X\ 0.77\ X\ HDD\ X\ 24\ X\ .018}{1000\ X\ HSPF}$$

Where:

DL_{pre} = Pre-improvement duct leakage at 25 Pa (ft3/min

DL_{post} = Post-improvement duct leakage at 25 Pa (ft3/min)

60 = Constant to convert from minutes to hours

0.77 = Factor to correlated design load hours to EFLH under actual working conditions (to account for the fact that people do not always operate their heating system when the outside temperature is less than 65°F)

HDD = Heating Degree Day from Table F-6
24 = Constant to convert from days to hours
0.018 = Volumetric heat capacity of air (Btu/ft3°F)
1,000 = Constant to convert from W to kW
HSPF = Heating Seasonal Performance Factor of existing system (Btu/W·hr) = 7.7 (default)

Table F-6: Heating Degree Days by Weather Zone for Duct Sealing

Weather Zone	HDD
Zone 6: El Dorado, AR 11	2,673
Zone 7: Lawton, OK 12	3,017
Zone 8a: Oklahoma City, OK	3,663
Zone 8b: Tulsa, OK	3,641
Zone 9: Fayetteville, AR 13	4,027

Equation F-16: Heating Savings (Electric Resistance)

$$kWH_{savings,C} = \frac{\left(DL_{pre} - DL_{\boldsymbol{post}}\right) X\ 60\ X\ 0.77\ X\ HDD\ X\ 24\ X\ .018}{3{,}412}$$

Where:

DL_{pre}= Pre-improvement duct leakage at 25 Pa (ft3/min
DL_{post}= Post-improvement duct leakage at 25 Pa (ft3/min)
60= Constant to convert from minutes to hours
0.77= Factor to correlated design load hours to EFLH under actual working conditions (to account for the fact that people do not always operated their heating system when the outside temperature is less than 65°F)
HDD= Heating Degree Day from Table F-6
0.018= Volumetric heat capacity of air (Btu/ft3°F)
3,412= Constant to convert from Btu to kWh

F.1.2.3 Ceiling Insulation

ADM utilized the AR TRM for the savings algorithms and scaled deemed savings values. Deemed savings provided in the AR TRM are based on the R-value of the baseline insulation. Savings are calculated by multiplying the applicable savings value by the square footage insulated. The savings algorithms require new insulation to meet a minimum R-value of R-38.

Table F-7: Deemed Savings for R-38 Ceiling Insulation

Ceiling Insulation R-38							
Impact per sq. ft.							
Baseline Insulation R-Value	**AC/Gas Heat kWh**	**Gas Heat (No AC) kWh**	**Gas Heat Therms**	**AC/Electric Resistance kWh**	**Heat Pump kWh**	**AC Peak Savings kW**	**Peak Gas Savings Therms**
Zone 9							
0 to 1	1.716	0.254	0.342	9.366	5.071	0.0014	0.00541
2 to 4	0.969	0.141	0.189	5.212	2.764	0.0008	0.00283
5 to 8	0.586	0.084	0.114	3.136	1.653	0.0005	0.00164
9 to 14	0.364	0.052	0.07	1.926	1.013	0.00032	0.001
15 to 22	0.172	0.025	0.034	0.931	0.486	0.00014	0.00047
Zone 8							
0 to 1	1.948	0.227	0.312	9.334	4.669	0.003	0.00539
2 to 4	1.097	0.125	0.172	5.179	2.548	0.002	0.00284
5 to 8	0.642	0.074	0.102	3.145	1.503	0.001	0.00165
9 to 14	0.402	0.044	0.063	1.933	0.933	0.001	0.00099
15 to 22	0.191	0.022	0.031	0.093	0.450	0.000	0.00048
Zone 7							
0 to 1	1.841	0.164	0.233	7.424	3.815	0.002	0.00482
2 to 4	1.027	0.091	0.129	4.117	2.112	0.001	0.00254
5 to 8	0.595	0.053	0.078	2.489	1.245	0.000	0.00149
9 to 14	0.371	0.033	0.047	1.519	0.764	0.000	0.0009
15 to 22	0.178	0.016	0.022	0.728	0.363	0.000	0.00043
Zone 6							
0 to 1	2.213	0.132	0.191	6.761	3.537	0.001	0.0044
2 to 4	1.248	0.074	0.107	3.795	1.991	0.001	0.00235
5 to 8	0.720	0.045	0.065	2.319	1.266	0.000	0.00137
9 to 14	0.448	0.028	0.039	1.427	0.787	0.000	0.00082
15 to 22	0.080	0.004	0.005	0.020	0.121	0.000	0.0004

F.1.2.4 Water Heater Jackets

For water heater jackets, a review of the tracking system showed that conservative assumptions were used to inform the use of the deemed savings. Savings values corresponding to 2” thick jackets on 40-gallon tanks were used for all sites. The deemed savings for this measure depend on 1) insulation thickness and 2) water heater tank size. The table below shows the deemed savings for water heater jackets installed on electric water heaters.

Table F-8: Deemed Savings – Electric Water Heater Jacket

Approximate Tank Size	Electric					
	Energy Savings (kWh)			Peak Savings (kW)		
	40	52	80	40	52	80
2" WHJ savings kWh	68	76	101	0.005	0.006	0.008
3" WHJ savings kWh	94	104	139	0.007	0.008	0.011

F.1.2.5 Water Heater Pipe Insulation

Water heater pipe insulation involves insulating of all hot and cold vertical lengths of pipe, plus the initial length of horizontal hot and cold-water pipe, up to three feet from the transition, or until wall penetration, whichever is less. The OKDSD specifies deemed values below for energy and demand impacts of water heater pipe insulation measures.

Table F-9: Deemed Savings – Electric Water Heater Pipe Insulation

Elec. Water Heater Pipe Insulation		Gas Water Heater Pipe Insulation	
Annual kWh Savings Per home	Peak kW Savings Per Home	Therm Savings Per home	Peak Therm Savings Per Home
44	0.014	4.4	0.00420

F.1.2.6 LED Light Bulbs

The OKDSD specifies the following formula for use in calculating energy and demand impacts of ENERGY STAR® Omni-Directional LED measures, except for Hours. ADM used an estimated hour of use (HOU) of 960.61 (as described in the benchmarking study performed in 2016[109]). This reflects an average daily HOU of 2.63 times 365.25 days per year.

Equation F-17: Energy Savings (LEDs)

$$kWH_{savings} = ((W_{base} - W_{post})/1000)\ X\ Hours\ X\ ISR\ X\ IEF_E$$

[109] ADM HOU Memo, 2016.

Where:

W_{base} = Based on wattage equivalent of the lumen output of the purchased LED Omni-directional lamp and the program year purchased/installed; for Omni-directional LED, use the following base wattages

W_{post} = Wattage of LED purchased/installed

Hours = Average hours of use per year (960.61)

ISR = In-Service Rate or percentage of rebate units that get installed, to account for units purchased but not immediately installed. (0.96, ADM calculated)

IEFE = Interactive Effects Factor to account for cooling energy savings and heating energy penalties (see Table F-10)

Table F-10: ENERGY STAR® Omni-Directional LED – EISA Baseline 2007

Minimum Lumens	Maximum Lumens	Incandescent Equivalent 1st Tier (Wbase)
310	749	29
750	1,049	43
1,050	1,489	53
1,490	2,600	72

Table F-11: ENERGY STAR® Omni-Directional LED – Interactive Effects Factor for Cooling Energy Savings and Heating Energy Penalties

Heating Type	Interactive Effects Factor (IEFE)
Gas	1.15
Electric Resistance	0.44
Heat Pump	0.84
Heating Unknown	0.96

Equation F-18: Summer Peak Demand Savings

$$kW_{savings} = ((W_{base} - W_{post})/1000)\ X\ CF\ X\ ISR\ X\ IEF_D$$

Where:

Wbase = Baseline wattage equivalent for the lumen output of purchased bulb

Wpost = Wattage of purchased bulb

CF = Summer peak coincidence factor for measure, 9% indoor and 0% outdoor

ISR = In Service Rate, or percentage of discounted bulbs that get installed (97%)

IEFD = Interactive Effects Factor to account for cooling demand savings and heating demand penalties; this factor also applies to outdoor and unconditioned spaces (1.53. see Table F-12)

Table F-12: ENERGY STAR® Omni-Directional LED – Interactive Effects Factor for Cooling Demand Savings and Heating Energy Penalties

Heating Type	Interactive Effects Factor (IEFD)
Gas	1.53
Electric Resistance	
Heat Pump	

F.1.3 Energy Saving Products Program

This section includes the measure level algorithms and deemed savings values utilized for the verified Gross kWh and kW savings calculations. Deemed savings values and guidelines from the OKDSD were used whenever applicable.[110] When deemed savings calculations were not available in the OKDSD, ADM relied on one of the following other technical reference manuals (TRMs): AR TRM, the Illinois TRM v7.0 (IL TRM)[111], the Texas TRM v6.0 (TX TRM)[112], or the 2016 Pennsylvania TRM (PA TRM).[113]

F.1.3.1 ENERGY STAR® LEDs

ADM checked LED model numbers listed in the program tracking system against ENERGY STAR® databases (www.energystar.gov) to verify that each LED distributed during each program year was (1) ENERGY STAR® certified and (2) assigned the correct Watts per lamp.

Deemed kWh savings values for LEDs are unavailable in the OKDSD. However, the baseline wattages from the OKDSD account for Energy Independence and Security Act (EISA) requirements that took effect in 2012, 2013, and 2014. Thus, kWh savings for LEDs were calculated via Equation F-17 above.

Peak demand savings for LEDs discounted through the program were also calculated using the algorithm from the OKDSD, shown in Equation F-18 above.

[110] Residential Oklahoma Deemed Savings, Installation & Efficiency Standards, *prepared by* Frontier Associates, LLC; November 27, 2013.
[111] Illinois Statewide Technical Reference Manual for Energy Efficiency, version 7.0 volume 3: Residential Measures, September 28, 2018.
[112] Texas Technical Reference Manual, version 6.0 volume 2: Residential Measures, November 7, 2018.
[113] Pennsylvania Technical Reference Manual, June 2016.

Point-of-Sale Measure Leakage

Programs that provide incentives at the point-of-sale can result in installations outside of the territory of the sponsoring utility. This effect, referred to as "leakage", can be particularly prominent when a service territory is not geographically contiguous, or when a major retailer is located near the border of a service territory. When leakage takes place, bulbs that have been discounted through a utility's program are installed outside of its service territory and therefore the energy and demand impacts from the discounted bulbs are not realized within the territory of the utility that financially supported and claimed the savings.

For PY2016-2018, ADM utilized the AR TRM Protocol K: Leakage[114] guidelines for assessing the impact of leakage on the Energy Saving Products program's savings. This protocol was developed based on Arkansas Public Service Commission guidance as to how to quantify and apply the effects of leakage. ADM's leakage study was conducted in PY2015 and yielded an estimate that 3.6% of CFLs and LEDs "leaked" out of PSO's territory. For PY2019-PY2021, ADM conducted a new leakage study focused on LED bulb leakage following the same methodology. Estimates of leakage were assessed using an approach that combines general population survey responses with geo-spatial mapping. Overall, the analysis was built around the following steps:

- First, ADM developed a map of concentric circles surrounding the participating retailers. The initial modeling assumed the "reach" of a retailer is a 60-minute drive, which is then modified by the presence of an alternative sponsoring retailer (i.e., if a customer is within a 60-minute drive of two sponsoring retailers, it is assume they will purchase from the closest one). This allowed for an initial leakage score to be applied to each participating retail location based upon the percent of customers within the concentric circle that are served by the sponsoring utility.
- Second, several relevant questions were integrated into the general population survey to assess the shopping habits of customers within the radius of participating retailers. This was used to assess the total and maximum drive time that Oklahoma consumers would accept when shopping for products incentivized by the Program. Additionally, the survey was used to modify the initial 60-minute drive assumption established in Step 1.
- Finally, the percentage of LEDs that "leaked" out of the PSO territory and were installed out of state was calculated.

Ultimately, ADM estimated that out-of-state leakage of LEDs is approximately 0.2%. The complete findings can be found in a separate report entitled "*2019 Lighting Sales Leakage*

[114] Arkansas Technical Reference Manual, version 7.0 volume 1: EM&V Protocols, *prepared by* The Independent Evaluation Monitor, *approved in Docket* 10-100-R, August 31, 2017, page 80.

Memo". The leakage estimate developed during PY2019 will be used throughout the PY2019-PY2021 program evaluation cycle. The decision to use the leakage estimate from PY2019 throughout the portfolio cycle is reliable since the lighting program is unlikely to change significantly over that time frame. Any substantial changes to the program will be reviewed on an annual basis.

Cross Sector Sales Adjustments

ADM used an estimated HOU equal to 960.61 based on a meta-analysis completed in PY2016. This reflects an average daily HOU of 2.63 blended hours for indoor/outdoor applications and applies a 0.688 degradation factor to indoor bulbs times 365.25 days per year. While this is within the range of HOU estimates from previous studies of residential lighting use, it likely underestimates HOU for bulbs that are installed in non-residential buildings. In non-residential settings, annual HOU is higher and implies a shorter expected useful life for the bulbs (in years). The time period in which the savings occur affects the applicable baseline wattage and discount factor for cost effectiveness savings. ADM calculated a peak coincidence factor (CF) and HOU for bulbs installed in non-residential settings based on the type of businesses where LEDs were installed from the Business Rebates program during each program year. A weighted average for CF and HOU was calculated. Responses from the general population surveys were used to estimate the percentage of purchased bulbs that were installed in non-residential settings. This has the effect of increasing annual energy savings and peak demand reduction for the percentage of bulbs estimated to be installed in non-residential settings. Lifetime energy savings for these bulbs also increases to the extent that the savings occur sooner, before EISA Tier 2 baselines become effective.

