Public Service Company of Oklahoma 2020 Energy Efficiency & Demand Response Programs: Annual Report

Prepared for:

Oklahoma Corporation Commission

In accordance with annual reporting requirements:
Title 165: Oklahoma Corporation Commission
Chapter 35. Electric Utility Rules
Subchapter 41. Demand Programs
165:35-41-7. Reporting

March 2021

Prepared by:

ADM Associates, Inc.
3239 Ramos Circle
Sacramento, CA95827
916.363.8383

Table of Contents

List of Figures

List of Tables

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 2020. 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 second program year (PY2020) of the implementation cycle, spanning from January 1, 2020 to December 31, 2020.[1]

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

- **Projected Impacts** refer to the annual 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 annual energy savings (kWh) and peak demand (kW) reduction estimates based on actual customer participation in PY2020 before program evaluation activities.
- **Verified Impacts** refer to energy savings (kWh) and peak demand (kW) reduction estimates for PY2020 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.

All impacts presented in this report represent energy savings or peak demand reduction at-the-meter except for Section 1.4, Appendix B, Appendix C, and Appendix D, where

[1] All the programs represent program participation from January 1, 2020 – December 31, 2020, except the Energy Saving Products Program. The reported savings for LED retail discounts span the time period of December 1, 2019 – November 30, 2020. This 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 H.

impacts are presented at the generator. At-the-generator impacts are adjusted using an estimated line loss factor of 1.0586 for energy efficiency and 1.0781 for demand. Program impacts including projected, reported, and verified annual energy savings and peak demand reduction during 2020 are summarized in the following sections.

1.1 2020 Program Offerings

In 2020, PSO offered customers eight energy-efficiency programs that includes 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, program year 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 1st, 2020
Multi-Family	Residential & Commercial	January 1st, 2020
Home Weatherization	Low-Income Residential	January 1st, 2020
Energy Saving Products	Residential	December 1st, 2019
Homes Rebates	Residential	January 1st, 2020
Education	Residential	January 1st, 2020
Behavioral Modification	Residential	January 1st, 2020
Conservation Voltage Reduction	Multiple Classes	January 1st, 2020
Demand Response Programs		
Power Hours	Residential	January 1st, 2020
Business Demand Response	Commercial & Industrial	January 1st, 2020

1.2 Summary of Energy Impacts

At the portfolio level, reported annual energy savings for the program year were 147,573 MWh. Total gross verified annual energy savings were 154,399 MWh, resulting in a realization rate for gross energy savings of 105%.

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 85%, resulting in a net annual energy savings of 131,870 MWh. Table 1-2 summarizes the energy impacts of PSO's energy efficiency and demand response programs for the program year.

Table 1-2: Summary of Gross Energy Impacts – PY2020[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	41,129	45,328	47,421	105%	94%	44,396
Multi-Family	1,728	3,114	3,112	100%	100%	3,106
Home Weatherization	2,328	4,258	4,240	100%	100%	4,240
Energy Saving Products	36,382	47,019	51,665	110%	64%	33,256
Home Rebates	7,288	6,249	6,067	97%	88%	5,313
Education	4,395	3,787	3,596	95%	100%	3,596
Behavioral	20,790	19,980	21,063	105%	100%	21,063
Conservation Voltage Reduction	18,124	15,705	14,426	92%	100%	14,426
Energy Efficiency Totals	**132,165**	**145,439**	**151,589**	**104%**	**85%**	**129,396**
Demand Response Programs						
Power Hours	2,047	2,134	2,773	130%	88%	2,438
Business Demand Response	131	0	37	-	100%	37
Demand Response Totals	**2,178**	**2,134**	**2,810**	**132%**	**88%**	**2,475**
Research and Development	**144**	**0**	**0**	**-**	**0%**	**0**
Portfolio Totals	**134,486**	**147,573**	**154,399**	**105%**	**85%**	**131,870**

1.3 Summary of Peak Demand Impacts

At the portfolio level, reported peak demand reduction in the program year was 110.33 MW. Total gross verified peak demand reduction was 85.79 MW. The realization rate for peak demand reduction was 78%. The portfolio-level NTG ratio for peak demand reduction was estimated as 95%, resulting in a net peak demand savings of 81.37 MW.

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

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

Table 1-3: Summary of Demand Impacts – PY2020[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	7.42	7.36	8.31	113%	91%	7.54
Multi-Family	0.30	0.85	0.82	96%	100%	0.82
Home Weatherization	1.12	2.25	2.25	100%	100%	2.25
Energy Saving Products	4.42	7.77	9.24	119%	64%	5.93
Home Rebates	2.76	3.22	2.51	78%	87%	2.22
Education	0.52	0.73	0.74	101%	100%	0.74
Behavioral	3.78	3.70	4.11	111%	100%	4.11
Conservation Voltage Reduction	4.20	0.00	4.17	0%	100%	4.17
Energy Efficiency Totals	**24.50**	**25.89**	**32.14**	**124%**	**86%**	**27.77**
Demand Response Programs						
Power Hours	17.98	16.40	6.24	38%	99%	6.19
Business Demand Response	52.28	68.04	47.41	70%	100%	47.41
Demand Response Totals	**70.25**	**84.45**	**53.65**	**64%**	**100%**	**53.60**
Research and Development	**0.32**	**0.00**	**0.00**[6]	**0%**	**0%**	**0.00**
Portfolio Totals	**95.08**	**110.33**	**85.79**	**78%**	**95%**	**81.37**

Table 1-4 compares the verified net energy impacts to projected net savings for PSO's programs during the program year. The results indicate verified annual energy and peak demand reduction savings of 131,870 and 81.37, respectively. The low net peak demand reductions is the impact of the mild summer temperatures that resulted in only one residential demand event and only test events for business customers.

[5] Rounding may affect totals and net-to-gross ratio multiplication/division in table.
[6] Preliminary results have been calculated but they will not be claimed for the 2020 program year.

Table 1-4: Summary of Net Energy Impacts – PY2020

Program	Projected Net		Verified Net		Percent of Goals/Projections	
	MWh	MW	MWh	MW	MWh	MW
Energy Efficiency Programs						
Business Rebates	37,478	6.74	44,396	7.54	118%	112%
Multi-Family	1,606	0.29	3,106	0.82	193%	286%
Home Weatherization	2,328	1.12	4,240	2.25	182%	201%
Energy Saving Products	18,306	2.22	33,256	5.93	182%	267%
Home Rebates	6,195	2.34	5,313	2.22	84%	93%
Education	3,316	0.39	3,596	0.74	108%	189%
Behavioral	20,790	3.78	21,063	4.11	101%	109%
Conservation Voltage Reduction	18,124	4.20	14,426	4.17	80%	99%
Energy Efficiency Totals	**108,144**	**21.08**	**129,396**	**27.77**	**120%**	**132%**
Demand Response Programs						
Power Hours	1,535	17.98	2,438	6.19	159%	34%
Business Demand Response	131	52.28	37	47.41	28%	91%
Demand Response Totals	**1,666**	**70.25**	**2,475**	**53.60**	**149%**	**76%**
Research and Development	**136**	**.32**	**0**	**0.00**	**0%**	**0%**
Portfolio Totals	**109,946**	**91.65**	**131,870**	**81.37**	**120%**	**89%**

1.4 Summary of Portfolio Benefit-Cost Ratios

ADM calculated the annual cost-effectiveness of PSO's 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$35,212,333. The methods used to calculate cost-effectiveness were informed by the California Standard Practice Manual.[7]

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

[7] 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	4.11	2.58	0.76	2.95	3.65
Multi-Family	1.74	2.29	0.58	2.86	4.42
Home Weatherization	1.97	2.87	0.75	3.45	3.97
Energy Saving Products	7.82	7.95	0.64	12.30	22.49
Home Rebates	0.92	1.41	0.49	1.71	2.97
Education	2.52	2.41	0.59	3.02	4.80
Behavioral	1.19	1.26	0.43	1.26	-
Conservation Voltage Reduction	1.69	1.84	0.67	2.31	-
Total – Energy Efficiency Programs	**2.53**	**2.39**	**0.67**	**2.98**	**5.52**
Demand Response Programs					
Power Hours	1.35	1.58	0.60	1.70	8.03
Business Demand Response	2.87	8.02	2.86	8.02	4.01
Total - Demand Response Programs	**2.24**	**3.87**	**1.48**	**3.95**	**5.51**
Portfolio Averages	**2.50**	**2.47**	**0.75**	**3.04**	**5.52**

Portfolio performance can also be reviewed on a levelized dollar per energy savings (kWh) or dollar per peak demand reduction (kW) 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 lifetime energy savings (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[8]
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 the program year 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 are at the generator and include a line loss adjustment factor of 1.0586.

Table 1-6: Levelized $/kWh for Energy Efficiency Programs[9]

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%)	
2020 Residential[10]	$18,304,249.37	481,606,963	$0.038	420,515,538	$0.044
2020 Commercial[11]	$11,065,966.19	456,156,839	$0.024	396,647,582	$0.028
2020 CVR	$1,126,666.26	215,231,932	$0.055	172,949,860	$0.068
2020 EE Programs	**$30,766,418.73**	**1,152,995,734**	$0.036	**990,112,981**	$0.042

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 demand reduction (kW) per dollar basis.

[8] Calculated as described in Appendix B.
[9] Lifetime savings reduced by 5% societal discount or weighted average cost of capital discount factor.
[10] Residential Programs include: Home Weatherization, Home Rebates, Energy Savings Products, Education, and Behavioral.
[11] Commercial Programs include: Business Rebates and Multi-Family.

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 the program year. The verified net peak demand reduction in Table 1-7 includes a line loss adjustment factor of 1.0781.

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

Program Year	Total Costs	Verified Net Peak Demand Reduction from DR (kW)	$/kW
2020	$4,445,914	58,001	$76.65

1.5 Cumulative Portfolio Performance

This was the second program year for the 2019 – 2021 Demand Portfolio. Portfolio-level energy and demand impact estimates for the program year and historical years are shown in Table 1-8.

Table 1-8: 2019 - 2020 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				
2019	159.20	132.69	29.81	25.16
2020	151.59	129.40	32.14	27.77
Cumulative EE Totals	**310.79**	**262.09**	**61.95**	**52.93**
Demand Response Programs				
2019	2.92	2.57	63.66	63.66
2020	2.81	2.47	53.65	53.60
Cumulative DR Totals	**5.73**	**5.04**	**117.31**	**117.26**
Cumulative Totals	**316.52**	**267.13**	**179.26**	**170.19**

1.6 Summary of Overall Program Satisfaction

Participants from each program were surveyed about their satisfaction with their overall experience with the program. In general, participant satisfaction for the program year is estimated at 91%.[12] Participant satisfaction results by program are summarized in Table 1-9. Process evaluation findings by program are presented in Chapters 3 and 4 of this report.

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

Program	Percent Satisfied
Business Rebates	94%
Multi-Family[13]	100%
Home Weatherization	96%
Energy Saving Products	86%
Homes Rebates - Single Upgrades	92%
Homes Rebates - Multiple Upgrades	95%
Homes Rebates – New Homes[14]	84%
Education[15]	98%
Behavioral[16]	88%
Power Hours	67%
Business Demand Response	97%

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

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

[14] Percent of builders that reported being somewhat satisfied or very satisfied with the overall PSO New Homes program.

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

[16] 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 2020. 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 PY2020. ADM's evaluation findings for each energy efficiency program are provided in Chapter 3 of this report, evaluation findings for the demand response program are provided in Chapter 4, and evaluation findings for pilot programs are provided in Chapter 5.

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	30.72%	1,284	16
Multi-Family	2.11%	112	17
Home Weatherization	2.89%	2,163	10
Energy Saving Products	31.86%	1,233,128[17]	16
Homes Rebates	4.23%	3,522	20
Education	2.57%	16,001	4
Behavioral	13.54%	193,195	1
Conservation Voltage Reduction	10.64%	27,488	1
Cumulative EE Totals	**98.55%**	**243,765**	**85**
Power Hours	1.45%	23,681	2
Business Demand Response	0.00%	245	1
Cumulative DR Totals	**1.45%**	**23,926**	**3**
Cumulative Portfolio Totals	**100%**	**267,691**	**88**

2.1 Reduced Emissions and Water Consumption

Reduced emissions occur as the result 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 2019, and revised in March of 2019.[18] 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.

[17] Value represents the number of measures for both upstream and downstream. The number of participants for upstream measures is unknown and there were 1720 downstream participants.
[18] 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 (CO_2) (lb/MWh)	Methane (CH_4) (lb/GWh)	Nitrous oxide (N_2O) (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 2020 results in the estimated emissions reductions listed in Table 2-3.

Table 2-3: Emission Reduction Estimates

Lifetime Energy Savings[19] (Net at Generator) (MWh)	Carbon dioxide reduction (CO_2) (tonnes)	Methane reduction (CH_4) (tonnes)	Nitrous oxide reduction (N_2O) (tonnes)
1,635,943	1,233,695	89.79	14.10

Reductions in water consumption at participant homes/facilities resulting from PSO's 2020 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, 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 PY2020.

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 in 2020 was made up of coal (~8%), natural gas (~21%), purchased power non-wind (~50%) 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,

[19] 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 2020 portfolio, and a line-loss adjustment factor of 1.0611.

as the steam itself circulates in a closed system. A portion of the water used for this 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)[20] provides estimates of water consumption per MWh 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 2020 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 MWh Consumed (Gallons/MWh)	Lifetime Water Savings (Gallons)
1,635,943	78%	510	650,778,051

2.2 Milestones Achieved in Market Transformation Programs

While eight 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 2020 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.

Starting in 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.

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

Home Rebates – New Homes: The program provides educational trainings for both builders and raters that influence energy efficiency offerings in building performance and new homes. During 2020, 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. 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 E. 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, for the program year as well as the previous two years.

Table 2-5: Utility Growth Rates 2018 – 2020

Year	Net Sales (GWh)	Sales Growth	Energy at Generator (GWh)	Energy Growth	Peak Demand (MW)	Demand Growth
2018	18,877	5.01%	19,957	4.62%	4,107	2.40%
2019	18,662	-1.14%	19,775	-0.91%	4,104	-0.08%
2020	17,668	-5.33%	18,782	-5.02%	3,884	-5.37%
Compound Growth Rate		-3.26%		-2.99%		-2.76%

Table 2-6 shows weather-normalized annual growth rates and 2018 - 2020 growth rates for utility energy sales by customer class.

Table 2-6: 2018 – 2020 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**
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%
2020	6,336	3.27%	4,712	-4.45%	5,711	-7.23%	1,202	-3.08%	17,961	-2.72%	8	-0.27%	17,969	-2.72%
Compound Growth Rate		1.75%		-2.38%		-3.43%		-2.05%		-1.31%		-3.20%		-1.31%

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

Table 2-7: 2020 Demand Portfolio Funding

2020 Demand Portfolio Program Cost ($M)	$35.2
2020 Operating Revenues ($M) Preliminary Estimate	$1,500
Program Cost as % of Utility Operating Revenue	2.3%

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

Table 2-8: 2020 Net Demand Portfolio Energy Savings

2020 Demand Portfolio Net Energy Savings (GWh)	132
2020 Metered Energy Sales (GWh)	17,668
Savings as % of Utility Sales	0.75%

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 the program year, and the opt out percentage of total energy sales.

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

Metric	2020	
	Opt-out eligible	Chose to opt-out -EE
Number of accounts	8,111	4,406
2020 Electric Sales (GWh)	6,420	6,270
Aggregate load as a percentage of total sales	36.3%	35.5%

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	2020	
	Opt-out eligible	Chose to opt-out -DR
Number of accounts	8,111	4,324
2020 Electric Sales (GWh)	6,420	6,010
Aggregate load as a percentage of total sales	36.3%	34.0%

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 the program year. 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 has ten full-time employees dedicated to the implementation of energy efficiency and demand response programs. 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 D.

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 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 Belo, formerly known as Cubic Creative. Examples of marketing materials used during the program year to promote PSO's energy efficiency and demand response programs are provided in Appendix F.

For most programs in the program year 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 E. During the program year, PSO's energy efficiency and demand response programs sponsored:

- 48 in-store residential lighting promotional events
- 51 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 and fourth quarters of the program year, ADM completed surveying and interview efforts for the process evaluation. Program participants, service providers, and program staff were largely satisfied with the program year portfolio offerings. Key process evaluation-related findings are summarized below. Additional findings are presented in Chapters 3 and 4.

2.8.1 Business Rebates

2.8.1.1 Prescriptive & Custom and Small Business Energy Solutions (SBES)

- Prescriptive and Custom as well as SBES 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.

- 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.
- Findings from trade ally and staff interviews indicate the Prescriptive and Custom and SBES programs were able to maintain strong participation in 2020, building upon past year's successes and outreach methods.
- Consistent with past program years, SBES and Prescriptive and Custom program satisfaction remains high. Most survey respondents shared high levels of satisfaction across all aspects of the program as well as the programs overall.
- From the trade allies and customers' perspectives, the Prescriptive and Custom Program was implemented successfully in 2020 with generally positive feedback about the program. Though some trade allies and customers noted the program could improve its application requirements or tools as well as the level of support that is offered by Program staff.
- Most program participants indicated that the COVID-19 pandemic had affected their company adversely.

2.8.1.2 Commercial Midstream

- Survey and interview results indicate the program's design and implementation processes are well understood and implemented without significant issues.
- Customer surveys and distributor interviews indicate that COVID-19 affected program sales and customers' ability to take advantage of the PSO discounts.
- HVAC distributor interviews suggest there is growing understanding and acceptance of the Midstream Program's design, though some distributors still have reservations and concerns.
- Lighting end use customer survey results indicate the Midstream Program discount played an important role in customer's decision to buy energy efficient lighting. Some HVAC end use customers indicated prior plans to purchase energy efficient equipment before learning of program incentives.
- Survey and interview results indicate the Midstream Program is serving a wide variety of business types and size, though lighting distributor interviews and end user survey results indicate there is potential to expand the reach of the program by diversifying the types of lighting products that are discounted through the program.
- ADM found that HVAC end users had varying levels of awareness about the program discount, their company's decision-making process, and the HVAC distributor that sold their company the equipment. Lighting end user surveys

showed customers were generally more aware of the discount, decision making process, and lighting distributor.

2.8.2 Multi-Family

- Program staff indicated that efforts to recruit participants in PY2019 led to sustained interest and awareness in PY2020 from multifamily property owners and managers. Decision maker survey responses suggest that the program's service providers play a crucial role in recruiting participants.
- The decision maker survey results show high overall satisfaction with the program.

2.8.3 Home Weatherization

- The addition of mobile homes to the program in PY2020 allowed additional customers to benefit from the program's services.
- Nearly one-third of survey respondents said that they had heard about the program from word-of-mouth from a friend, relative, or colleague. Program staff also reported that a significant portion of participants had been referred by a past participant.
- Consistent with ADM's past customer surveys, most survey respondents were satisfied with the program overall, the measures they received, as well as with PSO as their electric utility.

2.8.4 Energy Saving Products

2.8.4.1 Cross-cutting Findings

- Most program participants purchased their rebated products within Tulsa, Wagoner, and Comanche counties. Furthermore, most of the upstream rebated measures (lighting and non-lighting) were purchased from Lowe's and Home Depot. Advanced power strips were primarily bought from the Dollar General and Dollar Tree stores.
- Program experienced changes to incentive value to offset effects of COVID-19. Program staff indicated they adjusted some of their incentive values at the beginning of the pandemic to prevent sale losses. According to staff, more people decided to invest money in home improvements during PY2020.
- Sales representatives had to change their engagement strategies due to the pandemic. The sales representative's information station for 2020 now plays a recurring video clip about LED lightbulbs, there are additional handouts and other information materials on the table, and the sales representative stands a few feet

away to reduce potential viral transmission. According to staff, retailers have been satisfied with the new set-up. Program staff believes they will most likely create new media focusing on lighting and non-lighting measures in the future.

2.8.4.2 Upstream Measures

- Fifty-eight percent of customer respondents indicated they purchased their LED light bulbs from Walmart, 33% from Lowe's, and 22% from The Home Depot. However, many of the respondents did not know the bulbs' prices had decreased (78%). Overall, survey participants reported they were satisfied with the quality of the bulbs (77%) and the savings on the electricity bills since installing the LEDs (39%).
- In general, participants reported to be satisfied or very satisfied with the quality of the measure they purchased. However, customers who purchased an advanced power strip and air filters were not satisfied with the noticeable savings their monthly bill reported after installing the measures.
- Survey respondents stated they have increased the time they spent in their homes (74%) and 75% stated the bills increased by about $10 every month since the onset of the pandemic. However, participants indicated the pandemic did not affect their ability to participate in the PSO energy efficiency programs (48%).

2.8.4.3 Downstream Measures

- Fifty-eight percent of participants learned about the rebate when they made the purchase or through a salesperson (54%). Many customers chose to buy a clothes washer, dryer, or refrigerator to save money with their energy bills, so they purchased energy efficient equipment to replace their existing appliance.
- Most survey participants reported high levels of satisfaction regarding the rebate program overall (86%), application process (74%), the quality of the rebated appliances (75%), and rebate turnaround times (70%).

2.8.4.4 Level 2 EV Charger

- Despite the pandemic, program staff indicated they were able to improve their relationships and communication among many car dealers and other important stakeholders involved with electric vehicles. However, program participation did not increase during 2020, so program staff continues to try and partner with other PSO energy efficiency programs to improve recruitment. Program staff is also encouraging dealerships to partner with community associations interested in electric transportation.

2.8.5 Home Rebates

2.8.5.1 New Homes

- Although residential construction was declared an essential business in Oklahoma, COVID-19 affected the supply chain and labor workforce. Many people decided to buy homes during the program year, however, there are not enough homes being built in part due to labor shortages. Additionally, the only two HERs Raters available for home audits have been overwhelmed by the recent demand, according to the interviewees.
- For three of the six builders, PSO's financial incentive is very important for their company. On average, a PSO program-qualifying home can cost a builder from $3,000 to $10,000 (depending on the square footage) more compared to a house not built to program standards. All home builders trust PSO to provide reliable sources about energy efficient building techniques or practices.
- Homebuilders with smaller projects will build approximately ten to twenty homes this year, while companies with more extensive projects expect to build 150 to 200 homes by the end of the program year. Yet, builders indicated they were unsure of the future state of the housing market for 2021. The economic ramifications of the COVID-19 pandemic have affected interest rates, supply chains, and the sector's labor force.
- In general, builders noted that their clients are aware the houses are built to energy efficiency standards but are unsure if the buyers know about PSO's rebate. Furthermore, four out of the six builders indicated the number of eligible homes would increase.

2.8.5.2 Multiple Upgrades

- Changes in program operations allowed service providers to install more measures and increase their participation in the program. For in-home installations, PSO developed a best practices guideline that included the step-by-step installation procedure as well as recommended safety protocol. Interviewees indicated the change in process has increased participation among service providers, which is why PSO has decided to discontinue conducting in-person test-ins for next year.
- To ensure HVAC sales continued despite the pandemic, PSO decided to offer an additional $500 HVAC bonus from June 1st to July 15th, a total discount of $1,000 for an HVAC. Program staff indicated they used billboard and Facebook ads to promote the incentive. As a result, the HVAC sales doubled, and many customers purchased 16 SEER rated units.

- This year, the program conducted a pilot for HVAC tune-ups for homes. The implementer indicated the pilot was successful and cost effective. There are plans to launch the program statewide for 2021.
- Most participants have increased the amount of time they spend at home due to the coronavirus pandemic. They indicated that they were more aware of the advantages of energy efficiency since the upgrades were made to their homes, but most also reported that they have not changed their thermostats to save energy, nor have they visited the PowerForwardwithPSO.com website where they could learn more about energy saving and additional programs.
- Program participants were generally satisfied with their contractors and with PSO program staff. The trade allies, too, had positive feedback for the program staff and indicated that their communication with program staff was helpful. None of the trade allies had any issues with the Third-Party Verifiers (TPV), and they reported their program training in 2020 to be helpful.

2.8.5.3 Single Upgrade

- To assess quality of Single Upgrade projects remotely, program staff indicated they utilized their Geo-tagging tool to verify the installations. The implementer indicated that desktop QA rose to almost 90% during the program year.
- Most participants have increased the amount of time they spend at home due to the coronavirus pandemic. They indicated that they were more aware of the advantages of energy efficiency since the upgrades were made to their homes, but most also reported that they did not visit the PowerForwardwithPSO.com website where they could learn more about energy saving and additional programs.
- Program participants were generally satisfied with their contractors and with PSO program staff. The trade allies, too, had positive feedback for the program staff and indicated that their communication with program staff was helpful. They also indicated that the program staff could be quicker in responding to questions. None of the trade allies had any issues with the Third-Party Verifiers (TPV), and they reported their program training in 2020 to be helpful.

2.8.6 Education

- Parents, teachers, and students were highly satisfied with the program. Parents indicated high levels of satisfaction with the program kit and curriculum and 92% of students rated the program “good” or “excellent”. In addition, ADM’s survey of teachers found that 98% of teachers would like to participate in the program again, and PSO’s survey of teachers found that all the 72 teachers surveyed would recommend the program to others.

- The Program succeeded in educating students about energy and energy efficiency. Analysis of the scores on program quizzes found that student scores increased by an average of 22%, from an average of 60% before the teachers taught the curriculum, to an average of 82% after completing the curriculum.
- The pandemic did not affect program goals. Implementers indicated they received a low response rate from the recruitment emails sent to most teachers this year, so they opted to call them instead. According to interviewees, some teachers appreciated the phone calls and expressed that emails were no longer the most effective way to communicate with them.
- PSO staff stated they revamped the look of the school kits for this year, but the measures in the kit remained the same. Additionally, program staff stated they examined the workbooks and made any necessary updates. Implementers indicated they have provided teachers with digital materials if they needed or wanted to present the lessons and activities online.
- Many of the survey participants have previously participated in the program. Seventy-eight percent of respondents indicated they had participated in the School Kits program prior to the 2020 school year, with 20% indicating this was the first year they had participated. Among the teachers who responded to the survey, 69% indicated they had participated in the School Kits program for more than three years.
- Most teachers stated they actively engaged with the kits this year. Teachers reported spending, on average, about 15 hours teaching the Super Power Saver curriculum. Sixty-nine percent of teachers reported that they presented some material from the Super Power Savers curriculum every day until it was covered. Fifty percent of survey respondents indicated they took two to three weeks covering the curriculum, followed by 32% who stated it took them one week or less. Most teachers agreed that the program curriculum was up to date and relevant, was appropriate for the learning level of their students, and was a useful learning tool.
- The pandemic created some challenges for teachers. Teachers reported the pandemic affected their ability to complete all the lesson plans (46%), classroom activities (57%), or distribute kits (27%). Some teachers shared their experience with distance and virtual learning. Many expressed it was difficult to implement some of the activities.
- According to participants, the information in the kits complemented or enriched their curriculums. Most teachers (68%) reported teaching concepts that they normally teach in their regular curriculum. Many teachers indicated they would most likely have not taught students about energy efficiency or their instruction on

the subject would have been limited. Many indicated the student kits are a great component that adds additional value to their own curriculum and instruction.

- Most teachers received positive feedback from their students regarding the program. Eighty-three percent of survey participants agreed that their students were engaged with the lessons and 90% agreed their students demonstrated a better comprehension of energy efficiency from the lessons. A plurality of teachers (45%) gave students less than one week to return their completed survey, followed by 36% who gave one to two weeks.

2.8.7 Behavioral Modification

- Program Staff indicated engagement this year increased due to modifications in the energy report template. The changes have increased engagement with the call center, improved the types of questions participants receive in the quizzes, and increased registration to the web portal reported program staff. Staff also stated they have included a fourth wave to their program.
- The rewards program increased engagement and participant retention during the program year, according to staff. This year, the program offered rewards for completing ongoing activities. Participants had the chance to earn points for registering in the program, completing an online profile, have consecutive logins, and even enrolling in PSO’s Power Hours program. Logging onto the portal was associated with taking energy-saving actions, including buying energy efficient equipment.
- Respondents generally reported the information in the HER was easy to understand, that the information on their home’s energy use was accurate and valuable, and that the reports influenced them to take energy-saving actions. They also were generally satisfied with the method and frequency of receiving the HER, the information provided in it, and the number of PSO emails they received on their home’s energy use. A large majority of respondents reported that their knowledge of energy efficiency has increased since they started receiving HERs. In the end, most respondents said either their opinion toward PSO had improved or had not changed since receiving the reports.
- Just over one-half of respondents reported participating in Smart Energy Rewards. The most common activities were taking a quiz and filling out the My Energy Advisor profile.
- About one-quarter of respondents reported they had purchased or installed energy efficient equipment or appliances other than lighting in 2020. The most common items were ENERGY STAR® appliances. Higher rated program influence was

related to purchasing or installing more equipment. A large majority of respondents reported buying LED bulbs in 2020.

2.8.8 Power Hours

- Program staff indicated the program exceeded its enrollment goal of 3,000 participants for this year. With more customers using smart thermostats, the staff continues to explore how to expand their thermostat selection for their customers.
- Program staff indicated they revamped their website and added a new feature to the online enrollment process. They also added more how-to videos on the program's website, changed some of the wording used, improved the impact of network traffic on the Power Hours website, and included more tips for customers about saving energy. The online application now has a new feature where the customer can see the completion percentage during their application process.
- Marketing strategies implemented for 2020 improved participant engagement overall. Program staff and the implementation team sent a variety of email campaigns that varied in objective and target audience. Program staff indicated they received positive feedback from all their campaigns. For PY2020, the staff were able to participate in several community events prior to the COVID-19 pandemic. They used a mobile van that featured educational videos about all the programs. According to the program supervisor, the public responded positively toward the mobile van.
- Staff indicated they had one event the entire summer because of mild weather patterns. Program staff scheduled the event in July and reiterated they did not give notifications before the event to prevent people from precooling. Customers do, however, receive a notification during the event.
- Seventy-eight percent of respondents stated they enrolled online. More than half (62%) of survey respondents reported visiting the PSO website to learn more about the Power Hours program. Of the respondents who have gone online to learn about the program, 92% indicated they had a better understanding of Power Hours after visiting the website (n = 109).
- The per event incentive had an impact on decisions not to opt-out of an event. Thirty-six percent of participants stated the incentive prevented them from opting out of an event to a great degree, and 37% said that it did not prevent them from opting out at all.
- Over 80% of survey participants reported either completely or somewhat understanding how the Time of Day (TOD) subprogram works. 22% of survey respondents did not find it challenging to reduce electricity usage during the on-

peak hours, while 9% found it to be a great challenge. Most participants (80%) had installed a phone app to use with their smart thermostat. Among those who installed a phone app, many reported using it to adjust their home temperature, set temperature schedules, monitor the home temperature when away from home, control HVAC systems, and for geofencing.

- Seventy-one percent of survey respondents indicated they increased their time at home since the onset of the pandemic. More than half (64%) noticed their bills had increased by about $10 a month or more. The survey results suggest the pandemic did not significantly impact customers' ability to participate in energy efficiency programs.
- More than half of survey respondents (67%) were very or somewhat satisfied with Power Hours. The program's most popular aspect was the rebate that customers received for purchasing a smart thermostat, and the least popular aspect was the bill credits.

2.8.9 Business Demand Response

- Most current program participants are located throughout the PSO territory. Most organizations are in Wagoner (21%), Tulsa (17%), and Comanche counties (8%). The businesses also vary in size and industry sector. The top three facility types that participated during the program year were K-12 schools (29%), offices, and industrial/ manufacturing facility (11%).
- Oklahoma experienced a mild summer, according to program staff, so they conducted test events rather than peak events. Test events are stipulated in the program contract and need to be conducted before the second Friday of June. Staff indicated they send reminder emails regarding test events.
- Most of the survey respondents play a managerial (45%) or administrative role (20%) in their company or organization. Most of the respondents work in education K-12 schools (27%) or the industrial/manufacturing sector (22%). The respondents expressed they had been responsible for signing up their organization to program (67%) and becoming the key contact for program staff (67%). They are also responsible for communicating the days and times of an event to everyone at the organization.
- There was a total of four test events. Each organization had the liberty of choosing the date. They could tailor the date to their specific needs. Organizations needed to participate in one of those dates. Although Peak Performers program description states there could be up to 12 events conducted in a program year, organizations prefer to participate in almost half the amount (average score = 5.87, same score for standard deviation calculation).

- Although there were no peak events due to the mild weather, 85% of survey respondents indicated the coronavirus pandemic did affect them during that time-period. Of the organizations affected by the pandemic, 67% indicated they had been impacted or greatly impacted. Yet, COVID-19 did not affect the organizations' abilities to reduce energy during a test event (68%).
- Overall, 97% of participants were satisfied with the program in the program year. Peak Performer participants indicated the event notification process (93%), incentive amount (87%), and the energy usage data available to them while participating in the program (73%) were satisfactory. Seventy-four percent have already recommended the program to others, and 95% stated they plan to participate in the Peak Performers for PY2021.

3 Energy-Efficiency Programs

PSO's energy-efficiency portfolio in 2020 consisted of ten programs: five residential, one commercial/industrial, two cross-sector programs and two demand response programs. This chapter reports on the energy efficiency programs. Chapter four reports on the demand response programs. Energy efficiency programs annual energy impacts 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	Verified Lifetime Savings	Gross Realization Rate	NTG Ratio	Net Annual Energy Savings (MWh)
Energy Efficiency Programs							
Business Rebates	41,129	45,328	47,421	643,321	105%	94%	44,396
Multi-Family	1,728	3,114	3,112	40,584	100%	100%	3,106
Home Weatherization	2,328	4,258	4,240	72,157	100%	100%	4,240
Energy Saving Products	36,382	47,019	51,665	597,584	110%	64%	33,256
Home Rebates	7,288	6,249	6,067	109,233	97%	86%	5,313
Education	4,395	3,787	3,596	36,939	95%	100%	3,596
Behavioral	20,790	19,980	21,063	21,063	105%	100%	21,063
Conservation Voltage Reduction	18,124	15,705	14,426	360,647	92%	100%	14,426
Energy Efficiency Totals	**132,165**	**145,439**	**151,589**	**1,881,527**	**104%**	**85%**	**129,396**

Program-level peak demand reduction (kW) for the energy efficiency programs 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	7.42	7.36	8.31	113%	91%	7.54
Multi-Family	0.30	0.85	0.82	96%	100%	0.82
Home Weatherization	1.12	2.25	2.25	100%	100%	2.25
Energy Saving Products	4.42	7.77	9.24	119%	64%	5.93
Home Rebates	2.76	3.22	2.51	78%	87%	2.22
Education	0.52	0.73	0.74	101%	100%	0.74
Behavioral	3.78	3.70	4.11	111%	100%	4.11
Conservation Voltage Reduction	4.20	0.00	4.17	0%	100%	4.17
Energy Efficiency Totals	**24.50**	**25.89**	**32.14**	**124%**	**86%**	**27.77**

The remainder of this section provides evaluation findings for each of the program year 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 a range of energy efficiency measures for small businesses, large businesses, schools, municipalities, and industrial businesses to participate in receiving an incentive to reduce energy consumption. The Business Rebates Program offered subprograms of Small Business Energy Solutions (SBES), Midstream, and Custom and Prescriptive (C&P). The program offers incentives for many measures including lighting, plug load & controls, Insulation, Windows & Doors, Appliance & Equipment, HVAC, and Refrigeration.

To participate in the Small Business Energy Solutions (SBES) subprogram, businesses must use 220,000 kWh or less annually (2 GWh aggregated annually) and use a PSO approved service provider. Current energy efficiency offerings in this subprogram include lighting and refrigeration.

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. This subprogram allows customers to receive instant rebates on qualifying equipment.

The Custom & Prescriptive path allows all business types and sizes to participate through a large offering of energy efficiency measures. In addition to the wide range of prescriptive measures, as listed on the Power Forward website[21], customers have additional subprograms to receive incentives through custom applications. Custom applications include a channel for Oil & Gas and Agriculture projects as well as Energy Coaching. PSO has partnered with Trane to conduct free preliminary assessments to determine energy efficiency potential. If potential is found, Trane will conduct a detailed audit to provide recommendations on improvements in operations, controls, and mechanical system equipment.

The Business Rebates Program exceeded annual energy savings goals within budget for the 2020 program year. 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 subprogram and measure are presented in this chapter.

[21] https://powerforwardwithpso.com/business/rebates/

Table 3-3: Performance Metrics – Business Rebates Program

Metric	PY2020
Number of Projects	1,284
Budgeted Expenditures	$11,389,217
Actual Expenditures	$10,952,859
Energy Impacts (kWh)	
Projected Energy Savings	41,482,596
Reported Energy Savings	45,327,537
Gross Verified Energy Savings	47,420,753
Net Verified Energy Savings	44,396,059
Peak Demand Impacts (kW)	
Projected Peak Demand Savings	7,491
Reported Peak Demand Savings	7,365
Gross Verified Peak Demand Savings	8,309
Net Verified Peak Demand Savings	7,541
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	2.58
Utility Cost Test Ratio	4.11

The evaluation included a process evaluation as well as an impact evaluation. Evaluation activities included surveying, in-depth interviews, program tracking data review, virtual verification interviews, 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
Virtual M&V interviews (total with desk reviews)	36 (43)	18
Customer Decision Maker Survey	50	37
In-depth Interviews with Program Staff	2	2
Trade Ally Interview	10	4

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% below estimated (ex-ante) annual energy savings.

3.1.2 Custom and Prescriptive

PSO's Business Rebates Program seeks to generate energy savings for custom and prescriptive projects by promoting high-efficiency electric end-use products. 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.

For custom and prescriptive projects, ADM found a 106% realization rate for gross energy savings and a 130% realization rate for gross peak demand reduction. ADM found a lighting net-to-gross ratio for energy savings of 89.5% and 91.5% for peak demand reduction. The non-lighting net-to-gross ratio for energy savings was found to be 94.8% and 83.1% for peak reduction.

3.1.2.1 Impact Evaluation Overview

PSO's prescriptive and custom projects provided rebates for a total of 587 projects. Lighting system retrofit projects continued to be the main source of program savings with approximately 45% of ex-ante annual energy savings (kWh). Custom projects accounted for approximately 28% of ex-ante savings, and projects with multiple measures accounts for approximately 12%. Individual measures within this category differed across 29 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 the percentage of program savings is shown in Table 3-5.

Table 3-5: Measure Type as Percentage of Ex-ante Annual Energy Savings

Aggregated Measure List	Percent of Program
Retrofit Lighting	45%
New Construction Lighting	3%
Multiple	12%
Custom	28%
Oil & Gas	6%
Refrigeration & Kitchen Equipment	4%
Unitary HVAC & VFDs	3%
Agriculture	<1%
Building Envelope	<1%
Total	**100%**

Overall, the number of rebated projects decreased from 850 in PY2019 to 587 in PY2020, however, the gross energy savings realization rate is 106%, while the gross peak demand reduction realization rate is 130%. Table 3-6 provides a summary of Custom and Prescriptive project savings in the program.

Table 3-6: Performance Metrics – Custom & Prescriptive

Metric	PY2020
Number of Projects	587
Energy Impacts (kWh)	
Ex-ante Energy Savings	33,252,191
Gross Ex-post Energy Savings	35,349,714
Net Ex-post Energy Savings	32,617,773
Peak Demand Impacts (kW)	
Ex-ante Peak Demand Savings	4,338
Gross Ex-post Peak Demand Savings	5,618
Net Ex-post Peak Demand Savings	5,173
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	2.49
Utility Cost Test Ratio	4.11

3.1.2.2 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 50 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

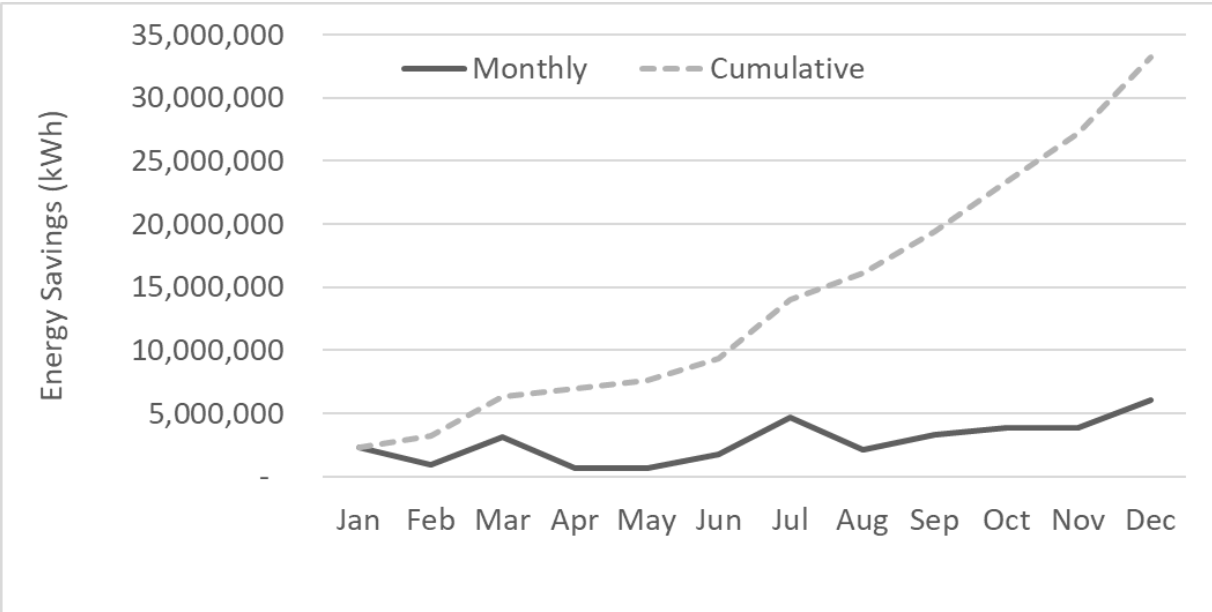


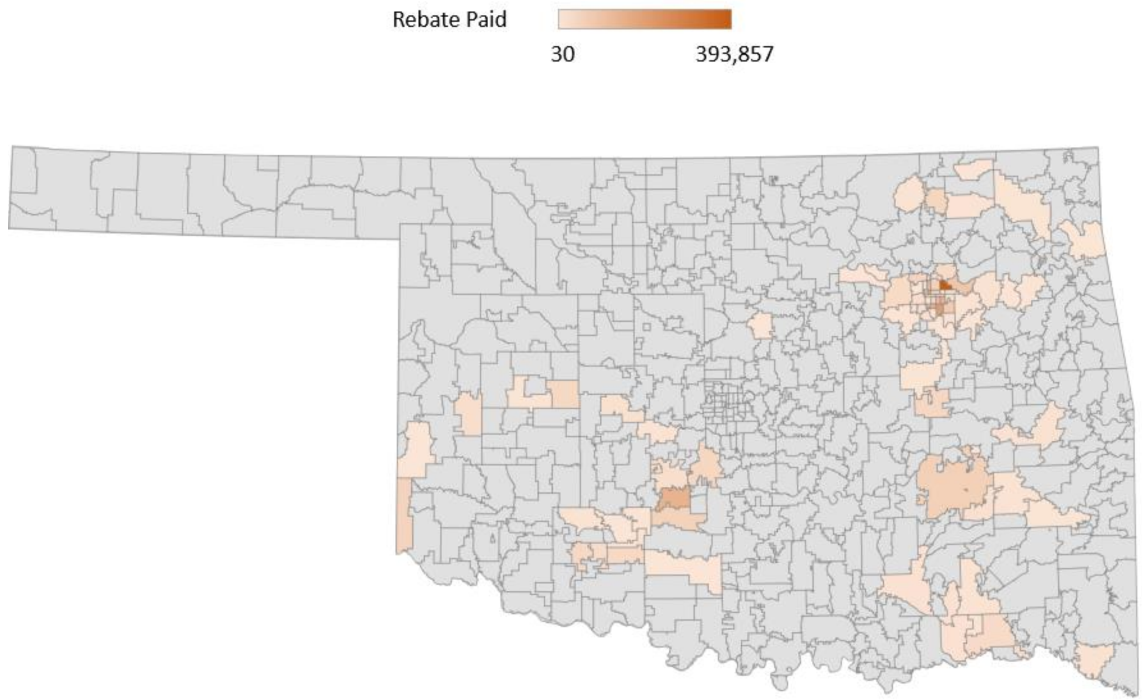
Table 3-7 summarizes the share of ex-ante savings by district. As with past program years, a large amount of savings comes from the Tulsa region; however, compared to the previous program year, the Eastern District saw an increase in annual energy savings.

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	2,330,081	7%	212,440	7%
Tulsa District	24,574,675	74%	2,064,843	73%
Tulsa Northern District	1,326,866	4%	78,386	3%
Western District	5,020,568	15%	488,781	17%
Total	**33,252,191**	**100%**	**2,844,450**	**100%**

A detailed depiction of geographic incentive allocation is shown in Figure 3-2. This heat map shows the concentration of incentive dollars throughout the PSO Territory based on zip code.

Figure 3-2: Distribution of Custom and Prescriptive Projects



* **Grey** zip code did not receive funding. **Sunset colored** zip codes received funding.

3.1.2.3 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. Detailed energy savings methodologies are provided in Appendix G of this report.

Data Collection

Data for analysis is collected through review of program materials, virtual 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 random sample is developed for virtual data collection to statistically represent the population.

Site-specific verification visits are performed for each project selected in the random sample. For 2020, verification visits were achieved virtually through a combination of phone interviews, email exchanges, and video calls. Video calls, the preferred method, and performed using Streem, Microsoft Teams, or a platform selected by the participant. Site verification visits are used for verification of baseline conditions, energy efficiency equipment specifications, quantities, and operating conditions. When available, data from energy monitoring is collected to support the energy savings analysis. Data is collected through building automation systems, equipment control systems, or facility tracking systems.

In addition, all available project documentation is acquired for sampled projects. Project documentation includes ex-ante energy savings analysis, invoices, specification sheets, and pre-and-post implementation inspection reports. In the situation where all data and information requested is not available during virtual verification, these project documents may be relied on to support verification. Projects evaluated in which only partial information was collected from the site contact are to be considered desk reviews.

In addition to virtual data collection, customer surveys provide self-reported data for the NTG analysis and process evaluation. The customer survey is administered online for a census of program participants. A total of 50 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 ten program contractors.

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

Table 3-8: Sample Sizes for Data Collection Efforts

Data Collection Activity	Achieved Sample Size
Virtual M&V interviews	36
Sample Desk Review	7
Customer Decision Maker Surveys	50
Trade Ally Interviews	10
Program Staff Interviews	2

Sampling Plan

ADM created a stratified random sample based on the amount of annual energy savings and type of measure installed in each project. Ratio estimation is 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 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 ±10% precision at the 90% confidence level for the program. Separate samples were drawn for custom and prescriptive projects, SBES projects, and Midstream projects. Table 3-9 shows the sample design that was used for custom and prescriptive projects. Stratum classifications were based on verified measure installations. The 43 projects that were sampled for evaluation verification account for approximately 31% 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	997,435	354 – 111,592	32	3
Custom & Other 2	3,790,944	155,045 – 433,736	13	4
Custom & Other 3	3,051,553	435,898 – 907,484	5	2
Custom & Other 4	5,362,355	933,559 - 1,291,245	5	2
NC Lighting 1	1,037,481	2,828 – 258,371	23	3
Prescriptive 1	781,521	240 – 39,250	154	6
Prescriptive 2	1,745,584	42,610 – 204,482	18	5
Prescriptive 3	1,287,019	508,006 – 778,013	2	2
Retrofit Lighting 1	1,770,046	5 – 28,119	204	4
Retrofit Lighting 2	4,357,237	28,204 – 107,380	84	5
Retrofit Lighting 3	5,559,620	108,492 – 336,290	33	5
Retrofit Lighting 4	1,721,465	401,199 – 886,482	3	1
Retrofit Lighting 5	1,789,932	1,789,932 – 1,789,932	1	1
Total	**33,252,191**		**587**	**43**

Impact Evaluation Methodology

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

- The program tracking database is reviewed to determine the scope of the program and to ensure there are no duplicate project entries. The tracking database is used to define a discrete set of rebated projects that make up the program population. A sample of projects is then drawn from the population established in the tracking system review.
- A detailed desk review is conducted for each project sampled for virtual 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 virtual 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, virtual verification/data collection interviews are scheduled for each sampled project. The interviews are used to collect data for savings calculations, verify measure installation, and determine measure operating parameters.
- The data collected during the virtual 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 virtual verification and data collection, changes are made to reflect actual operating conditions more accurately.
- 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 annual 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 is used for the net-to-gross analysis. These survey responses are reviewed to assess the likelihood that participants were free riders or whether there were spillover effects associated with non-rebated purchases by program participants.[22] Both the Custom and Prescriptive and SBES Programs utilized the same NTG methodology.

Several main criteria are used to determine the likelihood that a customer is a free rider. The first criterion is based on the participant having the financial capability to purchase the energy efficient equipment without support of the program. The second criterion is 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.

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 are analyzed to determine the likelihood that they are free riders. The three factors are:

- Plans and intentions of the firm to install a measure even without support from the program.
- Influence that the program has 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 are applied to develop binary variables indicating if a participant's behavior indicated free ridership.

- The first factor determines if a participant states that their intention is to install an energy efficiency measure without the program. Answers to a combination of several questions are used with a set of rules to determine whether a participant's behavior indicated likely free ridership.
- The second factor determines 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 third factor determines 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 four factors described above are used to construct four indicator variables that address free ridership behavior. For each customer, a free ridership value is assigned

[22] 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.

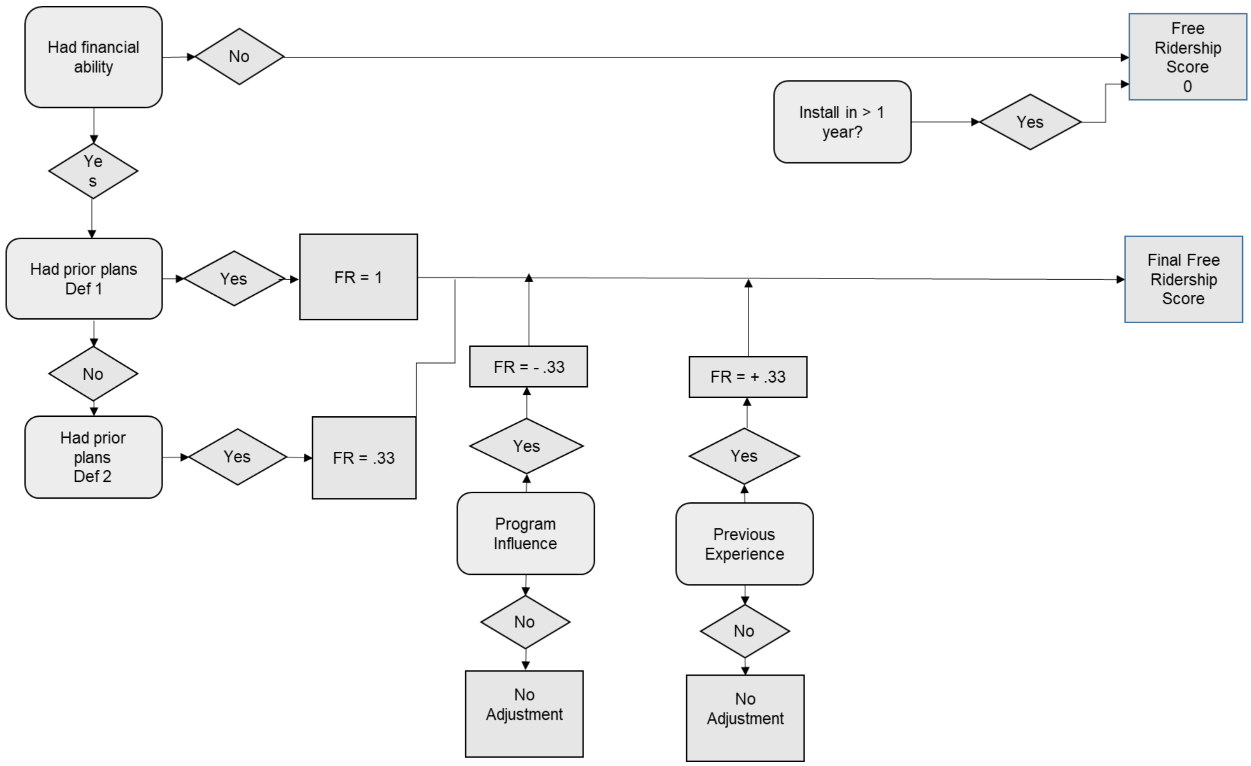
based on the combination of variables. With the four indicator variables, there are 12 applicable combinations for assigning free ridership scores for each respondent, depending on the combination of answers to the questions creating the indicator variables. Table 3-10 shows these values.

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%

Determination of free ridership from the four variables is represented as a flow chart in Figure 3-3.

Figure 3-3: Flow Chart of Free Ridership Determination



The customer decision maker survey also includes a series of questions used to analyze whether there are potential spillover effects associated with non-rebated purchases by program participants.[23] Specifically, survey respondents are 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" are identified as potential spillover candidates. Potential spillover candidates are 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 are asked the following two questions, which were used to assess if any savings resulting from the additional equipment installed was attributable to the program.

[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.

- [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:

$$\textit{Spillover Score} = \text{Average (SP1, SP2)}$$

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

Lifetime Energy Savings

Lifetime energy savings (kWh) is the product of annual energy savings (kWh) multiplied by the Effective Useful Life (EUL). The EUL considers the technical lifespan of the equipment as well as the change in energy savings over time. The EUL is determined by measure for each measure within each project of the evaluation sample. The EUL for prescriptive measures is sourced from the AR TRM v7.0. If a measure is not listed in the AR TRM then a different industry standard reference, such as another technical reference manual is considered. For custom equipment, the EUL is determined based on the lifespan of the equipment or if that cannot be determined then the industry standard of 20 years is applied. Energy savings for any behavioral measures in the program is only granted one year of EUL.

For lighting equipment, ADM determines lifetime savings by dividing the manufacturer specified useful life of the equipment by the verified annual operating hours. This is performed on a line-item basis for each fixture type and usage schedule within a project.

The lifetime savings for each project is the aggregation of the lifetime savings for all equipment incentivized within the project. Extrapolation to the population of projects is achieved in a similar fashion as applying a realization rate. A strata level aggregated lifetime energy savings is divided by the strata level aggregated annual energy savings to determine a strata-level EUL. This EUL is then applied to all projects in the population outside of the sample.

Process Evaluation Methodology

The process evaluation is designed to research and document the program delivery mechanisms and collective experiences of program participants, partners, and staff. The process evaluation is 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 include 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.

3.1.2.4 Impact Evaluation Findings

Impact evaluation findings determine net annual energy savings and net coincident peak demand reduction. Program level 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 annual energy savings for Prescriptive and Custom projects are summarized, by sampling stratum, in Table 3-12.

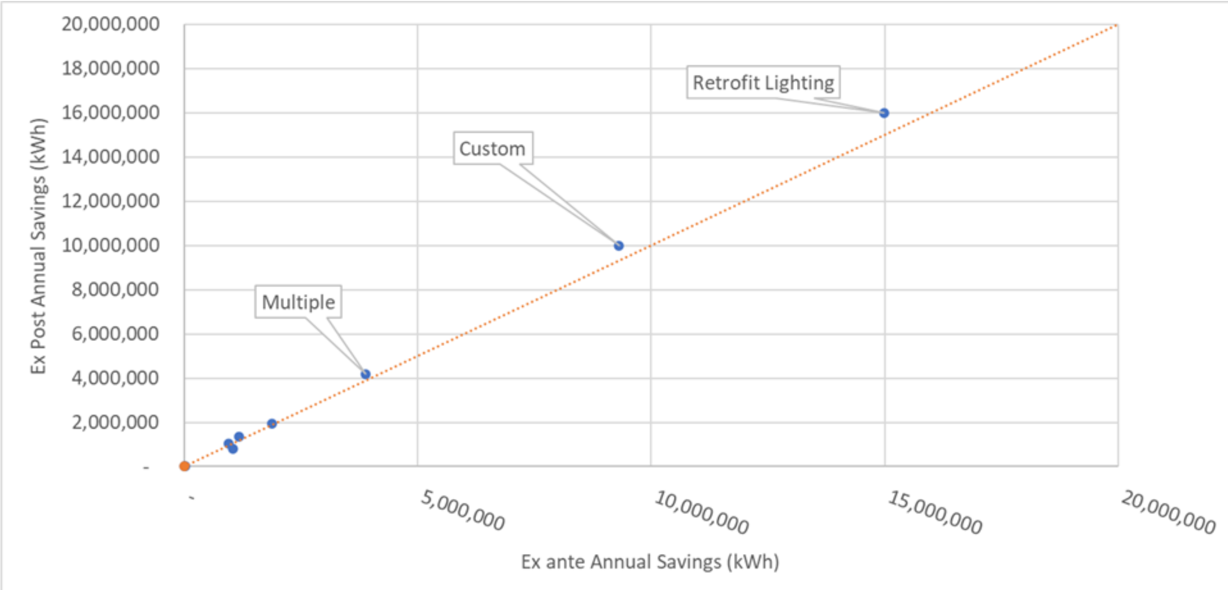
Table 3-12: Ex-Ante and Ex-Post Gross kWh Savings by Sampling Stratum – Prescriptive and Custom

Stratum	Ex-ante kWh Savings	Ex-post Gross kWh Savings	Gross kWh Realization Rate
Custom & Other 1	997,435	1,347,962	135%
Custom & Other 2	3,790,944	3,877,690	102%
Custom & Other 3	3,051,553	3,495,867	115%
Custom & Other 4	5,362,355	5,362,355	100%
NC Lighting 1	1,037,481	785,620	76%
Prescriptive 1	781,521	924,574	118%
Prescriptive 2	1,745,584	2,049,929	117%
Prescriptive 3	1,287,019	1,287,019	100%
Retrofit Lighting 1	1,770,046	2,859,059	162%
Retrofit Lighting 2	4,357,237	4,213,604	97%
Retrofit Lighting 3	5,559,620	5,322,346	96%
Retrofit Lighting 4	1,721,465	2,097,485	122%
Retrofit Lighting 5	1,789,932	1,726,204	96%
Total	**33,252,191**	**33,349,714**	**106%**

The achieved sample design results in ex-ante gross annual energy savings estimates with ±9.6% relative precision at the 90% confidence interval, and ±9.8% in ex-post gross annual energy savings.[24] Overall annual energy savings were found to be higher than expected. Large variability was found within individual projects, with realization rates ranging from 63% to 259%. Figure 3-4 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 the magnitude and is at a 107% realization rate.

[24] That is, we are 90% confident that the true verified gross savings are between 31,899,517 and 38,799,910 kWh based on the uncertainty introduced by sampling.

Figure 3-4: 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 1-5), and new construction lighting (NCL1). Due to the difference in energy savings methodologies, new construction lighting is extrapolated separately from retrofit lighting. Project level realization rates ranged from 63% to 259%.

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 virtual interview 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 is HOU. Findings indicate that some facility types have greater variability in the total annual HOU than others. These include manufacturing, retail, warehousing, and schools. The overall realization rate was 107%.

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 and are stipulated by space type. Project realization rates ranged from 63% to 94%. The variation in realization rates was due to the way LPD values were applied to different space types in the ex-ante analyses. Ex-ante analyses did not always break out all the necessary space types, particularly for exterior lighting. There was also some variation in the hours of use. The overall realization rate was 76%.

Custom & Other Projects

The variance in realization rates for custom and other equipment projects vary by measure and savings algorithm implemented. Custom analyses were performed for measures such as Oil & Gas, Chiller, indoor grow lighting, industrial process improvement and whole facility new construction. 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). Some larger projects underwent pre-payment reviews to help mitigate evaluation risk.

Most sampled projects fell within a realization rate of 80% to 120%. Project representing a higher level of risk included:

- A new construction retail facility received incentives for various HVAC measures and lighting. Measurement and Verification showed larger savings than claimed across all measure types. The portion of new construction lighting represented the highest realization rate due to ex-ante savings treating the lighting power density as a whole facility as opposed to breaking it out by space type. These differences resulted in a realization rate of 202%.
- A facility converted from an office building to a hotel received incentives for building envelope improvements and a new water source heat pump (WSHP). Measurement and verification showed higher savings than claimed through IPMVP Option D: Calibrated simulation analysis. ADM found that estimated savings assumed no efficiency gain from the WSHP, resulting in a realization rate of 177%.
- An industrial facility received an incentive for the installation of a new fibre laser cutter that replaced a CO_2 laser. Measurement and verification showed higher savings due to an update in equipment run time. ADM employed Option A: Retrofit Isolation using equipment monitored data provided by the participant and implementation team. This resulted in a realization rate of 129%.

Overall, custom projects represented a realization rate above 100%.

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 principal focus is on operational and behavioral improvements. Energy Coaching projects have been listed as Custom projects in the program tracking data and were treated as such. Four Energy Coaching projects were in the evaluation sample. Review of these projects indicates energy savings based on IPMVP Option C, a whole facility billing regression analysis.[25] Project level realization rates ranged from 64% to 105% with an overall realization rate of 101%.

ADM adhered to ASHRAE Guide 14 and IPMVP guidelines in performing billing regression analyses. This resulted in the use of additional baseline data in the regression as well as the application of normalizing the baseline and efficient condition regressions to typical year (TMY3) weather. The regression analysis is normalized to typical year because of the measure life exceeding one year. In addition, ADM reviewed each project for impacts of non-routine events. The facility in one project was found to have been highly impacted by the non-essential business shutdown in 2020 due to the pandemic.

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 111%, with individual projects ranging from 82% to 239%. 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.

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

Table 3-13: Realization Rate by Project Type

Project Type	Realization Rate	Percent of Custom and Prescriptive
Retrofit Lighting	107%	45%
Custom	107%	28%
Multiple	108%	12%
Oil & Gas	104%	6%
Refrigeration & Kitchen Equipment	114%	4%
Unitary HVAC & VFDs	111%	3%
New Construction Lighting	76%	2%
Agriculture	118%	<1%
Building Envelope	118%	<1%

Gross Coincident Peak Demand Reduction (kW)

The ex-post gross coincident peak demand reduction (kW) is summarized by sampling stratum in Table 3-14. The peak demand reduction realization rate for prescriptive and custom projects is 130%.

Table 3-14: Ex-ante and Ex-post Gross Peak Demand 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	128.51	213.54	166%
Custom & Other 2	447.26	883.99	198%
Custom & Other 3	114.92	132.23	115%
Custom & Other 4	474.89	893.18	188%
NC Lighting 1	249.94	310.27	124%
Prescriptive 1	106.41	116.33	109%
Prescriptive 2	208.28	283.10	136%
Prescriptive 3	185.80	181.43	98%
Retrofit Lighting 1	301.66	410.26	136%
Retrofit Lighting 2	763.72	881.90	115%
Retrofit Lighting 3	933.76	861.52	92%
Retrofit Lighting 4	226.93	254.96	112%
Retrofit Lighting 5	195.89	195.35	100%
Total	**4,337.97**	**5,618.07**	**130%**

The achieved sample design resulted in ex-ante gross peak demand reduction estimates with ±22.60% relative precision at the 90% confidence interval and 22.66% for ex-post peak demand reduction.[26] Peak demand 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.[27]

For lighting projects, the ADM ex-post lighting calculators generate an hourly curve (8760 hours) to determine the average peak demand 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.

[26] That is, we are 90% confident that the *ex-post* gross peak demand reduction is between 4,345 and 6,891 kW based on the uncertainty introduced by sampling.

[27] 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. Completed survey responses represent 50 custom and prescriptive projects. Calculation of NTG was determined based on the ridership criteria (four areas of questions) and spillover. NTG was determined separately for lighting projects and non-lighting projects.

Table 3-15 shows percentages of total gross ex-post annual energy savings associated with different combinations of free ridership indicator variable values for the lighting component. The magnitude of free ridership was determined by the amount of annual energy savings and peak demand reduction attributed to free ridership within each project. Most of the free ridership from lighting projects was driven by participants intention to purchase energy efficient lighting without need of the program.

Table 3-15: Estimated Free Ridership for Lighting Projects

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	7%	100%
Y	Y	N	Y	0%	100%
Y	Y	Y	N	1%	67%
N	Y	N	Y	0%	67%
N	Y	N	N	5%	33%
N	Y	Y	N	1%	0%
N	Y	Y	Y	0%	33%
N	N	N	Y	1%	33%
N	N	N	N	39%	0%
N	N	Y	N	21%	0%
N	N	Y	Y	11%	0%
Required program to implement measures				**13%**	**0%**
Project would have been deferred by one year or more in the absence of a program				**87%**	**0%**
Total				**100%**	**10.5%**

Overall, the estimated percentage of program free ridership for lighting is 10.5%. Project specific free ridership was determined on a measure level basis.

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 NTG for lighting projects is calculated as 1 – free-ridership + participant spillover. This results in a NTG of 89.5% for annual energy savings and 91.5% for peak demand reductions. Table 3-16 shows the amount of savings and peak demand reduction impacted by free ridership and spillover.

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

Savings	Free Ridership	Spillover
kWh	1,785,790	0
kW	246.81	0

Table 3-18shows percentages of total gross ex-post savings associated with different combinations of free ridership indicator variable values for Non lighting projects.

Table 3-17: Estimated Free Ridership for Non-Lighting Projects

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	6%	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	5%	0%
N	N	Y	N	68%	0%
N	N	Y	Y	10%	0%
Required program to implement measures				**10%**	**0%**
Project would have been deferred by one year or more in the absence of a program				**90%**	**0%**
Total				**100%**	**5.2%**

Overall, the estimated percentage of program free ridership for non-lighting projects is 5.2%. Project specific free ridership was determined on a measure level basis.

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 NTG for non-lighting projects is calculated as 1 – free-ridership + participant spillover. This results in a NTG of 94.8% for kWh savings and 83.1% for peak demand reductions. Table 3-18 shows the amount of annual energy 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 3-18: Free-Ridership and Spillover for Non-Lighting Projects

Savings	Free Ridership	Spillover
kWh	946,151	0
kW	458.03	0

The gross and net ex-post annual energy savings and peak demand reduction for Custom and Prescriptive projects is summarized in Table 3-19.

Table 3-19: Summary of Ex-post Gross and Net Impacts

Custom & Prescriptive	Ex-post Gross kWh Savings	Ex-post Net kWh Savings	Net-to-Gross Ratio	Ex-post Gross kW Reduction	Ex-post Net kW Reduction
Lighting Projects	17,004,318	15,218,528	89.5% - kWh* 91.5% - kW*	2,914.27	2,667.47
Non-Lighting Projects	18,345,395	17,399,244	94.8% - kWh* 83.1% - kW*	2,703.80	2,245.77
Total	**35,349,714**	**32,617,773**	**-**	**5,618**	**5,173**

*Values are rounded to one decimal place in this table

Lifetime Energy Savings

Lifetime savings were determined for each equipment type or line item incentivized within each project. Lifetime savings were aggregated for all projects within each stratum to determine a strata level lifetime savings. These lifetime savings were divided by the aggregated annual gross and net energy savings for each stratum to determine and EUL to be extrapolated to the population by strata. Sample level EUL's by strata as well as total population lifetime energy savings are show in Table 3-20.

Table 3-20: C&P EUL's and Lifetime Energy Savings

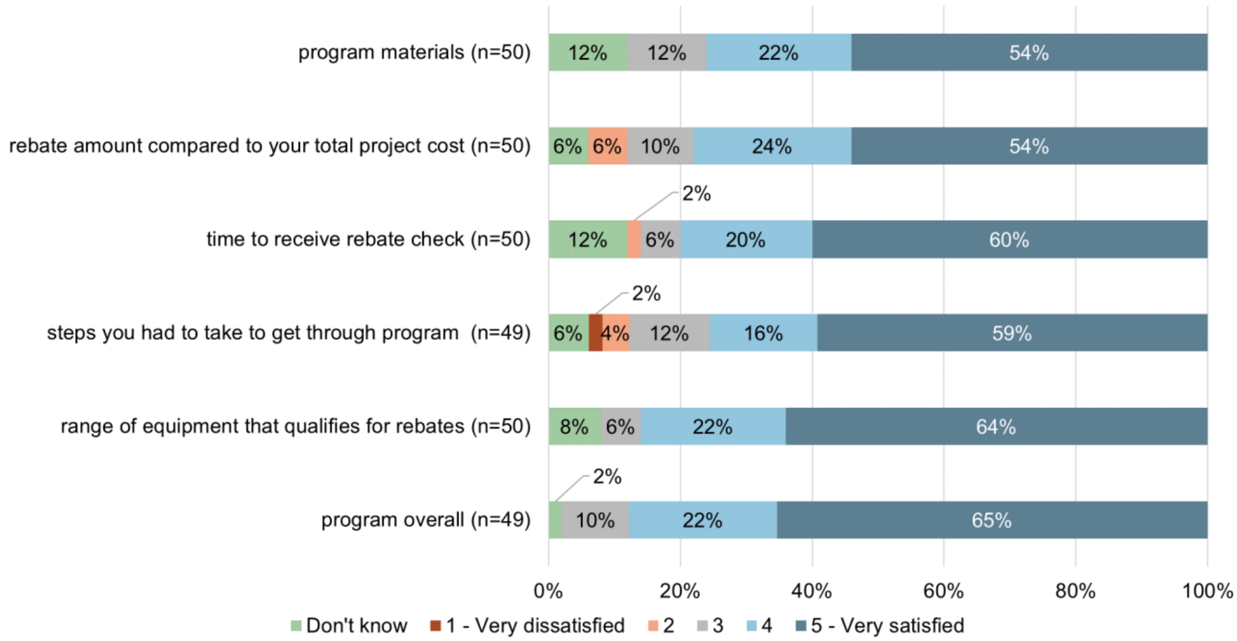
Stratum	EUL	Gross Program Lifetime Energy Savings (kWh)	Net Program Lifetime Energy Savings (kWh)
Custom & Other 1	16.85	22,717,945	21,546,283
Custom & Other 2	13.68	53,050,322	50,314,289
Custom & Other 3	17.31	60,530,875	57,409,037
Custom & Other 4	11.78	63,170,405	59,912,435
NC Lighting 1	11.32	8,889,950	7,956,329
Prescriptive 1	9.62	8,892,384	8,433,765
Prescriptive 2	11.59	23,765,227	22,539,552
Prescriptive 3	13.68	17,604,055	16,696,138
Retrofit Lighting 1	13.94	39,857,997	35,672,119
Retrofit Lighting 2	14.61	61,546,932	55,083,285
Retrofit Lighting 3	12.26	65,267,670	58,413,272
Retrofit Lighting 4	7.56	15,863,331	14,197,367
Retrofit Lighting 5	10.56	18,224,427	16,310,501
Total	**12.89**	**459,381,518**	**424,484,373**

3.1.2.5 Process Evaluation Findings

The process evaluation consisted of a participant survey, trade ally interviews, and program staff interviews. ADM provided a detailed process evaluation memo to PSO after the completion of the 2020 program year.