F.1.3.2 Room Air Purifiers (RAP)

ADM checked room air purifier (RAP) model numbers listed in the program tracking system against ENERGY STAR® databases to verify that each RAP distributed through the program each year was ENERGY STAR® certified and assigned the correct capacity and efficiency ratings.

Deemed kWh savings values for RAPs are unavailable in the OKDSD; however, the IL TRM has established deemed kWh savings and peak kW demand values that were used for this analysis.[115] Thus, kWh energy savings for RAPs were calculated via Equation F-19, below.

[115] Calculation for kWh savings and peak kW demand are based on the Mid-Atlantic TRM version 4.0. This specifies baseline kWh/year consumption and ENERGY STAR® kWh/year consumption based on the Clean Air Delivery Rate (CADR) for ENERGY STAR® room air purifier.

Equation F-19: Energy Savings (Room Air Purifiers)

$$Room\ Air\ Purifier\ kWh\ savings\ = kWh_{Base} - kWh_{ESTAR}$$

Where:

kWh_{Base} = Baseline kWh consumption per year; based on Table F-13 below

kWh_{ESTAR} = ENERGY STAR® kWh consumption per year; based on Table F-13 below

Table F-13: kWh per Year Usage Based on Clear Air Delivery Rate[116]

Clean Air Delivery Rate (CADR)	CADR used in calculation	Baseline Unit Energy Consumption (kWh/year)	ENERGY STAR® Unit Energy Consumption (kWh/year)	ΔkWH
CADR 51-100	75	441	148	293
CADR 101-150	125	733	245	488
CADR 151-200	175	1,025	342	683
CADR 201-250	225	1,317	440	877
CADR Over 250	300	1,755	586	1,169

The peak demand (kW) savings for RAPs was calculated via Equation F-20, shown below:

Equation F-20: Peak Demand Savings (Room Air Purifiers)

$$Room\ Air\ Purifier\ peak\ kW\ demand = \frac{\Delta kWh}{Hours} * CF$$

Where:

ΔkWh =Gross customer annual kWh savings for the measure

$Hours$ = Average hours of use per year
= 5844[117]

CF = Summer Peak Coincidence Factor for measure
= 0.667[118]

[116] Reproduced after lookup table on pg. 7 of the IL TRM.

[117] Consistent with ENERGY STAR® Qualified Room Air Clean Calculator; 16 hours a day, 365.25 days a year. As stipulated in the IL TRM, see footnote 7 on pg. 7 of the TRM.

[118] Assumes appliance use is evenly spread throughout the year. As stipulated in the IL TRM, see footnote 8 on pg. 7 of the TRM.

Table F-14: Peak kW Demand Based on Clear Air Delivery Rate

Clean Air Delivery Rate	ΔkW
CADR 51-100	0.034
CADR 101-150	0.056
CADR 151-200	0.078
CADR 201-250	0.100
CADR Over 250	0.133

F.1.3.3 Advanced Power Strips (APS)

ADM verified that each advanced power strip (APS) distributed each year was correctly assigned to the appropriate tier in the tracking system.

Energy savings (kWh) values for APS are not available in the OKDSD; however, deemed savings are described in the AR TRM. APSs are separated into two classifications: Tier 1 and Tier 2; only Tier 1 APSs are discounted through the ESP program. Tier 1 APS are controlled by a load sensor in the strip, which disconnects power from the control outlets when the master power draw is below a certain threshold. The load sensor feature allows for a reduction of power from peripheral consumer electronics that maintain some load even when off or in the standby position. Deemed savings were calculated for Tier 1 by average complete system as the type of installation was unknown. Additionally, an ISR adjustment was applied to the deemed APS gross savings. The reason for the adjustment is that most people do not install and utilize APS correctly, particularly as an upstream measure. Therefore, ADM relied on an estimated ISR of 50%.

Table F-15: Advanced Power Strip – Deemed Savings in Residential Applications

APS Type	System Type	Peripheral Device	kW Savings	kWh Savings
Tier 1	Average	Whole System Average	0.019	167.40

F.1.3.4 Bathroom Ventilation Fans (BVF)

ADM checked bathroom ventilation fan (BVF) model numbers listed in the program tracking system against the ENERGY STAR® databases to verify that each BVF distributed via the program each year was ENERGY STAR® certified.

Since deemed energy savings (kWh) values for BVFs are unavailable in the OKDSD, ADM referred to equations provided by the IL TRM. The energy (kWh) savings for BVFs was calculated via the following formula and is set at 27.4 kWh:

Equation F-21: Energy Savings (BVF)

$$BVF\ kWhsavings = CFM\ \times \frac{\frac{1}{\eta_{Baseline}} - \frac{1}{\eta_{Efficient}}}{1000} \times\ Hours = 27.4\ kWh$$

Where:

CFM = Nominal Capacity of the exhaust fan
= 92.4[119]

$\eta_{Baseline}$ = Average efficacy for baseline fan
= 2.2[120]

$\eta_{Efficient}$ = Average efficacy for efficient fan
= 5.3[121]

$Hours$ = Assumed annual run hours for continuous ventilation
= 1,089[122]

Demand savings (kW) were calculated via the following formula, and is set at 0.0034 kW:

Equation F-22: Peak Demand Savings (Ventilation Fan)

$$BVF\ kWsavings = CFM\ \times \frac{\frac{1}{\eta_{Baseline}} - \frac{1}{\eta_{Efficient}}}{1000} \times\ CF =\ 0.0034\ \mathrm{kW}$$

Where:

CFM = Nominal Capacity of the exhaust fan
= 92.4[123]

$\eta_{Baseline}$ = Average efficacy for baseline fan
= 2.2[124]

$\eta_{Efficient}$ = Average efficacy for efficient
= 5.3[125]

[119] As stipulated by the IL TRM for standard usage with an unknown minimum and maximum CFM, see pg. 125 of the TRM.
[120] As stipulated by the IL TRM for standard usage with an unknown minimum and maximum CFM, see pg. 125 of the TRM.
[121] As stipulated by the IL TRM for standard usage with an unknown minimum and maximum CFM, see pg. 125 of the TRM.
[122] As stipulated by the IL TRM for standard usage with an unknown minimum and maximum CFM, see pg. 125 of the TRM.
[123] As stipulated by the IL TRM for standard usage with an unknown minimum and maximum CFM, see pg. 125 of the TRM.
[124] As stipulated by the IL TRM for standard usage with an unknown minimum and maximum CFM, see pg. 125 of the TRM.
[125] As stipulated by the IL TRM for standard usage with an unknown minimum and maximum CFM, see pg. 125 of the TRM.

CF = Summer peak coincidence factor for standard usage
= 0.135[126]

F.1.3.5 Water Dispensers (WD)

ADM checked water dispenser (WD) model numbers listed in the program tracking system against the ENERGY STAR® databases to verify that each WD distributed via the program each year was ENERGY STAR® certified.

Deemed savings values for WDs are unavailable in the OKDSD, so the PA TRM was used. The energy savings (kWh) and demand savings (kW) were pulled from Table F-16.

Table F-16: Default Savings for ENERGY STAR® Water Dispensers[127]

Cooler Type	$kWh_{savings}$	kW_{peak}
Cold Only	47.50	0.00532
Hot & Cold Storage	481.80	0.0539
Hot & Cold On-Demand	733.65	0.0821

F.1.3.6 Weatherization Measures (WM)

ADM reviewed all tracking data, tabulating all home weatherization measures (WM) installed via the program each year. Savings from the installation of WMs were calculated based on the PA TRM's Interim Measure Protocol for WS.[128] Energy savings (kWh) and demand savings (kW) were calculated for WMs including door seals, door sweeps, and spray foam insulation using the following equations:

Equation F-23: Energy Savings (WM)

$$WM\ kWh\ savings\ = \mathrm{D}kWh_{cooling} + \mathrm{D}kWh_{heating}$$

Equation F-24: Cooling Energy Savings (WM)

$$\mathrm{D}kWh_{cooling} = \frac{1.08 \times \mathrm{D}CFM_{50} \quad \times CDD \times 24 \times LM \times DUA}{N \times \eta_{cool} \times 1{,}000}$$

[126] As stipulated by the IL TRM for standard usage with an unknown minimum and maximum CFM, see pg. 125 of the TRM.
[127] Reproduced after Table 2-95, pg. 165 of the PA TRM.
[128] Addendum document to the 2016 Pennsylvania TRM[113] for weather stripping, caulking, and outlet gaskets.

Equation F-25: Heating Energy Savings (WM)

$$DkWh_{heating} = \frac{1.08 \times DCFM_{50} \times HDD \times 24}{N \times \eta_{heat} \times 3{,}412}$$

Equation F-26: Peak Demand Savings (WM)

$$WM\ kW\ savings = \frac{\mathrm{D}kWh_{cooling} \times PCF}{1{,}000}$$

Where:

1.08	= Conversion factor between CFM air at 70°F to Btu/hr/°F
$\mathrm{D}CFM_{50}$	= Reduction in air leakage = 100 (spray foam) or 25.5 (door sweeps and seals)[129]
24	= Days to hours conversion factor
N	= Correlation factor (accounts for several variables that could influence air infiltration, such as wind shielding, climate, and building leakiness) = 16.65[130]
CDD	= Cooling degree-days per year = 2,095 [131]
HDD	= Heating degree-days per year = 3,971[132]
η_{cool}	= Cooling system efficiency = 13[133]
η_{heat}	= Heating system efficiency = 2.3[134]
DUA	= Discretionary use adjustment (accounts for uncertainty in residential occupants' cooling system usage patterns) = 0.75[135]

[129] As stipulated by the PA TRM Weather Stripping IMP, see Table 1-2, pg. 4 of the IMP. For spray foam, this estimate assumes just over 9 piping/plumbing/wiring penetrations per can.
[130] As stipulated by the PA TRM Weather Stripping IMP, see Table 1-1, pg. 3 of the IMP.
[131] Average cooling degrees per year derived for the Tulsa International Airport (site #723560) from the National Solar Radiation Data Base, 1991-2005: Typical Meteorological Year 3. Last accessed March 2020 via https://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/by_state_and_city.html.
[132] Average heating degrees per year derived for the Tulsa International Airport (site #723560) from the National Solar Radiation Data Base, 1991-2005: Typical Meteorological Year 3. Last accessed March 2020 via https://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/by_state_and_city.html.
[133] Assuming central air conditioning installed after 1/23/2006 – see Table 1-4 on pg. 5 of the PA TRM Weather Stripping IMP.
[134] Assuming air-source heat pumps installed after 1/23/2006 – see Table 1-5 on pg. 5 of the PA TRM Weather Stripping IMP.
[135] As stipulated by the PA TRM Weather Stripping IMP, see Table 1-1, pg. 3 of the IMP.

LM	= Latent multiplier for conversion of sensible load to total (sensible and latent) load = Total load ÷ sensible load = 8.5 ÷ 2.0 = 4.3[136]
$1{,}000$	= Conversion factor between kilowatts and watts
$3{,}412$	= Conversion factor between kilowatt hours and Btu
PCF	= Peak demand savings conversion factor = 0.017[137]

F.1.3.7 Room Air Conditioners (RAC)

ADM will check room air conditioner (RAC) model numbers listed in the program tracking system against the ENERGY STAR® databases to verify that each RAC distributed via the program each year was ENERGY STAR® certified.

Deemed savings values for RAC are not available in the OKDSD, so the AR TRM was used. The energy savings (kWh) and peak demand savings (kW) for RAC were calculated via Equation F-27 and Equation F-28, respectively.

Equation F-27: Energy Savings (RAC)

$$RAC\ kWhsavings = CAP\ \times 1\frac{kW}{1000\ W}\ \times\ RAF\ \times\ EFLH_C\ \times\ (\frac{1}{\eta_{base}} - \frac{1}{\eta_{post}})$$

Equation F-28: Peak Demand Savings (RAC)

$$RAC\ kW\ savings = CAP\ \times 1\frac{kW}{1000\ W}\ \times \left(\frac{1}{\eta_{base}} - \frac{1}{\eta_{post}}\right) \times CF$$

Where:

CAP	= Rated equipment cooling capacity of the new unit (Btu/hr)
η_{base}	= Energy efficiency rating (EER) of the baseline cooling equipment, *see* Table F-17
η_{post}	= Energy efficiency rating (EER) of the installed cooling equipment, see Table F-17
RAF	= Room AC adjustment factor = 0.49[138]
$EFLH_C$	= Equivalent full-load cooling hours, see Table F-18.
CF	= Coincidence factor = 0.87[139]

[136] For Tulsa, OK; *see* Table 2 *in* Harriman III, L. G., Plager, D., and Kosar, D. (1997) Dehumidification and Cooling Loads from Ventilation Air. *ASHRAE Journal*.
[137] As stipulated by the PA TRM Weather Stripping IMP, see Table 1-1, pg. 3 of the IMP.
[138] As stipulated by the AR TRM, see derivation described in Table 67, pg. 75 of the TRM.
[139] As stipulated by the AR TRM, see pg. 74 and footnote 80 in the TRM.