ADM conducted a mixed mode (phone/email) participant survey of a census of Prescriptive and Custom participants, in September 2020. The survey resulted in 50 completes. 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 (Figure 3-5). Furthermore, 52% of respondents said they would not change anything about the program (38%) or that they did not know what they would change to improve it (14%).

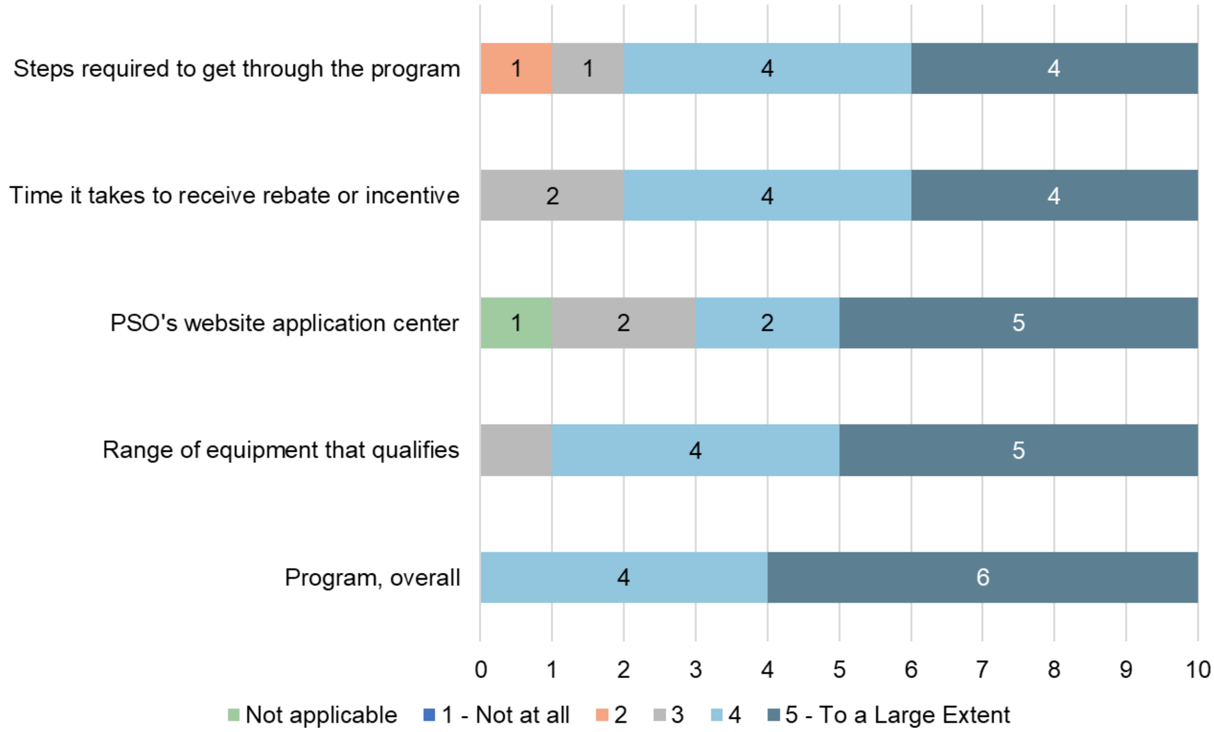
Figure 3-5: Overall Respondent Satisfaction with Aspects of Program Participation



In September 2020, ADM spoke with 10 PSO Prescriptive and Custom rebate trade allies, including electrical, HVAC, mechanical contractors, and lighting/electrical distributors. Trade allies are largely satisfied with the program design and participation process, with some offering suggestions for improvement. All trade allies indicated they were satisfied with the program overall as well as the range of equipment that qualifies and PSO's website application center (Figure 3-6).[28]

[28] A rating of 4 or 5 on a scale from 1 (very dissatisfied) to 5 (very satisfied).

Figure 3-6: Trade Ally Satisfaction



3.1.2.6 Custom and Prescriptive Conclusions and Recommendations

This section presents conclusions and recommendations for the Custom and Prescriptive subprogram based on the 2020 evaluation.

Conclusions

- The program was able to obtain a high level of program savings given the difficult implementation environment in 2020. Net annual energy savings for the program year are 32,617,773 kWh for an overall net realization rate of 98%.
- Lighting projects continue to contribute most to program level energy savings, but the wide range of offerings presents many opportunities for customers.
- Energy Coaching projects increased in 2020 and demonstrate the available potential for controls and operational related energy efficiency projects.
- Evaluation risk was found for several measures. New construction lighting and custom projects represent the largest project level realization rate risk.
- Participant and trade ally lack of awareness and comprehension of the program's non-lighting offerings represents a potential opportunity for expansion.

- 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.
- Consistent with past program years, satisfaction remains high. Most survey respondents shared high levels of satisfaction across all aspects of the program as well as the programs overall.

Recommendations

- The largest realization rate risk by measure was for new construction lighting. There is potential for mitigation with more detailed ex-ante analysis. We recommend requesting pre-payment reviews by ADM for large new construction lighting projects.
- While there is a wide range of offerings for customers, there may be more potential for projects in the areas of continuous energy improvement and retrocommissioning.
- Continue to review and update the application and project review process for the PSO's Custom and Prescriptive program. Most participant survey respondents and trade allies were satisfied with the program and participation process, but a portion of trade allies and participants indicated that the participation process could be improved.
- Consider creating targeted marketing for specific program measures or to highlight certain types of energy saving projects. Trade ally interviews and survey responses indicate that there is a lack of awareness or understanding of non-lighting energy efficiency rebates that are available for PSO Business Customers.

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 105% realization rate for gross energy savings and a 88% realization rate for gross peak demand reduction.

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.

3.1.3.1 Impact Evaluation Overview

The impact evaluation of the SBES Program consisted of a gross and net annual energy savings and peak demand reduction determination. Gross energy savings were determined through M&V practices with virtual data collection. Net-to-gross was determined through survey efforts of participants and trade allies to calculate values of free ridership and spillover.

PSO's SBES projects provided rebates for a total of 412 projects. The number of rebated projects increased from 323 in PY2019 to 412 in PY2020. The ex-ante energy savings increased from 8,303 MWh (PY2019) to 10,188 MWh (PY2020). As with previous years, program energy savings were driven by lighting projects.

The estimated annual energy savings NTG ratio decreased from 101% in 2019, to 99.8% in 2020. The estimated peak demand NTG ratio changed from 101% in PY2019 to 99.4% for PY2020. Table 3-21 provides projected, ex-ante, and ex-post energy and demand impacts, as well as other program performance metrics for SBES projects.

Table 3-21: Performance Metrics – Small Business Energy Solutions

Metric	PY2020
Number of Projects	412
Energy Impacts (kWh)	
Ex-ante Energy Savings	10,187,945
Gross *Ex-post* Energy Savings	10,662,463
Net *Ex-post* Energy Savings	10,639,823
Peak Demand Impacts (kW)	
Ex-ante Peak Demand Savings	2,788
Gross *Ex-post* Peak Demand Savings	2,457
Net *Ex-post* Peak Demand Savings	2,443
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	2.88
Utility Cost Test Ratio	5.03

3.1.3.2 Process Evaluation Overview

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 37 customer decision makers responded to the participant survey.

Participation in SBES increased steadily as the year progressed, with a notable increase at the end of the year. Figure 3-7 displays the accrual of ex-ante energy savings.

Figure 3-7: Accrual of Reported kWh Savings during the Program Year

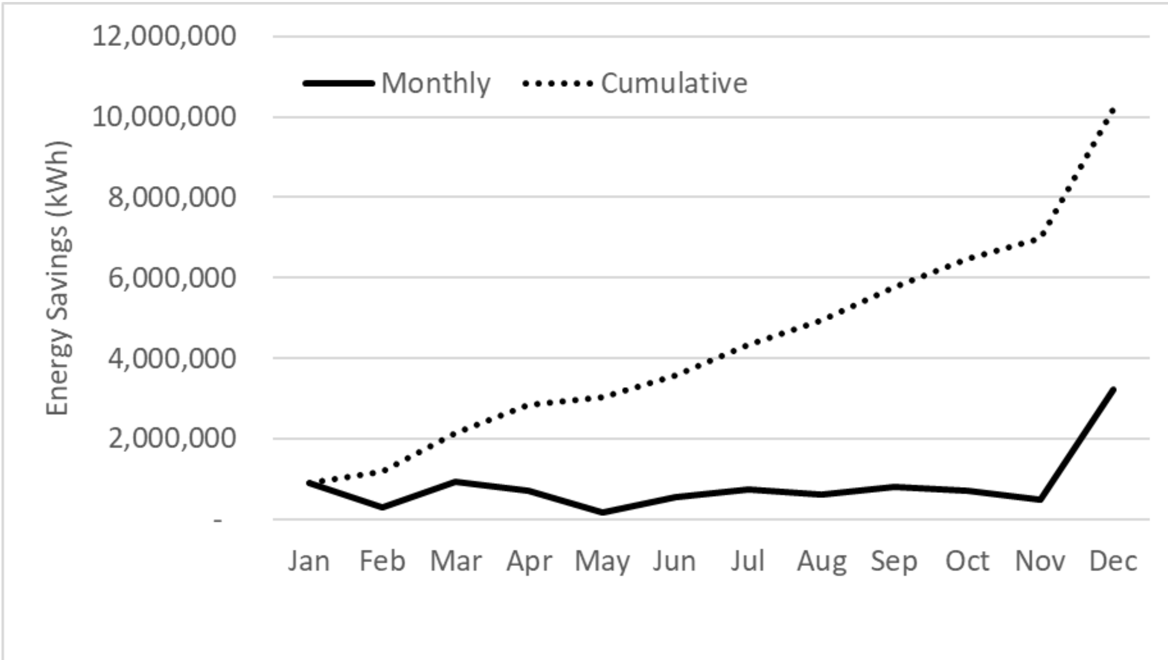


Table 3-22 summarizes program activity by service provider. Four lighting service providers represented most of the energy savings. National Resource Management (NRM) represented 2% of energy savings with refrigeration equipment. Two service providers from 2019, Lighting Inc. and US Energy Recovery, did not participate in 2020.

Table 3-22:Summary by Service Provider

Service Provider	Sum of Ex-ante Energy Savings (kWh)	Percentage of Projects kWh
Bridgepoint Electric	2,409,513	24%
Entegrity Partners	2,431,266	24%
First Light Systems	3,335,505	33%
Luminous of OK	1,762,750	17%
National Resource Management	248,911	2%

Project Activity by Location

Table 3-23 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.

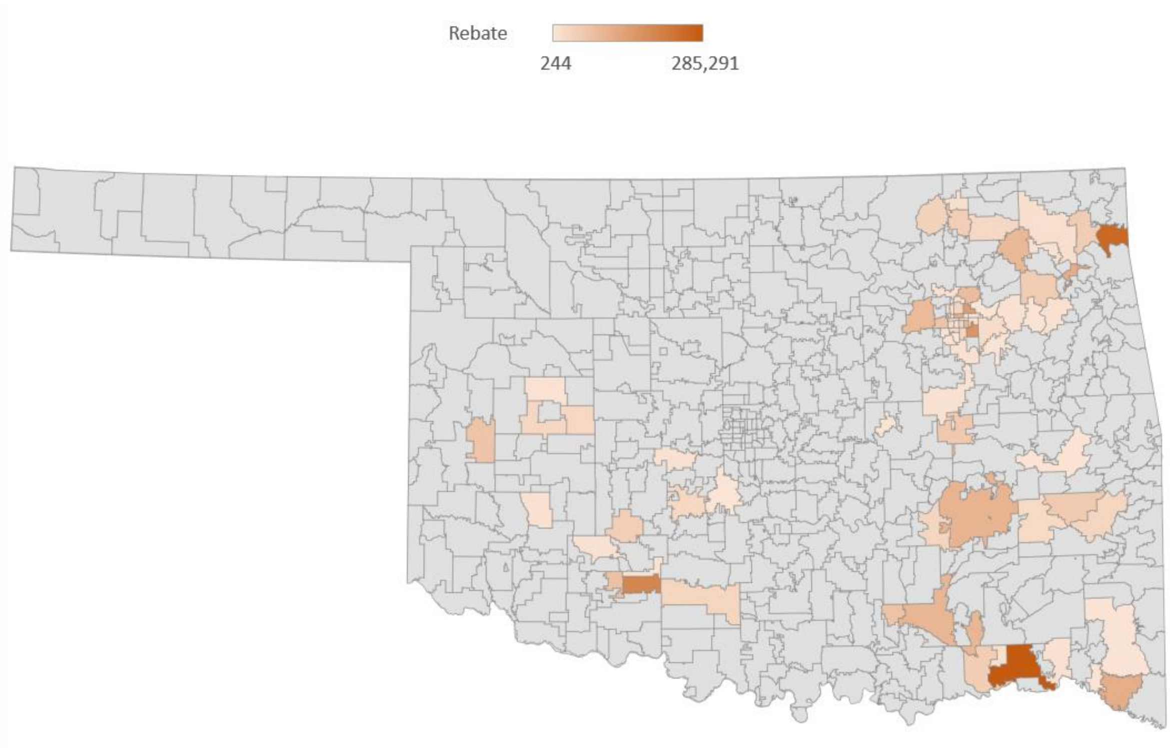
Table 3-23: District Share of Ex-Ante kWh Savings

Region	Sum of Ex-Ante Total Energy Savings (kWh)	Percentage of Projects kWh
Eastern District	2,503,441	30%
Tulsa District	3,595,162	43%
Tulsa Northern District	2,351,114	28%
Western District	1,738,228	21%
Total	**10,187,945**	**100%**

Twenty-two different building types participated in the SBES. Buildings types with highest energy savings coming from education, Office space, Retail, and Manufacturing. The subprogram continues to have strong participation from education facilities.

Figure 3-8 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 grey indicate that no incentives were achieved.

Figure 3-8: Distribution of Small Business Energy Solutions Projects



*Grey zip code did not receive funding. Sunset colored zip codes received funding.

Four projects consisting of reported annual energy savings over 200,000 kWh represented 11% of SBES projects annual energy savings. Three out of four projects were for schools located in Tulsa North District.

3.1.3.3 Evaluation Methodology

This section provides an 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.

Data Collection

Data for the analysis were collected through review of program materials, virtual inspections, and interviews with participating customers and service providers. A sample was developed for virtual 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 virtual verification visits. Virtual 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.

In addition to the virtual data collection effort, customer surveys provided self-report data for the net-to-gross analysis and process evaluation. A total of 37 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 four program contractors.

In-depth interviews with two PSO and implementation staff members were conducted to provide additional perspectives for the process evaluation. Table 3-24 shows the achieved sample sizes for the different types of data collection employed for this study.

Table 3-24: Sample Sizes for Data Collection Efforts – SBES

Data Collection Activity	Achieved Sample Size
Virtual M&V Interviews	18
Customer Decision Maker Survey	37
Program Staff Interviews	2
Trade Ally interviews	4

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 3-25 below shows the sample design that was used for SBES projects. Stratum classifications were based on verified measure installations. The 18 projects that were sampled for virtual measurement and verification account for approximately 13% of reported program annual energy savings.

Table 3-25: 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	906,006	29 – 9,882	179	3
Lighting 2	2,015,667	10,042 – 24,521	122	4
Lighting 3	1,816,981	25,068 – 47,292	52	2
Lighting 4	1,612,781	47,535 – 93,271	25	2
Lighting 5	2,076,614	98,237 – 165,433	16	2
Lighting 6	1,510,985	176,435 – 346,688	6	3
Multiple	248,911	7,110 – 36,953	11	2
Total	**10,187,945**		**412**	**18**

Impact Evaluation Methodology

The evaluation of gross ex-post annual 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 virtual 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 virtual fieldwork by identifying potential uncertainties and

missing data. Additionally, the review process involved assessing the reasonableness of deemed savings values and calculation input assumptions.

- After reviewing the project materials, virtual verification and data collection were scheduled for each sampled project. The virtual visits were used to collect data for savings calculations, to verify measure installation, and to determine measure operating parameters.
- The data collected during the virtual 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 reflect actual operating conditions more accurately.
- 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. This methodology includes both free ridership and participant spillover. The methodology for SBES is the same as Custom and Prescriptive and described in the Custom and Prescriptive Evaluation Methodology section.

Lifetime Energy Savings

Lifetime energy savings (kWh) is the product of annual energy savings (kWh) multiplied by the Effective Useful Life (EUL). The EUL considers the technical lifespan of the equipment as well as the change in energy savings over time. The EUL is determined by measure for each measure within each project of the evaluation sample. The EUL for prescriptive measures is sourced from the AR TRM v7.0. If a measure is not listed in the AR TRM then a different industry standard reference, such as another technical reference manual is considered. For custom equipment, the EUL is determined based on the lifespan of the equipment or if that cannot be determined then the industry standard of 20 years is applied. Energy savings for any behavioral measures in the program is only granted one year of EUL.

For lighting equipment, ADM determines lifetime savings by dividing the manufacturer specified useful life of the equipment by the verified annual operating hours. This is performed on a line-item basis for each fixture type and usage schedule within a project.

The lifetime savings for each project is the aggregation of the lifetime savings for all equipment incentivized within the project. Extrapolation to the population of projects is achieved in a similar fashion as applying a realization rate. A strata level aggregated lifetime energy savings is divided by the strata level aggregated annual energy savings to determine a strata-level EUL. This EUL is then applied to all projects in the population outside of the sample.

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 3-26 provides a summary of data collection activities for the process evaluation.

Table 3-26: 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
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.

3.1.3.4 Impact Evaluation Findings

Impact evaluation findings determine net annual energy savings and net coincident peak demand reduction. Net energy impacts are achieved through several steps of evaluation, starting from M&V on a statistically representative sample of projects in which gross energy impacts are extrapolated to the population. The effects of free ridership and spillover are then applied to the population (on a project level basis) to determine program level net energy impacts.

Gross Annual Energy Savings

The ex-post gross annual energy savings for SBES projects are summarized by sampling stratum in Table 3-27 Projects saw an overall realization rate of 105%.

Table 3-27:Ex-Ante and Ex-Post Gross Annual Energy Savings by Sampling Stratum – SBES

Stratum	Ex-ante kWh Savings	Ex-post Gross kWh Savings	Gross kWh Realization Rate
Lighting 1	906,006	916,802	101%
Lighting 2	2,015,667	2,015,414	100%
Lighting 3	1,816,981	1,977,096	109%
Lighting 4	1,612,781	1,740,312	108%
Lighting 5	2,076,614	2,143,963	103%
Lighting 6	1,510,985	1,621,698	107%
Non-Lighting	248,911	247,177	99%
Total	**10,187,945**	**10,662,463**	**105%**

The achieved sample design resulted in ex-ante gross annual energy savings estimates with ±9.30% relative precision at the 90% confidence interval and ex-post at ±9.46% for kWh.[29] Realization rates varied from project to project and stratum to stratum.

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

Project level realization rates ranged from 76% to 131%. The project with the lowest realization rate was incentivized for refrigeration evaporator fan controls and nighttime shutoff controls for vendor coolers. The ex-ante calculations for these measures are based on the contractors developed methodologies whereas ADM incorporated the AR TRM v7.0 methodologies. The methodologies differ the most in the savings calculations for the evaporator fan motor control.

Gross Coincident Peak Demand Reduction (kW)

The ex-post gross peak demand reduction is summarized by sampling stratum in Table 3-28. Overall, the ex-post gross peak demand reduction is equal to 88% of the reported reduction for SBES projects.

[29]That is, we are 90% confident that the true verified gross savings are between 9,653,828 and 11,671,098 kWh based on the uncertainty introduced by sampling.

Table 3-28: 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	286.25	252.64	88%
Lighting 2	586.82	579.38	99%
Lighting 3	477.93	371.95	78%
Lighting 4	371.23	407.87	110%
Lighting 5	634.05	598.51	94%
Lighting 6	410.45	217.08	53%
Non-Lighting	20.99	29.99	143%
Total	**2,787.72**	**2,457.42**	**88%**

The achieved sample design resulted in ex-ante gross peak demand reduction estimates with ±17.99% relative precision at the 90% confidence interval and ex-post at ±18.77%.[30] 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 peak demand reduction value across the peak demand period for each lighting schedule within a project.

Net-to-Gross Estimation

The data used to assign free ridership scores were collected through a survey of SBES customer decision makers for projects rebated. Free ridership was estimated using the methodology described in the Evaluation Methodology section for Custom and Prescriptive. Results are based on 35 respondents representing 35 unique projects. A percentage of free ridership was determined for each of the 35 projects based on the four avenues of questions. The percentage of free ridership was then applied to each project's ex-post annual energy savings. The overall results were then extrapolated to the remaining projects in the program.

Table 3-29 shows percentages of total gross ex-post savings associated with different combinations of free ridership indicator variable values for the SBES incentive component.

[30] That is, we are 90% confident that the *ex-post* gross peak demand reduction is between 1,996 and 2,919 kW based on the uncertainty introduced by sampling.

Table 3-29: Estimated Free ridership for SBES

Had Plans and Intentions to Install Measure without SBES Program? (Definition 1)	Had Plans and Intentions to Install Measure without SBESI Program? (Definition 2)	SBES 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	1%	33%
N	Y	Y	N	0%	0%
N	Y	Y	Y	0%	33%
N	N	N	Y	0%	33%
N	N	N	N	43%	0%
N	N	Y	N	19%	0%
N	N	Y	Y	0%	0%
Required program to implement measures				**38%**	**0%**
Project would have been deferred by one year or more in the absence of the program				**62%**	**0%**
Total				**100%**	**0.2%**

Only a small amount of free ridership was determined through survey efforts. The small amount is attributed to participants with prior plans and intentions to purchase the equipment without the presence of the program. Ninety-eight percent of verified annual energy savings for the SBES Program resulted from lighting projects. A single free ridership score was determined for the program based on the distribution of equipment type.

Customer decision maker survey responses were also analyzed to estimate participant spillover effects. None of the survey respondents reported meeting the attribution criterion for any energy savings to be estimated. Therefore, no spillover was found in the program during this program year.

Both spillover and free ridership are determined as a percentage of each project for both annual energy savings and peak demand reduction. The magnitude determined of these metrics is shown in Table 3-31.

Table 3-30: Free-Ridership and Spillover for SBES Projects

Savings	Free Ridership	Spillover
kWh	22,640	0
kW	14.22	0

The final net-to-gross ratio for SBES projects is calculated as 1 – free-ridership + participant spillover. This results in an NTGR of 99.8% for annual energy savings and 99.4% for peak demand reductions. The SBES gross and net ex-post energy savings and peak demand reduction are summarized in Table 3-31.

Table 3-31: 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	10,662,463	10,639,823	99.8% - kWh 99.4% - kW	2,457.42	2,443.20

Lifetime Energy Savings

Lifetime savings were determined for each equipment type or line item incentivized within each project. Lifetime savings were aggregated for all projects within each stratum to determine a strata level lifetime savings. These lifetime savings were divided by the aggregated annual gross and net energy savings for each stratum to determine and EUL to be extrapolated to the population by strata. Sample level EUL's by strata as well as total population lifetime energy savings are show in Table 3-32.

Table 3-32:SBES EUL's and Lifetime Energy Savings

Stratum	EUL	Gross Program Lifetime Energy Savings (kWh)	Net Program Lifetime Energy Savings (kWh)
Lighting 1	13.95	12,790,777	12,763,618
Lighting 2	14.91	30,044,071	29,980,279
Lighting 3	14.29	28,262,348	28,202,339
Lighting 4	14.33	24,933,676	24,880,734
Lighting 5	14.76	31,652,582	31,585,374
Lighting 6	14.79	23,983,863	23,932,938
Non-Lighting	13.95	3,241,498	3,234,615
Total	**13.11**	**154,908,815**	**154,579,897**

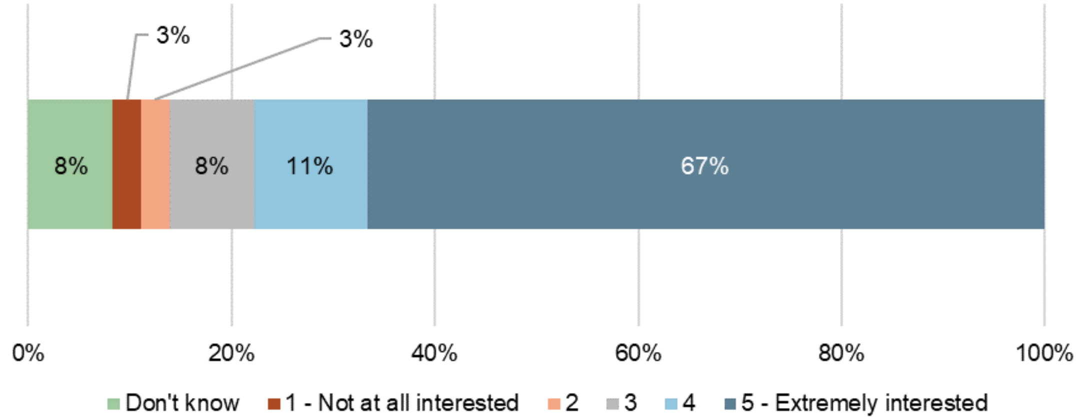
3.1.3.5 Process Evaluation Findings

The process evaluation consisted of a participant survey, trade ally interviews, and program staff interviews. ADM provided a detailed process evaluation memo to PSO after the completion of the 2020 program year.

ADM conducted a mixed mode (phone/email) survey of SBES participants, in September 2020. PSO staff sent 124 SBES participants an email to notify them of the survey and then ADM sent a survey invitation and two reminder emails. After email distribution of the survey, ADM made additional survey completions through phone calls.

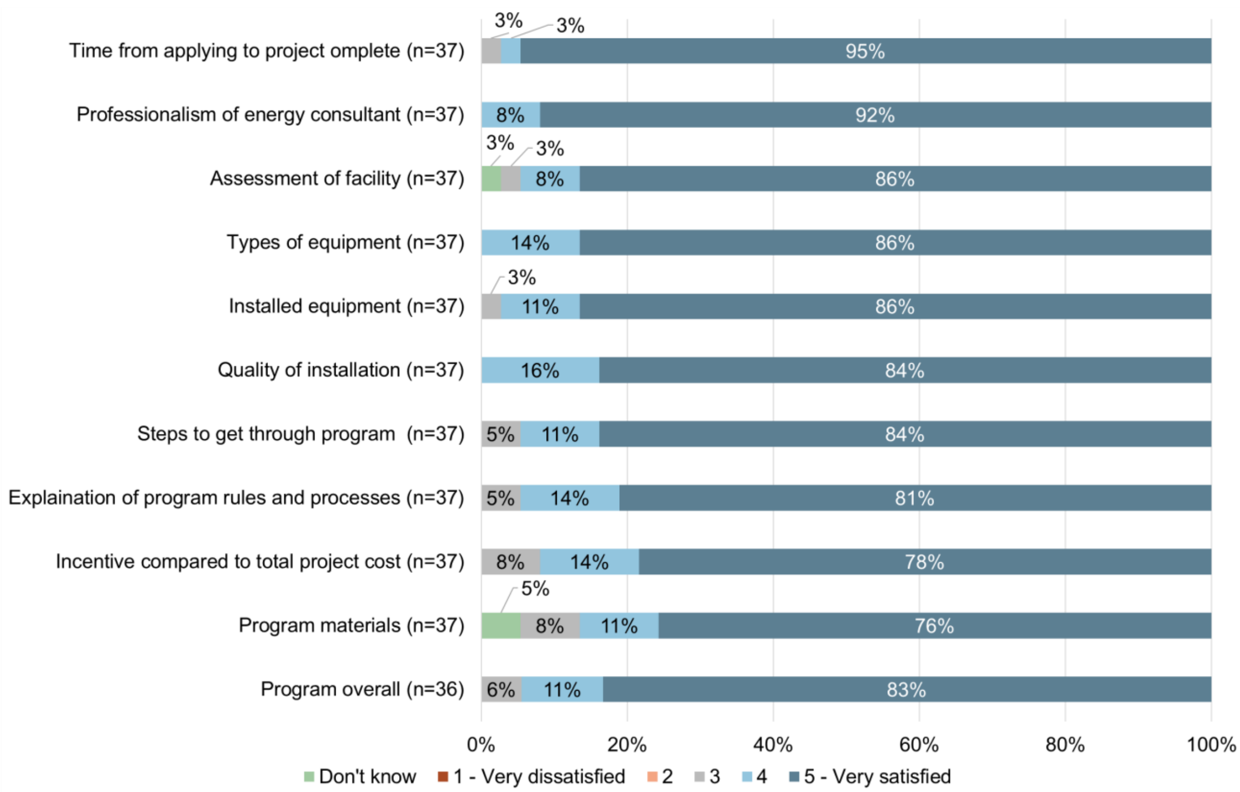
Survey findings indicate there is great potential to increase energy efficiency at small businesses through non-lighting equipment incentives across the Business Rebates Program. Consistent with ADM's 2019 survey of SBES participants, most respondents indicated interest in PSO incentives for non-lighting energy efficient equipment. Figure 3-9 displays respondents' interest in using PSO incentives for the specified non-lighting energy-efficient equipment.

Figure 3-9: Respondent Interest in using PSO Incentives for Efficient Equipment



Overall, responses showed a high degree of program satisfaction (Figure 3-10). Moreover, 76% of survey respondents either would not change anything about the program (68%) or did not know what they would change to improve the program (8%).

Figure 3-10: Participant Satisfaction with the SBES program



3.1.3.6 SBES Conclusions and Recommendations

This section presents conclusions and recommendations for the SBES Program based on the 2020 process and impact evaluation findings.

Conclusions

- Energy impact goals were met for the program year with net verified annual energy savings exceeding the ex-ante estimates.
- 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.
- 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.
- Findings from trade ally and staff interviews indicate the program was able to maintain strong participation in 2020, building upon past year's successes and outreach methods.
- 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 programs overall.
- Some SBES participants noted possible areas for program improvement including increasing communication from PSO and providing additional information about other rebate programs.
- Most program participants indicated that the COVID-19 pandemic had affected their company adversely.

Recommendations

- Consider creating targeted marketing for specific program measures or to highlight certain types of energy saving projects. Trade ally interviews and survey responses indicate that there is a lack of awareness or understanding of non-lighting energy efficiency rebates that are available for PSO Business Customers. The SBES Program's refrigeration contractor increased the number of projects they completed in 2020, but still makes up a very small portion of program savings.

3.1.4 Commercial Midstream

This section reports the findings from the Commercial Midstream lighting and HVAC projects. ADM performed an impact and process evaluation specific to this subprogram. The gross ex-post annual energy savings estimates for midstream projects resulted in a 77% realization rate for gross energy savings and a 95% realization rate for gross peak demand reduction. Net energy impacts were determined through survey efforts of participants as well as distributors. Separate net-to-gross ratio's (NTG) for both annual energy savings and peak demand reduction were determined for lighting and HVAC. The lighting NTG is 80.14% for annual energy savings and 78.15% for peak demand reduction. The HVAC NTG is 81.97% for annual energy savings and 80.44% for peak demand reduction.

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.

3.1.4.1 Impact Evaluation Overview

PSO's midstream projects provided rebates for a total of 285 projects. 176 projects consisted of lighting measures and 109 projects consisted of HVAC equipment. Table 3-33 provides projected, ex-ante, and ex-post energy and demand impacts, as well as other program performance metrics for midstream projects.

Table 3-33: Performance Metrics – Midstream Lighting and HVAC

Metric	PY2020
Number of Projects	285
Energy Impacts (kWh)	
Ex-ante Energy Savings	1,887,401
Gross *Ex-post* Energy Savings	1,408,576
Net *Ex-post* Energy Savings	1,138,463
Peak Demand Impacts (kW)	
Ex-ante Peak Demand Savings	239.20
Gross *Ex-post* Peak Demand Savings	233.73
Net *Ex-post* Peak Demand Savings	184.34
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	2.09
Utility Cost Test Ratio	1.23

3.1.4.2 Process Evaluation Overview

ADM performed a process evaluation including 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. 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?
- 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 2020 program year?
- Looking forward, what are the key barriers and drivers to program success within PSO's market?

To address these questions, ADM's PY2020 process evaluation activities included a review of program materials, program staff interviews distributor interviews and end-use customer surveys. Table 3-34 details PY2020's data collection activities.

Table 3-34: 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; information for calculation of a Net-to-Gross ratio, and satisfaction with program processes and the program overall.
End Use Customer Surveys	Gather data on participant knowledge and awareness of the program, motivation, business practices, satisfaction, reasons for participating, decision-making process, as well as data that will help to inform the calculation of a Net-to-Gross ratio.

3.1.4.3 Evaluation Methodology

This section provides an 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, end-users, and service providers. Program materials and documentation was gathered through the Sightline data management system. These materials were supplemented with information from manufacturers as well as the Air Conditioning, Heating and Refrigeration Institute (AHRI).

Impact Evaluation Methodology

The overall objective of the impact evaluation is to develop statistically valid estimates of gross and net annual energy savings (kWh), lifetime energy savings (kWh), and peak demand reductions (kW). ADM performed a census review of all midstream projects and line items. Ex-post savings from the Midstream Lighting program channel are 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.

Knowledge of baseline conditions is often not available in midstream applications. Baseline assumptions were determined with the implementation team following the AR TRM as well as other industry standards where the AR TRM is not applicable.

Determination of gross impacts from the Midstream channel will consist of several activities used to verify savings associated with the program. Those activities include:

- Verification of Equipment Counts: The number of units sold through the program will be verified through a review of distributor invoices.
- Verification of Fixture/Lamp Wattage and Lumen Output: Fixture and lamp wattages are reported in the program database and/or in the Point-of-Sale (POS) data provided by participating distributors. We will verify the reported values are correct by reviewing manufacturer specification sheets, Design Lighting Consortium (DLC), and/or ENERGY STAR certifications for a sample of fixtures/lamps sold through the program. The verified lumen output of the sold lamps will then be compared to the ex-ante baseline model to determine an appropriate baseline wattage.
- Verification of HVAC equipment: Equipment will be verified against the AHRI database.
- Categorize Building Types: The program data provided by the implementation contractor includes end user contact name, business name, and installation address. These data will be used to categorize the facility type where the sold

fixtures/lamps were installed. The facilities will be categorized according to the definitions provided in the AR TRM v7. The deemed Annual Operating Hours (AOH) and Coincident Factors (CF) provided in the TRM for each facility will be used in the ex-post energy savings calculations.

- Gross annual energy savings, peak demand reduction, and lifetime energy savings will be determined through industry standard methodologies. The AR TRM methodologies will be followed when applicable, with assumptions replaced by verifiable known conditions.

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. As a result, evaluating the net effects of the price discounts requires estimating free ridership without non-program sales data. ADM will investigate the PSO Midstream Program's net-to-gross ratio (NTGR) separately for Lighting and Non-Lighting (HVAC).

Midstream Lighting NTG

ADM will investigate the PSO Midstream Program's lighting net-to-gross ratio (NTGR) through both a survey of end-use customers as well as from a survey of participating lighting distributors.

ADM reviewed the survey data from each avenue prior to completing the analysis. If there were evidence that the buyers were not able to speak to how much the program influenced their decision, either because they were unaware of the discounted price or could not provide responses to multiple questions on program influence (e.g., responded by saying "don't know"), then we would have used the distributor scores to estimate program influence. However, sufficient information was reported from the end-user survey.

ADM will use self-reported responses from a random sample of customers who have purchased efficient light bulbs during the current program year to estimate lighting discount free ridership.