The η_{base} or energy efficiency rating (EER) of the baseline and η_{post} or energy efficiency rating (EER) of the installed cooling equipment is assigned based on the items listed in Table F-17.

Table F-17: RAC Replacement – Baseline and Efficiency Standards[140]

Reverse Cycle (Yes/No)	Louvered Sides (Yes/No)	Capacity (Btu/hr)	Baseline Efficiency (CEER)	Efficiency Standard (EER)
No	Yes	< 8,000	11.0	12.1
		≥ 8,000 and < 14,000	10.9	12.0
		≥ 14,000 and < 20,000	10.7	11.8
		≥ 20,000	9.4	10.3
No	No	< 8,000	10.0	11.0
		≥ 8,000	9.6	10.6
Yes	Yes	< 20,000	9.8	10.8
		≥ 20,000	9.3	10.2
Yes	No	< 14,000	9.3	10.2
		≥ 14,000	8.7	9.6

The equivalent full-load cooling hours are based on weather zone as shown below in Table F-18. Since full-load cooling hours are reported in the OKDSD, ADM will use those locally applicable values instead of those listed in the AR TRM.

Table F-18: RAC Replacement – Equivalent Full-Load Cooling Hours[141]

Weather Zone	$EFLH_C$
9	431
8b	490
7	555
6	573

F.1.3.8 Air Filters (AF)

Deemed savings values for air filters (AF) are not available in the OKDSD, so the TX TRM was used. The energy savings (kWh) and peak demand savings (kW) for AF were calculated via Equation F-29 and Equation F-30, respectively.

[140] Reproduced after Table 65, pg. 73 of the AR TRM.
[141] Reproduced after Table 61, pg. 64 of the OKDSD; values shown are pertinent to room air conditioners.

Equation F-29: Energy Savings (AF)

$$AF\ kWh\ savings = Capacity \times \left(\frac{1}{EER_{pre}} - \frac{1}{EER_{post}}\right) \times\ EFLH_C\ \times \frac{1\ kW}{1{,}000\ W} \times FL$$

Equation F-30: Peak Demand Savings (AF)

$$AF\ kW\ savings = Capacity \times \left(\frac{1}{EER_{pre}} - \frac{1}{EER_{post}}\right) \times\ DF_C\ \times \frac{1\ kW}{1{,}000\ W}$$

Where:

$Capacity$	= Rated equipment cooling capacity = for unknown models, assumed value of 3.7 tons[142] = 44,400 Btu/hr
EER_{pre}	= Cooling efficiency prior to tune-up (Btu/hr) = $(1 - EL) \times EER_{post}$
EL	= Efficiency loss due to dirty filter = 0.05[143]
EER_{post}	= Deemed cooling efficiency of the equipment following tune-up = 11.2[144]
$EFLH_C$	= Equivalent full load hours for cooling based on weather zone (see Table F-19)
DF_C	= Cooling demand factor = 0.87[145]
FL	= Factor to account for air filter useful life = 0.16667

[142] As stipulated by the TX TRM, pg. 2-345.
[143] As stipulated by the TX TRM, pg. 2-58.
[144] As stipulated by the TX TRM, pg. 2-58 and 2-60.
[145] As stipulated by the TX TRM, see footnote 122 on pg. 2-61 of the TRM.

Table F-19: Equivalent Full Load Hours[146]

Weather Zone	$EFLH_C$
6	1,738
7	1,681
8a	1,436
8b	1,486
9	1,305

F.1.3.9 Heat Pump Water Heaters (HPWH)

ADM checked heat pump water heater (HPWH) model numbers listed in the program tracking system against ENERGY STAR® databases to verify that each HPWH distributed via the program each year was ENERGY STAR® certified and assigned the correct capacity and efficiency ratings.

Deemed energy savings (kWh) values for HPWHs are not available in the OKDSD, so instead ADM has relied on the AR TRM. The variables that affect deemed savings include storage tank volume, energy factor (EF), installation location (conditioned vs. unconditioned space), and weather zone. Weather zones are based on established zones in Arkansas. Energy savings (kWh) for HPWHs were calculated via Equation F-31:

Equation F-31: Energy Savings (HPWH)

$$HPWH\ kWh\ savings = \frac{\rho \times C_p \times V \times \left(T_{SetPoint} - T_{Supply}\right) \times \left(\frac{1}{EF_{pre}} - \left(\frac{1}{\left(EF_{post} \times (1 + PA\%)\right)} \times Adj\right)\right)}{3{,}412\ Btu/kWh}$$

Where:

ρ = Water density
= 8.33

C_p = Specific heat of water (Btu/lb·°F)
= 1

V = Estimated annual hot water use (gal) (shown in Table F-21 below)

$T_{SetPoint}$ = Water heater set point
= 120°F[147]

[146] Reproduced after Table 61 of the OKDSD, pg. 64.
[147] As stipulated by the AR TRM, pg. 128.

T_{Supply} = Average supply water temperature, determined based on storage volume and draw pattern[148] (shown in Table F-22 below)

EF_{pre} = Baseline energy factor, determined based on storage volume and draw pattern[149]

EF_{post} = Energy Factor of new HPWH

$PA\%$ = Performance adjustment to account for ambient air temperature per DOE guidance

= 0.00008 × T_{amb}^3 +0.0011 × T_{amb}^2 − 0.4833 × T_{amb} + 0.0857[150]

T_{amb} = Ambient temperature dependent on location of HPWH (Conditioned or Unconditioned Space) and Weather Zone.

Adj = HPWH-specific adjustment factor to account for Cooling Bonus and Heating Penalty on an annual basis, as well as backup electrical resistance heating which is estimated at 0.92 EF. Adjustment factors are listed in Table F-25 below.

Table F-20: Arkansas Weather Zone Equivalents, by County, in Oklahoma

Weather Zone	Counties Included
9	Alfalfa, Craig, Dewey, Ellis, Grant, Harper, Kay, Major, Nowata, Ottawa, Roger Mills, Rogers, Washington, Woods, Woodward
8	Adair, Beckham, Blaine, Caddo, Canadian, Cherokee, Creek, Custer, Delaware, Garfield, Kingfisher, Logan, Mayes, Noble, Oklahoma, Okmulgee, Osage, Pawnee, Payne, Tulsa, Wagoner, Washita
7	Atoka, Bryan, Cleveland, Coal, Comanche, Cotton, Garvin, Grady, Greer, Harmon, Haskell, Hughes, Jackson, Kiowa, Latimer, Le Flore, Lincoln, McClain, McCurtain, McIntosh, Murray, Muskogee, Okfuskee, Pittsburg, Pontotoc, Pottawatomie, Seminole, Sequoyah, Stephens, Tillman
6	Carter, Choctaw, Jefferson, Johnson, Love, Marshall, Pushmataha

Table F-21: Estimated Annual Hot Water Use (gal)[151]

Weather Zone	Tank Size (gal) of Replaced Water Heater			
	40	50	65	80
9 Fayetteville	18,401	20,911	25,093	30,111
8 Fort Smith	18,331	20,831	24,997	29,996
7 Little Rock	18,267	20,758	24,910	29,892
6 El Dorado	17,815	20,245	24,293	29,152

[148] As stipulated by look up Table 138, pg. 122-123 of the AR TRM.
[149] As stipulated by look up Table 138, pg. 122-123 of the AR TRM.
[150] As stipulated by the AR TRM, pg. 128.
[151] Reproduced after Table 142, pg. 125 of the AR TRM.

Table F-22: Average Water Main Temperature[152]

Weather Zone	Average Water Main Temperature (°F)
9 Fayetteville	65.6
8 Fort Smith	66.1
7 Little Rock	67.8
6 El Dorado	70.1

Table F-23: Water Heater Replacement Baseline Energy Factors (Calculated)

Minimum Required Energy Factors by NAECA After 4/16/2015				
Fuel Type	**40**	**50**	**65**	**80**
Natural Gas or Propane	0.62	0.6	0.75	0.74
Electric	0.95	0.95	1.98	1.97

Table F-24: Average Ambient Temperatures (T_{amb}) by Installation Location[153]

Weather Zone	Conditioned Space	Unconditioned Space
9 Fayetteville	72.2	69.1
8 Fort Smith	73.4	69.4
7 Little Rock	73.4	71.1
6 El Dorado	72.9	73.3

[152] Reproduced after Table 143, pg. 126 of the AR TRM.
[153] Reproduced after Table 144, pg. 128 of the AR TRM.

Table F-25: HPWH Adjustment[154]

Weather Zone 9 Fayetteville					
Water Heater Location	**Furnace Type**	**40**	**50**	**65**	**80**
Conditioned Space	Gas	1.02	1.02	1.03	1.04
	Heat Pump	1.46	1.42	1.37	1.33
	Elec.Resistance	2.04	1.94	1.82	1.71
Unconditioned Space	N/A	1.06	1.06	1.06	1.06
Weather Zone 8 Fort Smith					
Water Heater Location	**Furnace Type**	**40**	**50**	**65**	**80**
Conditioned Space	Gas	1.02	1.03	1.03	1.04
	Heat Pump	1.43	1.39	1.35	1.31
	Elec.Resistance	1.95	1.86	1.75	1.66
Unconditioned Space	N/A	1.06	1.06	1.06	1.06
Weather Zone 7 Little Rock					
Water Heater Location	**Furnace Type**	**40**	**50**	**65**	**80**
Conditioned Space	Gas	0.99	1.00	1.01	1.02
	Heat Pump	1.41	1.38	1.34	1.30
	Elec.Resistance	1.96	1.87	1.76	1.66
Unconditioned Space	N/A	1.07	1.07	1.07	1.07
Weather Zone 6 El Dorado					
Water Heater Location	**Furnace Type**	**40**	**50**	**65**	**80**
Conditioned Space	Gas	0.95	0.96	0.98	0.99
	Heat Pump	1.34	1.31	1.28	1.25
	Elec.Resistance	1.84	1.76	1.66	1.58
Unconditioned Space	N/A	1.07	1.07	1.07	1.07

Demand savings (kW) for HPWH were calculated via the following formula:

Equation F-32: Peak Demand Savings (HPWH)

$$kWsavings = kWh_{savings} \times Ratio_{Annual\ kWh}^{Peak\ kW}$$

Where:

$\mathrm{Ratio}_{\mathrm{Annual\ kWh}}^{\mathrm{Peak\ kW}}$ = 0.0000877[155]

[154] Reproduced after Table 145, pg. 129 of the AR TRM.
[155] As stipulated by the AR TRM, pg. 130.

F.1.3.10 Clothes Dryers (CD)

ADM checked clothes dryer (CD) model numbers listed in the program tracking system against the ENERGY STAR® databases to verify that each CD distributed via the program each year was ENERGY STAR® certified and assigned the correct type dryer type (standard or compact) and the product class.

Deemed energy savings (kWh) values for CDs are unavailable in the OKDSD, so the IL TRM was used. The kWh savings for clothes dryers (CD) were calculated via the following formula:

Equation F-33: Energy Savings (CD)

$$CD\ kWhsavings = \left(\frac{Load}{CEF_{base}} - \frac{Load}{CEF_{eff}}\right) \times N_{cycles} \times \%Electric$$

Where:

$Load$ = The average total weight of clothes per drying cycle (lbs).
= 8.45 (standard CD) or 3 (compact CD)[156]

$\mathrm{CEF_{base}}$ = Combined energy factor (CEF) of the baseline unit is based on existing federal standards energy factor and adjusted to CEF as performed in the ENERGY STAR® analysis.

Table F-26: Combined Energy Factor$_{base}$ by Product Class[157]

Product Class	CEF (lbs/kWh)
Vented Electric, Standard (≥ 4.4 ft3)	3.11
Vented Electric, Compact (120 V) (<4.4 ft3)	3.01
Vented Electric, Compact (=240 V) (<4.4 ft3)	2.73
Ventless Electric, Compact (=240 V) (<4.4 ft3)	2.13
Vented Gas	2.84

CEF_{eff} = Combined energy factor of the ENERGY STAR® unit based on ENERGY STAR® requirements. Examples are shown below, though actual values will be taken from ENERGY STAR® for each model.

[156] As stipulated by the IL TRM, see pg. 46 and footnote 115 of the TRM.
[157] Reproduced after CEF_{base} look up table on pg. 46 of the IL TRM.

Table F-27: Combined Energy Factor$_{eff}$ by Product Class[9]

Product Class	CEF (lbs/kWh)
Vented Electric, Standard (≥ 4.4 ft3)	3.93
Vented Electric, Compact (120 V) (<4.4 ft3)	3.80
Vented Electric, Compact (=240 V) (<4.4 ft3)	3.45
Ventless Electric, Compact (=240 V) (<4.4 ft3)	2.68
Vented Gas	3.48

N_{cycles} = Number of dryer cycles per year
= 283[158]

$\%Electric$ = The percent of overall savings coming from electricity
= 100% (electric dryers) or 16% (gas dryers)[159]

Demand savings were calculated via the following formula:

Equation F-34: Peak Demand Savings (CD)

$$CD\ kWsavings = \frac{kWh_{savings}}{Hours} \times CF$$

Where:

$Hours$ = Annual run hours of clothes dryer
= 283[160]

CF = Summer peak coincidence factor
=0.038[161]

F.1.3.11 Clothes Washers (CW)

ADM checked clothes washer (CW) model numbers listed in the program tracking system against the ENERGY STAR® databases to verify that each CW distributed via the program each year was ENERGY STAR® certified.