The survey will aim to elicit information from which to estimate the number of bulbs that the customer would have purchased in the counterfactual scenario where the efficient light bulbs were not discounted. The survey effort will be conducted with a random sample of PSO customers through phone calls. The strength of this approach is that it also allows for further questioning regarding the fate of recently purchased bulbs (e.g., installed immediately, stored for future use, the location of installation, etc.). Survey respondents will be asked a series of questions to elicit feedback regarding influences on their light bulb purchasing decisions. Each respondent will then be assigned a free ridership score based on a consistent free ridership scoring algorithm. The scoring algorithm used is based on the methodology described in the AR TRM v7.0.

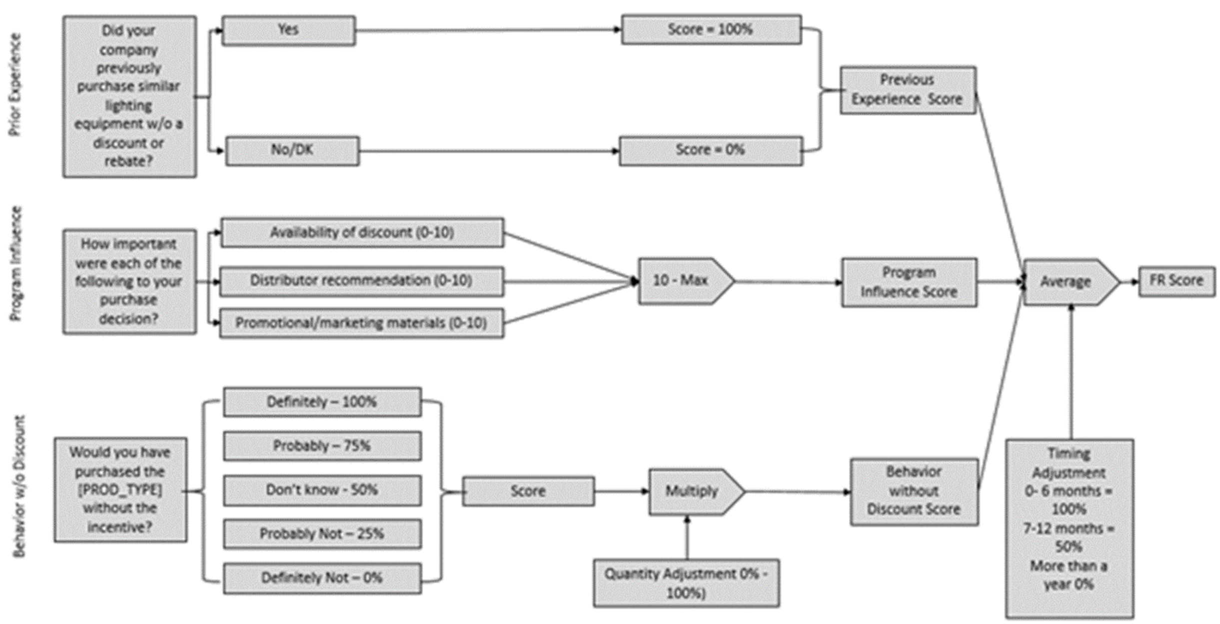
The final respondent net-to-gross score will be calculated as follows:

NTG = 1 – Free ridership

ADM will not assess spillover for the Midstream Lighting program for two reasons – there is limited spillover potential in a midstream program and the information required to calculate spillover would be burdensome and difficult for survey respondents to provide or estimate.

The free ridership scoring algorithm for light bulb purchases from the surveys is shown in Figure 3-11.

Figure 3-11: Free Ridership Scoring Algorithm



The flow diagram has three paths or branches. ADM will ask eight main questions to determine each respondent's free ridership score.

Prior Experience (first row): Two questions are used for prior experience:

- Prior to the purchase of the lighting, had your company purchased similar efficient lighting equipment?
- Did your company make any of those previous purchases without receiving a discount or rebate from PSO?

Program influence (second row): One question is used for influence/ importance:

- On a scale from 0 to 10, where 0 is “not at all important” and 10 is “very important”, how important was the following in your decision to purchase the [PROD_TYPE]?

Behavior without Discount (third row): There are five questions in this branch. One question is regarding customers’ behavior without a discount, there are two for the quantity adjustment, and two questions for the timing adjustment.

- Would you have purchased [PROD_TYPE] without the discount?
- Without the discounts from PSO, do you think you would have purchased the same amount, fewer, or more lamps?
- What percent of the lamps would you still have purchased if the discounts from PSO were not available?
- Did you purchase the [PROD_TYPE] earlier than you otherwise would have if the discount from PSO were not available? [DO NOT ASK TO NEW CONSTRUCTION PROJECT CUSTOMERS]
- When would you have purchased [PROD_TYPE] if the discounts from PSO were not available?

ADM will ask customers that provide conflicting responses an open-ended question to clarify the role of the discount in their decision-making process. Additionally, to provide context, ADM will ask customers how they learned about the discount and if they knew about the discount before they made the decision to purchase the product (these two questions are not typically directly included in the free ridership scoring algorithm but also provide context when needed).

Midstream Non-Lighting NTG

ADM will investigate the PSO Midstream HVAC Program’s net-to-gross ratio (NTGR) through both a survey of end-use customers as well as from a survey of participating HVAC distributors.

ADM reviewed the survey data from each avenue prior to completing the analysis. If there were evidence that the buyers were not able to speak to how much the program influenced their decision, either because they were unaware of the discounted price or could not provide responses to multiple questions on program influence (e.g., responded by saying “don’t know”), then we would have used the distributor scores to estimate program influence. However, sufficient information was reported from the end-user survey.

The methodology for end-user Midstream Non-Lighting is the same as Custom and Prescriptive and described in the Custom and Prescriptive Evaluation Methodology section.

Lifetime Energy Savings

Lifetime energy savings (kWh) is the product of annual energy savings (kWh) multiplied by the Effective Useful Life (EUL). The EUL considers the technical lifespan of the equipment as well as the change in energy savings over time. The EUL is determined by measure for each measure within each project of the evaluation sample. The EUL for prescriptive measures is sourced from the AR TRM v7.0. If a measure is not listed in the AR TRM then a different industry standard reference, such as another technical reference manual is considered. For custom equipment, the EUL is determined based on the lifespan of the equipment or if that cannot be determined then the industry standard of 20 years is applied. Energy savings for any behavioral measures in the program is only granted one year of EUL.

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 2020 program year?
- Looking forward, what are the key barriers and drivers to program success within PSO's market?

To address these questions, ADM's process evaluation activities included surveys to program participants as well as in-depth interviews with program staff and distributors. Table 3-35 provides a summary of data collection activities for the process evaluation.

Table 3-35: Midstream 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.
Distributor Interviews	Gather data on distributor knowledge and awareness of the program, motivation, business practices, satisfaction, reasons for participating, decision-making process, as well as general attitudes and behaviors regarding energy efficiency, PSO's Midstream Program, and PSO as their utility.
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.

3.1.4.4 Impact Evaluation Findings

Impact evaluation findings determine net annual energy savings and net coincident peak demand reduction. Gross energy impacts are assessed through M&V efforts on the total population of projects. The effects of free ridership are then applied to the population (on a project level basis) to determine program level net energy impacts.

Midstream Lighting Gross Impacts

The Midstream lighting program included 9,965 items sold with ex-ante energy savings of 852,893 kWh and ex-post savings of 882,369 kWh, resulting in a gross realization rate of 103%. The program channel also claimed a peak summer demand savings of 162.38 kW, while we calculated an ex-post summer peak demand savings of 159.71. This results in a realization rate of 98%. A summary of the program level savings is shown in Table 3-36.

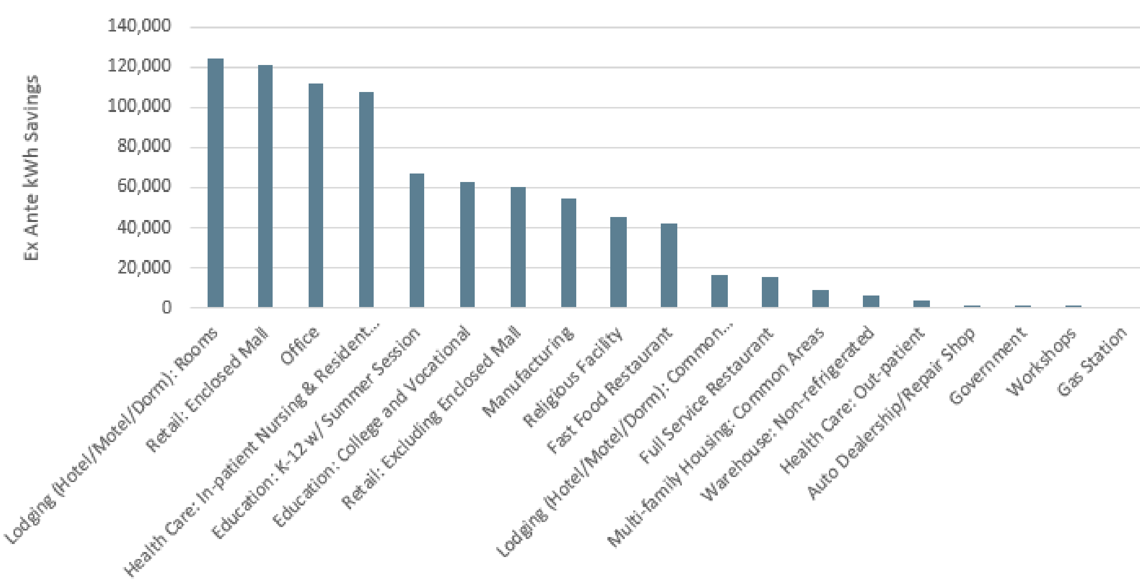
Table 3-36: Summary of Midstream Lighting Savings

Ex-ante kWh Savings	Ex-post kWh Savings	Gross kWh Realization Rate	Ex-ante kW Savings	Ex-post kW Savings	Gross kW Realization Rate
852,893	882,543	103%	162.38	159.94	98%

ADM determined ex-post savings for this program through a review of the tracking database provided by the implementation contractor. We reviewed the database to ensure there were no input errors or repeat entries and used the data provided to determine quantities and wattages of each lamp type sold. The database was used to determine final ex-ante annual energy savings and peak demand reduction savings as well as distributor name. The database was also reviewed to determine quantity of lamps sold, end customer name, lamp type, inducement amount, and sold lamp wattage. All ex-post savings were calculated using lamp types, wattages, and quantities provided in the tracking database.

A summary of savings by facility type can be seen in Figure 3-12. The facility type that contributed the most program savings was Lodging: Rooms. The facility type refers to all single room units of lodging facilities, including hotels, motels, and dormitories. This does not include common areas of each facility such as lobbies, hallways, and breakfast rooms. This facility type contributed savings of 47,009 kWh, 14.6% of overall savings.

Figure 3-12: Ex-ante kWh Savings by Facility Type



Variation between ex-ante and ex-post program savings are attributable to differences in the interactive effects. On average the energy interactive effect factor (IEFe) was 1.03 for ex-ante calculations while 1.05 was applied to all projects for ex-post kWh calculations.

The demand interactive effect (IEFd) averaged 1.14 in the ex-ante calculations while ex-post calculations applied a 1.1 IEFd for peak demand reduction. Other variation in savings occurred for Manufacturing and Health Care-In Patient facilities. The ex-ante calculations applied an annual operating hour (AOH) and coincidence factor of 5,589 and 0.77 for Manufacturing facilities, while ex-post calculations applied 4,457 and 0.89 per the AR TRM. Health Care-In Patient Facilities used an AOH and CF of 3,227 and 0.78 for ex-ante calculations and ex-post calculations applied 5,730 and 0.54. These differences contributed to 3% of total ex-post program savings.

Midstream Lighting NTG

ADM administered a phone survey to customers that purchased lighting through the PSO Midstream Lighting program. We made 63 calls and 6 emails to 52 unique end-use customers and completed 26 surveys (50% response rate). The customers that ADM spoke with had purchased a variety of lighting types including LED Linear Lamps, A-Line Lamps, LED Recessed Trim Kits, PAR lamps, BR lamps, MR lamps and Candelabras. The 26 customers that ADM spoke with represent 55% of Midstream Lighting Program kWh savings.

ADM used self-reported responses from customers who had purchased efficient lamps and fixtures to estimate free ridership at 80.14% for annual energy savings and 78.15% for peak demand reduction.

- Twelve respondents had free ridership scores of 33% or greater (representing 33% of the sample kWh savings). Free ridership is based on three categories, prior experience, program influence, and behavioral without a discount.
  - Prior Experience: All twelve respondents were assigned 100% “Prior Experience” scores because they reported having similar experience purchasing energy efficient lighting without a discount or rebate from PSO.
  - Program Influence: Two respondents were assigned a “Program Influence” partial free ridership score, indicating that the availability of the discount, recommendation from the distributor, and any marketing material they viewed had little or no impact on their decision-making process.
  - Behavior: Five respondents stated they would have purchased this energy efficient lighting without the discount and were therefore assigned free ridership.
- Fourteen respondents had free ridership scores of 25% or less. Of these respondents five were scored as having 0% free ridership, four respondents scored a partial free ridership score between 1 and 4%, four scored between 5 to 18%, and the remaining respondent was scored as having 25% free ridership.

See Table 3-37 and Table 3-38 for a summary of net savings impacts for the Midstream lighting program.

Table 3-37: Summary of Net kWh Savings - Midstream Lighting

Gross Ex-ante Savings kWh	Gross Ex-post Savings kWh	Gross Realization Rate	Gross Lifetime Savings kWh	kWh NTG Ratio	Net Ex-post Savings kWh	Net Lifetime Savings kWh
852,893	882,543	103%	9,056,595	80.14%	707,279	7,258,045

Table 3-38: Summary of Net kW Savings – Midstream Lighting

Ex-Ante kW Savings	Gross Ex-post Savings kW	Gross Realization Rate	kW NTG Ratio	Net Ex-post Savings kW
162.38	159.94	98%	78.15%	124.99

Midstream Non-Lighting Gross Impacts

The Midstream Non-Lighting program included 109 items over 59 projects consisting of unitary and split system air conditioners, air source heat pumps, dual enthalpy economizers, and variable refrigerant flow heat pumps. The gross ex-post energy savings and demand reduction was 526,033 kWh and 73.79 kW, resulting in realization rates of 51% and 96%, respectively. A summary of the program level savings is shown in Table 3-39

Table 3-39: Summary of Midstream Non-Lighting Savings

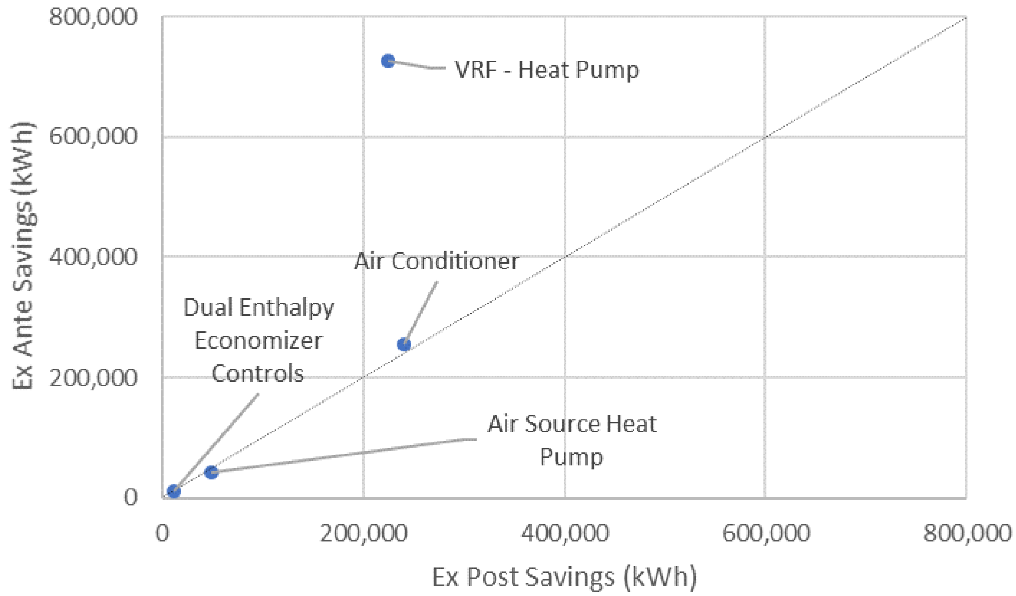
Ex-ante kWh Savings	Ex-post kWh Savings	Gross kWh Realization Rate	Ex-ante kW Savings	Ex-post kW Savings	Gross kW Realization Rate
1,034,508	526,033	51%	76.82	73.79	96%

ADM determined ex-post savings for the Midstream Non-Lighting Program using the program tracking data provided by the implementation contractor. The data was reviewed to identify and remove any input errors or duplicates prior to final analysis. Provided AHRI identification numbers were used to determine efficiency ratings of the installed equipment along with values determined from the Arkansas v7 Technical Reference Manual (TRM) and MidAtlantic v8 TRM.

A summary of savings by equipment type is shown in Figure 3-13. The figure plots the ex-ante annual energy savings versus the ex-post annual energy savings for the installed equipment types. Although it consisted of only three line-items, the “VRF – Heat Pump” equipment type was the largest contributing equipment type with ex-ante annual energy savings of 726,176 kWh. The gross annual energy savings realization rate for VRF equipment is 31%. When considering verified annual energy savings, the unitary and split

AC equipment type became the largest contributor to program ex-post annual energy savings at 240,205 kWh.

Figure 3-13: Ex-Ante Savings vs Ex-Post Savings (kWh) by Equipment Type



Generally, the discrepancies discovered in the Midstream Non-Lighting analysis were due to a difference in efficiency ratings which were determined using AHRI certificates for the installed equipment. Another discrepancy stemmed from a difference in effective full-load hours (EFLH) determined using zones identified by the zip code of project locations. The ex-ante calculations appeared to use only Zone 8 EFLH's, whereas some projects were in Zone 7 and Zone 9.

The driver of evaluation risk in this subprogram was from the VRF project with three VRF units. Ex-ante calculation used the AR TRM methodology consistent with ADM; however, the AR TRM table of efficiency values provides various units (COP and HSPF) within the same column in the table. The ex-ante calculations missed a required conversion to ensure consistency in units when comparing the baseline condition to the efficient condition. This project resulted in the subprogram realization rate to drop below 100%.

Midstream Non-Lighting NTG

ADM administered a phone survey to customers that purchased equipment through the PSO Midstream Non-Lighting program. We were able to complete 17 survey responses of which 12 respondents reported the necessary information to determine free ridership. The customers that ADM spoke with had purchased a variety of eligible equipment types including air source heat pumps, air conditioners, and dual enthalpy economizers.

ADM used these self-reported responses from customers who had purchased eligible equipment to estimate free ridership at 81.97% for verified annual energy savings and 80.44% for verified peak demand reduction. Only two respondents reported free ridership in the subprogram. Free ridership is applied as a percentage of each project's annual energy savings and peak demand reduction. Free ridership may be applied at 33%, 66% or 100% of the project's annual energy savings.

A full free ridership score was assigned to one respondent who purchased an air source heat pump who claimed they had plans to purchase the equipment without the program, would have purchased the equipment without the program and claimed the incentive had no influence on their purchase. A partial free ridership score was reported for a respondent with the purchase of unitary AC equipment with dual enthalpy controls. This respondent reported having the financial ability to purchase the equipment without the incentive as well as plans to purchase the equipment without the incentive. Free ridership was assigned to 33% of their annual energy savings.

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. See Table 3-40 and Table 3-41 for a summary of net savings impacts for the Midstream Non-Lighting Program.

Table 3-40: Summary of Net Annual Energy Savings - Midstream Non-Lighting

Gross Ex-ante Savings kWh	Gross Ex-post Savings kWh	Gross Realization Rate	Gross Lifetime Savings kWh	kWh NTG Ratio	Net Ex-post Savings kWh	Net Lifetime Savings kWh
1,034,508	526,033	51%	6,461,359	81.97%	431,184	5,296,312

Table 3-41: Summary of Net Peak Demand Reduction – Midstream Non-Lighting

Ex-Ante kW Savings	Gross Ex-post Savings kW	Gross Realization Rate	kW NTG Ratio	Net Ex-post Savings kW
76.82	73.79	96%	80.44%	59.35

Midstream Total Lifetime Energy Savings

Lifetime energy savings were determined for each equipment type or line item incentivized within each project. Lifetime energy savings are determined by multiplying verified annual energy savings with the effective useful life (EUL) from the associated TRM for the installed equipment type. Gross and net lifetime energy savings are provided in Table 3-42. Average EUL by measure classification is provided for reference.

Table 3-42:Midstream EUL's and Lifetime Energy Savings

Measure Classification	Average EUL	Gross Program Lifetime Energy Savings (kWh)	Net Program Lifetime Energy Savings (kWh)
Lighting	10	9,056,595	7,258,045
Non-Lighting	13	6,461,359	5,296,312
Total	**N/A**	**15,517,954**	**12,554,357**

3.1.4.5 Process Evaluation Findings

The process evaluation consisted of a participant survey, distributor interviews, and program staff interviews. ADM provided a detailed process evaluation memo to PSO after the completion of the 2020 program year.

Lighting End User Survey

ADM administered a phone survey to in July/August and in October 2020 to customers that purchased lighting through the PSO Midstream Program. ADM surveyed 28 customers after attempting to reach 52 customers with 78 phone calls and 13 emails, for a 54% completion rate.

Survey findings indicate that the discount played an important role in customers' decisions to retrofit or replace less efficient lighting, though a significant portion of respondents had purchased energy efficient lighting in the past without a discount.

- Sixty-eight percent of respondents said they would have bought fewer lamps without the PSO discounts. Similarly, 82% of respondents said that the availability of discounts was important in their decision to purchase the energy efficient lighting.[31]
- Sixty-eight percent of respondents said they had purchased similar energy efficient lighting in the past and 63% of those respondents reported having purchased it without a discount.

Most of the survey respondents said that all the discounted lamps they purchased through the program had been installed, though some respondents mentioned they had not had an opportunity to install all the lamps yet. Table 3-43 displays the percent of the program discounted lamps respondents reported having installed currently.

[31] Rated the importance of the discounts a 7 or higher on a scale from 0 (not at all important) to 10 (very important)

Table 3-43: In-service rates for discounted LED lamps

Product Type	Percent of Lamps Installed	n
BR Type Lamp(s)	100%	2
Candelabra(s)	100%	1
LED Downlight(s)/Trimkit(s)	100%	1
PAR Lamp(s)	98%	3
LED Linear Lamp(s)	99%	22
MR Type Lamp(s)	95%	1
A-Line Lamp(s)	92%	11

Lighting Distributor Interviews

In October 2020 ADM interviewed three lighting distributors that had participated in the PSO Midstream Program. The distributors said they were satisfied with the program staff, enrollment process, the program sales tracking process, and their overall experience with the program. The three distributors observed that training and support for the program remained strong in PY2020 and that marketing and outreach methods were consistent with the program's first year. Two distributors suggested broadening the types of lighting that were included in the program.

HVAC End User Survey

ADM administered a phone survey in July/August and in October 2020 to customers that purchased HVAC equipment through the PSO Midstream Program. ADM surveyed 17 customers after attempting to contact 39 participants with 58 phone calls and 25 emails, for a completion rate of 44%. All respondents confirmed that the equipment they purchased had been installed in PSO's service territory.

The twelve respondents who were aware that PSO sponsored a discount on the HVAC equipment they purchased answered questions regarding their decision-making process. Eleven of these respondents said they would have had the financial ability to complete the energy efficient HVAC equipment project without the program.

Nine of these respondents had plans to complete the HVAC equipment project before they heard about the PSO-sponsored program and all the respondents said they either probably (3 respondents) or definitely (9 respondents) would have completed the project without the PSO-sponsored discount.

Six respondents said they purchased more efficient HVAC equipment because of the discount.

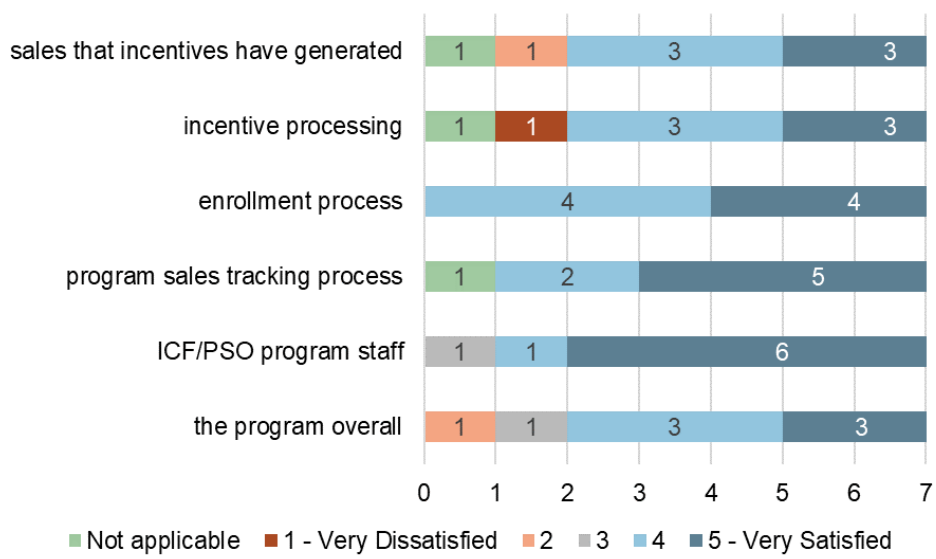
Five respondents said they had previous experience with PSO energy efficiency programs. Three of the respondents experienced with PSO's energy efficiency programs said that it important was important in their decision to complete the energy efficient HVAC equipment project through PSO's Midstream Program.

HVAC Distributor Interviews

ADM interviewed eight HVAC distributors that participated in the PSO Midstream Program in October 2020. Five distributors said their company primarily sold equipment to contractors. The other three distributors noted that they sold equipment to both HVAC contractors and end-use customers such as property managers or facility owners.

ADM asked the distributors to rate their satisfaction with various aspects of their program participation (see Figure 3-14). Six of the distributors indicated they were satisfied with the program overall. Two distributors said they were dissatisfied with the program's design. One HVAC distributor noted that they preferred the Prescriptive and Custom Program's contractor-driven model, previously used for HVAC equipment. The other distributor suggested the program direct payments to end use customers to avoid administrative and coordination burdens that the Midstream model requires distributors and contractors to overcome.

Figure 3-14: HVAC Distributor Satisfaction



3.1.4.6 Commercial Midstream Conclusions and Recommendations

This section presents findings from the process and impact evaluation and recommendations based on these findings.

Conclusions

- The Midstream subprogram saw a large increase in participation and annual energy savings per participant from the previous year. The tremendous effort by program and implementation staff to overcome the challenges of this year are noteworthy.

- Survey and interview results indicate the program's design and implementation processes are well understood and had been implemented without significant issues.
- Customer surveys and distributor interviews indicate that COVID-19 affected program sales and customers' ability to take advantage of the PSO discounts.
- HVAC distributor interviews suggest there is growing understanding and acceptance of the Midstream Program's design, though some distributors still have reservations and concerns. However, the increase in participation in the program indicates a positive trend towards understanding the program characteristics.
- Though the program's HVAC discounts act as motivation for some customers, survey results indicate a portion of customers would purchase energy efficient equipment without the program. The discount influenced several customers to purchase more efficient equipment, but in general the HVAC end user customer survey results suggest customers had plans to purchase equipment before learning of the discount and would have completed the HVAC installation or retrofit project without the discount.
- Lighting end use customer survey results indicate the Midstream Program discount played an important role in customer's decision to buy energy efficient lighting.
- Survey and interview results indicate the Midstream Program is serving a wide variety of business types and size, though Lighting distributor interviews and end user survey results indicate there is potential to expand the reach of the program by diversifying the types of lighting products that are discounted through the program.
- ADM found that HVAC end users had varying levels of awareness about the program discount, their company's decision-making process, and the HVAC distributor that sold their company the equipment. Lighting end user surveys showed customers were generally more aware of the discount, decision making process, and lighting distributor.

Recommendations

- Research and consider the benefits that may be achieved by adding additional lighting product types to enable a larger variety of businesses customers to participate.
- Implementation and PSO staff could use additional strategies to engage with business customers to increase awareness of the Midstream Program's discounts for both HVAC and lighting equipment. Additional marketing strategies could

include bill inserts and targeted emails with project examples and listings of eligible measures.

- Explore more ways to encourage Midstream Program end use customers to participate in other PSO energy efficiency programs and to consider other potential energy efficiency improvements for their organizations.

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 (kWh) and peak demand reduction (kW) with the inclusion of in-service rates, and net savings impacts. The process evaluation provides insights into program design and implementation.

3.2.1 Program Overview

The Multifamily Program is in its second year in the Public Service Company of Oklahoma (PSO) portfolio during program year 2020 (PY2020). The PY2020 reported Program savings were more than double the portfolio goal at 205%. While the Multifamily Program goal of serving 100 customers was the same as the previous year, the customers served increased from 105 to112 customers. Program expenditures also exceeded the budget; however, the additional energy savings outweighed the additional cost. Table 3-44 below illustrates performance metrics for the Multifamily Program.

To be eligible for the Multifamily Program, the property must be composed of three or more dwelling units with the service territory. Energy efficiency equipment is eligible within dwelling units, in common areas, and in office spaces.

Table 3-44: Performance Metrics - Multifamily Program

Metric	PY2020
Number of Customers	112
Budgeted Expenditures	$970,698
Actual Expenditures	$1,497,183
Energy Impacts (kWh)	
Projected Energy Savings	1,515,779
Reported Energy Savings	3,114,334
Gross Verified Energy Savings	3,111,730
Net Verified Energy Savings	3,106,403
Peak Demand Impacts (kW)	
Projected Peak Demand Savings	450
Reported Peak Demand Savings	853.88
Gross Verified Peak Demand Savings	821.69
Net Verified Peak Demand Savings	819.82
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	2.29
Utility Cost Test Ratio	1.74

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, ENERGY STAR® washing machines, ENERGY STAR® dryers, vending machine controls, and ice machines.

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.

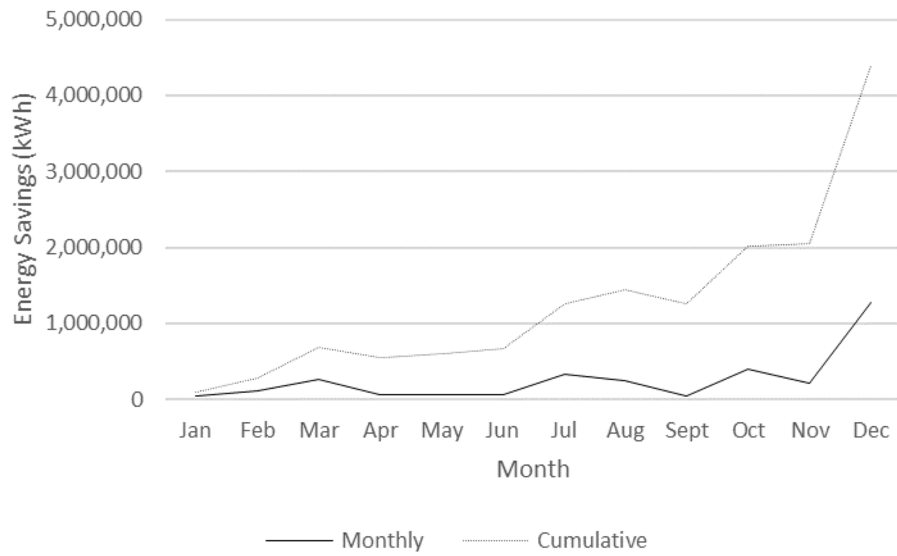
The Multifamily Program defines prescriptive rebate amounts to participating customers for some measures, including certain types of lighting, lighting controls, HVAC equipment, water-related equipment, and other equipment. The Multifamily Program pays rebates for custom projects (e.g., chillers) that do not fall into prescriptive measure categories on a per kWh and kW impact basis. Table 3-45 summarizes Multifamily Program activity by the percentage of reported savings by measure type.

Table 3-45: Percentage of Reported Savings by Measure Type

Measure Type	Percent of Program
HVAC	45.65%
Lighting	38.41%
Building Envelope	13.30%
Domestic Hot Water	1.61%
Pool Pumps	0.55%
Appliances	0.47%

Participation in the Multifamily Program varied throughout the year. The initial effects of the pandemic seem to have impacted the program for a few months. The largest projects, in terms of both savings and incentives were completed from July – December. Figure 3-15 illustrates program activity throughout the year, including monthly and cumulative project savings.

Figure 3-15: Accrual of Reported Annual Energy Savings during the Program Year



Program participation and savings goals were exceeded, with both metrics having increased from the previous program year.

3.2.2 EM&V Methodology

This chapter provides an overview of the data collection activities, gross and net impact calculation methodologies, and process evaluation methodologies that ADM employed in the evaluation of the Multifamily Program.

3.2.2.1 Data Collection

Data collection activities for the evaluation consisted of a review of program materials, ride along verification visits, and interviews with participating owners/managers and tenants.

Program information and documentation was obtained for the census of projects within the program. Documentation included energy savings algorithms and inputs, project invoices, equipment specification sheets, and any available implementation documents such as inspection reports. ADM also acquired information on equipment from industry references such as the Air Conditioning, Heating, and Refrigeration Institute (AHRI) and the Design Lighting Consortium (DLC). PSO uses Sightline in conjunction with an SQL Server Reporting Services (SSRS) system as its central tracking and reporting system. Review and collection of this documentation is the desk review portion of the impact evaluation.

In lieu of on-site data collection due to safety protocols during the pandemic, ADM performed limited ride along field visits and collected information virtually. During ride alongs, ADM was able to observe the program data collection process and perform any necessary measurement and verification data collection. ADM did not deploy any monitoring equipment but gathered baseline conditions and efficient equipment conditions such as quantities, specifications, locations, and operating conditions. While on-site, ADM employees strictly adhered to local, regional, and federal guidelines pertaining to any interaction with others.

Other data collection activities included customer surveys, property owner/manager surveys, and in-depth interviews with program staff, and in-depth interviews with service providers. Surveys and interviews are used to provide self-reported data for the net-to-gross (NTG) analysis as well as process evaluation. Table 3-46 shows the achieved sample sizes for the different types of data collection activities utilized for this study.

Table 3-46: Sample Sizes for Data Collection Efforts

Data Collection Activity	Achieved Sample Size
Ride Alongs	2
Property Owner/Manager Survey	14
Tenant Survey	2
In-depth Interviews with Program Staff	2
In-depth Interviews with Service Providers	2
Desk Review	Census

3.2.2.2 Gross Energy Impacts Methodology

ADM performed a census review of program tracking data to determine gross energy savings program results. 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 data issues such as duplicate entries or missing data.
- Periodic review of the program data was done throughout the year, to reduce the risk of evaluation uncertainty through performing desk reviews of initial project data and providing commentary to PSO regarding the utilized methodologies of savings calculations.
- ADM conducted a detailed desk review for each project completed through the Multifamily program. 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. The review process led to further requests for information and/or project documents for corresponding projects determined to have potential for savings realization discrepancies.

- ADM then calculated verified gross savings impacts. The sources for deemed savings algorithms are the 2013 Oklahoma Deemed Savings Document, Arkansas Technical Reference Manual v.7 (AR TRM), and Mid-Atlantic Technical Reference Manual v.8 (Mid-Atlantic TRM).
- ADM used the data collected through ride-alongs and surveys to revise any 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 reflect actual operating conditions more accurately.
- Net energy impacts are determined through survey results of property owners/managers to assess the impact of free ridership.
- Lifetime energy savings are determined through application of industry standard effective useful life (EUL) references by equipment type such as the AR TRM.