Deemed savings values from the AR TRM will be used for CWs as savings values for this measure are not provided in the OKDSD. The energy savings (kWh) and demand savings (kW) will be estimated for retrofit and new construction applications based on Table F-28 Since some configurations produce 0 kWh savings, ADM computed a weighted average savings value for clothes washers and applied that single value to all clothes washers rebated through the program.

[158] As stipulated by the IL TRM, see pg. 46 and footnote 120 of the TRM.
[159] As stipulated by the IL TRM, see pg. 47 and footnote 121 of the TRM.
[160] As stipulated by the IL TRM, see pg. 47 and footnote 122 of the TRM.
[161] As stipulated by the IL TRM, see pg. 47 and footnote 123 of the TRM.

Table F-28: ENERGY STAR® Clothes Washer – Deemed Savings in Retrofit or New Construction Applications[162]

Application	Baseline Configuration	Efficient Configuration	Water Heater Fuel Type	Dryer Fuel Type	kWh Savings	kW Savings
Retrofit	Top Loading	Top Loading	Gas	Gas	23	0.005
			Gas	Electric	192	0.045
			Electric	Gas	114	0.027
			Electric	Electric	282	0.067
	Top Loading	Front Loading	Gas	Gas	38	0.009
			Gas	Electric	198	0.047
			Electric	Gas	191	0.045
			Electric	Electric	351	0.083
	Front Loading	Front Loading	Gas	Gas	6	0.002
			Gas	Electric	93	0.022
			Electric	Gas	32	0.008
			Electric	Electric	119	0.028
	Front Loading	Top Loading	Gas	Gas	0	0.000
			Gas	Electric	87	0.021
			Electric	Gas	0	0.000
			Electric	Electric	50	0.012
New Construction	Top Loading	Top Loading	Gas	Gas	23	0.005
			Gas	Electric	192	0.045
			Electric	Gas	114	0.027
			Electric	Electric	282	0.067
	Top Loading	Front Loading	Gas	Gas	38	0.009
			Gas	Electric	198	0.047
			Electric	Gas	191	0.045
			Electric	Electric	351	0.083

F.1.3.12 Refrigerators (RF)

Deemed savings values from the AR TRM were used for RFs. The energy savings (kWh) for “replace-on-burnout” RFs was calculated using Equation F-35.

[162] Reproduced after Tables 172 and 173, pg. 167 of the AR TRM with additional entries calculated via savings equations provided in the TRM.

Equation F-35: Energy Savings for Replace-On-Burnout (RF)

$$RF_{ROB}\ kWh_{savings} = kWh_{baseline} - kWh_{ES}$$

Where:

$kWh_{baseline}$ = Federal standard baseline average energy usage, *Table F-29*

kWh_{ES} = ENERGY STAR® average energy usage, *Table F-29*

For RFs that are considered "early retirement" replacements, i.e. units that replaced working RFs, the energy (kWh) and demand (kW) savings must be calculated separately for two time periods: (1) the estimated remaining life of the equipment that is being removed, designated the remaining useful life (RUL); and (2) the remaining time in the EUL period. For the RUL, kWh savings were calculated via Equation F-36. For the remaining time in the EUL period, the annual savings were calculated as would be done for replace-on-burnout as shown above. Peak demand savings (kW) were calculated via Equation F-37.

Equation F-36: Energy Savings for RUL (RF)

$$RF\ kWhsavings_{ER} = (kWh_{manf} \times (1 + PDF)^{n}\ \times SLF) - kWh_{ES}$$

Equation F-37: Peak Demand Savings (RF)

$$RF\ kW\ savings = \frac{kWh_{savings}}{8{,}760\ hrs}\ \times\ TAF \times LSAF$$

Where:

kWh_{manf} = Annual unit energy consumption from the Association of Home Appliance Manufacturers (AHAM) refrigerator database[163]

PDF = Performance degradation factor
= 0.0125 per year[164]

n = Age of replaced refrigerator (years)

SLF = Site/Lab Factor
= 0.81[165]

TAF = Temperature adjustment factor
= 1.188[166]

$LSAF$ = Load shape adjustment factor
= 1.074[167]

[163] As stipulated by the AR TRM, see pg. 179 and footnote 240 in the TRM.
[164] As stipulated by the AR TRM, see pg. 179 and footnote 241 in the TRM.
[165] As stipulated by the AR TRM, see pg. 179 and footnote 242 in the TRM.
[166] As stipulated by the AR TRM, see pg. 180 and footnote 244 in the TRM.
[167] As stipulated by the AR TRM, see pg. 180 and footnote 245 in the TRM.

Table F-29: Example Formulas to Calculate the ENERGY STAR® Criteria for Each Refrigerator Product Category by Adjusted Volume[168]

Measure Category	Federal Standard Baseline Energy Usage (kWh/year)	ENERGY STAR® Average Energy Usage (kWh/year)
Refrigerator-only—manual defrost	6.79 × AV + 193.6	6.111 × AV + 174.24
Refrigerator-freezers—manual or partial automatic defrost	7.99 × AV + 225.0	7.191 × AV + 202.5
Refrigerator-only—automatic defrost	7.07 × AV + 201.6	6.363 × AV + 181.44
Built-in refrigerator-only—automatic defrost	8.02 × AV + 228.5	7.218 × AV + 205.65
Refrigerator-freezers—automatic defrost with bottom-mounted freezer without an automatic icemaker	8.85 × AV + 317.0	7.965 × AV + 285.3
Built-in refrigerator-freezers—automatic defrost with bottom-mounted freezer without an automatic icemaker	9.40 × AV + 336.9	8.46 × AV + 378.81
Refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker without TTD ice service	8.85 × AV + 401.0	7.965 × AV + 360.9
Built-in refrigerator-freezers—automatic defrost with side-mounted freezer without an automatic icemaker	10.22 × AV + 357.4	9.198 × AV + 321.66
Refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker without TTD ice service	8.51 × AV + 381.8	7.659 × AV + 343.62
Built-in refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker without TTD ice service	10.22 × AV + 441.4	9.198 × AV + 397.26
Refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker with TTD ice service	8.54 × AV + 432.8	7.686 × AV + 389.52
Built-in refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker with TTD ice service	10.25 × AV + 502.6	9.225 × AV + 452.34
Refrigerator freezers—automatic defrost with top-mounted freezer without an automatic icemaker	8.07 × AV + 233.7	7.263 × AV + 210.33

F.1.3.13 Electric Vehicle Chargers (EVC)

ADM reviewed all tracking data to ensure that all Level 2 electric vehicles rebated via the program each year were ENERGY STAR® certified. Since there are no established deemed savings calculations for Level 2 electric vehicle chargers in the OKDSD, ADM developed a well-researched approach to estimate energy savings (kWh) for this

[168] Reproduced, in part, after Table 177 on pg. 176-177 of the AR TRM.

measure (no appreciable demand savings (kW) were recorded). For each unit rebated through the program, energy savings was calculated using Equation F-38.

Equation F-38: Energy Savings (EVC)

$$EVC\ kWh\ savings = VMT_{OK} * \ avgMPG_e * \left(\frac{1}{EER_{base}} - \frac{1}{EER_{efficient}}\right) + ES_{gain}$$

Where:

VMT_{OK} = Vehicle miles traveled per year for Oklahoma residents
= 14,382[169]

$avgMPG_e$ = Average MPG_e (kWh/100 miles) of electric vehicles currently on the market
= 32[170]

EER_{base} = Energy efficiency rating of the base technology (Level 1 EVC)
= 0.822[171]

$EER_{efficient}$ = Energy efficiency rating of the efficient technology (Level 2 EVC)
= 0.853[172]

ES_{gain} = Efficiency gain of an ENERGY STAR® certified Level 2 EVC[173]
= 56

[169] State and Urbanized Area Statistics (2018) U.S. Department of Transportation, Federal Highway Administration. *Last accessed June 2019 via:* https://www.fhwa.dot.gov/ohim/onh00/onh2p11.htm

[170] Value provided by the Implementor, CLEAResult; corroborated by ADM via 2011-2017 sales data from U.S. Department of Energy: Energy Efficiency & Renewable Energy Alternative Fuels Data Center – *Last accessed July 2019 via:* www.afdc.energy.gov/data/ in addition to 2018 and partial 2019 sales data collected from Tesla Quarterly Reports and www.goodcarbadcar.net.

[171] Based on results of Level 1 charger high energy (>2kWh) events occurring at temperatures > 70°F – see Table 2 *in* Forward, E., Glitman, K., and Roberts, D. *for* Vermont Energy Investment Corporation (2013) EVT NRA R&D Electric Vehicle Supply Equipment Project Report: An Assessment of Level 1 and Level 2 Electric Vehicle Charging Efficiency, *Efficiency Vermont*.

[172] Based on results of Level 2 charger high energy (>2kWh) events occurring at temperatures > 70°F – see Table 2 *in* Forward, E., Glitman, K., and Roberts, D. *for* Vermont Energy Investment Corporation (2013) EVT NRA R&D Electric Vehicle Supply Equipment Project Report: An Assessment of Level 1 and Level 2 Electric Vehicle Charging Efficiency, *Efficiency Vermont*.

[173] Environmental Protection Agency (2013) ENERGY STAR® Market and Industry Scoping Report: Electric Vehicle Supply Equipment.

F.1.4 Home Rebates Program – New Homes, Multiple Upgrades, and Single Upgrades Components

This section includes the measure level algorithms and deemed savings values utilized for the verified gross kWh and kW savings calculations.

F.1.4.1 Infiltration Reduction

ADM utilized the AR TRM for the savings algorithms and deemed savings values shown in Section F.1.2.1, Equation F-12 and Equation F-13.

F.1.4.2 Duct Sealing

ADM used the OKDSD algorithm and inputs from the PSO duct leakage reduction results to calculate measure savings along with OKDSD full load hours. Program contractors performed duct blaster testing to estimate the duct leaked reduction in CFM for each home serviced. If a central AC (CAC) was installed with this project, the SEER value from the PSO data of the install was used in the savings calculations. If the existing CAC efficiency was not known, the default value of 13 SEER was used from OKDSD. The algorithms for cooling and energy saving listed in the OKDSD for duct sealing can be found in Section F.1.2.2: Equation F-14, Equation F-15 and Equation F-16.

F.1.4.3 Duct Replacement (Insulation)

Savings for this measure were calculated using the AR TRM algorithm, with full load hours and the CF value from the OKDSD. Deemed savings factors were based on the location of the ducts: attic or crawlspace. Savings were calculated by multiplying the deemed savings value for the corresponding area and weather zone by the square footage of the conditioned area of the home.

Table F-30: Duct Insulation Deemed Savings Values – Attic

Weather Zone	AC/Gas heat kWh per SF	Gas heat (no AC) kWh per SF	AC/Elec Resistance kWh/SF	Heat Pump kWh/SF	AC Peak Savings kW/SF
9	0.041	0	0.214	0.219	0.00008
8a	0.0888	0	0.2824	0.3037	0.0001
8b	0.088	0	0.2746	0.2993	0.00001
7	0.0918	0	0.2497	0.2469	0.00001
6	0.064	0	0.194	0.18	0.0001

Table F-31: Duct Insulation Deemed Savings Values – Crawlspace

Weather Zone	AC/Gas heat kWh per SF	Gas heat (no AC) kWh per SF	AC/Elec Resistance kWh/SF	Heat Pump kWh/SF	AC Peak Savings kW/SF
9	0.029	0	0.198	0.205	0.00002
8a	0.0462	0	0.2133	0.2272	0
8b	0.0475	0	0.2068	0.2248	0
7	0.0474	0	0.1809	0.1724	0
6	0.041	0	0.188	0.164	0.00003

F.1.4.4 Ceiling, Attic Insulation

ADM utilized the AR TRM for the savings algorithms and scaled deemed savings values. Deemed savings provided in the AR TRM are based on the R-value of the baseline insulation. Savings were calculated by multiplying the applicable savings value by the square footage insulated. The savings algorithms require new insulation to meet a minimum R-value of R-38. Savings were calculated for both R-38 and R-49 insulation, depending on the final insulation levels installed in the home.

Table F-32: Deemed Savings for R-38 Ceiling Insulation

Climate Zone	Baseline Insulation R-Value	AC/Gas Heat kWh/SF	Gas Heat (No AC) kWh/SF	AC/Electric Resistance kWh/SF	Heat Pump kWh/SF	AC Peak Savings kW/SF
9	1 or less	1.716	0.254	9.366	5.071	0.0014
	>1 and <=5	0.969	0.141	5.212	2.764	0.0008
	>5 and <=8	0.586	0.084	3.136	1.653	0.0005
	>8 and <=15	0.364	0.052	1.926	1.013	0.00032
	>15 and 22	0.172	0.025	0.931	0.486	0.00014
8	1 or less	1.8642	0.2203	8.734	4.572	0.00107
	>1 and <=5	1.0497	0.1215	4.846	2.495	0.00061
	>5 and <=8	0.6330	0.0728	2.909	1.495	0.00038
	>8 and <=15	0.3909	0.0446	1.784	0.917	0.00025
	>15 and 22	0.1847	0.0216	0.858	0.439	0.00011
7	1 or less	1.8820	0.1933	7.936	4.067	0.00201
	>1 and <=5	1.0505	0.107	4.401	2.252	0.00118
	>5 and <=8	0.6315	0.0643	2.643	1.355	0.00073
	>8 and <=15	0.3901	0.0394	1.624	0.834	0.00047
	>15 and 22	0.1854	0.019	0.781	0.4	0.00022
6	1 or less	2.1230	0.1703	7.482	3.873	0.00203
	>1 and <=5	1.1967	0.0954	4.2	2.18	0.00118
	>5 and <=8	0.7242	0.0578	2.545	1.324	0.00073
	>8 and <=15	0.4497	0.0356	1.574	0.82	0.00047
	>15 and 22	0.2116	0.0172	0.753	0.391	0.00021

Table F-33: Deemed Savings for R-49 Ceiling Insulation

Climate Zone	Baseline Insulation R-Value	AC/Gas Heat kWh/SF	Gas Heat (No AC) kWh/SF	AC/Electric Resistance kWh/SF	Heat Pump kWh/SF	AC Peak Savings kW/SF
9	1 or less	1.756	0.260	9.578	5.1820	0.00143
	>1 and <=5	1.009	0.146	5.424	2.8760	0.00084
	>5 and <=8	0.626	0.090	3.348	1.7640	0.00053
	>8 and <=15	0.404	0.057	2.139	1.1240	0.00036
	>15 and 22	0.212	0.031	1.143	0.0597	0.00018
8	1 or less	1.907	0.225	8.931	4.673	0.00109
	>1 and <=5	1.093	0.126	5.043	2.596	0.00064
	>5 and <=8	0.676	0.077	3.105	1.596	0.00040
	>8 and <=15	0.434	0.049	1.981	1.018	0.00027
	>15 and 22	0.228	0.026	1.055	0.539	0.00013
7	1 or less	1.925	0.198	8.115	4.159	0.00207
	>1 and <=5	1.093	0.111	4.581	2.344	0.00124
	>5 and <=8	0.674	0.069	2.822	1.447	0.00079
	>8 and <=15	0.433	0.044	1.803	0.926	0.00053
	>15 and 22	0.228	0.023	0.96	0.492	0.00027
6	1 or less	2.173	0.174	7.657	3.964	0.00208
	>1 and <=5	1.247	0.099	4.375	2.271	0.00123
	>5 and <=8	0.774	0.061	2.719	1.415	0.00078
	>8 and <=15	0.500	0.039	1.748	0.911	0.00053
	>15 and 22	0.262	0.021	0.928	0.482	0.00027

F.1.4.5 Floor Insulation

ADM used the OKDSD document for the savings factors along with project specific data installed square feet, and insulation R-value from PSO. The OKDSD prototype home model considered cell foam insulation for the measure, which is the product used for the insulation rebate. The cell foam insulation provides both sensible and latent cooling season savings. Savings were calculated by multiplying the corresponding savings value by the square footage insulated. The savings factors are in the following table:

Table F-34: Deemed Savings Values for Floor Insulation

Climate Zone	HVAC Type	kWh savings/SF	kW savings/SF
9	Electric AC with Gas Heat	0.265	0.0001
	Electric AC with Electric Resistance Heat	3.231	0.0001
	Heat Pump	1.981	0.0001
8A	Electric AC with Gas Heat	0.274	0.0001
	Electric AC with Electric Resistance Heat	3.897	0.0001
	Heat Pump	2.257	0.0001
8B	Electric AC with Gas Heat	0.390	0.0001
	Electric AC with Electric Resistance Heat	3.712	0.0001
	Heat Pump	2.208	0.0001
7	Electric AC with Gas Heat	0.309	0.0001
	Electric AC with Electric Resistance Heat	2.944	0.0001
	Heat Pump	1.713	0.0001
6	Electric AC with Gas Heat	0.358	0
	Electric AC with Electric Resistance Heat	2.520	0
	Heat Pump	1.440	0

F.1.4.6 Wall Insulation

Deemed savings values were calculated for each weather zone in accordance with the AR TRM. The savings algorithm requires new insulation to meet a minimum R-value of R-13. Deemed savings provided in the AR TRM are based on the heating and cooling system type of the home and the R-Value of the insulation installed. Savings are calculated by multiplying the corresponding savings value by the square footage insulated.

Table F-35: Deemed Savings Values for Wall Insulation

Climate Zone	Equipment	Savings kWh/SF		Peak Demand Savings kW/SF	
		R-13	R-23	R-13	R-23
9	Electric AC with Gas Heat	0.527	0.563	0.00041	0.00048
	Gas Heat Only (no AC)	0.206	0.226	NA	NA
	Elec. AC with Resistance Heat	6.644	7.324	0.00041	0.00048
	Heat Pump	3.424	3.447	0.00041	0.00048
8	Electric AC with Gas Heat	0.586	0.625	0.00027	0.00029
	Gas Heat Only (no AC)	0.179	0.197	NA	NA
	Elec. AC with Resistance Heat	60.59	6.689	0.00027	0.00029
	Heat Pump	2.946	2.980	0.00023	0.00025
7	Electric AC with Gas Heat	0.570	0.607	0.00047	0.00071
	Gas Heat Only (no AC)	0.156	0.173	NA	NA
	Elec. AC with Resistance Heat	5.315	5.900	0.00047	0.00072
	Heat Pump	2.479	2.592	0.00047	0.00061
6	Electric AC with Gas Heat	0.712	0.751	0.00046	0.00084
	Gas Heat Only (no AC)	0.134	0.151	NA	NA
	Elec. AC with Resistance Heat	4.798	5.389	0.00046	0.00084
	Heat Pump	2.223	2.388	0.00046	0.00071

F.1.4.7 Knee Wall Insulation

Deemed savings values were calculated for each weather zone in accordance with the AR TRM. The savings algorithms require new insulation to meet a minimum R-value of R-19. Deemed savings provided in the AR TRM are based on the heating and cooling system type of the home and the R-value of the installed insulation. Savings were calculated by multiplying the corresponding savings value by the square footage insulated.

Table F-36: Deemed Savings Value for Knee Wall Insulation

Climate Zone	Insulation Level Installed	AC/Gas Heat kWh/SF	Gas Heat (No AC) kWh/SF	AC/Electric Resistance kWh/SF	Heat Pump kWh/SF	AC Peak Savings kW/SF
9	R-19	1.104	0.131	5.073465	2.682	0.00079
	R-30	1.166	0.139	5.372651	2.839	0.00083
8	R-19	1.219	0.114	4.804000	2.489	0.00090
	R-30	1.289	0.121	5.086000	2.634	0.00094
7	R-19	1.230	0.100	4.405000	2.298	0.00090
	R-30	1.300	0.106	4.662000	2.430	0.00095
6	R-19	1.389	0.089	4.215000	2.255	0.00091
	R-30	1.468	0.094	4.461000	2.384	0.00096

F.1.4.8 Electronically Commutated (ECM) Furnace Fan Motor

Deemed heating and cooling savings values were calculated for each weather zone in accordance with the OKDSD. Cooling and peak demand savings are eligible only if the existing cooling system is left in place when the ECM is installed. Savings were calculated by multiplying the corresponding savings value by the square footage of the conditioned space of the home.

Table F-37: Deemed Savings Values for ECM

Climate Zone	Energy Savings in Heating Mode kWh/SF	Energy Savings in Cooling Mode kWh/SF	Peak Demand Savings kW/SF
Zone 9	0.1228	0.1402	0.000140
Zone 8a	0.1411	0.1610	0.000110
Zone 8b	0.1333	0.1628	0.000140
Zone 7	0.0956	0.1675	0.000140
Zone 6	0.0847	0.1985	0.000332

F.1.4.9 Air Conditioner and Air Source Heat Pump Retrofits

ADM utilized the OKDSD for the savings algorithms.

Equation F-39: Annual Energy Savings – Cooling

$$kWh_{\boldsymbol{savings,Clg}} = \left(Cap_{base}\ X \frac{1}{SEER_{Base}} - CAP_{AC}\ X\ \frac{1}{SEER_{post,AC}}\right) X\ \frac{1\ kW}{1{,}000\ W}\ X\ EFLH_C$$

Equation F-40: Annual Energy Savings – Heating

$$kWh_{\boldsymbol{savings,Htg}} = \left(Cap_{base}\ X \frac{1}{HSPF_{Base}} - CAP_{AC}\ X\ \frac{1}{HSPF_{HP}}\right) X\ \frac{1\ kW}{1{,}000\ W}\ X\ EFLH_H$$

Equation F-41: Peak Demand Reduction

$$kW_{\boldsymbol{savings}} = \left(Cap_{base}\ X \frac{1}{EER_{Base}} - CAP_{AC}\ X\ \frac{1}{EER_{post,AC/HP}}\right) X\ \frac{1\ kW}{1{,}000\ W}\ X\ CF$$

Where:

Cap_{base}	= Rated equipment cooling capacity of the existing unit (BTU/hr)
$Cap_{AC/HP}$	= Rated equipment cooling/heating capacity of the new unit (BTU/hr)[174]
$SEER_{Base}$	= Season Energy Efficiency Ratio of existing cooling equipment
$SEER_{post}$	= Season Energy Efficiency Ratio of installed cooling equipment
EER_{Base}	= Energy Efficiency Ratio of the existing equipment
EER_{post}	= Energy Efficiency Ratio of the installed equipment
$EFLH_C$	= Equivalent full load hours for cooling
$EFLH_H$	= Equivalent full load hours for heating
$HSPF_{Base}$	= Heating Seasonal Performance Factor for existing heating equipment
$HSPF_{post,}$	= Heating Seasonal Performance Factor for installed heating equipment
CF	= Coincidence Factor = 0.87 (default)

F.1.4.10 High Efficiency Windows

Although the window measure was not offered this program year, projects were completed from applications submitted last year. Deemed savings values were calculated for each weather zone in accordance with the AR TRM. Deemed savings are based on the heating and cooling type of the home and the existing windowpane type. Savings were calculated by multiplying the corresponding savings value by the square footage of the installed window, including the frame and sash.

[174] Rated capacity of the new unit shall not exceed capacity of the existing unit; if completing this with other measures, use existing unit capacity.

Table F-38: Deemed Values for ENERGY STAR® Windows

Climate Zone	Existing Windowpane Type	Electric AC & Gas Heat		Gas Heat (No AC)		Electric AC & Elec Res		Heat Pump	
		kWh/SF	kW/SF	kWh/SF	kW/SF	kWh/SF	kW/SF	kWh/SF	kW/SF
9	Single Pane	4.884	0.0031	0.275	NA	13.050	0.0031	8.509	0.0031
9	Double Pane	3.028	0.0019	0.243	NA	10.241	0.0019	6.303	0.0019
8	Single Pane	5.800	0.0036	0.187	NA	11.485	0.0036	7.768	0.0036
8	Double Pane	3.730	0.0037	0.156	NA	8.476	0.0037	5.484	0.0031
7	Single Pane	5.889	0.0035	0.160	NA	10.719	0.0035	7.278	0.0035
7	Double Pane	3.785	0.0036	0.134	NA	7.820	0.0035	5.072	0.0031
6	Single Pane	6.864	0.0037	0.127	NA	10.771	0.0037	7.526	0.0037
6	Double Pane	4.449	0.0042	0.109	NA	7.787	0.0042	5.198	0.0035

F.1.4.11 Omni-directional LEDs

ADM utilized the OKDSD for the savings algorithms and deemed savings values shown in Section F.1.2.6, Equation F-17 and Equation F-18.

F.1.4.12 Ground Source Heat Pump

ADM utilized the savings algorithms found in the OKDSD for units that meet the minimum efficiency requirements.

Equation F-42: Annual Energy Savings (Ground Source Heat Pump)

$$kWh_{savings,Clg} = Cap\ X\ \frac{1\ kW}{1{,}000\ W}\ X\ EFLH_C\ X\ \left(\frac{1}{EER_{Base}} - \frac{1}{EER_{GSHP}}\right)$$

$$kWh_{savings,Htg} = Cap\ X\ \frac{1\ kW}{3{,}412\ Btu}\ X\ EFLH_H\ X\ \left(\frac{1}{COP_{Base}} - \frac{1}{COP_{GSHP}}\right)$$

Equation F-43: Peak Demand Reduction (Ground Source Heat Pump)

$$kW_{savings} = CAP\ X\ \frac{1\ kW}{1{,}000\ W}\ X \left(\frac{1}{EER_{Base}} - \frac{1}{EER_{post,AC/HP}}\right)\ X\ CF$$

Where:

CAP	= Rated equipment cooling capacity of the new unit (Btu/hr)
$EFLH_C$	= Equivalent full load hours for cooling
$EFLH_H$	= Equivalent full load hours for heating
EER_{base}	= Energy Efficiency Ration of the baseline cooling equipment
EER_{GSHP}	= Energy Efficiency Ration of the installed GSHP
COP_{Base}	= Coefficient of Performance for the baseline heating equipment

COP_{GSHP} = Coefficient of Performance of the GSHP
CF = Coincidence Factor = 0.87

F.1.4.13 Radiant Barrier

ADM utilized the OKDSD for the savings algorithms and deemed savings values.