ADM used the algorithms in

Table 3-47 below to calculate annual energy savings, peak demand reductions, and lifetime energy savings for the Multifamily Program.

Table 3-47: References for Energy Savings Calculations

Measure	Methodology 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	2013 OKDSD, section 5
Faucet Aerators	Arkansas TRM v.7.0, section 2.3.4
Heat Pumps	2013 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	2013 OKDSD, section 6
Lighting Efficiency	Arkansas TRM v.7.0, section 2.5.1.4
	Arkansas TRM v.7.0, section 2.5.1.3
	Arkansas TRM v.7.0, section 3.6.2
	Arkansas TRM v.7.0, section 3.6.3
ENERGY STAR® Dryer	Mid-Atlantic TRM v8.0
ENERGY STAR® Washing Machine	Arkansas TRM v7.0 2.4.1

3.2.2.3 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 are not considered. 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?
- 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.

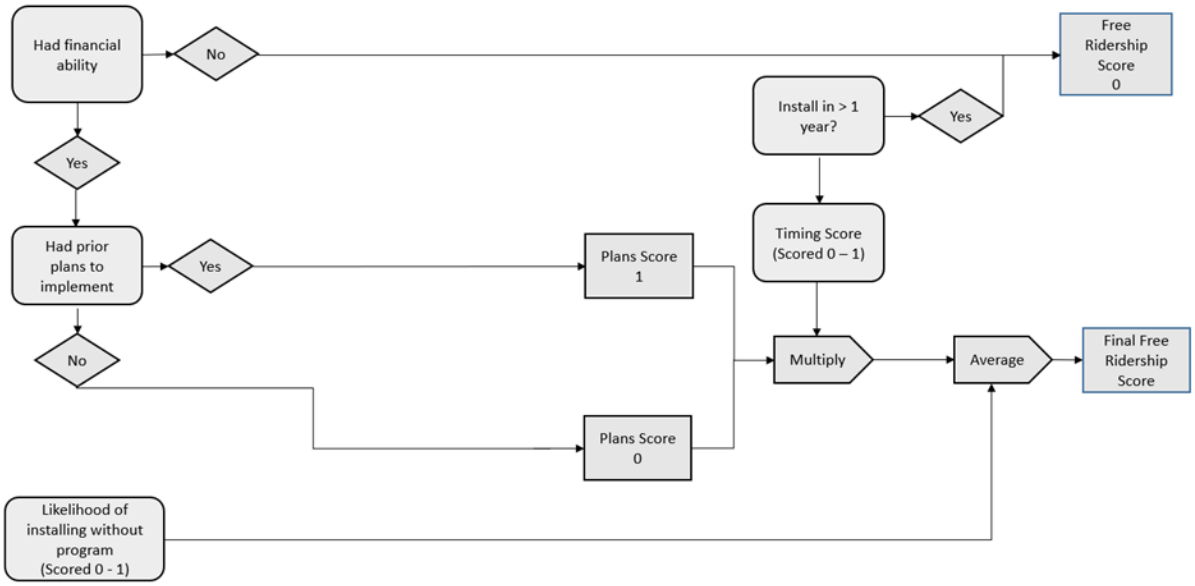
The estimation of free ridership incorporated the program's influence on the timing of the project in one of two ways. First, consistent with the Arkansas TRM definition of free ridership, respondents who indicated that the project would have been completed in more than one year if the program were not 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 was not provided or if the measure was not 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 3-16.

Figure 3-16: Non-Direct Install Scoring Flow Chart



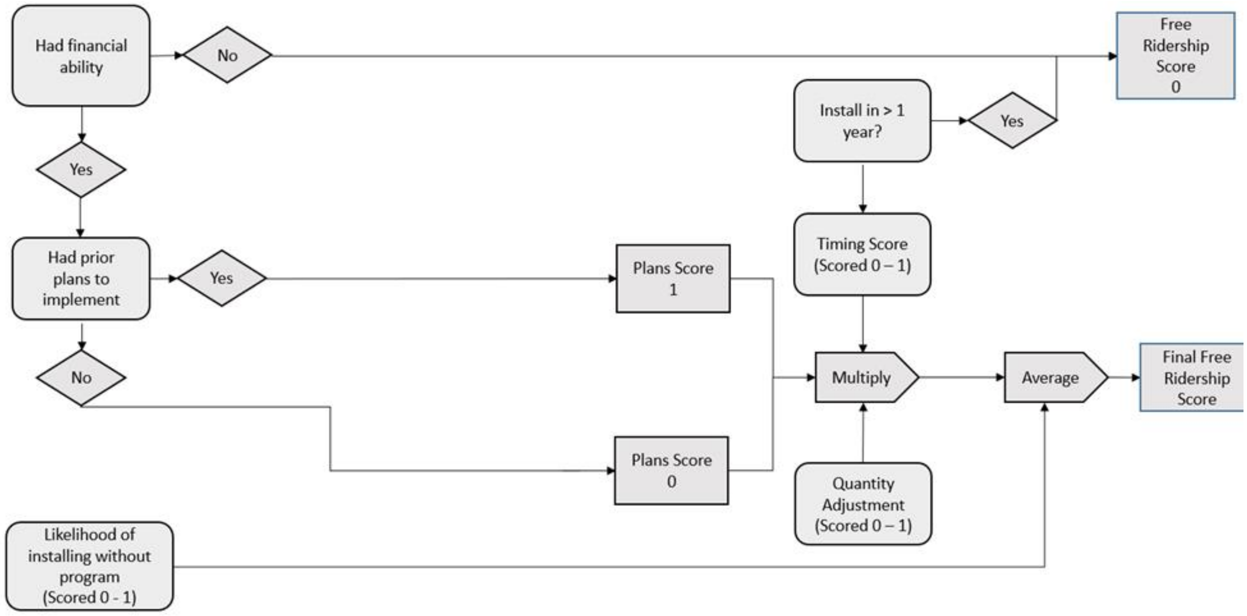
Free-Ridership (Direct Install)

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 3-17.

Figure 3-17: 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)

3.2.2.4 Lifetime Energy Savings

Lifetime energy savings (kWh) is the product of annual energy savings (kWh) multiplied by the Effective Useful Life (EUL). The EUL considers the technical lifespan of the equipment as well as the change in energy savings over time. The EUL is determined by measure for each measure within each project of the evaluation sample. The EUL for prescriptive measures is sourced from the AR TRM v7.0. If a measure is not listed in the AR TRM then a different industry standard reference, such as another technical reference manual is considered.

3.2.2.5 Process Evaluation Methodology

The process evaluation will be designed to answer the following research questions:

- How effective were the marketing efforts for the program? How did PSO market this program? Which marketing methods were most effective?
- What motivates owners/property managers to participate in the program? What barriers prevent participation?
- How well did PSO staff, service providers, implementation contractors, and property managers/owners 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 property managers/owners 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?
- Did property managers/owners find the energy survey of their property to be beneficial? If not, how could the survey be improved?
- What are PSO staff and implementation staff perspectives on the program? What are reactions to program design choices that have been implemented?
- What are key indicators of program success? Is the program achieving success? Do various stakeholders perceive the program to be successful?
- What do property managers/owners like about the program? Why? What would they like to change about the program? Why?
- What share of projects are associated with specific property managers/owners? Are most applicant's property managers/owners or service providers? How are savings distributed across them? Are there any differences in opinion between active and less active participants?
- What types of multifamily properties participated in the program? Could certain facility types be targeted more effectively?
- Were there any significant obstacles during the 2019 program year?

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

To address these questions, ADM's process evaluation activities will include two surveys and in-depth interviews with program staff and service providers. One survey will seek to gather information from property owners/managers that participated in the program. The other survey will target tenants at multifamily properties that participated in the program. ADM also plans to interview service providers and program staff to gain insight into program design and implementation.

Table 3-48 details the data collection activities performed for this program's evaluation.

Table 3-48: Process Evaluation Data Collection Activities Summary

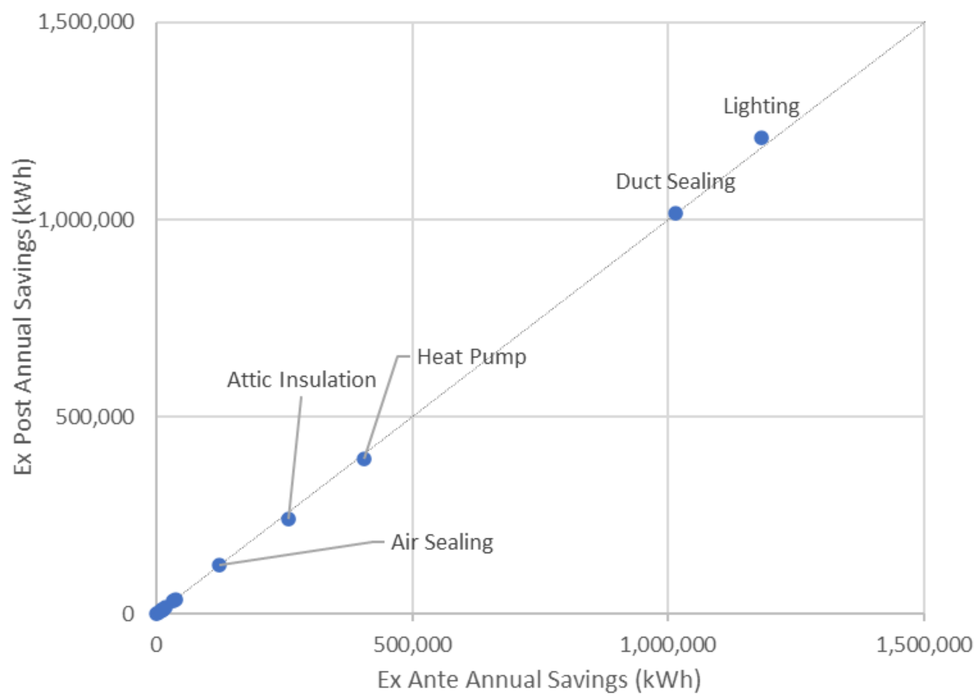
Data Collection Activity	Process Evaluation Research Objectives
Program Staff Interviews	Assess program staff perspectives regarding program operations, strengths, or barriers to success.
Review Program Materials	Review materials pertaining to program design or implementation, marketing materials, program procedure manuals, program websites, and other program documentation as it becomes available. This includes application forms, savings calculation spreadsheets, databases, and tracking systems to verify relevant information needed for the evaluation is being collected.
Property Owner/Manager Survey	Gather data on participant knowledge and awareness of the program, business practices, satisfaction, reasons for participating, decision-making process, as well as general attitudes and behaviors regarding energy efficiency, PSO's Multifamily program, and PSO as their utility.
Tenant Survey	Gather data that will help to inform the calculation of an in-service rates and hours of use for direct install measures. Gather data on participant knowledge and awareness of the program, satisfaction, as well as general attitudes and behaviors regarding energy efficiency, PSO's Multifamily program, and PSO as their utility.

3.2.3 Impact Evaluation Findings

Impact evaluation findings determine net annual energy savings and net coincident peak demand reduction. Net impact results are determined through the application of net-to-gross ratios applied to the verified gross energy impacts through evaluation activities. Gross energy impacts have been determined through a census desk review of all projects accompanied by data collection of surveys and site inspections.

The Multifamily program in 2020 consisted of 14 main measure types spanning both direct install measures and non-direct install measures. A graphical representation of the relative contribution of measures to the overall Multifamily Program savings and realization rates is in Figure 3-18 below. As shown in the figure, lighting and duct sealing are the measures with the largest impact on the program, with realization rates of 102% and 100%, respectively. The top five contributing measures are labeled while measures with minimal impact are not labeled. These include faucet aerators, windows, low flow showerheads, ENERGY STAR® washing machines, dryers, pool pumps, new construction lighting, and lighting controls.

Figure 3-18: Ex-Ante vs. Ex-Post Measure Level Energy Savings



The program level realization rate for energy savings is 100% with measure level variation from 91% to 102%. Findings for measure types that deviated from ex-ante estimates are explained in Table 3-49 below.

Table 3-49: Verified Gross Annual Energy Savings by Measure

Equipment	Total Ex-Ante kWh	Total Ex-Post kWh	kWh RR
Air Sealing	124,067	124,067	100%
Attic Insulation	257,511	243,014	94%
Duct Sealing	1,015,183	1,015,654	100%
Faucet Aerator	12,422	12,529	101%
Heat Pump	406,658	394,225	97%
Low Flow Shower Head	37,665	37,411	99%
Pool Pump	17,264	17,357	101%
Windows	32,669	32,669	100%
Lighting	1,182,591	1,207,390	102%
Whole Building Approach (NC Lighting)	13,441	12,559	93%
Occupancy Sensor (Lighting)	99	90	91%
ENERGY STAR Dryer	4,937	4,936	100%
ENERGY STAR Washing Machine	9,828	9,828	100%
Total	**3,114,334**	**3,111,730**	**100%**

3.2.3.1 Gross Annual Energy Savings (kWh)

Attic insulation

The annual energy savings realization rate for ceiling insulation measures is 94%. There was a group of line items from a single project with a reported R value that was ineligible for savings, whereas the tracking data had reported savings. In addition, the AR TRM specifies the use of linear interpolation when the post-retrofit R-value falls between R-38 and R-49. It appears some project level realization rates are greater than 100% when efficient conditions exceed R-38.

Heat Pump

ADM calculated the annual energy savings and demand reductions for Heat Pumps in the Multifamily Program using the Oklahoma deemed savings document. 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. instances where these values do not match are the cause of realization discrepancy. In addition, there appear to be minor discrepancies in the application of weather zones from the 2013 OKDSD Table 61.

Retrofit Lighting

ADM calculated the deemed savings values for Residential Lighting in the Multifamily Program using the AR TRM. The annual energy savings and demand reduction realization rates are 102% and 106%, respectively. Several minor discrepancies in some projects led to differences in projects, which were caused by:

- Variation in baseline fixture wattages.
- Efficient condition fixture wattages varying from DLC or specification sheet values.
- Variation in application of In-Service-Rate (ISR).

Whole Building Approach (New Construction Lighting)

The whole building approach (new construction lighting) consisted of a single line item, which had negligible impact on program savings. The annual energy savings and demand reduction realization rates were determined to be 93% and 160%, respectively. The verified annual energy savings for this measure were calculated using the AR v7 TRM with the space type of “Multi-Family”.

Occupancy Sensor

The occupancy sensor measure consisted of a single line item. The associated annual energy savings realization rate was 93%. The line item was calculated as a lighting project with a reduction in efficient hours by 30% as per the AR TRM.

3.2.3.2 Coincident Peak Demand Reduction (kW)

The overall realization rates for the peak demand reduction are 94%. The main difference in calculated peak demand reduction values is in the calculation for heat pumps. Discrepancies in the calculation of heat pump kW is due to a difference in cooling capacity and EER values as determined by the AHRI certificates of installed heat pumps from the ratings listed in the tracking data. Demand reduction by measure is explained in Table 3-50.

Table 3-50: Verified Gross Peak Demand Reduction by Measure

Equipment	Total Ex-Ante kW	Total Ex-Post kW	kW RR
Air Sealing	27.21	27.21	100%
Attic Insulation	105.59	105.23	100%
Duct Sealing	325.84	325.35	100%
Faucet Aerator	1.29	1.30	101%
Heat Pump	130.50	83.72	64%
Low Flow Shower Head	4.05	3.89	96%
Pool Pump	3.96	3.96	100%
Windows	18.16	18.16	100%
Lighting	217.78	230.51	106%
Whole Building Approach (NC Lighting)	12.23	19.54	160%
ENERGY STAR Dryer	4.94	0.49	10%
ENERGY STAR Washing Machine	2.32	2.32	100%
Total	**853.88**	**821.69**	**94%**

ENERGY STAR® Dryer

The peak demand reduction realization rate for ENERGY STAR® Dryers is 10%. The reason for the discrepancy in peak demand reduction was determined to be a magnitude error in the coincidence factor used in the ex-ante calculations.

3.2.3.3 Net-To-Gross Estimation Impact Findings

ADM collected survey data to assign free ridership scores from property owners/manager as well as tenants. Due to the low participation by tenants, free ridership has been determined based on the 14 self-claimed survey results of the property owners/managers. Separate free ridership scores were determined for direct install measures (8 respondents) and non-direct install measures (6 respondents). Partial free ridership was considered at the project level for respondents.

For the direct installation of screw-in light bulbs, survey results indicated no free ridership in the program. Free ridership was found in relation to the installation of windows, duct sealing, and attic insulation. In the three project instances of free ridership, only partial free ridership was claimed. Reasoning included prior plans to install (windows) and acknowledgement they would have installed without the program (windows, duct sealing, and attic insulation). These acknowledgements resulted in an overall free ridership score of 0.02% for the program.

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.

The NTG ratios are calculated as 1-free-ridership plus spillover. This results in a program level annual energy savings NTG of 99.8%. Results by measure classification are shown in Table 3-51 for annual energy savings and Table 3-52 for peak demand reduction.

Table 3-51: Net Energy Savings for Direct Install & Non-Direct Install Measures

Component	Expected kWh Savings	Verified Gross kWh Savings	Free Ridership (kWh)	Verified Net kWh Savings	Net to Gross Ratio
Non-Direct Install	2,035,241	2,007,064	5,327	2,001,737	99.7%
Direct Install	1,079,093	1,104,666	0	1,104,666	100.0%
Total	**3,114,334**	**3,111,730**	**5,327**	**3,106,403**	**99.8%**

Table 3-52: Net Peak Demand Savings for Direct Install & Non-Direct Install Measures

Component	Expected Peak kW Reductions	Verified Gross kW Reductions	Free Ridership (kWh)	Verified Net kW Reductions	Net to Gross Ratio
Non-Direct Install	632.34	587.36	1.87	585.49	99.7%
Direct Install	221.54	234.22	0.00	234.22	100.0%
Total	**853.88**	**821.69**	**1.87**	**819.82**	**99.8%**

3.2.3.4 Lifetime Energy Savings

Lifetime energy savings were calculated by multiplying the annual energy savings by the effective useful life (EUL) from the corresponding AR TRM section. Lifetime energy savings and average EUL by measure type are shown in Table 3-53.

Table 3-53: Measure EUL's and Lifetime Energy Savings

Equipment	EUL	Gross Lifetime Savings (kWh)	Net Lifetime Savings (kWh)
Air Sealing	11	1,364,735	1,361,113
Attic Insulation	20	4,860,273	4,847,372
Duct Sealing	18	18,281,777	18,233,251
Faucet Aerator	10	125,292	125,292
Heat Pump	16	6,307,604	6,290,862
Low Flow Shower Head	10	374,113	374,113
Pool Pump	10	173,568	173,107
Windows	20	653,375	651,641
Lighting	19	22,940,406	22,931,704
Whole Building Approach (NC Lighting)	11	138,154	137,787
Occupancy Sensor (Lighting)	8	722	720
ENERGY STAR Dryer	14	69,110	68,927
ENERGY STAR Washing Machine	14	137,592	137,227
Total		**55,426,720**	**55,333,115**

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. ADM provided a detailed process evaluation memo to PSO after the completion of the 2020 program year.

3.2.4.1 Service Provider Perspectives

ADM interviewed the two primary service providers that participated in the PSO Multifamily Program. 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

Overall survey-takers were satisfied with interactions with program staff, the quality of the contractor's work, the process of applying for the program and having equipment installed, performance of the equipment installed, wait time to receive services, and the quality of the contractor's work and the program overall.[32] Most respondents noted having recommended the program to someone else. All the decisionmakers said they were satisfied with PSO as their electric utility.

3.2.4.3 Tenant Survey

ADM researchers designed a survey invitation flier with a QR code and link to gather feedback as well as information to determine in-service rates for direct install measures from tenants at participating properties. The invitation fliers were all distributed through the Third-Party Verifier.

Two tenants completed the survey and provided feedback regarding program participation in June and July of 2020. Both respondents reported being very satisfied with the quality of the contract's work, their interactions with the contractor and their overall experience with the contractor. ADM will seek to gather additional responses using this method in future evaluation cycles and continue to investigate other methods of learning about tenants' program experience and in-unit in-service rates.

3.2.5 Conclusions and Recommendations

Evaluation of the Multifamily Program consisted of a process and impact evaluation to determine ex-post verified net 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 3-54 and Table 3-55.

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

Table 3-54: 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	3,114,334	3,111,730	100%	99.8%	3,106,403

Table 3-55: 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	853.88	821.69	96%	99.8%	819.82

ADM developed the following conclusions from the evaluation findings.

- Lighting became the primary driving factor in program savings, with similar numbers when compared to last year. Duct sealing was the second highest contributor to the program.
- Incentivized measures offered by the program have expanded from the previous year, but new additions to the program have minimal impact on program savings.
- Even with the onset of a global pandemic, the program was able to exceed goals and maintain a similar scope as the introductory year, possibly indicating that more can be done to increase awareness and participation in the coming years.
- Staff interviews indicate that the program was successfully marketed and promoted in 2020; however, findings from ADM's service provider interviews suggest that there is an opportunity 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 to continue to exceed goals.
- Increase program funding to support the strong demand from Multifamily properties for energy efficiency improvements. Program budget was exceeded for the second year in a row. A limited budget may be hindering growth of the program when there would otherwise be demand. Both service providers noted strong demand for the program.
- Evaluation and implementation teams work closely to ensure consistency and accuracy in M&V methodologies and program tracking data. Enhanced efforts in data collection can provide valuable insights for future program implementation.

- Increase collaboration with service providers to market and promote the program to eligible Multifamily properties. The program had effective marketing and promotion strategies in 2020 but including the program's foremost service providers in the marketing strategy to a greater extent may provide multiple benefits. Increased collaboration would bolster the relationship with service providers and potentially reach a wider variety of Multifamily properties.

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. PY2020 performance metrics are summarized in Table 3-56.

Table 3-56: Performance Metrics – Weatherization

Metric	PY2020
Number of Customers	2,163
Budgeted Expenditures	$3,409,467
Actual Expenditures	$3,316,716
Energy Impacts (kWh)	
Projected Energy Savings	2,464,670
Reported Energy Savings	4,257,823
Gross Verified Energy Savings	4,239,629
Net Verified Energy Savings	4,239,629
Peak Demand Impacts (kW)	
Projected Peak Demand Savings	1,203
Reported Peak Demand Savings	2,249
Gross Verified Peak Demand Savings	2,245
Net Verified Peak Demand Savings	2,245
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	2.87
Utility Cost Test Ratio	1.97

In 2020, PSO partnered with three organizations to deliver the efficiency improvements: Titan ES, Rebuilding Tulsa Together (RTT), and KI BOIS Community Action Foundation.

- Titan ES is a home weatherization contractor that provides diagnostic energy assessments, customer education, and installation of weatherization measures to improve energy efficiency;
- 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.” Their programs serve every age, ethnic and gender group in the area and include children services, senior programs, public transportation, case management, and Veteran services.

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 3-57 shows measures installed through the program in 2020. Air Infiltration was the most common measure type and in conjunction with attic insulation and duct sealing, made up most of the program savings. In 2020 the program expanded and added several measures intended for mobile homes (low flow showerheads, faucet aerators, advanced power strips, LED lightbulbs, and mobile home air infiltration). These measures made up about two percent of program savings.

Table 3-57: Summary of Measures Implemented

Measure	Number of Projects	% Share of Reported kWh Savings
Air Infiltration	1714	22%
Attic Insulation	1690	36%
Duct Sealing	1573	39%
Water Heater Jacket	85	<1%
Water Heater Pipe Insulation	509	<1%
Showerheads - Mobile	61	<1%
LED-Mobile	85	<1%
Faucet Aerators - Mobile	65	<1%
APS - Mobile	68	<1%
Air Infiltration - Mobile	71	<1%

PSO’s Home Weatherization Program serviced 2,163 households during the 2020 program year. Participants saved an average of 1,959 kWh. This compares to an average of an average of 2,111 kWh in 2018 and 1,828 kWh in 2019. Table 3-58 shows number of homes serviced by each agency.

Table 3-58: Homes by Agency

Agency	Number of Homes
Titan	2,111
RTT	44
KI BOIS Community Action, Inc.	8
Total	**2,163**

Participation in the Home Weatherization Program remained fairly consistent throughout the year, though from April through May there was decreased program activity. Figure 3-19 displays the accrual of reported energy savings throughout 2020.

Figure 3-19: Accrual of Reported kWh Savings During the Program Year

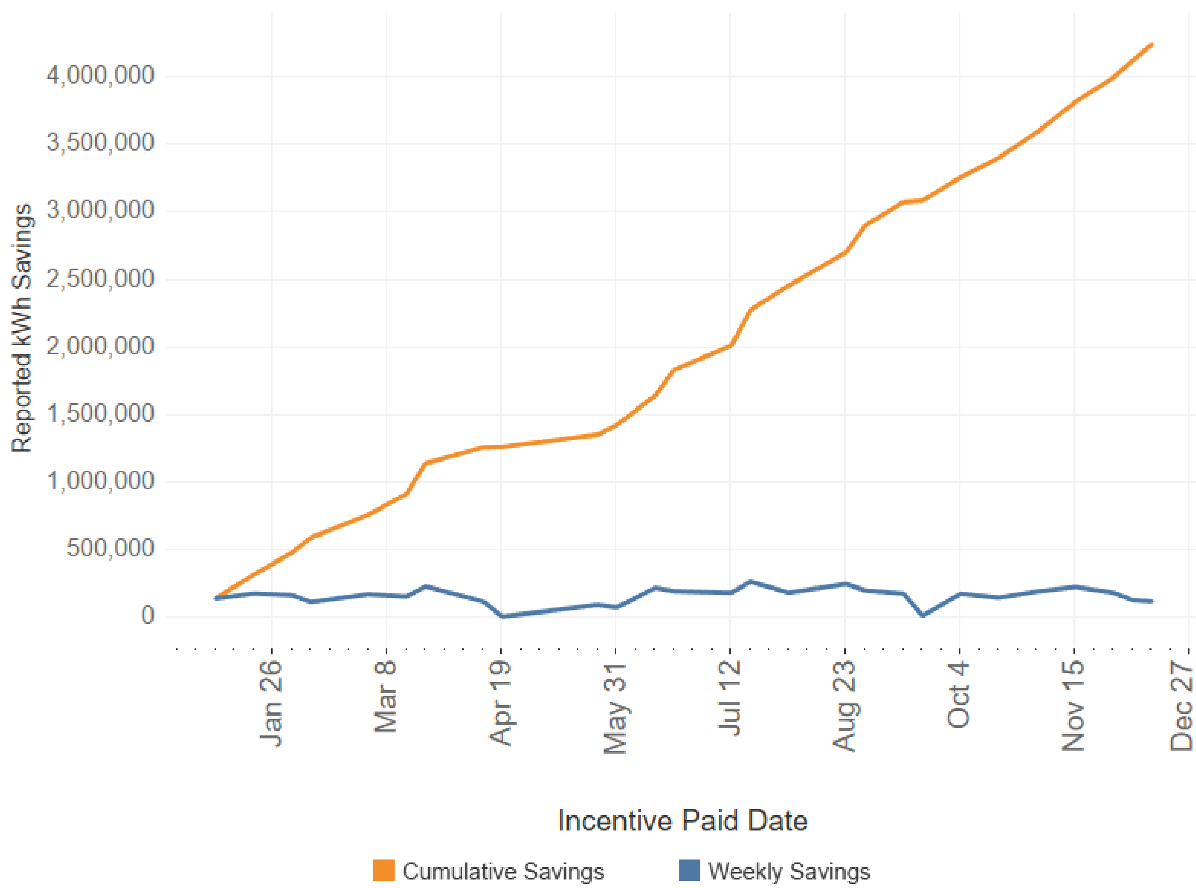
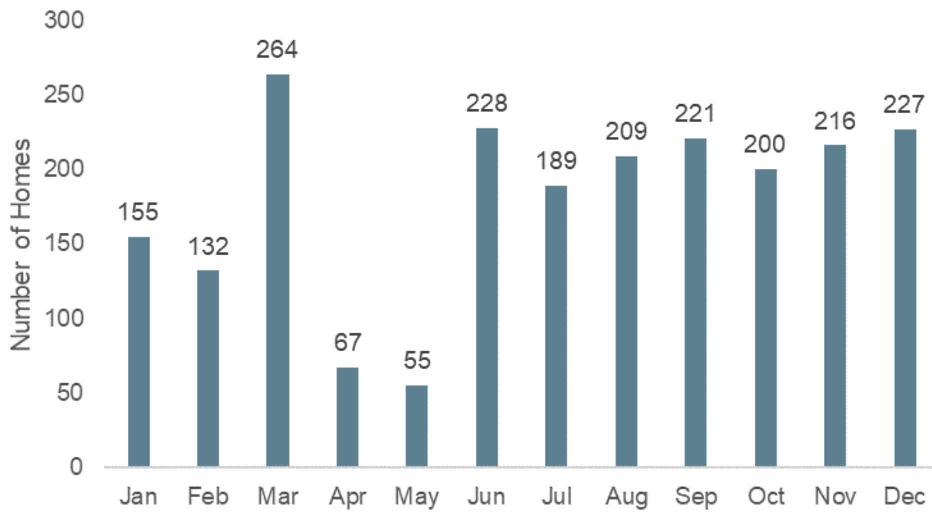


Figure 3-20 displays the number of homes invoiced each month. March had the highest number of homes invoiced. April and May had the fewest number of homes.

Figure 3-20: Number of Projects 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 phone surveys, virtual verification with participating customers, virtual ride-alongs with the primary program contractor, and staff interviews. Table 3-59 summarizes the data collection activities and purpose.

Table 3-59: Data Collection

Data Collection Activity	Achieved Size	Purpose
Virtual Ride-Alongs with Contractors	3	Measure and Installation Process Verification
Virtual verification with participating customers	9	Measure and Installation Verification
Customer Surveys	152	Measure Verification, In-Service Rate, and Customer Satisfaction
In-Depth Interviews with Program Staff	2	Process Evaluation

Telephone Survey Sampling Plan

ADM conducted a phone survey in PY2020 and designed the survey's sample to be statistically representative of the program population and ensures accurate program insights. For this effort, our sample approach was designed to achieve a minimum 10% precision at a 90 percent confidence level (90/10).

For the calculation of sample size for survey completes, a coefficient of variation of 0.5 was assumed.[33] With this assumption, a minimum sample size of 68 participants was required, as shown in the following formula:

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)

Although 68 was the minimum sample size, ADM conducted phone surveys with 152 participants across the service territory. The additional survey completes were obtained to increase the chance of participation in all areas the program impacted and to increase the chance of receiving feedback regarding all program measures.

Telephone Survey Procedure

The survey informs 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 used to develop In-Service Rates (ISRs). The telephone survey questions also seek to evaluate the customer satisfaction with individual measure as well as the program. Participants were given a $10 Walmart gift card for their time.

Additionally, program participants that receive direct install measures such as advanced power strips, LED light bulbs, faucet aerators, low flow showerheads, or water heater pipe insulation or jackets are asked if they are willing to participate in a video call to further

[33] 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.

verify the installation of program measures. Section 3.3.3.1 provides details regarding the findings of these virtual site visits.

3.3.2.2 Gross Impact Methodologies

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

- **Verifying measure installation:** ADM calculates installation rates (ISR) by measure for a sample of program participants utilizing data from its telephone survey.
- **Reviewing reported savings estimates for each measure:** ADM reviews reported savings calculations for all measures to provide an explanation of any savings discrepancies.
- **ADM calculates verified savings utilizing:**
    - Oklahoma Deemed Savings Document (OKDSD)
    - Arkansas Technical Reference Manual v7 (AR TRM)

A brief description of each measure calculation methodology is identified in this section. Appendix G includes the detailed measure level algorithms and deemed savings values utilized for the verified energy (kWh) and demand (kW) impact savings calculations.

Air Infiltration Reduction

ADM will use 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.

Mobile Home Air Infiltration Reduction

Similar to air infiltration reduction conducted on other homes, mobile home air infiltration involves sealing leaks from doors, windows, plumbing penetrations and other areas. As blower door tests are not feasible on mobile homes, ADM developed prescriptive-like savings from its 2018 air infiltration savings analysis which were calculated using the AR TRM.

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 are calculated for each home in accordance with the AR TRM with scaled values. Additional detail regarding the AR TRM scaled values can be found in Appendix G. 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.

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 is using the OKDSD[34] in conjunction with the duct leakage reduction results to calculate measure savings. The duct leakage reduction estimate in CFM is obtained through duct blaster testing performed by the program contractor pre- and post-installation for each home serviced.

Pipe Insulation and Water Heater Jackets

The deemed savings for water heater jackets installed on electric water heaters are sourced from the OKDSD. 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 G.

Electric water heating is required for the installation of pipe insulation and/or water heater jackets.

Low Flow Showerheads

This measure consists of removing existing showerheads and installing low flow showerheads in homes with electric water heating. The baseline flow rate is 2.5 gallons per minute (gpm) and the efficient showerhead is 1.5 gpm which saves 3,246 gallons of water per year and has a ratio of 0.000104 peak kW demand reduction to annual kWh savings.

[34] 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.

Faucet Aerators

This measure involves the retrofit of aerators on kitchen and bathroom water faucets. The deemed savings are per faucet aerator installed. The baseline faucet flow rate is 2.2[35] gallons per minute (gpm) and the efficient faucet aerators is 1.5 gpm.

Advanced Power Strips

This measure involves the installation of a 5 plug Advanced Power Strip (APS) that can automatically disconnect related equipment loads (i.e., speakers, video games, Blu-ray, etc.) depending on when the "master" device (i.e., television) is turned off. The baseline condition for this measure is the absence of an APS, where the devices are connected to a traditional power strip or wall outlet.

Energy STAR Omni-Directional LEDs

This measure provides savings for replacing an inefficient lamp with an Omni-directional LED in residential applications. The replacement must be ENERGY STAR qualified. ADM will use AR TRM v7.0 to assess savings and demand reduction for the installation of ENERGY STAR® Omni-Directional LEDs (9.5W).

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

3.3.2.4 Virtual Ride-Alongs with Contractor

ADM uses a visual verification software application (Streem) to perform virtual ride-alongs.[36] To use the service, ADM sends a link which the recipient can open through any internet browser on a smart phone. Once the recipient opens the link, the phone's camera is made accessible and allows the Streem user to take photos and videos and visit the recipient's setting in a virtual manner. ADM's virtual ride-alongs consisted of two Streem video calls with Titan ES: one initial call to verify the pre-condition and one call after the improvements had been made.

3.3.3 Impact Evaluation Findings

This section provides information on the impact evaluation activities conducted for PY2020.