Equation F-44: Annual Energy Savings, Radiant Barrier

$$kWh_{Savings} = SF\ X\ ESF$$

Equation F-45: Coincident Peak Demand Reduction, Radiant Barrier

$$kW_{Savings} = SF\ X\ DSF$$

Where:

SF = Square feet of radiant barrier over conditioned space
ESF = The energy savings value corresponding to the climate zone and heating and cooling type in the following tables
DSF = The demand savings value corresponding to the climate zone and heating and cooling type in the following tables

Table F-39: Deemed Savings for Radiant Barrier

Climate Zone	Existing Insulation R-Value	AC/Gas Heat kWh/SF	Gas Heat (No AC) kWh/SF	AC/Electric Resistance kWh/SF	Heat Pump kWh/SF	AC Peak savings kW/SF
Zone 9	≤R-19	0.2960	0.0040	0.5430	0.5080	0.00042
	>R19	0.2020	0.0020	0.3590	0.3470	0.00031
Zone 8A	0.4366	0.0053	0.6801	0.6230	0.0004	0.4366
	0.3507	0.0031	0.5216	0.4893	0.0004	0.3507
Zone 8B	≤R-19	0.4262	0.0060	0.6910	0.6326	0.00040
	>R19	0.3418	0.0037	0.5341	0.4996	0.00040
Zone 7	≤R-19	0.4625	0.0057	0.7173	0.6359	0.00040
	>R19	0.3767	0.0036	0.5659	0.5133	0.00030
Zone 6	≤R-19	0.4210	0.0040	0.6500	0.5740	0.00050
	>R19	0.2910	0.0020	0.4380	0.4030	0.00040

F.1.4.14 ENERGY STAR® Pool Pumps

ADM used the deemed savings method in the OKDSD. Depending on the usage of summer only or year-round, and the size of the pump motor, results in energy and peak demand savings.

Table F-40: Deemed Savings for VSD Pumps

Annual Operation	Horsepower (HP)	kWh Savings	kW Savings
Summer only	<1.0 HP	576	0.130
	≥1.0 HP and ≤2.0 HP	1,428	0.395
	>2.0 HP	1,829	0.474
Year round	<1.0 HP	1,256	0.130
	≥1.0 HP and ≤2.0 HP	3,116	0.395
	>2.0 HP	3,991	0.474

F.1.5 Education Program

F.1.5.1 ENERGY STAR® LEDs

The energy savings for ENERGY STAR® LEDs were calculated by using the following equations.[175] Inputs for lighting calculations were determined from the data from the participant surveys in combination with algorithms and inputs found in the AR TRM.

Equation F-46: Energy Savings (LEDs)

$$kWh_{savings} = ((\Delta Watts)/1{,}000)\ x\ Hours\ x\ ISR\ x\ IEF_E$$

Equation F-47: Demand Reduction (LEDs)

$$kW_{demand\ reduction} = ((\Delta Watts)/1{,}000)\ x\ CF\ x\ ISR\ x\ IEF_D$$

Where:

$\Delta Watts$ Average delta watts for the specified measure. Delta watts for LEDs are determined by the difference in watts between an EISA compliant baseline bulb and the distributed LED. Baseline wattages will be determined based on the lumen range of the measure and the EISA baseline standards.

$Hours$ = Average hours of use per year, assumed to be 960 hours.[176]

[175] Algorithm source: AR TRM Vol. 8.1, page 226.
[176] Based on 2016 Energy Saving Products Memo.

ISR = In-service rate, the percentage of LEDs distributed that are installed.

CF = Summer Peak Coincidence Factor for measure

Lamp Location	CF
Indoor	10%
Outdoor	0%

IEF_E = Interactive effects factor to account for cooling energy savings and heating energy penalties (Heating/Cooling Unknown = 0.97)

IEF_D = Interactive effects factor to account for cooling energy savings and heating energy penalties (Heating/Cooling Unknown 1.25)

F.1.5.2 Advanced Power Strips (APS)

ADM utilized the deemed savings values for "residential" applications from the AR TRM. An ISR of 50% was used for the APS, as documented in PSO's PY2019 – PY2021 Demand Portfolio Model filed on June 29, 2018.

Table F-41: Demand and Annual Energy Savings for Advanced Power Strips

System Type	kW Demand Reduction	kWh Savings
Residential		
Home Entertainment System	0.03	252.2
Home Office	0.008	82.5
Average APS	0.019	167.4

F.1.5.3 FilterTone® Alarm

Equation F-48: Energy Savings (FilterTone® Alarm)

$$kWh_{savings} = (EFLH_{Heat} + EFLH_{Cool})\ x\ kW_{motor}\ x\ EI\ x\ ISR$$

Where:

$EFLH_{Heat}$	= Assumed to be 800 hours.[177]
$EFLH_{Cool}$	= Assumed to be 800 hours.
kW_{motor}	= Average motor full load electric demand (kW), assumed to be 0.5 kW.
EI	= Efficiency improvement assumed to be 15% or 0.15.[178]
ISR	= In-service rate, or percentage of units that get installed.

Equation F-49: Peak Demand Reduction (FilterTone® Alarm)

$$kW_{demand\ reduction} = kW_{motor}\ x\ EI\ x\ ISR\ x\ CF$$

Where:

kW_{motor}	= Average motor full load electric demand (kW), assumed to be 0.5 kW.
EI	= Efficiency improvement assumed to be 15% or 0.15.
ISR	= In-service rate, or percentage of units that get installed.
CF	= Coincidence factor, assumed to be 0.87.[179]

F.1.5.4 LED Night Light

ADM utilized the following equation for calculating the kWh savings from the PA TRM.[180]

Equation F-50: Energy Savings (LED Night Light)

$$kWh_{savings} = \left[(W_{base} - W_{post}) \times \left(\frac{Hours \times 365 \frac{days}{year}}{1000\ \frac{W}{kW}} \right) \right] \times ISR$$

Where:

W_{base}	= Assumed to be a 7-watt incandescent nightlight.
W_{post}	= Assumed to be a 1-watt LED nightlight.
$Hours$	= The nightlight is assumed to operate 12 hours per day.

[177] $EFLH_{Heat}$ and $EFLH_{Cool}$ based on PSO's 2019-2021 DSM Portfolio Plan
[178] EI is a deemed value from the 2016 Pennsylvania TRM, page 72.
[179] Coincidence factor for demand reduction associated with air conditioning units provided in Arkansas TRM Vol 8.1.
[180] Algorithm source: 2016 Pennsylvania TRM, Page 28.

ISR = In-Service Rate, or percentage of delivered units that get installed.

There is no peak demand reduction associated with this measure.

F.1.6 Multifamily Program

F.1.6.1 Air Infiltration

ADM utilized the AR TRM for the savings algorithms shown in Section F.1.2.1, Equation F-12 was used annual energy savings (kWh) and Equation F-13 was used to calculate peak demand savings (kW).

F.1.6.2 Ceiling Insulation

ADM utilized the AR TRM for the deemed savings shown in Section F.1.2.3; Table F-7.

F.1.6.3 Duct Sealing

ADM utilized the OKDSD for the savings algorithms shown in Section F.1.2.2; Equation F-14 is used to determine annual cooling savings, and Equation F-15 and Equation F-16 are used to determine heating savings for electric resistance heat and gas heat, respectively.

F.1.6.4 Faucet Aerator

ADM utilized the deemed savings values from the AR TRM for faucet aerator annual savings. Savings are calculated by multiplying the applicable savings value by the number of installed faucet aerators. Deemed savings were calculated under the assumption that all faucet aerators in a home were replaced. All faucet aerators in a home must have been replaced for savings to be applicable.

Equation F-51: Energy Savings (Faucet Aerator)

$$kWh_{savings} = \frac{\left[\rho \times \mathrm{C_p} \times \mathrm{V} \times \left(\mathrm{T_{Mixed}} - T_{Supply}\right) \times \left(\frac{1}{RE}\right)\right]}{Conversion\ Factor} \times ISR$$

Where:

ρ = Water Density = 8.33 lb/gallon
C_p = Specific heat of water = 1 BTU/lb*°F
V = gallons of water saved per year per faucet

Flow Rate	Gallons of Water Saved Per Year
1.5 gpm	381
1.0 gpm	636

T_{Mixed} = Mixed water temperature, 104.3 ˚F, see Table F-42
T_{Supply} = Average supply water temperature, see Table F-42
RE = Recovery Efficiency; if unknown, use 0.98 as a default for electric resistance water heaters, 2.2 for heat pump water heaters, or 0.79 for natural gas water heaters
Conversion Factor = 3,412 Btu/kWh
ISR = In-service rate, or percentage of units that get installed.

Equation F-52: Peak Demand Savings (Low Flow Shower Head)

$$kW_{savings} = kWh_{savings} \times Ratio_{Annual\ kWh}^{Peak\ kW}$$

Where:

$$Ratio_{Annual\ kWh}^{Peak\ kW} = 0.000104$$

Table F-42: Mixed Water Temperature Calculation (Faucet Aerator)

Weather Zone	Average Water Main Temperature (˚F)	Percent Hot Water	Mixed Water Temperature (˚F)
9 Fayetteville	65.6	66.9%	102.0
8 Fort Smith	66.1	66.9%	102.2
7 Little Rock	67.8	66.9%	102.7
6 El Dorado	70.1	66.9%	103.5
Average for Arkansas (T_{mixed})			**102.6**

F.1.6.5 Heat Pump

ADM utilized the OKDSD for the savings algorithms shown in Section F.1.4.9, Equation F-39 and Equation F-40 are used to calculate annual energy savings (kWh) and Equation F-41 for peak demand reduction (kW).

F.1.6.6 Low Flow Shower Head

The following equations were used to calculate energy savings for Low Flow Shower Heads. The values used in the calculations come from the AR TRM.

Equation F-53: Energy Savings (Low Flow Shower Head)

$$kWh_{savings} = \frac{\left[\rho \times \mathrm{C_p} \times \mathrm{V} \times \left(\mathrm{T_{Mixed}} - T_{Supply}\right) \times \left(\frac{1}{RE}\right)\right]}{Conversion\ Factor} \times ISR$$

Where:

ρ = Water Density = 8.33 lb/gallon
C_p = Specific heat of water = 1 BTU/lb*˚F

V = Showerhead water gallons saved per year = 2.0 gpm
T_{Mixed} = Mixed water temperature, 104.3 ˚F, see Table F-43
T_{Supply} = Average supply water temperature, see Table F-43
RE = Recovery Efficiency; if unknown, use 0.98 as a default for electric resistance water heaters, 2.2 for heat pump water heaters, or 0.79 for natural gas water heaters
Conversion Factor = 3,412 Btu/kWh
ISR = In-service rate, or percentage of units that get installed.

Equation F-54: Peak Demand Savings (Low Flow Shower Head)

$$kW_{savings} = kWh_{savings} \times Ratio_{Annual\ kWh}^{Peak\ kW}$$

Where:

$$Ratio_{Annual\ kWh}^{Peak\ kW} = 0.000104$$

Table F-43: Mixed Water Temperature Calculation (Low Flow Shower Head)

Weather Zone	Average Water Main Temperature (˚F)	Percent Hot Water	Mixed Water Temperature (˚F)
9 Fayetteville	65.6	70.1%	103.7
8 Fort Smith	66.1	70.1%	103.9
7 Little Rock	67.8	70.1%	104.4
6 El Dorado	70.1	70.1%	105.1
Average for Arkansas (T_{mixed})			104.3

F.1.6.7 ENERGY STAR® Pool Pump

ADM utilized the AR TRM for calculating energy savings and demand reductions. The following algorithms are sourced from the AR TRM.

Equation F-55: Energy Savings (Pool Pumps)

$$kWh_{savings} = kWh_{conv} - kWh_{ES}$$

Where:

kWh_{conv} = Conventional single-speed pool pump energy (kWh)
kWh_{ES} = ENERGY STAR® variable-speed pool pump energy (kWh)

Algorithms to calculate the above parameters are defined as:

$$kWh_{conv} = \frac{PFR_{conv} * 60 * hours_{conv} * days}{EF_{conv} * 1000}$$

$$hours_{conv} = \frac{V_{pool} * PT}{PFR_{conv} * 60}$$

$$kWh_{ES} = kWh_{HS} + kWh_{LS}$$

$$kWh_{HS} = \frac{PFR_{HS} * 60 * hours_{HS} * days}{EF_{HS} * 1000}$$

$$kWh_{LS} = \frac{PFR_{LS} * 60 * hours_{LS} * days}{EF_{LS} * 1000}$$

$$PFR_{LS} = \frac{V_{pool}}{t_{turnover} * 60}$$

Where:

kWh_{HS}	= ENERGY STAR® variable speed pool pump energy at high speed (kWh)
kWh_{LS}	= ENERGY STAR® variable speed pool pump energy at low speed (kWh)
$hours_{conv}$	= Conventional single-speed pump daily operating hours (Table F-44)
$hours_{HS,VS}$	= ENERGY STAR® variable speed pump high speed daily operating hours = 2 hours
$hours_{LS,VS}$	= ENERGY STAR® variable speed pump low speed daily operating hours = 10 hours
$hours_{HS,MS}$	= ENERGY STAR® multi-speed pump high speed daily operating hours = 2 hours
$hours_{LS,MS}$	= ENERGY STAR® multi-speed pump low speed daily operating hours (Table F-45)
days	= Operating days per year = 7 months x 30.4 days/month = 212.8 days (default)
PFR_{conv}	= Conventional single-speed pump flow rate (gal/min) (Table F-44)
$PFR_{HS,VS}$	= ENERGY STAR® variable speed pump high speed flow rate = 50 gal/min (default)
$PFR_{LS,VS}$	= ENERGY STAR® variable speed pump low speed flow rate (gal/min) = 30.6 (default)
$PFR_{HS,MS}$	= ENERGY STAR® multi-speed pump high speed flow rate (gal/min) (Table F-45)

$PFR_{HS,MS}$ = ENERGY STAR® multi-speed pump low speed flow rate (gal/min) (Table F-45)

EF_{conv} = Conventional single-speed pump energy factor (gal/W·hr) (Table F-44)

$EF_{HS,VS}$ = ENERGY STAR® variable speed pump high speed energy factor = 3.75 gal/W·hr (default)

$EF_{LS,VS}$ = ENERGY STAR® variable speed pump low speed energy factor = 7.26 gal/W·hr (default)

$EF_{HS,MS}$ = ENERGY STAR® multi-speed pump high speed energy factor (gal/W·hr) (Table F-45)

$EF_{LS,MS}$ = ENERGY STAR® multi-speed pump low speed energy factor (gal/W·hr) (Table F-45)

V_{pool} = Pool volume = 22,000 gal (default)

PT = Pool turnovers per day = 1.5 (default)

$t_{turnover,VS}$ = Variable speed pump time to complete 1 turnover = 12 hours (default)

$t_{turnover,MS}$ = Multi-speed pump time to complete 1 turnover (Table F-45)

60 = Constant to convert between minutes and hours

1000 = Constant to convert W to kW

Table F-44: Conventional Pool Pumps Assumptions

Pump HP	$hours_{conv}$	PFR_{conv}(gal/min)	EF_{conv}(gal/W*h)
0.5	11	50.0	2.71
0.75	10.4	53.0	2.57
1	9.2	60.1	2.40
1.5	8.6	64.4	2.09
2	8.5	65.4	1.95
2.5	8.1	68.4	1.88
3	7.5	73.1	1.65

Table F-45: Multi-Speed Pool Pumps Assumptions

Pump HP	$t_{turnover,MS}$	$hours_{MS,LS}$	$PFR_{HS,MS}$ (gal/min)	$EF_{HS,MS}$ (gal/min)	$PFR_{LS,MS}$ (gal/min)	EF_{conv} (gal/W*h)
1	11.8	9.8	56.0	2.40	31.0	5.41
1.5	11.5	9.5	61.0	2.27	31.9	5.43
2	11.0	9.0	66.4	1.95	33.3	5.22
2.5	10.8	8.8	66.0	2.02	34.0	4.80
3	9.9	7.9	74.0	1.62	37.0	4.76

Demand savings were derived using the following:

Equation F-56: Peak Demand Savings (Poop Pumps)

$$kW_{savings} = \left[\frac{kWh_{conv}}{hours_{conv}} - \frac{kWh_{HS} + kWh_{LS}}{hours_{HS} + hours_{LS}}\right] * \frac{CF}{days}$$

Where:

CF = Coincidence factor
= 0.31

F.1.6.8 ENERGY STAR® Windows

ADM utilized the OKDSD for the ENERGY STAR® Window deemed savings values. ADM used the deemed savings values from climate zone 8B.

Table F-46: ENERGY STAR® Windows Deemed Savings

Existing Windowpane Type	AC/Gas Heat kWh	Gas Heat (no AC) kWh	Gas Heat (no AC) Therms	AC/Electric Resistance kWh	Heat Pump kWh	AC Peak Savings kW
	Per sq. ft.	Per sq. ft.	Per sq. ft.	Per sq. ft.	Per sq. ft.	Per sq. ft.
Single Pane	6.9022	0.3863	0.5562	17.8098	13.3434	0.0044
Double Pane	5.0567	0.1777	0.2666	10.4856	8.4996	0.0031

F.1.7 Lighting Measures

ADM utilized the AR TRM for the savings algorithms and deemed savings values for the lighting measures as detailed in Section F.1.1.1.

F.2 Demand Response Programs

F.2.1 Power Hours Program

F.2.1.1 Smart Thermostat

The Power Hours smart thermostat annual savings is based on the AR TRM. The smart thermostats measure involves the replacement of a manually operated or programmable thermostat with a smart programmable thermostat. This measure applies to all residential applications. For homes with both electric cooling and heating, the deemed savings presented below are additive. Savings values were calculated using an average square footage of 1,832 ft^2 based on county assessor data average size of homes in a population of 202,962 homes in Tulsa County.

Table F-47: Deemed Energy Savings for Smart Thermostats

Baseline	% of population	Electric Cooling Energy Savings (kWh/SF)	Electric Resistance Heating Energy Savings (kWh/SF)	Electric HP Heating Energy Savings (kWh/SF)	Gas Heating Energy Savings (Therms/SF)
Manual or manually operated T'stat	85%	0.45	0.845	0.395	0.037
Properly programmed Programmable T'stat	15%	0.113	0.212	0.099	0.009
Default		0.399	0.75	0.351	0.033

Appendix G. Overview of ADM Associates

ADM Associates is a professional services corporation providing research and consulting services in applied energy engineering and economics to utilities and other clients nationwide. The services ADM provides primarily relate to comprehensive energy research and energy efficiency program implementation and evaluation. ADM's headquarters are in Sacramento, California with regional field offices in Nevada (Las Vegas, Reno) and the California Bay Area (Fremont). From these offices, ADM conducts energy-related studies and projects throughout the United States and Canada for utility companies, government agencies and other clients.

ADM has been performing energy research and evaluation activities for nearly forty (40) years and has demonstrated its commitment to quality and customer service. ADM is currently conducting evaluations of residential, commercial, and industrial programs for utilities across the United States.

ADM is dedicated to creating a safe work environment and to provide training for our employees. All ADM employees undergo general safety training. Our field technicians and engineers undergo additional safety training related to fieldwork. We encourage all our employees to be responsible and alert to identify hazardous conditions wherever they may exist be it in transportation to the customer or at the customer's facility. If hazardous conditions are found, they are to report them immediately to their supervisor or the ADM Safety Officer. Never are they to proceed to work in an identified hazardous situation. ADM follows Cal/OSHA rules and guidelines for safety in the workplace and these rules are as or more stringent than the federal OSHA rules.

Personal Protective Equipment (PPE) is provided and the procedures to use it as appropriate for the work expected. Our field staff is provided training to safely conduct activities they may encounter. Specifically, this includes the use of ladders and the rules associated with working at heights. Three points of contact on ladders are required at all times. It is trained that body harnesses are required when being lifted by a man lift or bucket, although we also train to avoid the use of lifts. If rooftops need to be accessed, our field staff is trained to identify if it is safe to be there and the requirements for perimeter protection. For those that will make electrical measurements, electrical safety training is given for new hires and periodically reviewed for all employees working in such conditions. Electrical safety training includes the use of PPE and the voltage the PPE is appropriate for use around. Arc flash training reinforces the reason for using PPE. ADM does not conduct any measurement activity on systems over 500 Volts. Other training includes exposure to asbestos, lead, and hydrogen sulfide. Employees are trained to follow safety procedures and there are consequences for not following proper procedures which can include termination of employment.

Appendix H. Lighting Discounts Price Response Model Details

H.1 Introduction

In order to develop one estimate of free ridership for discounted LED bulb sales, ADM developed a price response model using sales data and associated information provided by the program administrator. This approach to free ridership estimation uses econometric techniques to estimate the effect of price changes on the number of bulb packages sold. The model uses variation in bulb package pricing over time to estimate price elasticity of demand (the change in quantity demanded as prices change). The model is used to predict what level of sales would have occurred under the counterfactual scenario where no discount program is offered, and bulbs are sold at their original retail prices.

H.2 Data Sources and Processing

The program administrator provided ADM with weekly sales data for the Lighting Discounts component of the ESP program. The data included sales quantities separated by retailer and bulb model number. Data was used for the majority of PY2019 (48 weeks) and a portion of PY2018 (4 weeks). Additional records regarding dates and retail locations of in-store promotional events was combined with the sales tracking data to create the final dataset used for the price response modeling.

For each unique combination of retailer, model number, and price discount, the dataset contained the following field used for the econometric model:

- Original retail price
- Target retail price (price after any manufacturer incentives and program-sponsored discounts)
- Rated lumens and wattage
- Bulb type designation (omni-directional LED, directional LED)
- Promotional events for given retailers in given time periods
- Month in which the product was sold
- Number of bulbs in each pack sold

Summary statistics for the final dataset used to estimate the price response model are provided in the tables below.

Table H-1: Count of SKUs by Bulb Type and Store Type

Bulb Type	Discount	DIY	Mass Merchant	Total
LED Directional	4	67	73	144
LED Omni-Directional	4	136	49	189
Total	**8**	**203**	**122**	**333**

Table H-2: Summary Statistics by Bulb Type

Bulb Type	Total Packages Sold	Total SKUs	Average Retail Price Per Package	Average Program Discount Per Package
LED Directional	261,947	144	$13.37	$2.85
LED Omni-Directional	71,419	189	$12.63	$4.22
Total	**333,366**	**333**	**$13.05**	**$3.45**

H.2.1 Price Response Model Development and Specification

The econometric approach used to estimate the price response model was informed by past evaluations of residential lighting programs in Maine[181] and Michigan.[182] Program sales data are, by their nature, non-negative integer values (i.e., count data). Typical ordinary least squares (OLS) estimation procedures are designed to deal with continuous dependent variables that are normally distributed. Count data dependent variables can be adapted for OLS estimation through logarithmic or square root transformations, but these models may produce nonsensical predictions, such as negative sales. ADM chose instead to use a negative binomial model[183] based on the prior research in Maine and summary statistics of the available data.

The program sales data can be arranged as a panel, with a cross-section of program packages modeled over the 52 weeks for which there is information. However, the large number of “zeroes” introduced by missing sales data presents a problem for estimating a model with good fit and predictive power. There are econometric techniques for modeling excessive zeros (hurdle models, zero-inflated models) but the theoretical justification for these techniques does not align with a situation where the zeroes represent sales data that does not exist (no sales data that week) or an incentive was not available. Instead of

[181] http://www.efficiencymaine.com/docs/Efficiency-Maine-Residential-Lighting-Program-Final-Report_FINAL.pdf

[182] http://www.nmrgroupinc.com/wp-content/uploads/2013/10/Consumers-Energy_2013-ES-Lighting_Price-Elasticity-Model.pdf

[183] A negative binomial regression is a type of generalized linear model that is implemented using maximum likelihood estimation. For a detailed description of the negative binomial regression, see Cameron, A.C. and P.K. Trivedi (2013), *Regression Analysis of Count Data*, Second Edition, Cambridge University Press.

preserving the panel structure of the data by leaving the "zeroes" in the model, ADM opted to estimate a cross-sectional negative binomial regression, omitting any instances of "zero" sales. That is, rather than modeling sales over a 52-week period, each weekly package sales quantity was modeled as if it was sold during the same time period, with "zero sales" instances removed from the model.[184] Seasonal effects on sales quantities were controlled for through a set of monthly dummy variables.

After determining the general modeling approach,[185] ADM tested several different specifications to determine program impacts on standard LED and specialty LED demand. Ultimately, a model similar to the final model for the Michigan evaluation was chosen, as it provided the best statistical fit to the program sales data with the best predictive power of the models compared. The model assumes that three broad factors affect bulb sales: prices, the presence of promotional events and seasonal trends. The final model uses dummy variables to control for seasonal effects (month dummies) and bulb type (model number dummies). A separate model was run for each bulb type (omni-directional LED and directional LED). The basic equation of the price response model was estimated as follows (for bulb model *i*, in period *t*):

Equation H-1: Price Response Model

$$\ln(Q_{it}) = \beta_1 + \beta_2 * \ln(P_{it}) + \beta_3 Packsize_i + \beta_4 EventDummy_{it} + \sum_{\pi} \beta_\pi ModelNumberDummy_i + \sum_{\gamma} \beta_\gamma MonthDummy_t + \sum_{\rho} \beta_\rho LargeDiscountDummy_i + \varepsilon_{it}$$

Where:

ln = natural logarithm
Q = quantity of packs *i,* sold during week *t*
P = retail price (after markdown) for package of bulbs, *i*, during week *t*
Packsize = number of bulbs in pack *i*
EventDummy = a binary variable equaling 1 if a promotional event occurred at the retailer selling bulb pack, *i*, during week *t*; 0 otherwise
ModelNumberDummy = a binary variable equaling 1 for each unique model number; 0 otherwise
MonthDummy = a binary variable equaling 1 in a given month; 0 otherwise

[184] By omitting all "zeroes", some instances of truly zero sales are ignored. However, a review of the data indicates that "true zeros" are a very small proportion of the omitted data. The vast majority represent missing sales data due to non-program pricing.