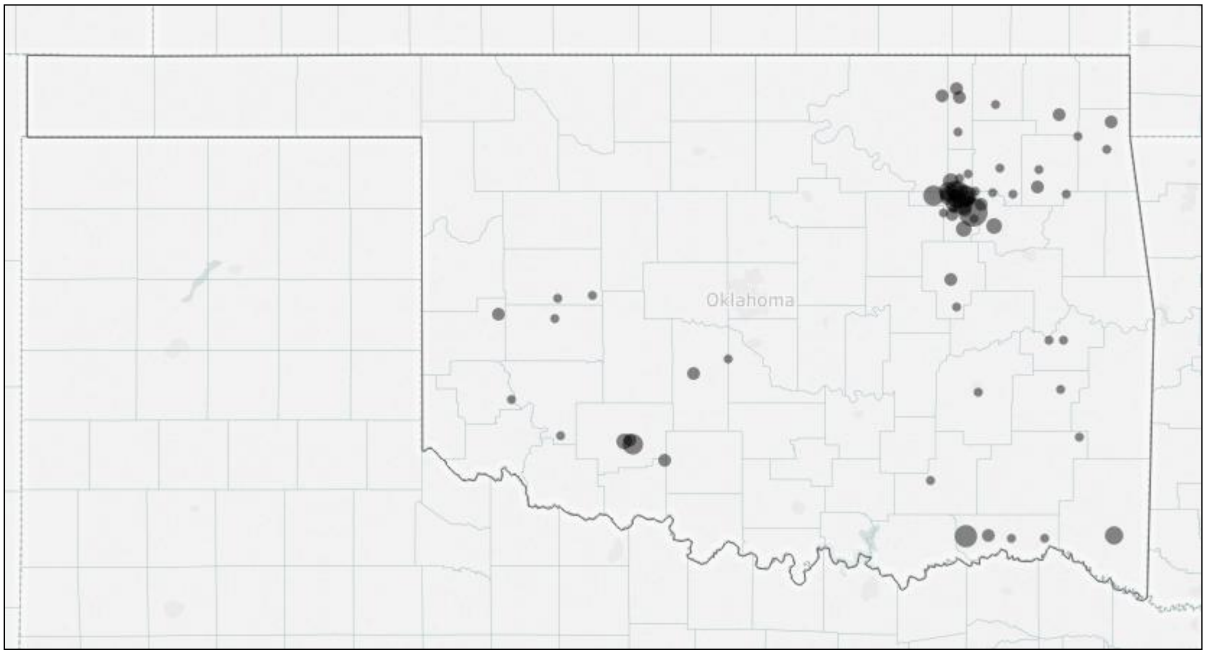
[35] Maximum flow rate federal standard for lavatories and aerators set in Federal Energy Policy Act of 1992 and codified at 2.2 GPM at 60 psi in 10CFR430.32

[36] ADM utilized Streem's visual verification software. More information about this software can be found here: https://streem.pro/

3.3.3.1 Telephone Survey Findings

ADM completed phone surveys with 152 participants across the service territory. ADM's in-house survey team called 827 participants and completed 152 surveys. Survey responses represented 25 counties and 69 zip codes. Survey participants by zip code is shown in Figure 3-21.

Figure 3-21: Number of Survey Participants by Zip Code[37]



3.3.3.2 Virtual Verification Findings

ADM conducted virtual visits with nine program participants. Eight of these customers verified receiving all measures reported in the program tracking data and one customer required follow-up with the implementation team for verification. The quantity of measures verified during virtual site visits is shown in Table 3-60.

[37] Size of circle varies depending on the number of projects in each zip code (max = 10, min = 1)

Table 3-60: Customer Virtual Verification Summary

Measure	Claimed Quantity	Installed Quantity
Air Infiltration	8	8
Water Heater Pipe Wrap	6	6
Water Heater Tank Jacket	1	1
Advanced Power Strip(s)	2	1
Low Flow Showerhead	2	1
Faucet Aerator(s)	4	2
LED(s)	6	6

3.3.3.3 Virtual Ride-Along Findings

ADM conducted three virtual ride-along visits with Titan ES in September and October 2020. The primary goal of the virtual ride-along visits was to verify contractor procedures and to visually verify the installation of major program measures (attic insulation, duct sealing, and air insulation).

On an initial video call the Titan ES crew supervisor showed ADM's field technician the areas that they intended to conduct air sealing or duct sealing on, as well as initial blower door test and duct leakage test results. The Titan ES supervisor also showed ADM the pre-condition of the ride-along homes' attics.

ADM ended the initial video call once we had observed the pre-condition of the home. Titan ES staff contacted ADM's field technician once work was completed to have a second post-improvement call. ADM's field technician observed Titan ES staff perform blower door and duct sealing tests and the Titan ES staff showed the ADM technician all the air seal measures installed as well as the attic insulation installed through the program.

For each of the ride-alongs, ADM noted the following pre- and post-conditions for each program measure:

- Air Sealing: ADM observed homes with gaps around doors, under sinks, and around pipes and windows before Titan ES performed improvements. After Titan ES staff completed their work, ADM observed weatherstripping around doors, foam sealant under sinks around pipes, and caulking around windows and doors.
- Duct Sealing- ADM noted gaps around registers and plenum holes prior to Titan ES conducting weatherization improvements. We noted signs of mastic and tape on ducts, plenums, registers and returns after weatherization was complete.
- Attic Insulation- ADM observed that the three homes had unevenly spread insulation at depths ranging from 3-6 inches. After Titan ES staff completed

weatherization, ADM's field technician verified insulation evenly spread at depths from 14-16 inches.

During the ride-alongs the ADM technician observed test in and test out values for both blower door and duct blaster tests and took pre- and post-pictures of the measures performed. The results were as expected with all three homes.

3.3.3.4 Air Infiltration

A total of 125 customers were asked to confirm air infiltration improvements made through the program. ADM investigated multiple respondent claims of not receiving air infiltration improvements and was able to determine that the measures were completed. Visually identifying caulking and/or sealing is not always apparent. 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 928,917 kWh and 264 kW, respectively. Energy savings methodologies were consistent with the ex-ante calculations. For mobile home air infiltration ADM found 39,201 kWh savings and 13.2 kW peak demand reduction. The program level realizations rates for air infiltrations were 100% for kWh savings and kW peak demand reduction.

3.3.3.5 Attic Insulation

A total of 120 survey respondents were asked to confirm whether they had attic insulation installed. All but one of these respondents confirmed the installation of insulation at their home. One respondent could not recall whether insulation was installed. 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 1,547,313 kWh and 1,270 kW, respectively. The savings methodology was consistent with ex-ante estimates. The program level realizations rate for attic insulation was 100% for kWh savings and kW peak demand reduction.

3.3.3.6 Duct Sealing

A total of 110 customers were asked to confirm duct sealing improvements made through the program.

ADM investigated multiple respondents claims of not receiving duct sealing improvements and was able to determine that the measures were completed. Visually identifying duct sealing is not apparent. 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 duct sealing as

1,665,073 kWh and 688 kW, respectively. The program level realizations rates for duct sealing were 100%.

3.3.3.7 LED Light Bulbs

Thirteen survey respondents confirmed receiving LEDs through the program. These respondents reported receiving a total of 61 LED light bulbs. None of the respondents reported removing any of the LED lightbulbs. Therefore, 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 12,652 kWh and 1.9 kW, respectively. LED bulb calculations resulted in realization rates of 99% kWh and 99% for peak demand reduction. The reason for the less than 100% realization rate for kWh savings and kW peak demand reduction is because 5 line items in the program's tracking data did not assign AR TRM savings values. This did not have a significant impact on program level realization rates as LED savings made up a small portion of total program savings (0.3%).

3.3.3.8 Water Heater Jackets and Pipe Insulation

ADM completed 36 verification surveys with customers that had water heater insulation installed in their homes through the program. Thirty-two respondents were able to confirm installation of water heater jackets or pipe insulation. The remaining respondents, while unaware of the installation, appeared to have received the measure resulting in an ISR of 100%.

For water heater jackets, a review of the tracking system showed that conservative assumptions were used to inform the use of the deemed savings. 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 to be 5,780 kWh and 12,980 kWh, respectively. We calculated the demand reduction for water heater jackets and pipe insulation to be 0.4 kW and 4.1 kW, respectively.

Water heater pipe insulation calculations resulted in realization rates of 63% for peak demand reduction and 62% kWh savings. The primary reason for the less than 100% realization rates is that the program tracking data indicated 171 homes had a quantity of two water heater pipe insulation installed.

Therefore, these homes were allocated 88 kWh and 0.028 kW compared to the 44 kWh and 0.014 as deemed by the OKDSD. This equates to a difference of 7,524 kWh and 2.394 kW at the program level.

Water heater jacket calculations resulted in 98% realization rates for kWh savings and kW peak demand reduction. The primary reason for the less than 100% realization rates is that the program tracking data indicated 2 homes had a quantity of two water heater jackets installed. Therefore, these homes were allocated 136 kWh and 0.01 kW compared to the 68 kWh and 0.005 kW as deemed by the OKDSD.

ADM verified that this issue did not occur in previous years' program tracking data from 2016-2019. Titan staff confirmed that prior to PY2020 their staff had only insulated outlet pipes and billed the program for one pipe insulation. In 2020 they changed their procedure to insulate and bill both inlet and outlet pipes if possible, to follow Building Performance Standards.

3.3.3.9 Advanced Power Strip(s)

Nine survey respondents confirmed receiving an advanced power strip through the program. Seven stated the power strips were still installed. Based on these findings, an ISR of 78% was applied. ADM determined the total program level energy (kWh) and demand impacts (kW) savings for advanced power strips and pipe insulation as 13,339 kWh and 1.6 kW, respectively. Savings methodologies were consistent with the ex-ante estimates. We found a realization rate of 78% for peak demand reduction and kWh savings. The reason for the less than 100% realization rate is the ISR that was found from the customer survey.

3.3.3.10 Faucet Aerator(s)

Eight survey respondents confirmed receiving faucet aerators through the program (a total of 12 aerators). Two respondents said that they had removed one of the two aerators they received through the program. Based on these findings, an ISR of 83% was applied.

ADM found the total savings attributable to faucet aerators to be 3,148 kWh and peak demand reduction to be 0.3 kW. Savings methodologies were consistent with the ex-ante estimates.

We found a realization rate of 82% for peak demand reduction and 85% for kWh savings for this measure. The application of the ISR was the primary driver of the less than 100% realization rate.

3.3.3.11 Low Flow Showerhead(s)

ADM confirmed with 8 survey respondents that they received showerheads through the program. Five of these respondents confirmed that the low flow showerhead they received through the program was still installed. ADM applied an ISR of 63% to low flow showerheads based on these findings.

ADM found the total savings attributable to faucet aerators to be 11,227 kWh and peak demand reduction to be 1.2 kW. Savings methodologies were consistent with the ex-ante estimates.

We found a realization rate of 63% for peak demand reduction and 62% for kWh savings for this measure. The application of ISRs brought the peak demand reduction and kWh savings was the main driver of the less than 100% realization rate for low flow showerhead(s). Additionally, two projects had an incorrect weather zone assigned. Soper, OK has a zip code of 74759 but tracking data listed the zip code as 74759.

3.3.3.12 Impact Evaluation Summary

ADM utilized current prescriptive methodologies to determine annual energy savings and peak demand reduction. These gross energy savings were adjusted to account for in-service rates based on participant survey responses. ADM found consistent application of prescriptive methodologies with minor data issues. Realization rate risk was apparent for some measures in the application of in-service rates to gross savings. Table 3-61 displays the results.

Table 3-61*: Home Weatherization In-Service Rates*

Measure	Verified/Claimed	Number of Measures	ISR
Attic Insulation	Verified	119	100%
	Claimed	119	
Duct Sealing	Verified	101	100%
	Claimed	101	
Infiltration	Verified	118	100%
	Claimed	118	
WH Pipe Wrap/Insulation	Verified	32	100%
	Claimed	32	
LED Bulbs	Verified	61	100%
	Claimed	61	
Faucet Aerators	Verified	10	83%
	Claimed	12	
Advanced Power Strip(s)	Verified	7	78%
	Claimed	9	
Low Flow Showerheads	Verified	5	63%
	Claimed	8	

Ex-post and ex-ante kWh and peak demand reduction by measure are shown in Table 3-62. As shown, the measures with the largest impact are air infiltration, attic insulation, and duct sealing. This is consistent with past years as the program attributed most of its savings to air infiltration, attic insulation, and duct sealing in 2018 and 2019 as well.

Table 3-62: Reported and Verified Energy Savings (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	928,272	264.4	928,917	264.4	100%	100%
Attic Insulation	1,547,163	1,270.7	1,547,313	1,270.3	100%	100%
Duct Sealing	1,665,073	687.7	1,665,073	687.7	100%	100%
Water Heater Jacket	5,916	0.4	5,780	0.4	98%	98%
Water Heater Pipe Insulation	20,548	6.5	12,980	4.1	63%	63%
Low Flow Showerheads (Mobile home)	17,989	1.9	11,227	1.2	62%	63%
LED (Mobile home)	12,806	1.9	12,652	1.9	99%	99%
Faucet Aerators (Mobile home)	3,705	0.4	3,148	0.3	85%	82%
Advanced Power Strip(s) (Mobile home)	17,150	2.0	13,339	1.6	78%	78%
Air Infiltration (Mobile home)	39,201	13.2	39,201	13.2	100%	100%
Total	**4,257,823**	**2,249**	**4,239,629**	**2,245**	**100%**	**100%**

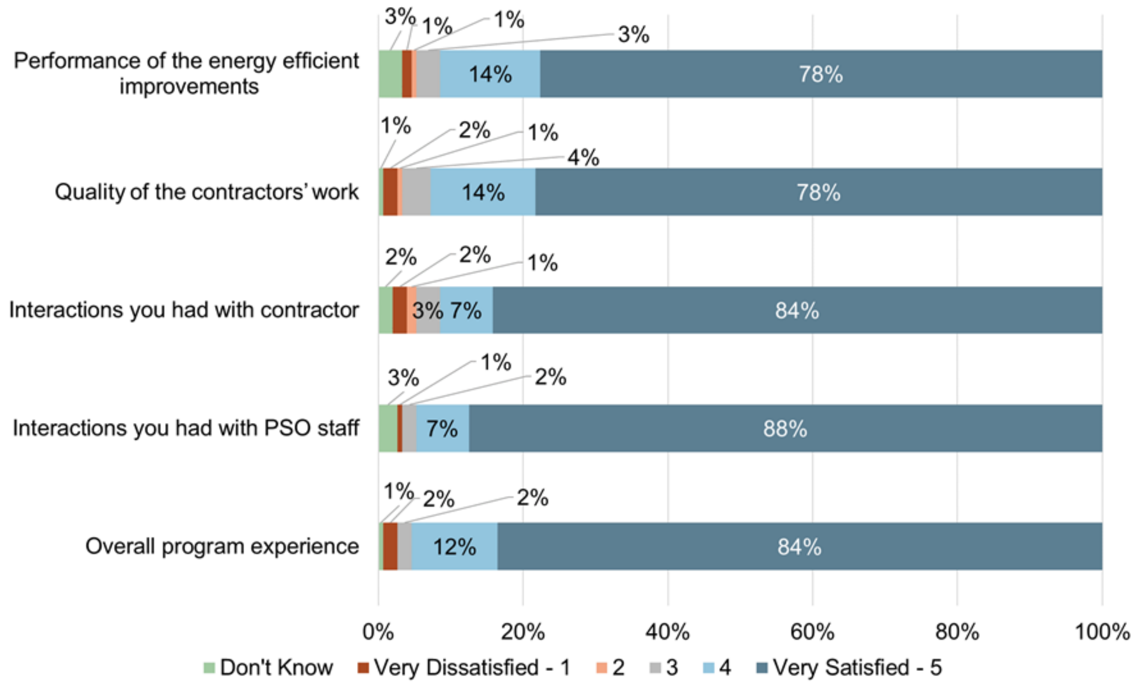
3.3.4 Process Evaluation Findings

ADM's process evaluation activities included a participant survey and interviews with program staff. ADM provided a process evaluation memo to PSO in December of 2020 with participant survey and program staff summary information.

Most survey respondents stated they were satisfied with the performance of the improvements that were made, the quality of the contractor's work, and the interactions they had with the contractor and PSO staff (Figure 3-22). Furthermore, nearly all survey respondents indicated satisfaction with their overall program experience[38] and said they were satisfied with PSO as their electric utility.[39]

[38] A rating of 4 (12%) or 5 (84%).
[39] A rating of 4 (8%) or 5 (88%).

Figure 3-22: Customer Satisfaction



Twenty-six respondents (17%) provided written feedback with recommendations to improve the program or aspects of the program that they were dissatisfied with. A few of the comments provided some additional detail or insights beyond their ratings. Fourteen mentioned dissatisfaction with the program contractor and either noted dissatisfaction with the amount, quality, or cleanliness of the contractor's work. Two respondents stated that they had not received expected benefits or services from the program (one respondent noted not receiving a final inspection and one a referral bonus).

Other comments provided little or no detail beyond their ratings. Seven respondents noted that they had not noticed any significant energy savings since participating. Two respondents noted dissatisfaction with the wait time to receive services.

Other participants made suggestions to improve the program's implementation. Four participants suggested that additional measures be added to the program (discounts for energy efficient window installation, basement insulation, and tree trimming). Three respondents mentioned increasing advertisement for the program.

Section 3.3.5 summarizes key findings from the process and impact evaluation of the Home Weatherization Program.

3.3.5 Conclusions and Recommendations

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

- **The program met its energy savings goals**. When interviewed in Fall 2020, PSO and Titan staff indicated the program would achieve the kWh savings goals set for PY2020. ADM's review of final program data confirmed that the program attained its savings goals.
- **Overall, reported and evaluated energy savings were consistent.** The program had an overall realization rate of 100% and measure level realization rates at or close to 100% for the largest contributors to the program.
- **Expanded customer eligibility assisted the program to reach additional customers.** The addition of mobile homes to the program in PY2020 allowed additional customers to benefit from the program's services. Program staff mentioned that the program was reviewing its requirements and considering updates for the program's next cycle that would begin in PY2022.
- **Participant referrals continue to be a significant recruiting tool.** Nearly one-third of survey respondents said that they had heard about the program from word-of-mouth from a friend, relative, or colleague. Program staff also reported that a significant portion of participants had been referred by a past participant.
- **Benefits of participation are unclear to some customers.** Some survey respondents indicated that they had not noticed savings on their utility bill or an improvement in home comfort since participating in the program.
- **Program satisfaction remains high.** Consistent with ADM's past customer surveys, most survey respondents were satisfied with the program overall, the measures they received, as well as with PSO as their electric utility. Most respondents were satisfied with their experience overall.

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

- **Add customer email addresses to the AEG/Sightline data tracking system.** Program staff interviews noted that a significant portion of customers sign up for the program after receiving marketing emails or after seeing social media advertising. If customer email addresses were added to program tracking data it would enable ADM to conduct mixed-mode surveys, thereby expanding the survey efforts to additional participants and allowing more participants to provide feedback and potentially ease the administrative burden of surveying.
- **Consider ways to explicitly demonstrate savings and improvements in comfort to customers.** Titan ES and other program contractors could leave behind information on other services and tools such as PSO's My Energy Advisor. The program contractors could consider working to ensure all participants understand the services provided and explain "test in" and "test out" procedures

for air and duct sealing improvements. Another possibility is developing comparative reports to send to past participants a year after the date their home was weatherized to illustrate the change in energy usage.

- **Continue to align program tracking data ex-ante savings and peak demand reduction methodologies.** ADM worked with PSO and the Applied Energy Group in 2020 to align savings calculations. Final 2020 tracking data reflects the majority of the adjustments and alignments discussed; however continued collaboration will be necessary to ensure 100% realization rates for all program measures.

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 PY2020 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 program also included distribution of free LEDs in partnership with food banks and local food pantries within the PSO service territory during PY2020. Discounted LED bulbs, including the free LEDs distributed through local food pantries, made up approximately 81% of the reported energy savings for the PY2020 ESP Program.

In PY2020 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, 298,662 packages of LEDs and 1,163,008 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 67,782, while the total number of measures rebated through the downstream portion of the program was 2,338. Overall, the ESP Program supported the purchase of over 1.2 million energy efficient measures during PY2020.

Table 3-63 provides a summary of program metrics for the 2020 program year. Program costs were $3,113,265. Reported annual energy 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.

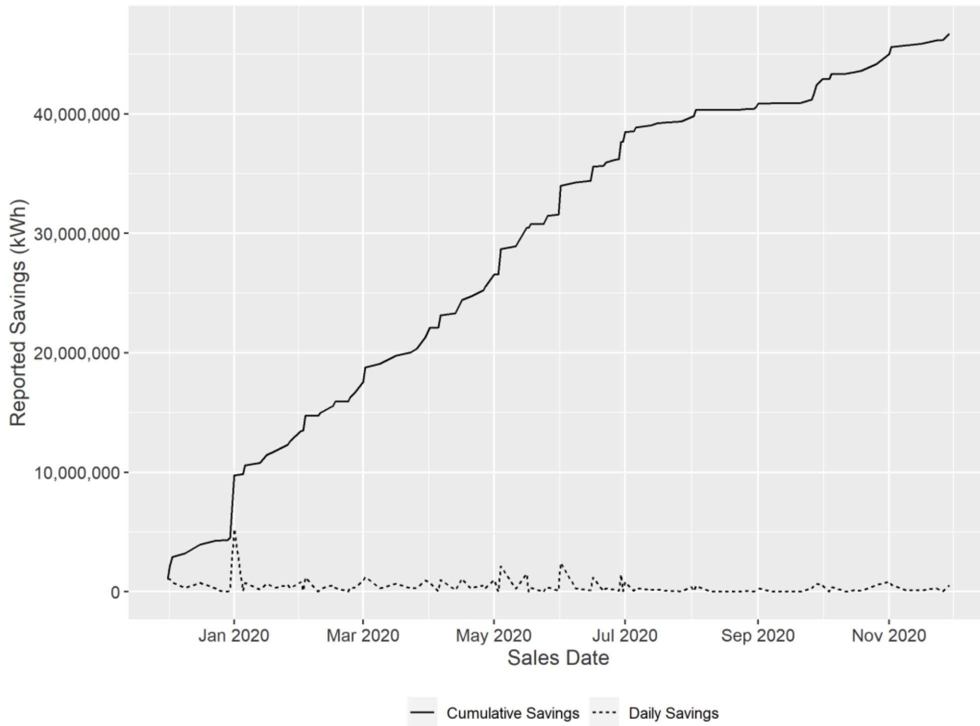
Table 3-63: Performance Metrics – Energy Saving Products Program

Metric	PY2020
Number of Measures[40]	**1,233,128**
Budgeted Expenditures	$2,831,582
Actual Expenditures	$3,113,265
Energy Impacts (kWh)	
Projected Energy Savings	36,382,395
Reported Energy Savings	47,018,578
Gross Verified Energy Savings	51,665,119
Net Verified Energy Savings	33,255,910
Peak Demand Impacts (kW)	
Projected Peak Demand Savings	4,415.86
Reported Peak Demand Savings	7,769.68
Gross Verified Peak Demand Savings	9,243.01
Net Verified Peak Demand Savings	5,933.83
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	7.95
Utility Cost Test Ratio	7.82

Participation in the ESP Program was mostly consistent throughout the 2020 program period, though participation plateaued from July through September, likely correlated with the increased transmission rate of COVID-19 locally. On the following page, Figure 3-23 shows the reported daily kWh savings and the cumulative reported kWh savings throughout the 2020 program year.

[40] Due to the upstream portion of the program, the number of participants is unknown. Information on the quantity of verified measures is shown in Table 3-100.

Figure 3-23: Accumulation of Reported Savings during the 2020 Program Year



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 Energy Saving Products 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. This tracking data was used as the basis for quantifying participation and assessing program impacts. Supplemental tracking data was also provided by the implementor 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 2020 and November 2020. The final sample size for each primary data collection activity is presented in Table 3-64 below.

Table 3-64: ESP Data Collection Activities

<table>
<tr><th colspan="2">Data Collection Activities</th><th>N</th></tr>
<tr><td colspan="2">General Population Survey</td><td>356</td></tr>
<tr><td rowspan="2">Downstream Rebate Participant Survey</td><td>Appliance Survey</td><td>179</td></tr>
<tr><td>Electric Vehicle Level 2 Charger Survey</td><td>1</td></tr>
<tr><td colspan="2">Program Staff Interviews</td><td>2</td></tr>
</table>

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.

Eight percent of the PSO customers contacted began the survey (4,889 individuals). Of these individuals, only 356 participants qualified for the survey and completed it fully. For a disaggregation of qualifying survey responses by measure, see Table 3-65. 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 3-65: Measures Bought During 2020

Measure	Number of Eligible Respondents
LED light bulbs	305
Air filters	62
Spray foam, door seals, or door sweeps	47
Energy saving advanced power strips	7
ENERGY STAR® room air conditioners	15
ENERGY STAR® room air purifiers	5
ENERGY STAR® bathroom ventilation fans	5
ENERGY STAR® water dispensers	4

Note: the number of eligible responses column does not sum to 356 (the number of surveys completed) since surveyed customers could have purchased more than 1 discounted measure.

Customers that had received rebates for heat pump water heaters, clothes dryers, clothes washers, refrigerators, and 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 3-66 breaks down what types of appliances the survey respondents purchased.

Table 3-66: Rebated Measure Participants Contacted vs. Survey Responses

Rebated Equipment	Percent of Survey Respondents (n = 179)
ENERGY STAR® Clothes Dryer Only	8%
ENERGY STAR® Clothes Washer Only	34%
ENERGY STAR® Refrigerator Only	30%
ENERGY STAR® Clothes Dryer and Clothes Washer	20%
ENERGY STAR® Clothes Washer and Refrigerator	11%
ENERGY STAR® Clothes Dryer and Refrigerator	--
ENERGY STAR® Clothes Dryer Clothes Washer, and Refrigerator	4%

To inform the process evaluation, ADM also conducted in-depth interviews with program staff at PSO and the implementation contractor. These interviews provided insight into various aspects of the program and its organization, but also focused on changes to the program that occurred during 2020. 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 “2020 Process Evaluation Memo”.

3.4.2.2 Gross Impact Estimation Methodology: Upstream Program

This subsection summarizes the methods used to verify all measures as well as calculate gross energy savings and gross demand reduction for each measure. Further details, including specific savings algorithms for each calculation, can be found in Appendix G, G.1.3.

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]

[41] ADM HOU Memo, 2016.

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 supported and claimed the savings. During 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

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

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 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

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

[44] Adjusted population is equal to the population multiplied by the relative propensity to visit the store.

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 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 (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.

Non-Lighting Measures

Savings calculations for non-lighting measures are outlined in the sections below. The detailed algorithms can be found in Appendix G, G.3.1.

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

[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.

deemed savings values and (3) verifying that the deemed per-unit impacts were applied appropriately.

Air Filters

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

Verification

For air filters (AF), 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.

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.

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

---

[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.

[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.

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.

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.

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.

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.

---

[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.

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.

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

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.

---

[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.

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.

Electric Vehicle Chargers

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

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.

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 2020 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.

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 25,008 LED packages (100,032 bulbs) distributed through local food banks, the 100% net-to-gross ratio is assumed because customers do not shop for the lighting products at these locations but rather, they 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 just over 8% 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

[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.

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.

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 PY2020 ESP program lighting component, ADM developed two separate estimates of free ridership, each using a different methodology. Table 3-67 provides a summary of the methodologies and their relative advantages and disadvantages. Details regarding each methodology are provided in Table 3-67.

Table 3-67: 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.

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:

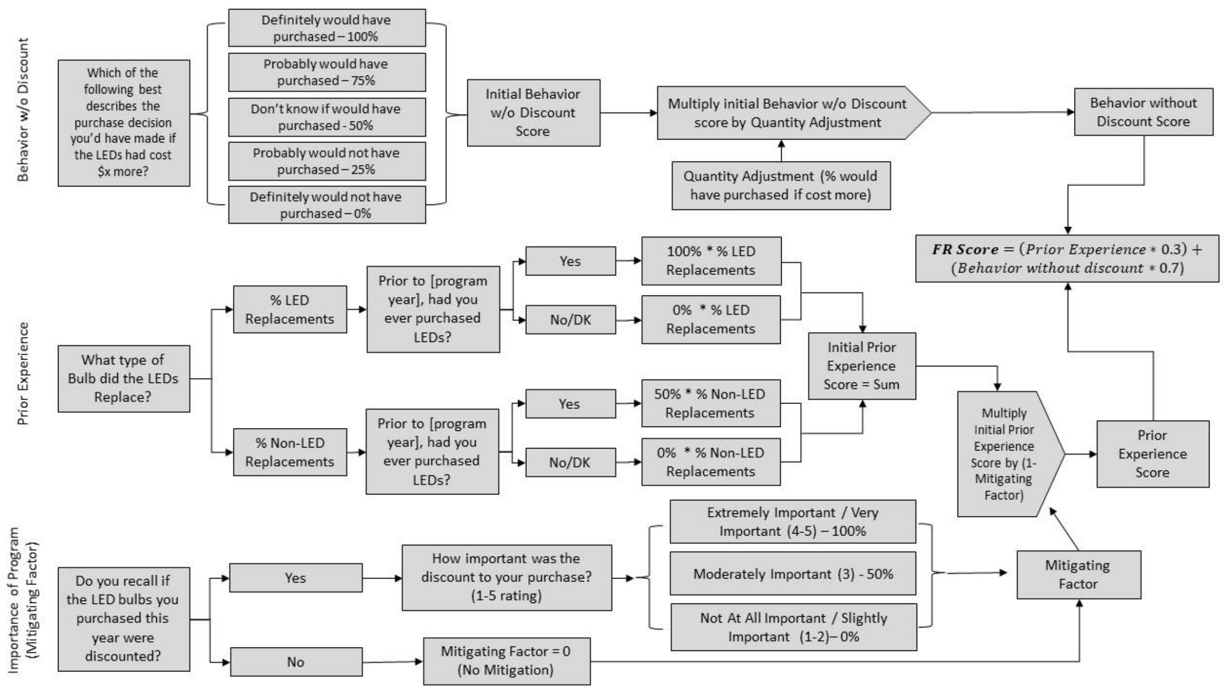
- The survey-based effort for calculating free ridership was conducted using emails from a sample of randomly selected residential customers. The strength of this approach is the ability to obtain a random and relatively large sample size cost-effectively. It also allows for further questioning regarding 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 3-24.

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 3-24: Free Ridership Scoring for LEDs



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 “zeroes” in most cases do not actually represent zero sales, but rather a

[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.

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 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 I provides further technical details regarding the price response model development and results.

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 because 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 because 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 heat pump water heaters 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

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

calculated and will be used as shown in Table 3-68. Our review was based upon publicly available net savings results for this measure for programs offering a similar incentive amount and design.

Table 3-68: 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 the implementor and provided through AEG for the ESP program lighting component identified a total of 273,654 packages of LEDs were discounted through participating retail stores (2,613 of which were packages of LEDs included with fixtures). An additional 25,008 packages of LEDs were distributed free-of-charge through local food banks. Table 3-69 shows the reported quantities and impacts of measures discounted or distributed free-of-charge through the ESP Program during PY2020.

Table 3-69: 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)	2,613	3,455	170,854	25.51
	Directional LED	69,229	243,679	9,447,764	1,410.73
	Omni-directional LED	201,812	815,842	25,533,980	3,812.71
Food Bank	Omni-directional LED	25,008	100,032	3,042,341	454.28
Totals		**298,662**	**1,163,008**	**38,194,939**	**5,703.24**

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 PY2020, ADM calculated verified energy and demand impacts based on OKDSD but used an adjusted value for hours of use (960.61 hours). 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.

Table 3-70 provides the estimated impact each of these adjustments had over reported kWh savings. ADM identified 15 LED models in the program tracking data that significantly differed[61] from the calculated savings. Many of these differences are due to parameters such as wattage, baseline wattage, or lumens being reported differently from the verified values in the ENERGY STAR® database. There are also many instances of omnidirectional bulbs that appear to use Tier 2 baseline wattages for the savings calculations instead of Tier 1.

[61] The table does not include models with very small discrepancies that are likely a result of rounding issues.

Table 3-70: Gross kWh Savings Adjustments – Lighting Only

Model Number	Lamp Category	Watts		Lumens		Baseline Watts		Energy Savings (kWh)	
		Reported	Verified	Reported	Verified	Reported	Verified	Reported	Verified
32119	Decorative	7	5	500	500	45	45	34.0	35.8
32113	Decorative	7	5	500	500	45	45	34.0	35.8
35569	Decorative	3	3.5	250	250	25	25	19.7	19.2
32255	Decorative	3	3.5	250	250	25	25	19.7	19.2
32211	Decorative	4	3.5	300	300	25	25	18.8	19.2
LED11400E-2	Directional	15	17	1250	1200	72	72	51.0	49.3
45894	Directional	32	32	3000	3000	250	90	195.0	51.9
67615	Directional	10	10	800	800	43	65	29.5	49.2
67615	Directional	10	10	800	800	20	65	29.5	49.2
67607	Directional	6	7	480	500	29	45	20.6	34.0
67607	Directional	6	7	480	500	12	45	20.6	34.0
457002	Directional	9	10	650	800	65	65	50.1	49.2
GVBR3065W27 KD4	Directional	8	9	650	650	65	65	51.0	50.1
GVBR3065W50 KD4	Directional	8	9	700	700	65	65	51.0	50.1
472423	Omnidirectional	16	23	1600	2150	72	72	30.4	32.2
472423	Omnidirectional	16	23	1600	2150	45	72	30.4	32.2
GVA10027NDE 4	Omnidirectional	16	15	1600	1600	72	72	32.2	35.8
GVA10027NDE 4	Omnidirectional	16	15	1600	1600	45	72	32.2	35.8
GVA10050NDE	Omnidirectional	16	15	1650	1650	72	72	32.2	51.4
GVA10050NDE	Omnidirectional	16	15	1650	1650	45	72	30.0	51.4
93122666	Omnidirectional	17	13.5	1600	1600	45	72	30.0	51.4
93122666	Omnidirectional	17	13.5	1600	1600	72	72	30.9	51.4
93122667	Omnidirectional	17	13.5	1600	1600	45	72	30.0	51.4
93122667	Omnidirectional	17	13.5	1600	1600	72	72	30.0	51.4
93121845	Omnidirectional	13	10.5	1100	1100	28	53	50.1	43.8
93121845	Omnidirectional	13	10.5	1100	1100	53	53	50.1	43.8
93121900	Omnidirectional	13	10.5	1100	1100	28	53	50.1	51.0
93121900	Omnidirectional	13	10.5	1100	1100	53	53	50.1	51.0

In-Service Rate Adjustments

For the purpose of calculating program cost effectiveness, an average of the first year ISR from the general population survey, 79%, and the full year ISR of 97% was assumed (88%). 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.[62]

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 76,689 kWh and 11.45 kW.

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 297 LED purchasers who responded to this question, 13 indicated that they installed bulbs in a non-residential setting[63]. Those 13 participants reported installing a total of 89 LEDs in non-residential settings, which represents 4.38% of all LEDs described by survey participants. The resulting non-residential allocation is therefore 2.51%.

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

[62] Calculating cost-effectiveness requires an estimation of when the bulbs are installed 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).

[63] This does not include one respondent that answered this question was removed from this calculation for being an extreme outlier.

methodologies used.[64] The average non-residential allocation estimate from these studies was 6.7%. In 2020, only 4.38% of survey respondents (13 participants) 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 4,575,246 kWh and similarly increase demand reduction by 1,463.20 kW.

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 38,344,494 kWh. The initial verified gross peak demand reduction estimated was 5,725.57 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 3-71 compares reported and verified impact estimates for this program component following the verification review.

[64] 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 3-71: 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)	3,455	170,854	170,853	25.51	25.51
	Directional LED	243,679	9,447,764	9,512,061	1,410.73	1,420.33
	Omni-directional LED	815,842	25,533,980	25,619,238	3,812.71	3,825.44
Food Bank	Omni-directional LED	100,032	3,042,341	3,042,341	454.28	454.28
Total		**1,163,008**	**38,194,939**	**38,344,494**	**5,703.24**	**5,725.57**

After considering leakage and cross-sector adjustments, annual energy savings for the ESP Program were estimated to be 42,843,050 kWh and verified peak demand savings were 7,177.32 kW. The application of the leakage and cross-sector adjustments is presented in Table 3-72.

Table 3-72: 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)	3,455	170,854	190,898	25.51	31.98
	Directional LED	243,679	9,447,764	10,628,011	1,410.73	1,780.47
	Omni-directional LED	815,842	25,533,980	28,624,874	3,812.71	4,795.41
Food Bank	Omni-directional LED	100,032	3,042,341	3,399,267	454.28	569.47
Total		**1,163,008**	**38,194,939**	**42,843,050**	**5,703.24**	**7,177.32**

3.4.4.2 Air Filter Gross Energy Savings and Peak Demand Impacts

ADM's review of program tracking data identified that a total of 8,854 qualifying air filters (AFs) were sold at participating retail stores during the 2020 program year. Table 3-77 shows the reported quantities and impacts of AFs through the ESP Program during PY2020.

Table 3-73: Reported Measure Quantities and Impacts – Air Filters

Distribution	Measure	Total Quantity	Reported kWh	Reported kW
Retail Discounts	AFs	8,854	464,540	1,607.20

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 in the program tracking data. Any differences in total verified savings and demand reduction are attributable to differences in rounding.

Final Verified Gross Savings Estimates

Table 3-78 compares reported and verified impact estimates for AFs rebated through the program in 2020. The total verified energy savings for all AFs was calculated to be 464,546 kWh and the verified demand impact was 1,607.20 kW.

Table 3-74: ESP Program Impact Findings – Air Filters

Distribution	Measure	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW
Retail Discounts	AFs	8,854	464,540	464,546	1,607.20	1,607.20

3.4.4.3 Advanced Power Strip Gross Energy Savings and Peak Demand Impact

ADM's review of program tracking data identified that a total of 6,341 qualifying advanced power strips (APS) were sold at participating retail stores during the 2020 program year. Table 3-75 shows the reported quantities and impacts of APS through the ESP Program during PY2020.

Table 3-75: Reported Measure Quantities and Impacts – Advanced Power Strips Only

Distribution	Measure	Total Quantity	Reported kWh	Reported kW
Retail Discounts	APS	6,341	530,742	60.24

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. This review found that all AFs were assigned the correct kWh and kW savings in the program tracking data.

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.

Final Verified Gross Savings Estimates

Table 3-76 compares reported and verified impact estimates for APS discounted through the program in 2020. The total verified energy savings for all APS was calculated to be 530,742 kWh and the verified demand impact was 60.24 kW. ADM found no discrepancies between the reported and verified impact findings.

Table 3-76: ESP Program Impact Findings – Advanced Power Strips

Distribution	Measure	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW
Retail Discounts	APS	6,341	530,742	530,742	60.24	60.24

3.4.4.4 Bathroom Ventilating Fan Gross Energy Savings and Peak Demand Impact

ADM's review of program tracking data identified that a total of 474 qualifying bathroom ventilation fans (BVFs) were sold at participating retail stores during the 2020 program year. Table 3-77 shows the reported quantities and impacts of BVFs through the ESP Program during PY2020.

Table 3-77: Reported Measure Quantities and Impacts – Bathroom Ventilating Fans

Distribution	Measure	Total Quantity	Reported kWh	Reported kW
Retail Discounts	BVFs	474	13,111	1.63

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 in the program tracking data.

Final Verified Gross Savings Estimates

Table 3-78 compares reported and verified impact estimates for BVFs rebated through the program in 2020. The total verified energy savings for all BVFs was calculated to be 12,988 kWh and the verified demand impact was 1.61 kW.

Table 3-78: ESP Program Impact Findings – Bathroom Ventilating Fans

Distribution	Measure	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW
Retail Discounts	BVFs	474	13,111	13,111	1.63	1.63

3.4.4.5 Clothes Dryer Gross Energy Savings and Peak Demand Impacts

ADM's review of program tracking data identified that a total of 612 qualifying clothes dryers (CDs) were rebated during the 2020 program year. Table 3-79 shows the reported quantities and impacts of CDs through the ESP Program during PY2020.

Table 3-79: Reported Measure Quantities and Impacts – Clothes Dryers

Distribution	Measure	Reported Quantity	Reported kWh	Reported kW
Downstream Rebates	CDs	612	98,260	13.19

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.

In addition, a few models were assigned incorrect savings values in the tracking data (shown in Table 3-80). The reasons for these discrepancies are one model (WED9290FC*) was assigned no savings in the tracking data and the two models with a gas fuel type (DVG50R85*** and WGD6620H**) were assigned incorrect savings values. The reasons for the discrepancies in the fourth model are unknown.

Table 3-80: Clothes Dryers Savings Discrepancies

Model Number	Number in Program	Reported kWh	Verified kWh	Reported kW	Verified kW
WED9290FC*	1	0	237.51	0	0.03189
DVG50R85***	1	81.75	24.78	0.01098	0.00333
WGD6620H**	1	81.75	24.78	0.01098	0.00333
WKEX200H*A	1	93	161.98	0.022	0.02175

Final Verified Gross Savings Estimates

Table 3-81 compares reported and verified impact estimates for CDs rebated through the program in 2020. The total verified energy savings for all CDs was calculated to be 98,257 kWh and the verified demand impact was 13.19 kW.

Table 3-81: ESP Program Impact Findings – Clothes Dryers

Distribution	Measure	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW
Downstream Rebates	CDs	610	98,260	98,257	13.19	13.19

3.4.4.6 Clothes Washer Gross Energy Savings and Peak Demand Impact

ADM's review of program tracking data identified that a total of 1,077 qualifying clothes washers (CWs) were rebated during the 2020 program year. Table 3-82 shows the reported quantities and impacts of CWs through the ESP Program during PY2020.

Table 3-82: Reported Measure Quantities and Impacts – Clothes Washers

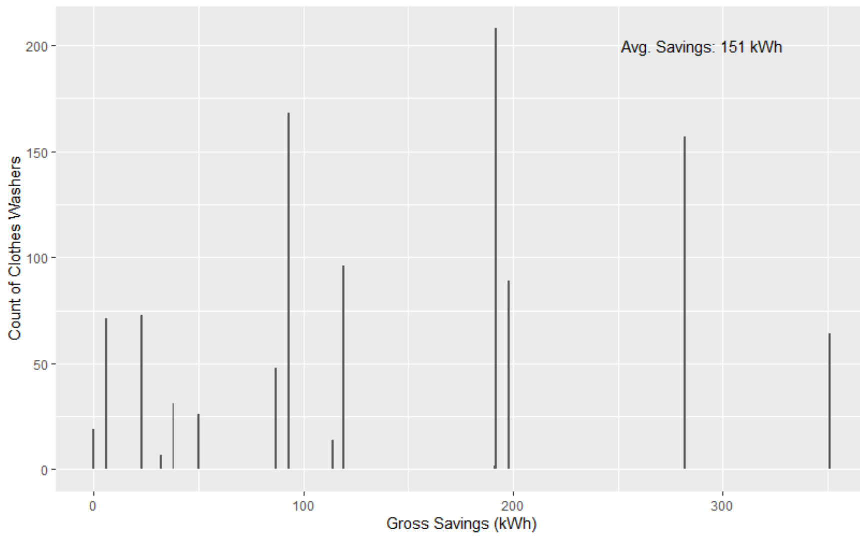
Distribution	Measure	Reported Quantity	Reported kWh	Reported kW
Downstream Rebates	CWs	1,077	173,287	40.98

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 3 CW 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 models.

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 PY2020 is plotted in Figure 3-25. ADM determined a deemed savings value of approximately 151 kWh per CW and a deemed demand reduction value of 0.036 kW per CW.

Figure 3-25: Distribution of Clothes Washer Savings



Final Verified Gross Savings Estimates

Table 3-83 compares reported and verified impact estimates for CWs rebated through the program in 2020. The total verified energy savings for all CWs was calculated to be 162,453 kWh and the verified demand impact was 38.42 kW.

Table 3-83: ESP Program Impact Findings – Clothes Washers

Distribution	Measure	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW
Downstream Rebates	CWs	1,074	173,287	162,453	40.98	38.42

3.4.4.7 Electric Vehicle Charger Gross Energy Savings and Peak Demand Impacts

ADM's review of program tracking data identified that a total of 6 qualifying EVCs were rebated through the program during the 2020 program year. Table 3-84 shows the reported quantities and impacts of EVCs through the ESP Program during PY2020.

Table 3-84: Reported Measure Quantities and Impacts – Electric Vehicle Chargers

Distribution	Measure	Total Quantity	Reported kWh	Reported kW
Downstream Rebates	EVCs	6	1,557	0.12

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.

Final Verified Gross Savings Estimates

Table 3-85 compares reported and verified impact estimates for EVCs rebated through the program in 2020. The total verified energy savings for all EVCs was calculated to be 1,557 kWh and the verified demand impact was 0.12 kW.

Table 3-85: ESP Program Impact Findings – Electric Vehicle Chargers

Distribution	Measure	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW
Downstream Rebates	EVCs	6	1,557	0.12	1,557	0.12

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

ADM's review of program tracking data identified that a total of 1 qualifying heat pump water heaters (HPWHs) was rebated during the 2020 program year. Table 3-86 shows the reported quantities and impacts of HPWHs through the ESP Program during PY2020.

Table 3-86: Reported Measure Quantities and Impacts – Heat Pump Water Heaters

Distribution	Measure	Total Quantity	Reported kWh	Reported kW
Downstream Rebates	HPWHs	1	2,089	0.18

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 slight difference in the savings attributed to the single HPWH in the program, which may be due to differences in weather zone mapping or methodology.

Final Verified Gross Savings Estimates

Table 3-87 compares reported and verified impact estimates for HPWHs rebated through the program in 2020. The total verified energy savings for all HPWHs was calculated to be 2,046 kWh and the verified demand impact was 0.18 kW.

Table 3-87: ESP Program Impact Findings – Heat Pump Water Heaters

Distribution	Measure	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW
Downstream Rebates	HPWHs	1	2,089	2,046	0.18	0.18

3.4.4.9 Refrigerator Gross Energy Savings and Peak Demand Impacts

ADM's review of program tracking data identified that a total of 652 qualifying refrigerators (RF) were rebated during the 2020 program year. Table 3-88 shows the reported quantities and impacts of RFs through the ESP Program during PY2020.

Table 3-88: Reported Measure Quantities and Impacts –Refrigerators

Distribution	Measure	Reported Quantity	Reported kWh	Reported kW
Downstream Rebates	RF	652	37,547	5.47

Verification

To verify the types, quantities, and savings associated with distributed measures, ADM performed a census review of the program tracking data for RFs sold through the program. This review found that 4 RFs discounted through the program were 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 these models. This review also found that found that 9 RFs were reported with incorrect savings values. The discrepancies for these models are detailed in Table 3-89.

Table 3-89: Refrigerator Savings Discrepancies

Model Number	Number in Program	Reported kWh (per Unit)	Verified kWh (per Unit)	Reported kW (per Unit)	Verified kW (per Unit)
ATFR1801EWE	1	138	52	0.02001	0.00757
GL35BK65	2	28	4	0.00408	0.00058
FFPA4422UM	1	89	31	0.01296	0.00452
GFE28GSK****	3	72	70	0.01049	0.01020
DFE28JMK****	1	72	70	0.01049	0.01020
DFE28JSK****	1	72	70	0.01049	0.01020
PYE22KEL****	1	67	65	0.00976	0.00947
PYE22KSK****	1	67	65	0.00976	0.00947
RF260B*AE**	1	361	61	0.05258	0.00888

Final Verified Gross Savings Estimates

Table 3-90 compares reported and verified impact estimates for RFs rebated through the program in 2020. The total verified energy savings for all RFs was calculated to be 36,746 kWh and the verified demand impact was 5.35 kW.

Table 3-90: ESP Program Impact Findings – Refrigerators Only

Distribution	Measure	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW
Downstream Rebates	RFs	647	37,547	36,746	5.47	5.35

3.4.4.10 Room Air Conditioner Gross Energy Savings and Peak Demand Impacts

ADM's review of program tracking data identified that da total of 1,758 qualifying room air conditioners (RACs) were sold at participating retail stores during the 2020 program year. Table 3-91 shows the reported quantities and impacts of RACs through the ESP Program during PY2020.

[65] Model GL35BK has two entries in the EnergyStar database. Given that there are two different variations, and that the program tracking data provided no additional clarification on which entry was correct, ADM opted to use the model with the smaller savings estimate.

Table 3-91: Reported Measure Quantities and Impacts – Room Air Conditioners

Distribution	Measure	Total Quantity	Reported kWh	Verified kWh
Retail Discounts	RACs	1,758	109,340	189.47

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 two models were not assigned correct savings values. For these models, ADM found the cooling capacity (Btu/Hr) of the model to differ from the cooling capacity listed in the program tracking data.

Table 3-92: Room Air Conditioner Savings Discrepancies

Model Number	Number in Program	Cooling Capacity (Btu/Hr)		Reported kWh (per Unit)	Verified kWh (per Unit)	Reported kW (per Unit)	Verified kW (per Unit)
		Reported	Verified				
1001597791	4	14,000	15,000	34.04	64.03	0.06044	0.11369
1002800392	1	18,000	22,000	224.3	403.36	0.39825	0.71617

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

Final Verified Gross Savings Estimates

Estimates for RACs rebated through the program in 2020. The total verified energy savings for all RACs was calculated to be 109,639 kWh and the verified demand impact was 190.00 kW. Table 3-93 compares reported and verified impact estimates for RACs rebated through the program in 2020.

Table 3-93 ESP Program Impact Findings – Room Air Conditioners

Distribution	Measure	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW
Retail Discounts	RACs	1,758	109,340	109,639	189.47	190.00

3.4.4.11 Room Air Purifier Gross Energy Savings and Peak Demand Impact

ADM's review of program tracking data identified that a total of 888 qualifying room air purifiers (RAPs) were sold at participating retail stores during the 2020 program year. Table 3-94 shows the reported quantities and impacts of RAPs through the ESP Program during PY2020.

Table 3-94: Reported Measure Quantities and Impacts – Room Air Purifiers

Distribution	Measure	Total Quantity	Reported kWh	Reported kW
Retail Discounts	RAPs	888	465,827	53.18

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.

Final Verified Gross Savings Estimates

Table 3-95 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 465,827 kWh and the verified demand impact was 53.40 kW. Any differences between the reported kW savings and the verified kW savings are due to rounding discrepancies.

Table 3-95: ESP Program Impact Findings – Room Air Purifiers

Distribution	Measure	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW
Retail Discounts	RAPs	888	465,827	465,827	53.18	53.40

3.4.4.12 Water Dispenser Gross Energy Savings and Peak Demand Impacts

ADM's review of program tracking data identified that a total of 676 qualifying water dispensers (WDs) were sold at participating retail stores during the 2020 program year. Table 3-96 shows the reported quantities and impacts of WDs through the ESP Program during PY2020.

Table 3-96: Reported Measure Quantities and Impacts – Water Dispensers

Distribution	Measure	Total Quantity	Reported kWh	Reported kW
Retail Discounts	WDs	676	340,307	38.07

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.

Final Verified Gross Savings Estimates

Table 3-97 compares reported and verified impact estimates for WDs rebated through the program in 2020. The total verified energy savings for all WDs was calculated to be 350,126 kWh and the verified demand impact was 39.17 kW.

Table 3-97: ESP Program Impact Findings – Water Dispensers

Distribution	Measure	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW
Retail Discounts	WDs	676	340,307	350,126	38.07	39.17

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 are discussed collectively in this report as ADM used the same savings algorithm to evaluate them. ADM's review of program tracking data identified that a total of 4,435 door seals, 3,758 door sweeps, and 40,598 cans of spray foam were sold at participating retail stores during the 2020 program year. Table 3-98 shows the reported quantities and impacts of WMs through the ESP Program during PY2020.

Table 3-98: Reported Measure Quantities and Impacts – Weatherization Measures

Distribution	Measure	Total Quantity	Reported kWh	Reported kW
Retail Discounts	Door Seals	4,435	174,516	1.50
Retail Discounts	Door Sweeps	3,758	147,876	1.27
Retail Discounts	Spray Foam	40,598	6,264,640	53.95
WM Total		**48,791**	**6,586,107**	**56.72**

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.

Final Verified Gross Savings Estimates

Table 3-99 compares reported and verified impact estimates for WMs rebated through the program in 2020. The total verified energy savings for door seals was calculated to be 174,512 kWh, for door sweeps energy savings was calculated to be 147,873 kWh, and for spray foam, energy savings was calculated to be 6,264,634 kWh. Overall, ADM calculated the verified energy savings for WMs to be 6,587,019 kWh and the verified demand impact for WMs to be 56.79 kW.

Table 3-99: ESP Program Impact Findings – Weatherization Measures

Distribution	Measure	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW
Retail Discounts	Door Seals	4,435	174,516	174,512	1.50	1.51
Retail Discounts	Door Sweeps	3,758	147,876	147,873	1.27	1.28
Retail Discounts	Spray Foam	40,598	6,264,640	6,264,634	53.95	54.00
Total		**48,791**	**6,587,032**	**6,587,019**	**56.72**	**56.79**

3.4.4.14 Summary of Impact Evaluation Findings

Table 3-100 on the following page provides a detailed summary of ADM's impact evaluation findings for all measures included in the ESP Program in 2020. Overall, the program's realization rates (RR) were high, with a RR of 110% for the gross verified energy savings and a RR 119% for the gross verified demand impact.

Table 3-100: 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	8,854	530,742	530,742	60.24	60.24	100%	100%
	APS	6,341	464,540	464,546	1,607.20	1,607.20	100%	100%
	BVFs	474	13,111	13,111	1.63	1.63	100%	100%
	RACs	1,758	109,340	109,639	189.47	190.00	100%	100%
	RAPs	888	465,827	465,827	53.18	53.40	100%	100%
	WDs	676	340,307	350,126	38.07	39.17	103%	103%
	WMs	48,791	6,587,032	6,587,019	56.72	56.79	100%	100%
Non-LED Retail Discount Subtotals		**67,782**	**8,510,899**	**8,521,010**	**2,006.51**	**2,008.43**	**100%**	**100%**
LED Retail Discounts	LEDs	1,163,008	38,194,939	42,843,050	5,703.24	7,177.32	112%	126%
LED Retail Discount Subtotals		**1,163,008**	**38,194,939**	**42,843,050**	**5,703.24**	**7,177.32**	**112%**	**126%**
Downstream Rebates	CDs	610	98,260	98,257	13.19	13.19	100%	100%
	CWs	1,074	173,287	162,453	40.98	38.42	94%	94%
	EVCs	6	1,557	1,557	0.12	0.12	100%	100%
	HPWHs	1	2,089	2,046	0.18	0.18	98%	100%
	RFs	647	37,547	36,746	5.47	5.35	98%	98%
Downstream Rebate Subtotals		**2,338**	**312,740**	**301,059**	**59.94**	**57.26**	**96%**	**96%**
Program Totals		**1,233,128**	**47,018,578**	**51,665,119**	**7,770**	**9,243**	**110%**	**119%**

3.4.5 Net-to-Gross Estimation Results

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 Lighting Free Ridership Estimate from General Population Survey

ADM evaluators analyzed survey responses from 356 people who participated in the 2020 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 330 surveyed customers reporting having purchased LEDs from participating retailers within the program year, though the responses from only 222 customers were fully validated for use in calculating free ridership.[66] Calculated scores from the survey responses are presented in Table 3-101.

Table 3-101: General Population Survey Free Ridership Estimate

Year	Respondent Type	N	Prior Experience Score	Behavior without Program Score	Free Ridership Estimate	Mitigating Factor
2020	LED Purchasers	222	0.26	0.54	0.35	-0.162

The average free ridership score for all 222 respondents was 35%. This is 7% lower than the free ridership level estimated from the same survey in PY2019 but may have been impacted by unconstrained changes in participants' purchasing behaviors linked to the COVID-19 pandemic.

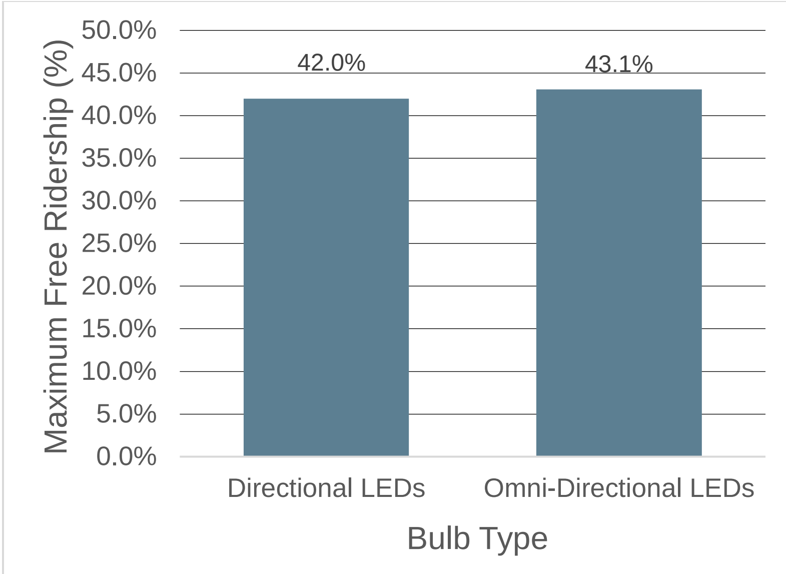
Price Response Model Free Ridership Estimate

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 42.2%.

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 on the following page in Figure 3-26.

[66] 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.

Figure 3-26: 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 I.

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 35.0%. The price response modeling resulted in a free ridership estimate of 42.2%.

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 38.6%. Ultimately, both a survey-based and non-survey-based methodology resulted in a similar estimate for free ridership that was 2.9% lower than the estimate in PY2019 (41.5%).

3.4.5.3 Final Net-to-Gross Ratio

The measure level net-to-gross ratios are calculated as 1 - *estimated free ridership*.[67] The final net-to-gross ratios and associated net savings for each measure in the ESP Program are shown in Table 3-102. Note that LEDs distributed through the food bank giveaways and sold at Dollar General are assumed to have a net-to-gross ratio of 1.0.

[67] This is sometimes referred to as a net-of-free-ridership ratio, as it excludes any estimation of spillover or market effects.

Table 3-102: Verified Gross and Net Impacts – ESP Program

Measure Type		Gross Verified kWh	Gross Verified kW	NTGR	Net kWh	Net kW
Directional LED		10,818,909	1,812.45	0.614	6,642,810	1,112.84
Omni-directional LED	Other Retailers	28,161,023	4,717.70	0.614	17,290,868	2,896.67
	Dollar General	463,851	77.70	1.000	463,851	77.70
	Food Bank	3,399,267	569.47	1.000	3,399,267	569.47
Air Filters		530,742	60.24	0.614	325,876	36.99
Advanced Power Strips		464,546	1,607.20	0.614	285,231	986.82
Bathroom Ventilation Fans		13,111	1.63	0.614	8,050	1.00
Clothes Dryers		98,257	13.19	0.660	64,850	8.71
Clothes Washers		162,453	38.42	0.800	129,962	30.74
Electric Vehicle Chargers		1,557	0.12	0.800	1,246	0.10
Heat Pump Water Heaters		2,046	0.18	0.860	1,760	0.15
Refrigerators		36,746	5.35	0.800	29,397	4.28
Room Air Conditioners		109,639	190	0.614	67,318	116.66
Room Air Purifiers		465,827	53.4	0.614	286,018	32.79
Water Dispensers		350,126	39.17	0.614	214,977	24.05
Weatherization Measures		6,587,019	56.79	0.614	4,044,430	34.87
Total		**51,665,119**	**9,243**	**0.644**	**33,255,911**	**5,934**

3.4.5.4 Lifetime Savings

For LED measures, there are two different ways in which lifetime savings were calculated. For directional LEDs, lifetime savings for all measures are calculated by simply multiplying the ex-post energy savings values by the expected useful lifetime (EUL) of the measure. For omnidirectional bulbs, an additional step is needed.

The EUL of an LED is 20 years[68], but in 2023 the way in which savings are calculated for omni-directional LEDs will change. In 2023 omnidirectional bulbs will begin using tier 2 baseline wattages as part of their savings calculations, which will have a significant impact on savings for this measure[69]. To take that into account, lifetime savings were calculated by adding together Tier 1 and Tier 2 lifetime savings values. Tier 1 energy savings were calculated by taking the ex-post savings from this year multiplied by three years (the number of years from 2020 to 2023). Tier 2 savings were calculated by multiplying what

[68] Per the OKDSD.
[69] This is following the Arkansas TRM version 8 guidelines recommending that Tier 2 baselines are used starting in 2023.

the ex-post savings would have been for this year had tier 2 baselines been used, by 17 years (20 years minus the 3 years used in the tier 1 savings calculation). Table 3-103 shows the Tier 1 and Tier 2 lifetime savings values for LED measures.

Table 3-103: Lifetime Savings, LED Measures -- ESP Program

Measure Type		Tier 1 Annual kWh	Tier 1 EUL (years)	Tier 1 Lifetime Savings (kWh)	Tier 2 Annual kWh	Tier 2 EUL	Tier 2 Lifetime Savings (kWh)
Directional LED		6,642,810	20	132,856,200	N/A	0	0
Omni-directional LED	Other Retailers	17,290,868	3	51,872,604	5,378,669	17	91,437,375
	Dollar General	463,851	3	1,391,553	134,312	17	2,283,307
	Food Bank	3,399,267	3	10,197,801	984,287	17	16,732,877

For all measures other than LEDs, lifetime savings for all measures are calculated by simply multiplying the ex-post energy savings values by the expected useful lifetime (EUL) of the measure. Table 3-104 shows the lifetime savings values for all non-LED measures.

Table 3-104: Lifetime Energy Savings, non-LED Measures – ESP Program

Measure Type	Net kWh	EUL (years)	Total Lifetime Savings (kWh)
Air Filters	325,876	0.17	54,313
Advanced Power Strips	285,231	10.00	2,852,310
Bathroom Ventilation Fans	8,050	12.00	96,602
Clothes Dryers	64,850	13.00	843,050
Clothes Washers	129,962	14.00	1,819,468
Electric Vehicle Chargers	1,246	10.00	12,460
Heat Pump Water Heaters	1,760	10.00	17,600
Refrigerators	29,397	17.00	499,749
Room Air Conditioners	67,318	10.50	706,839
Room Air Purifiers	286,018	9.00	2,574,162
Water Dispensers	214,977	10.00	2,149,770
Weatherization Measures	4,044,430	15.00	60,666,450

Table 3-105 shows the total lifetime savings values for the program.

Table 3-105: Total Lifetime Energy Savings – ESP Program

Measure Type		Total Lifetime Savings (kWh)
Directional LED		132,856,200
Omni-directional LED	Other Retailers	143,309,979
	Dollar General	3,674,860
	Food Bank	26,930,678
Air Filters		54,313
Advanced Power Strips		2,852,310
Bathroom Ventilation Fans		96,602
Clothes Dryers		843,050
Clothes Washers		1,819,468
Electric Vehicle Chargers		12,460
Heat Pump Water Heaters		17,600
Refrigerators		499,749
Room Air Conditioners		706,839
Room Air Purifiers		2,574,162
Water Dispensers		2,149,770
Weatherization Measures		60,666,450
Total		**379,064,490**

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 the implementation team. ADM provided a portfolio level process evaluation memo to PSO after the completion of the 2020 program year. The following summarizes the key finding from the process evaluation of the ESP Program.

- **ESP met the energy savings goals**. When interviewed, PSO staff indicated the ESP Program would achieve the annual energy savings goals set for PY2020. Staff indicated there was an increase in sales of non-lighting measures, which included water coolers, air purifiers, room air conditioners, spray foam, door sweeps, and door seals.
- **Program experienced changes to incentive value to offset effects of COVID-19.** Program staff indicated they adjusted some of their incentive values at the beginning of the pandemic to prevent sale losses. However, because Oklahoma did not implement a restrictive stay-at-home order, many

establishments did not close, and the public continued to shop. According to staff, more people decided to invest money in home improvements during PY2020.

- **Marketing strategies and outreach at retail stores changed during PY2020.** When field work resumed, sales representatives had to change their engagement strategies. The sales representative's information station for 2020 now plays a recurring video clip about LED lightbulbs, there are additional handouts and other information materials on the table, and the sales representative stands a few feet away to reduce potential viral transmission. According to staff, retailers have been satisfied with the new set-up. Program staff believes they will most likely create new media focusing on lighting and non-lighting measures in the future.

3.4.6.1 Upstream Measures

The following highlights findings affecting all the upstream measures component of the program.

- **Many PSO customers purchased a variety of LED light bulbs during PY2020.** Fifty-eight percent of respondents indicated they purchased their LED light bulbs from Walmart, 33% from Lowe's, and 22% from The Home Depot. However, many of the respondents did not know the bulbs' prices had decreased (78%). Overall, survey participants reported they were satisfied with the quality of the bulbs (77%) and the savings on the electricity bills since installing the LEDs (39%).
- **Participants who purchased non-lighting discounted measures through the Upstream program channel were satisfied with the quality of their purchases.** In general, participants reported to be satisfied or very satisfied with the quality of the measure they purchased. However, customers who purchased an advanced power strip and air filters were not satisfied with the noticeable savings their monthly bill reported after installing the measures.
- **The coronavirus pandemic did not affect surveyed participants' ability to participate in utility-sponsored programs**. Survey respondents stated they have increased the time they spent in their homes (74%) and 75% stated the bills increased by about $10 every month since the onset of the pandemic. However, participants indicated the pandemic did not affect their ability to participate in the PSO energy efficiency programs (48%).

3.4.6.2 Downstream Measures

The following highlights findings affecting all the downstream measures component of the program.

- **Program participants primarily learned about the program while shopping at the store.** Fifty-eight percent of participants learned about the rebate when they made the purchase or through a salesperson (54%). Many of the customers chose to buy a clothes washer, dryer, or refrigerator to save money with their energy bills, so they purchased energy efficient equipment to replace their existing appliance.

- **Overall satisfaction with different aspects of the program depended on the participant's reported wait times of rebates.** Customers who at the time of taking the survey had not received their rebate (1%) or had to wait more than eight weeks (five percent) stated they were dissatisfied with the program. Participants who expressed dissatisfaction with the wait times also expressed feeling less satisfied with the rebate application process. Most survey participants reported high levels of satisfaction regarding the rebate program overall (86%), application process (74%), the quality of the rebated appliances (75%), and rebate turnaround times (70%).
- **Program participants can use a rebate status tracker to check the progress of their rebate reimbursements.** Program staff indicated the rebate tracker is available to customers who have applied for a rebate. The implementation team maintains the tracker and can alert customers of any problems they identify with the tracker.
- **The coronavirus pandemic did not affect program participants' ability to participate in utility-sponsored programs**. Survey respondents stated they have increased the time they spent in their homes (77%) and 72% stated the bills increased by about $10 every month since the onset of the pandemic. However, participants indicated the pandemic the did not affect their ability to participate in the PSO energy efficiency programs (60%).

3.4.7 Conclusions and Recommendations

The following summarizes the key findings from the evaluation of the Energy Saving Products Program.

- The verified net annual energy savings for PY2020 is 33,255,835 kWh, and net peak demand reduction is 5,933.82 kW. The lighting net-to-gross ratio increased slightly in 2020 compared to 2019. This was identified both through the 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:

- **Expand the quarterly review of program tracking data.** In 2020, ADM began doing quarterly reviews of program tracking data with PSO. Consider expanding the scope of these reviews so that program tracking data can be reconciled quarterly. This will ensure issues within the data are identified and corrected quickly.

- **Continue to develop video marketing material to use in the field.** Consider creating how-to videos for sales representative to use while promoting the different measures in the field. The how-to videos could guide the customer on what kind of measure to buy, how many, and emphasize the energy savings.
- **Explore the possibility of revamping the monthly billing statements by emphasizing the program.** Consider creating a space on the upper left-hand side of the page that promotes PSO's ongoing upstream discounts. Each month, they can highlight a different measure or fact about the program and the energy saving benefits it may have on the customer.
- **Consider adding an avatar support feature to the rebate status tracker and application portal.** Explore the possibility of creating a virtual support guide that could guide customers through a step process when completing the form. Ideally, the avatar should move around the screen with anthropomorphic qualities and be able to let the person know how much progress they have made in completing the application.

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:

- Utilized 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 2020, customers needed to install two or more eligible equipment upgrades. Eligible measures included:

Table 3-106: 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 $1,000
Air Conditioner/Heat Pump Replacement	-
ENERGY STAR® SEER 16-16.99	$300
ENERGY STAR ® SEER 17-17.99	$300
ENERGY STAR ® SEER 18-19.99	$900
ENERGY STAR ® SEER 20	$1,200
Ground Source Heat Pump	$1,200 + $525 per ton
Duct Replacement (based on HVAC tonnage)	Up to $3,000
Duct Sealing (based on HVAC tonnage)	Up to $1,500

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 after the upgrades were installed. 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, customers needed to install one or two eligible equipment upgrades. Eligible measures included:

Table 3-107: 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	$200
ENERGY STAR ® SEER 17-17.99	$200
ENERGY STAR ® SEER 18-19.99	$600
ENERGY STAR ® SEER 20	$800
Ground Source Heat Pump	$800 + $350 per ton
ENERGY STAR® Swimming Pool Pump	$400
HVAC Tune-Up (based on existing HAVC unit)	$150 + $25 per pound of refrigerant*
Mobile Home Duct Sealing (based on HVAC tonnage)	Up to $850

**Up to 2 pounds of refrigerant per project*

PY2020 performance metrics are summarized in Table 3-108.

Table 3-108: Performance Metrics – Home Rebates Program

Metric	PY2020
Number of Participants	3,522
Budgeted Expenditures	$7,431,058
Actual Expenditures	$8,268,131
Energy Impacts (kWh)	
Projected Energy Savings	7,288,439
Reported Energy Savings	6,248,852
Gross Verified Energy Savings	6,067,194
Net Verified Energy Savings	5,312,912
Peak Demand Impacts (kW)	
Projected Peak Demand Savings	2,756.50
Reported Peak Demand Savings	3,220.75
Gross Verified Peak Demand Savings	2,509.57
Net Verified Peak Demand Savings	2,217.29
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	1.41
Utility Cost Test Ratio	0.92

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 HERS rater documentation, building drawings, and builder provided documentation)
- 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.

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 98% 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 2% 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 3-109 below summarizes the final sample framework and demonstrates that the evaluation exceeded the targeted 10% precision.

Table 3-109: Sample Design New Homes

Strata	Measure	Reported Energy Savings (kWh)	Population Size	CV*	Sample Size	Relative Precision
Stratum 1	Rater 1	813,587	500	0.35	25	12%
Stratum 2	Rater 2	399,126	222	0.35	15	15%
Stratum 3	Rater 3	202,946	79	0.35	6	23%
Stratum 4	Rater 4	47,444	29	0.35	5	26%
Stratum 5	Other	25,615	17	0.35	3	33%
Total	**-**	**1,488,718**	**847**	**-**	**54**	**8.16%**

** 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 0.35.*

Data Collection

Data collection activities that supported the evaluation included builder interviews, 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.

Due to adherence and safety practices accommodating for COVID-19, ADM suspended in-person on site verification for 2020. For the program year, engineering desk reviews were supplemented with quality assurance (QA) forms provided by the implementation contractor. The QA forms provided additional photos and building notes that helped provide simulation model inputs during the implementation reviews. 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.