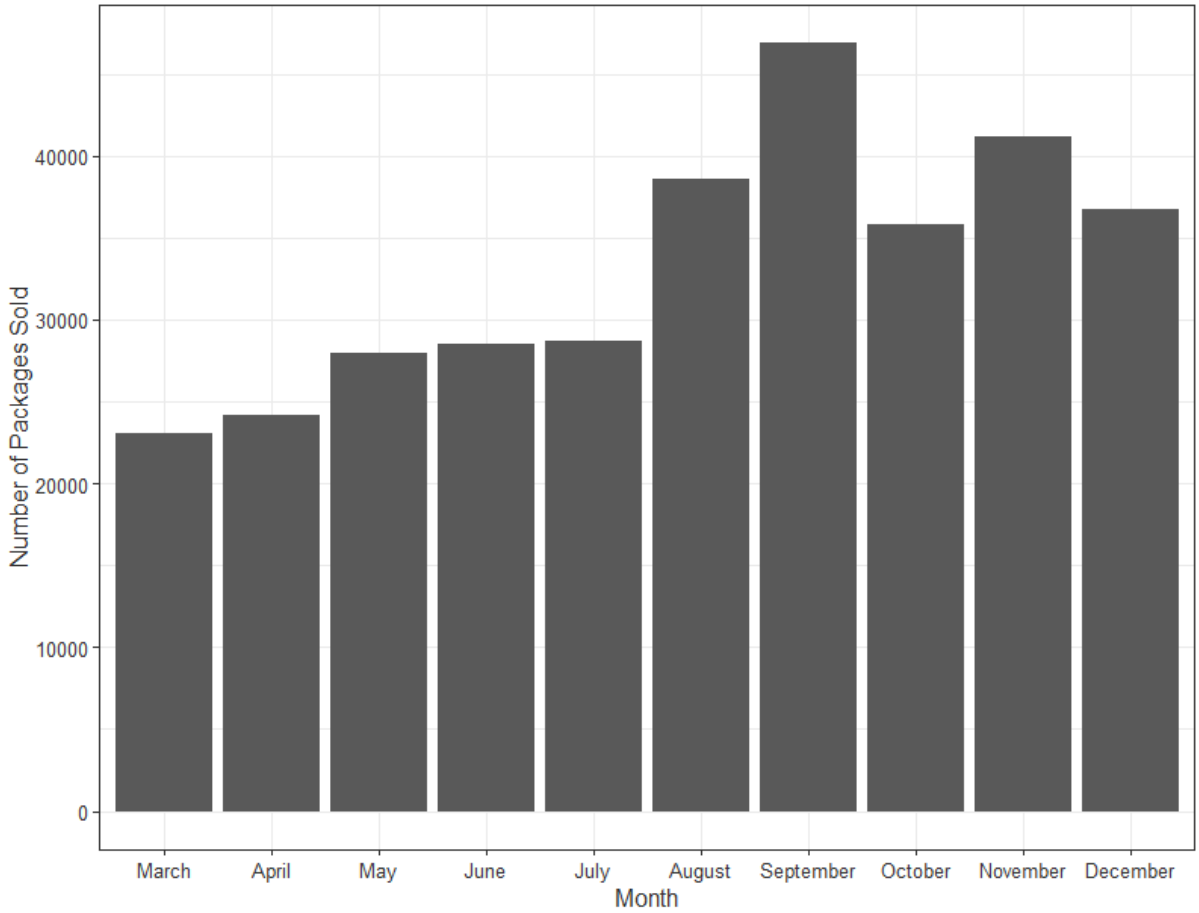
[185] Hurdle models, Poisson models, and zero-inflation models were all considered. However, the nature of the "zero" sales quantities eliminated hurdle and zero-inflation models. Overdispersion eliminated the Poisson model from consideration.

LargeDiscountDummy = a binary variable equaling 1 if the discount on the pack is greater than $10; 0 otherwise

The β_2 coefficient in the model represents average price elasticity of demand holding the effects of all other independent variables constant. The β_3 coefficient captures the impact of promotional events on bulb sales. Under the counterfactual scenario where no program exists, the EventDummy variable is always zero, indicating the absence of program sponsored promotional events. In some cases, there were multiple promotional events at a given retailer during a single sales period, however, ADM used a binary indicator variable to indicate promotional events in all cases. To the extent that the program influenced positive product placement, there may have been additional sales independent of price changes. Therefore, the free ridership values estimated through this model may be conservative because they do not account for the effects of the featured placements. The coefficient β_4 captures the impact of how many bulbs are in the package. This ensures the price elasticity estimate is as accurate as possible by not only taking into consideration the price of the pack, but how many bulbs one gets for that price as well.

The β_π and β_γ coefficient captures the impact of light bulb model and seasonality on sales volume, respectively. Figure H-1 shows total package sales by during each month of PY2019 and demonstrates clear demand fluctuation across months. Note that January and February were not included, as sales data for these months were not available. The sales volume variation is partly due to naturally occurring seasonality in bulb sales, and partly due to variations in program intensity (i.e., funding, discount levels). Inclusion of the month indicator variables help capture some of the sales volume variation attributable to the program intensity, thus potentially biasing the free ridership estimate upwards. The alternative specification (leaving the month indicator variables out of the model) could potentially attribute naturally occurring sales increases to the program. Since both approaches have inherent uncertainty, the more conservative approach (in terms of free ridership estimation) was used by including the month indicator variables. Finally, β_ρ captures the effect of large package discounts on how many bulbs are sold. These cases are rare and thus harder to predict without allowing for a variable like this one to capture the effects of these odd cases.

Figure H-1: PY2019 Package Sales by Month



The tables below show the estimated coefficients and related measures of fit for the final model by bulb type (omni-directional LED and directional LED). Using the coefficients from the model, ADM was able to estimate bulb sales under various conditions. To estimate a free ridership ratio, ADM used the model to estimate what bulb sales would have been at the original retail price and absent any in-store promotional events.

Table H-3: Negative Binomial Regression - Price Response Model for Standard LEDs (Dependent Variable: Bulb Packages Sold / Week)

Variable	Coefficient	Standard Error	z	p-value
Constant	5.04	0.32	15.536	< 0.001
ln(Price)	-0.15	0.020	-7.427	< 0.001
EventDummy	-0.03	0.021	-1.411	0.158
August	-0.06	0.041	-1.549	0.121
December	-0.07	0.048	-1.562	0.118
February	0.24	0.102	2.324	0.020
July	-0.12	0.041	-2.995	0.002
June	-0.09	0.039	-2.430	0.015
March	0.08	0.039	1.965	0.049
May	-0.07	0.040	-1.658	0.097
November	0.019	0.040	0.482	0.629
October	0.07	0.040	-1.840	0.065
September	-0.05	0.039	-1.307	0.191
LargeDiscountDummies	0.61	0.193	3.165	0.002
ModelNumberDummies	OMITTED			

Table H-4: Negative Binomial Regression - Price Response Model for Specialty LEDs (Dependent Variable: Bulb Packages Sold / Week)

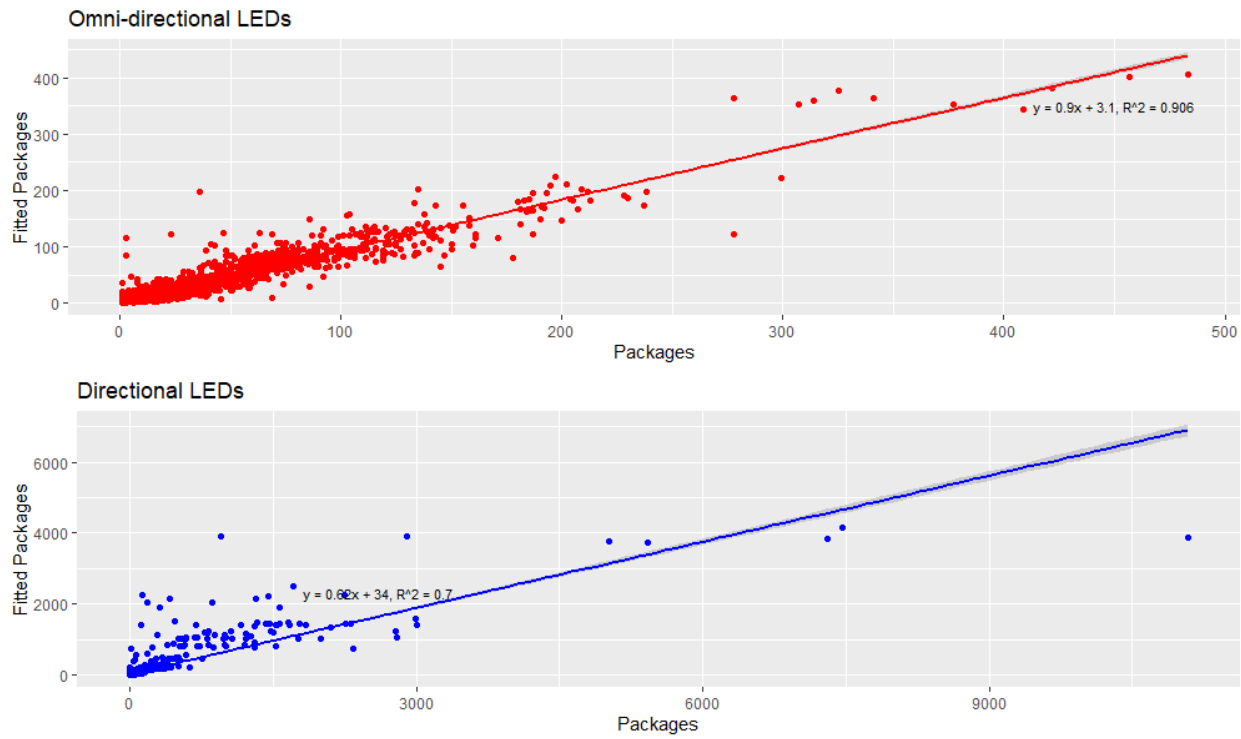
Variable	Coefficient	Standard Error	z	p-value
Constant	6.96	0.266	26.149	< 0.001
ln(Price)	-0.09	0.022	-3.970	< 0.001
EventDummy	0.03	0.025	1.085	0.278
August	-0.13	0.0436	-2.987	0.002
December	0.01	0.047	0.121	0.903
February	0.16	0.126	1.256	0.209
July	-0.13	0.042	-3.029	0.002
June	-0.12	0.040	-2.821	0.004
March	-0.10	0.042	-2.297	0.021
May	-0.06	0.041	-1.518	0.128
November	-0.05	0.043	-1.242	0.214
October	-0.16	0.044	-3.585	< 0.001
September	-0.19	0.043	-4.347	< 0.001
Packsize	-1.48	0.157	-9.401	< 0.001
ModelNumberDummies	OMITTED			

Table H-5: Negative Binomial Regression - Price Response Model for all Bulb Types Summary Statistics

Bulb Type	Null Deviance	Null Degrees of Freedom	Log-likelihood	AIC	BIC	Residual Deviance	Residual Degrees of Freedom
Omni-directional LED	18,614.5	2,176	-15,108.367	15,514.37	16,668.56	2,423.3	1,975
Directional LED	52,314.1	2,817	20,611.508	20,927.51	21,866.63	2,846.6	2,661

Figure H-2 below shows actual weekly package sales vs. model fitted quantities for standard omni-directional LEDs and directional LEDs. Included is a linear regression fit of the total number of packages versus the fitted number of packages based on the price response model by bulb type (the gray area around the line of fit represents the 95% standard error).

Figure H-2: Actual Packages vs. Fitted Package Sales – Price Response Model



H.2.2 Free Ridership Estimation Results

Free ridership ratios were calculated for the program as follows. First, the price response model was used to estimated bulb package sales under program and non-program pricing scenarios. The non-program scenario represents pricing at original retail levels along with the absence of any program sponsored promotional events. Bulb package sales under both scenarios were then multiplied by the number of bulbs per package to arrive at total bulb sales under the program and non-program scenarios. Finally, deemed savings values (gross kWh) from the OKDSD were applied to the estimated number of bulbs sold under both scenarios.[186] A free ridership ratio was calculated using the following formula:

Equation H-2: Free Ridership Methodology

$$Free\ ridership\ ratio = \frac{\sum_i^n (E[Bulbs_{NoProgram_i}] * kWh_i)}{\sum_i^n (E[Bulbs_{Program_i}] * kWh_i)}$$

Where:

$E[Bulbs_{NoProgram_i}]$ = the expected number of bulbs of type, *i*, purchased given original retail pricing (as predicted by the model).

[186] The deemed gross kWh savings values were applied on a model-by-model basis, given actual bulb wattages and equivalent baseline wattages as specified in the deemed savings documents.

$E[Bulbs_{Program_i}]$ = the expected number of bulbs of type, *i*, given program discounted pricing (as predicted by the model).

kWh_i = The average gross kWh savings for bulb type, *i*.

The free ridership ratio is then subtracted from one to develop a net-to-gross ratio (NTRG) estimate for comparison with the other attribution estimates developed in this evaluation. This NTGR estimate does not include any estimate of spillover or market effects. As such, it should be considered a partial estimate of the true NTGR and may understate the true effects of the program.

The final free ridership estimate was determined by taking the weighted average of both bulb types' free ridership estimates, where the weights were the number of bulbs sold per bulb type. The final free ridership estimate calculated using the price response model for the overall program is 42.4%, as shown in the table below.

Table H-6: Price Response Model Free Ridership Estimates

Bulb Type	Estimated Free Ridership	Estimated Net-to-Gross
Omni-Directional LEDs	0.521	0.479
Directional LEDs	0.404	0.596
Overall	**0.424**	**0.576**

H.2.3 Strengths and Weaknesses of the Approach

The price response model was just one of several approaches used to estimate free ridership for the retail lighting discounts portion of the Energy Saving Products program. There are several advantages to the price response model, as well as several drawbacks. Advantages include:

- Estimate is developed from actual sales data as opposed to customer self-report data
- The approach considers the effects of program pricing and program promotional events
- The approach can provide some results by bulb type and retailer type

Disadvantages include:

- Prediction outside of program pricing. The free ridership estimates are developed using sales and pricing data variation within the program. If a certain package of bulbs normally sells for $8.99, but the program sales data only includes pricing from $1.99 to $3.99, the model must estimate for "out-of-sample" pricing to predict sales volume under non-program conditions.

- The model likely does not include all variables that affect LED sales, which presents the potential for omitted variable bias. In particular, the pricing and sale quantities of non-program bulbs are likely of importance. Different types of light bulbs are substitute goods with positive cross-price elasticity. The purchasing behavior for LEDs is determined not only by their own pricing, but also by the pricing of other, less efficient but interchangeable bulbs. In addition, stocking patterns of bulbs are not considered in this model.
- The approach is also subject to inherent error associated with statistical modeling.