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 implementation QA forms 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 created in Ekotrope and initially submitted by participating builders/HERs raters to the implementation contractor. ADM then retrieved each simulation model directly from Ekotrope.
- ADM engineering staff reviewed these models within the Ekotrope software[70] and confirmed that Ekotrope conforms to RESNET standard algorithms when calculating internal loads (e.g., lighting and appliances). Ekotrope inputs were then compared to the program provided tracking data and each simulation model was verified to ensure reconciliation of the program claimed kWh savings per home.

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 3-110. Values for the listed parameters were taken from either the Oklahoma residential building code or minimum efficiency values defined by the National Appliance Energy Conservation Act (NAECA). 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.

[70] ADM purchased a license from Ekotrope to facilitate this evaluation.

Table 3-110: 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

A feature in Ekotrope allowed ADM staff to produce all baseline assumptions programmed into each Ekotrope simulation model. This allowed ADM to verify all inputs that were applied to the reference home and confirm the measures were in accordance with Oklahoma residential building codes and NAECA minimum efficiencies.

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, virtual 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.

Execute Building Simulation Analysis and Quantify Site Impacts

Upon completion of all data collection for each sampled home, ADM conducted its ex-post simulation by comparing existing key inputs of the provided simulation models, to what was found during the data collection efforts. The model inputs were then changed to reflect what was verified during the data collection process.

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.

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.

- **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] Why would you have built fewer homes?
- 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:

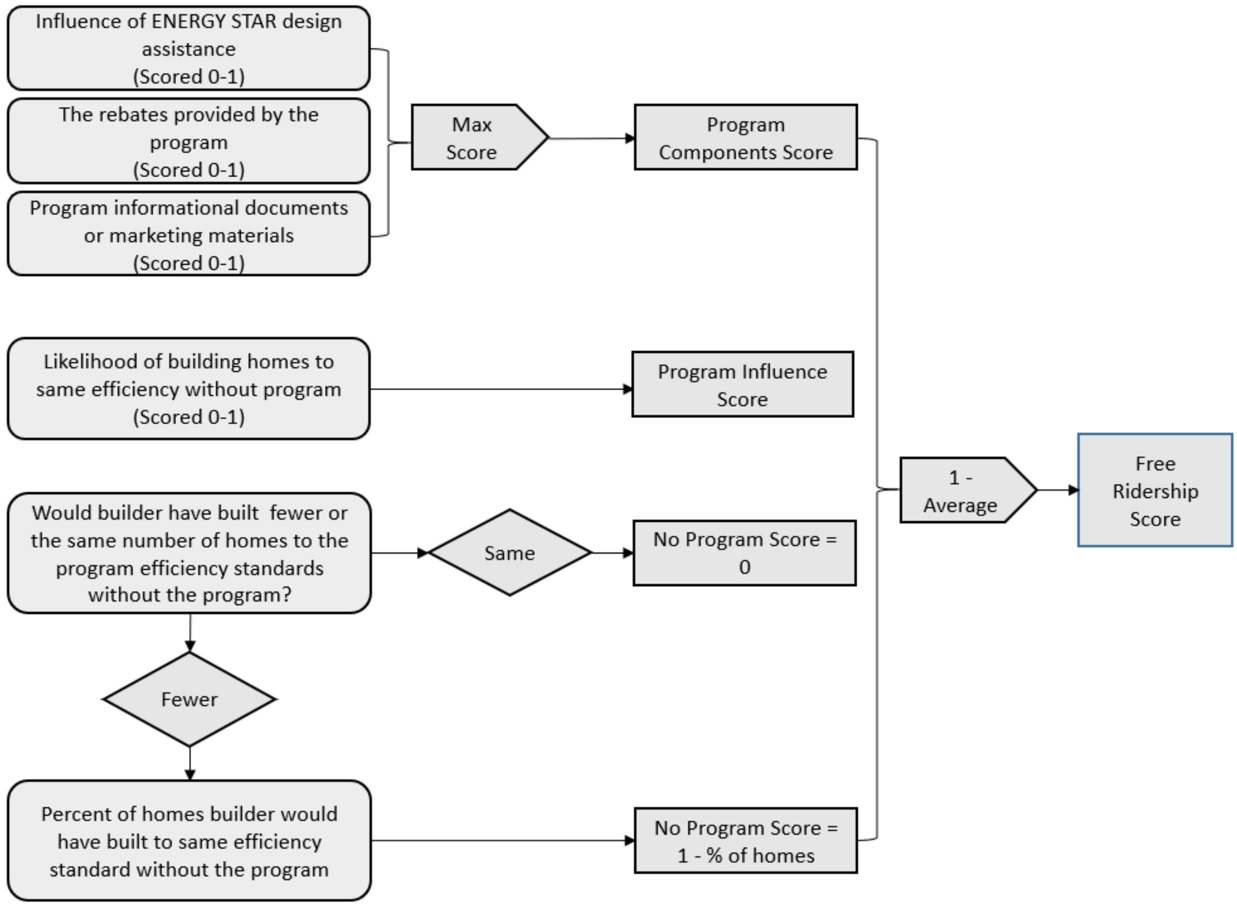
1 – Average (% Homes Built in Absence of the Program/100)

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 3-27 summarizes the scoring procedure.

Figure 3-27: 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 0.

Program Activity for New Homes

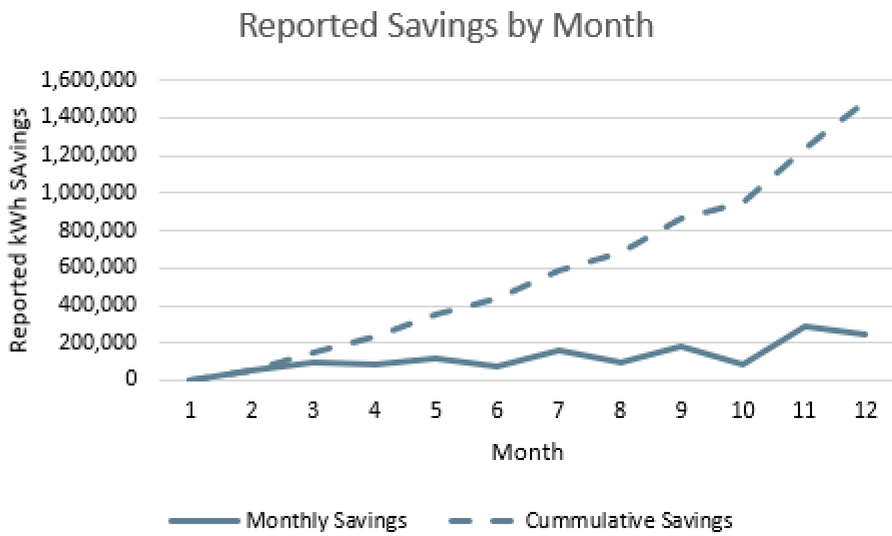
Participation and savings per builder are shown below in Table 3-111. The top participating builders contributed most of the homes and savings.

Table 3-111: Participation and Savings per Builder

Builder	Number of Homes	Reported Energy (kWh)	Reported Demand (kW)	Percent of Program Energy Savings
Builder 1	297	406,418	152.53	27.3%
Builder 2	168	309,796	123.10	20.8%
Builder 3	113	215,845	83.76	14.5%
Builder 4	39	105,044	42.71	7.1%
Builder 5	45	96,911	38.02	6.5%
Builder 6	47	75,352	28.59	5.1%
Builder 7	24	50,047	19.65	3.4%
Builder 8	29	47,444	19.64	3.2%
Builder 9	12	26,288	10.23	1.8%
Builder 10	16	23,460	7.63	1.6%
Builder 11	9	21,011	8.35	1.4%
Builder 12	5	16,813	2.69	1.1%
Builder 13	6	15,042	5.84	1.0%
Builder 14	5	12,383	4.80	0.8%
Builder 15	5	10,984	4.39	0.7%
Builder 16	6	9,175	2.83	0.6%
Builder 17	4	7,548	2.79	0.5%
Builder 18	2	7,229	3.16	0.5%
Builder 19	3	7,074	2.60	0.5%
Builder 20	3	6,924	2.95	0.5%
Builder 21	3	5,942	2.28	0.4%
Builder 22	2	3,148	1.23	0.2%
Builder 23	1	3,134	1.26	0.2%
Builder 24	1	2,155	0.37	0.1%
Builder 25	1	1,797	0.56	0.1%
Builder 26	1	1,754	0.64	0.1%
Total	**847**	**1,488,718**	**573**	**100%**

Participation in the New Homes program is shown below in Figure 3-28. There was consistent participation from May to November, with an uptick in participation in December.

Figure 3-28: 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 3-112 below.

Table 3-112: 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)	Net Lifetime Energy Savings (kWh)
New Homes	1,487,311	572.28	75%	75%	1,113,767	428.81	16,680,808

New Homes Reported and Verified Gross Savings

Reported and gross annual energy savings are summarized in Table 3-113 for the program, and then broken down by strata in Table 3-114. An EUL of 20 was applied to program lifetime savings. A 20-year EUL is based on typical measures installed in new home construction.

Table 3-113: 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)	Lifetime Energy Savings (kWh)	kWh Realization Rate	kW Realization Rate
New Homes	1,488,718	572.59	1,487,311	572.28	29,746,215	100%	100%

Table 3-114: 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)	Lifetime Energy Savings (kWh)	kWh Realization Rate	kW Realization Rate
Rater1	813,587	310.50	817,981	310.94	16,359,619	101%	100%
Rater2	399,126	157.10	393,083	156.13	7,861,652	98%	99%
Rater3	202,946	77.35	201,794	78.06	4,035,884	99%	101%
Rater4	47,444	19.64	47,574	19.14	951,485	100%	97%
Other	25,615	8.00	26,879	8.01	537,575	105%	100%

The difference in the reported and gross annual energy savings results were generated by differences between ex-ante model assumptions and physical homes verified by ADM (e.g. differences in key model inputs).

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 engineering desk reviews, though there were some areas, predominantly regarding HVAC equipment, where ADM found consistent differences:

- **Cooling Equipment Efficiency –** ADM found a different Annual Fuel Utilization Efficiency (AFUE) for 19 sampled homes. Variation for this measure lead to a slight decrease in savings.
- **Furnace Auxiliary Energy Consumption Rating –** 46 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.
- **Cooling Equipment Efficiency –** During documentation review, ADM found five 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 had a small net increase in savings.
- **HVAC Equipment Capacity –** ADM found that the HVAC heating capacity ratings differed from ex-ante assumptions on 32 of the sampled projects and HVAC cooling capacities differed for 25 homes. Adjustments were made in both direction and the ultimate impact of this change was negligible.

Ex-post adjustments to the models resulted in minor impacts to the program savings. Due to only minor changes in the ex-post models, the program achieved a 100% realization rate for program year 2020.

New Homes NTG Estimation Results

Twelve builders that contributed 91% of program kWh savings participated in interviews for 2020. 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 75% for energy savings and 75% 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 surveys, virtual verifications, in-depth interviews with program staff,[71] and discussions with trade allies. 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-out photos and data, and contractor invoices for the work performed.

Sampling Plan

Table 3-115 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.

[71] Interviews were conducted to gain insight into how the COVID-19 pandemic effected the Home Rebates Program in PY2020.

Table 3-115: Sample Sizes for Data Collection Efforts – Multiple Upgrades

Data Collection Activity	Achieved Sample Size
Participant Surveys Completed	76
Virtual Verifications	23
In-Depth Interviews with Program Staff	3

Participant Surveys

For the calculation of sample size for survey completes, a coefficient of variation of 0.5 was assumed.[72] 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
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)

Sample Design

For virtual verifications, ADM pulled all available participants who had contact information (i.e., phone number and/or email address) listed in the tracking data and who was not contacted to complete the participant survey. An outreach was performed to schedule a virtual visit for every measure in the program, excluding ground source heat pumps.[73] However, due to the restraints of the virtual verifications, no insulation measures were visually verified due to safety concerns for the program participants. There was a total of 23 virtual site visits performed in PY2020. Table 3-116 below lists the total number of measures sampled.

[72] 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)).

[73] There were no ground source heat pump projects in the program in PY2020.

Table 3-116: Virtual Verifications - Multiple Upgrades

Measure	Population Size	Total Number Sampled[74]
Air Sealing	64	5
Duct Sealing	855	21
Duct Replacement	196	5
Insulation – Attic	166	7
Insulation – Floor	2	0
Insulation - Exterior Wall	4	0
Insulation - Knee Wall	25	0
Heating System ECM Fan	35	0
Central AC	789	17
Heat Pump	32	3
Ground Source Heat Pump	0	0
Total	**2,168**	**58**

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. Any participant with a valid email address was sent the online participation survey. A total of 289 participants were sent the online survey, which resulted in 76 survey completes.

Virtual Verifications

Due to safety concerns from COVID-19, field visits were performed virtually via video phone calls or through phone interviews with participant photos. Virtual verifications were scheduled, then performed by ADM staff, who verified the measure installation and operational characteristics. Pictures were collected during all virtual verifications to document measure installation. For HVAC equipment, a picture of the unit nameplate was also collected to record the unit's model number and serial number. For air sealing, it was noted what was performed on the home to reduce air leakage in the home by sealing up cracks and air bypasses. For duct sealing and replacement, the square footage of the home, if the HVAC unit was replaced, and the location of the ducts in the home (attic and/or crawlspace) was noted. A participant interview was also performed to collect the following information: house type (single family, multi-family, or mobile home), heating

[74] The total number of measures exceeds the total number of virtual site visits performed due to some participants having more than one measure as part of the program.

system fuel type, and if the home had central air conditioning. The findings from the virtual verifications were compared to information in the program tracking database to verify that input to savings calculations were correctly recorded.

Program Staff Interviews

ADM evaluators interviewed the PSO's program manager and program coordinator, as well as ICF's account manager to gain insight into how the COVID-19 pandemic effected the Home Rebates Program in PY2020.

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 virtual verifications.
- **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 virtual verifications 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 G 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. Only homes with electric cooling systems are eligible for the measure (central AC or room AC).

Duct Sealing and Duct Replacement: All savings for duct replacement projects were captured in the corresponding duct sealing project for PY2020. 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.[75] 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 SEER of the baseline unit is used.

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 were only two projects completed for floor insulation.

Exterior Wall Insulation: Savings were estimated by updating the savings algorithm inputs listed in the AR 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 were only four projects completed for exterior wall insulation.

Knee Wall Insulation: Savings were estimated by updating the savings algorithm inputs listed in the AR 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 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. ECM furnace fan motors were only installed if the cooling system was also replaced. Savings are captured in the air conditioner replacement measure based on graded SEER (which includes air handler fan performance).

[75] Pre-installation duct leakage measurements were discontinued in March 2020 due to safety concerns from COVID-19.

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[76]. OKDSD baseline SEER is 12.44 and baseline HSPF is 7.7, which were updated in the reported savings based on the 2016 federal minimum to 14 SEER and 8.2 HSPF, respectively. There were no ground source heat pump projects in Multiple Upgrades in PY2020.

Lifetime kWh Savings

Lifetime kWh savings were calculated by multiplying the gross annual kWh savings by the Estimated Useful Life (EUL) for each measure type. EUL values for each measure were based on the assumptions in the AR TRM and OKDSD. Table 3-117 shows the EUL and source for each measure type.

Table 3-117: Per-Measure Estimated Useful Life (EUL)

Measure Type	EUL (years)
Air Sealing	11
Duct Sealing	18
Duct Replacement	20
Insulation – Attic	20
Insulation – Floor	20
Insulation - Exterior Wall	20
Insulation - Knee Wall	20
Heating System ECM Fan	15
Central AC	19
Heat Pump	16
Ground Source Heat Pump	25

Net-to-Gross (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.

76 Federal minimum regulations equipment for Southeast region, https://www.energy.gov/sites/prod/files/2015/11/f27/CAC%20Brochure.pdf

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.

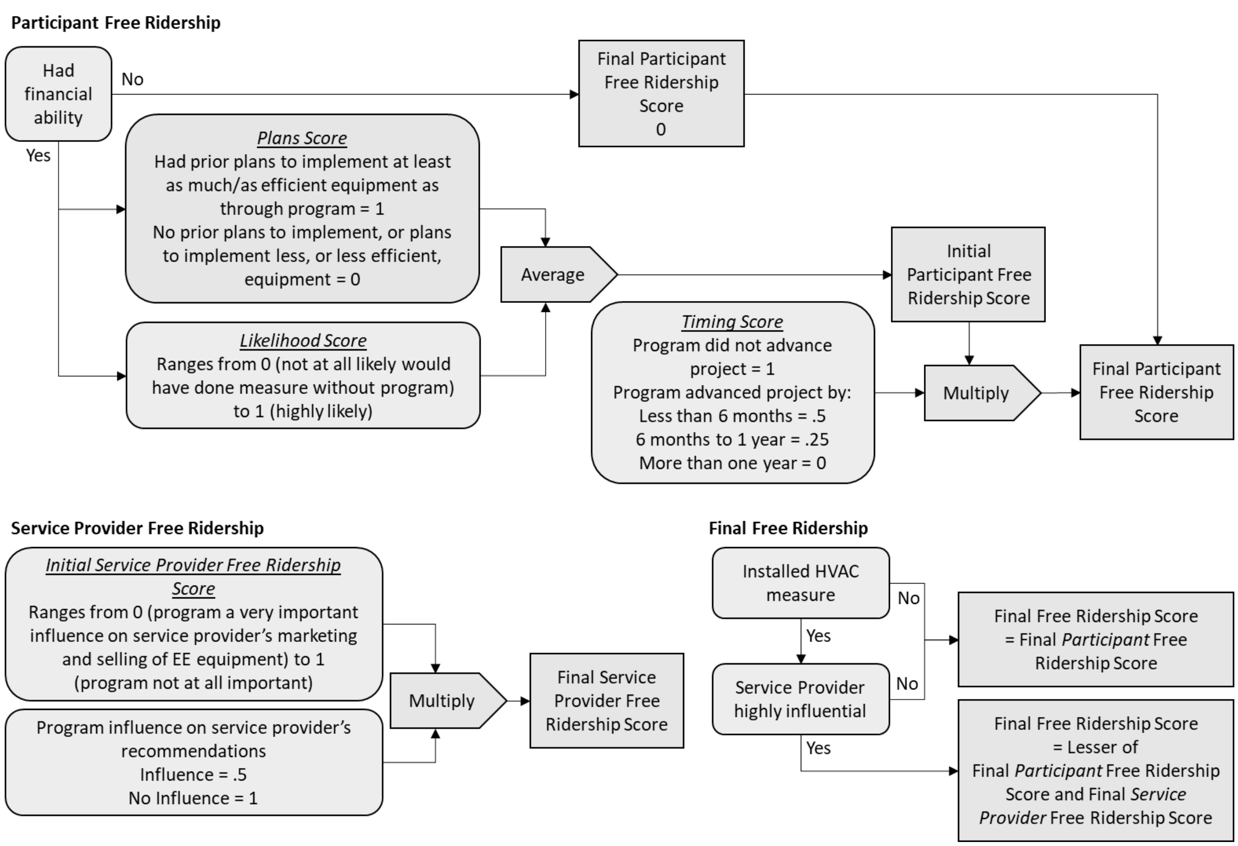
Final Free Ridership Score

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 3-29 illustrates the above process for generating the final free ridership score.

Figure 3-29: 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.

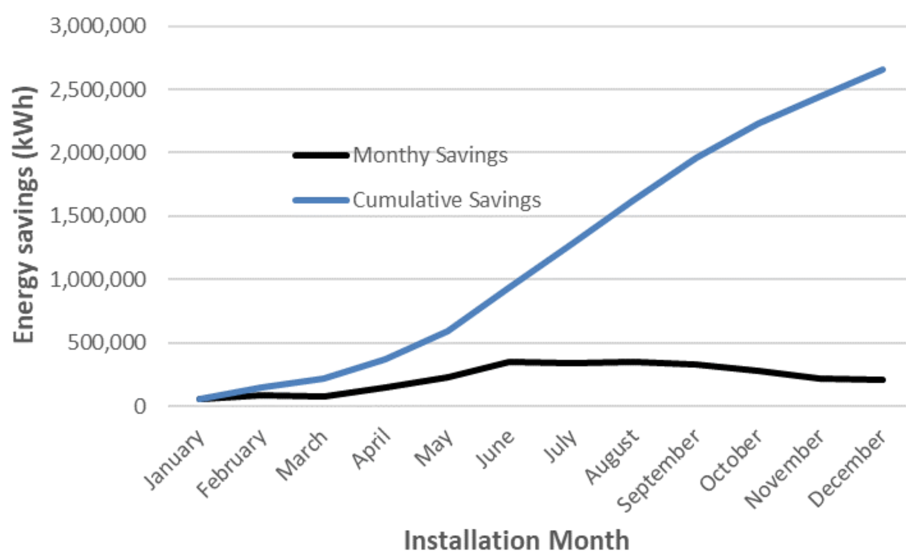
3.5.3.2 Impact Evaluation Findings

This section details the level of Multiple Upgrades activity for 2020, 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.

Program Activity

The Multiple Upgrades part of Home Rebates in 2020 had 927 total projects installed as part of the program. Final energy savings were based on a total of 2,168 energy-savings measures. Figure 3-30 below details the savings accumulated over the program year.

Figure 3-30: 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 2,359,341 kWh, and the total verified net peak demand savings are 1,216.79 kW. A summary of Multiple Upgrades impact findings is shown in Table 3-118.

Table 3-118: Multiple Upgrades - Gross/Net Verified Energy & Demand Savings

Program	Gross Verified Energy (kWh)	Gross Verified Demand (kW)	Net Verified Energy (kWh)	Net Verified Demand (kW)	NTG Ratio
Multiple Upgrades	2,507,673	1,293.51	2,359,341	1,216.79	94%

Reported and Verified Gross Savings

The Multiple Rebates program's gross verified savings estimates resulted in an energy savings realization rate of 94% and demand reduction realization rate of 78%. The following presents the gross verified savings by measure, lifetime energy savings (kWh), and realization rates.

Table 3-119: Reported and Verified Gross Energy & Demand Savings

Measure	Reported Energy (kWh)	Gross Verified Energy (kWh)	Reported Demand (kW)	Gross Verified Demand (kW)	Lifetime Energy Savings (kWh)	RR_{kWh}	RR_{kW}
Air Sealing	31,079	13.55	31,079	13.48	310,793	100%	100%
Duct Sealing & Duct Replacement[77]	1,483,863	930.54	1,506,373	864.76	27,114,710	102%	93%
Insulation – Attic	157,389	111.78	148,005	118.06	2,960,101	94%	106%
Insulation – Floor	6,650	0.64	5,958	0.25	119,160	90%	39%
Insulation - Exterior Wall	4,688	0.90	4,688	0.90	93,769	100%	100%
Insulation - Knee Wall	10,270	7.51	11,313	8.13	226,260	110%	108%
Heating System ECM-type Blower Fan[78]	-	-	-	-	-	-	-
Heat Pump	166,639	63.18	66,299	10.07	1,060,784	40%	16%
Central AC	799,384	524.64	733,958	277.85	13,945,198	92%	53%
Ground Source Heat Pump*	-	-	-	-	-	-	-
Total	**2,659,964**	**1,652.74**	**2,507,673**	**1,293.51**	**45,830,776**	**94%**	**78%**

** There were no ground source heat pump projects in the program in PY2020.*

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 virtual site visits. Findings from the virtual verifications determined a 100% ISR for all sampled measures in Multiple Upgrades for PY2020. All other measures not included in the virtual verification sample were assumed to have an ISR of 100% based on previous

[77] All savings for duct replacement projects were captured in the corresponding duct sealing project.
[78] All savings for ECM-type blower fans are captured in the corresponding HVAC project.

years' results. A description of verified gross findings for each measure type is included below:

Air Sealing (infiltration reduction): The energy savings for air sealing had a realization rate of 100% and the demand savings had a realization rate of 100%. ADM continued to utilize AR TRM 7.0 deemed values for all infiltration reduction projects. One air sealing project did, however, had reported savings of over 10,000 kWh. This is likely due to the savings algorithm not putting a cap on the maximum allowable pre-installation air leakage as defined in the AR TRM 7.0. A procedure has been put in place to not allow this to occur in future reported savings calculations.

Duct Sealing and Duct Replacement: All savings for duct replacement projects were captured in the corresponding duct sealing project for PY2020. These two measures were the largest energy savings measures of the program with 1,483,863 kWh of verified energy savings and 930.54 kW of demand savings. The estimated savings for the combined duct replacement and duct system sealing measures had an overall realization rate of 102% and 93% for energy and demand savings, respectively. Although the realization rates were close to 100%, the difference between the reported and verified savings may be due to the reported savings calculations using a blower subtraction method to account for the pre- and post-leakage for the whole house, while the verified energy savings are 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.

Attic Insulation: The realization rate for attic insulation was 95% for energy savings and 106% for demand savings. Verified energy savings values were calculated using the AR TRM 7.0 for attic insulation. The verified savings calculations used deemed values from the AR TRM based on whether the insulation was attic or roof deck. The reported savings calculations used deemed values for attic for all projects.

Floor Insulation: There were two floor insulation projects. The realization rate for energy savings was 90% and 39% for demand savings. The one project that had foam (low density) insulation is affecting the reported energy savings. For this project, the tracking data indicated the square footage installed was 1,000, which is most likely the square footage of the entire attic and not just the treated area.

Exterior Wall Insulation: There were also only four projects completed for wall insulation with a realized savings of 100% for both the energy and demand savings.

Knee Wall Insulation: The realization rate for knee wall insulation was 110% for energy savings and 108% for demand savings. The verified saving calculations are based on zero existing insulation due to the assumptions in the AR TRM 7.0 of the baseline being an uninsulated knee wall. However, multiple projects in the reported savings calculations had a baseline insulation depth reported.

Electronically Commutated (ECM) Furnace Fan Motors: All savings for ECM-type blower fans are captured in the corresponding HVAC project. Savings captured in the air conditioner replacement measure are based on graded SEER (which includes air handler fan performance).

Heat Pumps: The realization rate for heat pumps was 40% for energy savings and 16% for demand savings. 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 heat pump, 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).

The difference in kWh and kW savings between the reported savings calculations and verified savings calculations are a result of the verified savings calculations using the 2016 federal minimum baseline efficiency standards for all units in the program, while the reported savings calculations are using a combination of old and current federal minimum baseline values for HSPF, EER, and SEER. The verified savings calculations used a baseline HSPF, EER, and SEER of 8.2, 11.8, and 14, respectively, while the reported savings calculations used baseline HSPF of 7.7 and 8.2, baseline EER of 9.7 and 10.8, and baseline SEER of 10.7 and 14. Also, the reported savings for five heat pump projects appear to have interchanged BTU and tons, which is causing savings to be higher than they should be (over 10,000 kWh).

Central Air Conditioners: The realization rate for central air conditioners was 92% for energy savings and 53% for demand. The right sizing of the unit, reducing the capacity of new unit to less than the baseline unit, was considered when the 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 as any additional oversized baseline would have a different EFLH.

The difference in kWh savings between the reported savings calculations and verified savings calculations are a result of the verified savings calculations using the 2016 federal minimum SEER of 14 for all units in the program, while the reported savings calculations are using a combination the old and current federal minimum baseline SEER values of 10.7, 12.44, and 14. The difference in kW savings between the reported savings calculations and verified savings calculations are a result of the verified savings calculations using the 2016 federal minimum EER of 11.8 for all units in the program, while the reported savings calculations are using old federal minimum baseline EER values of 8.5, 9.7, and 10.8.

Ground Source Heat Pumps: There were no ground source heat pump projects in the program in PY2020.

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 21 responses provided specific details of the product, the savings were not considered spillover as some were gas saving measures, some participants claimed they already applied for a rebate for the measure, or their program influence score was not high enough to claim added savings in the NTG estimation.

The simple average free ridership score was 6%. 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 94%.

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 survey, a separate sample of virtual verifications, in-depth interviews with program staff,[79] and discussions with trade allies. 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.

[79] Interviews were conducted to gain insight into how the COVID-19 pandemic effected the Home Rebates Program in PY2020.

Sampling Plan

Table 3-120 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 3-120: Sample Sizes for Data Collection Efforts – Single Upgrade

Data Collection Activity	Achieved Sample Size
Participant Survey	156
Virtual Verifications	26
In-Depth Interviews with Program Staff	3

Participant Survey

The sample size for the participant survey was determined by the minimum sample size algorithm with 90% precision and 10% relative precision constants. With this assumption, a minimum sample size of 68 participants was needed, as shown in Equation 3-3. This minimum sample size of 68 was exceeded with 156 surveys completed.

Virtual Verifications

For virtual verifications, ADM pulled all available participants who had contact information (i.e., phone number and/or email address) listed in the tracking data and who was not contacted to complete the participant survey. An outreach was performed to schedule a virtual visit for every measure in the program, excluding mobile home duct sealing, HVAC tune-ups, and omnidirectional LEDs.[80] Due to the restraints of the virtual verifications, no insulation measures were visually verified due to safety concerns for the program participants. There was a total of 26 virtual site visits performed in PY2020. Table 3-121 below lists the total number of measures sampled.

[80] There were no mobile home duct sealing and HVAC tune-up projects in the program at the time the virtual verifications were performed. No virtual verifications were performed for omnidirectional LEDs due to no available participants in the sample.

Table 3-121: Virtual Verifications - Single Upgrade

Measure	Population Size	Total Number Sampled[81]
Heat Pump	168	8
Central AC	1,115	8
Ground Source Heat Pump	16	1
Insulation – Attic	161	2
Pool Pump	312	9
Mobile Home Duct Sealing	26	-
HVAC Tune-Up	31	-
Omnidirectional LED	18	-
Total	**1,847**	**28**

Data Collection

Participant Survey

For the Single Upgrade Program, there were a total of 156 completed surveys. All Single Upgrade participants were pulled from the tracking data and included in the survey sample list. Any participant with a valid email address was sent the online participation survey. A total of 812 participants were sent the online survey, which resulted in 156 survey completes.

Virtual Verifications

Due to safety concerns from COVID-19, field visits were performed virtually via video phone calls or through phone interviews with participant photos. Virtual verifications were scheduled, then performed by ADM staff, who verified the measure installation and operational characteristics. Pictures were collected during all virtual verifications to document measure installation. For HVAC equipment, a picture of the unit nameplate was also collected to record the unit's model number and serial number. For pool pumps, the pool pump horsepower, pool size, and pool usage (year-round or summer only) was noted. A participant interview was also performed to collect the following information: house type (single family, multi-family, or mobile home), heating system fuel type, and if the home had central air conditioning. The findings from the virtual verifications were compared to information in the program tracking database to verify that input to savings calculations were correctly recorded.

[81] The total number of measures exceeds the total number of virtual site visits performed due to some participants having more than one measure as part of the program.

Program Staff Interviews

ADM evaluators interviewed the PSO's program manager and program coordinator, as well as ICF's account manager to gain insight into how the COVID-19 pandemic effected the Home Rebates Program in PY2020.

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 virtual verifications.
- **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 virtual verifications 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 methodology has been described in the Multiple Upgrades section above (see Section 0), except variable speed drive pool pumps, mobile home duct sealing, HVAC tune-ups, and omnidirectional LEDs. Appendix G 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.

Mobile Home Duct Sealing: The mobile home duct sealing measure involves sealing leaks in ducts of the distribution system of mobile homes with either a central AC or a ducted heating system. 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.[82] 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

[82] Pre-installation duct leakage measurements were discontinued in March 2020 due to safety concerns from COVID-19.

another program. If existing unit efficiency is unknown, the SEER of the baseline unit is used.

HVAC Tune-Ups: This measure involves tuning up existing HVAC units. Savings were calculated using Method 2 from the AR TRM 7.0 algorithm and is a change in efficiency based on pre- and post- measurement of the system. Deemed savings factors are based on the pre and post EER of the HVAC unit.

Omnidirectional LEDs: Savings were estimated by the difference in the wattage of the new 9W LED lamp and a second tier EISA 2007 baseline of 28W 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.[83]

Lifetime kWh Savings

Lifetime kWh savings were calculated by multiplying the gross annual kWh savings by the Estimated Useful Life (EUL) for each measure type. EUL values for each measure were based on the assumptions in the AR TRM and OKDSD. Table 3-117 shows the EUL and source for each measure type.

Table 3-122: Per-Measure Estimated Useful Life (EUL)

Measure Type	EUL (years)
Heat Pump	16
Central AC	19
Ground Source Heat Pump	25
Insulation – Attic	20
Pool Pump	10
Mobile Home Duct Sealing	18
HVAC Tune-Up	10
Omnidirectional LED	19

Net-to-Gross (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

83 ADM HOU Memo, 2016.

score. Each part is described individually below. Details of the questions used for free ridership and spillover estimation are listed in Appendix G.

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), except in the Single Upgrade Program, each participant was limited to two equipment upgrades so the free ridership assessment was similarly limited.

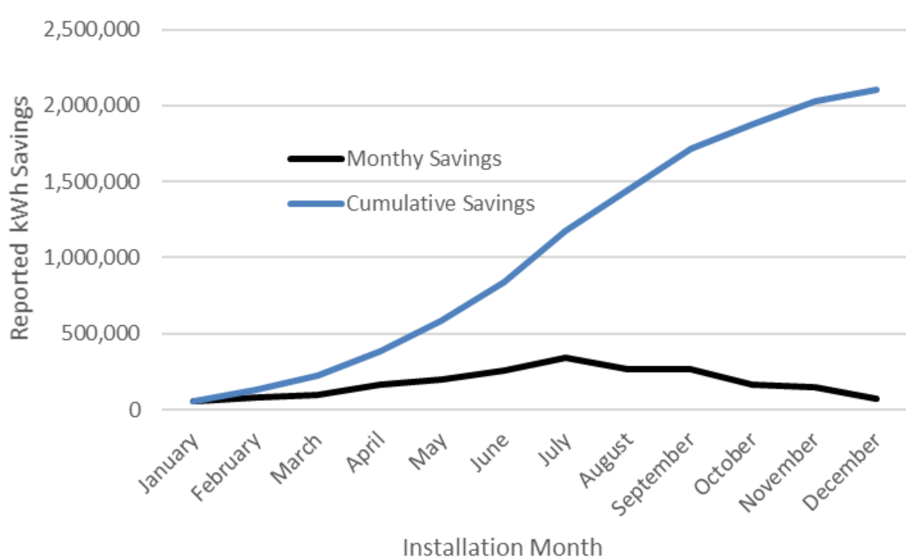
3.5.4.2 Impact Evaluation Findings for Single Upgrade

This section details the level of the Single Upgrade program activity for 2020, 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.

Program Activity for Single Upgrade

In PY2020, the Single Upgrade portion of Home Rebates had 1,748 total projects installed as part of the program. Final energy savings were based on a total of 1,847 energy-savings measures. Figure 3-31 lists the monthly energy savings along with the cumulative annual savings.

Figure 3-31: 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 1,839,804 kWh, and the total verified net peak demand savings are 571.69 kW. A summary of Single Upgrade impact findings is shown in Table 3-123.

Table 3-123: Single Upgrade-Gross, Net Energy & Demand Savings

Program	Gross Verified Energy (kWh)	Gross Verified Demand(kW)	Net Verified Energy (kWh)	Net Verified Demand (kW)	NTG Ratio
Single Upgrade	2,072,210	643.78	1,839,804	571.69	89%

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 99% and a peak demand reduction realization rate of 65%. The following presents the gross verified savings by measure, lifetime energy savings (kWh), and realization rates.

Table 3-124: Reported and Verified Gross Energy and Peak Demand Savings

Measure	Reported Energy (kWh)	Reported Demand (kW)	Gross Verified Energy (kWh)	Gross Verified Demand (kW)	Lifetime Energy Savings (kWh)	RR_{kWh}	RR_{kW}
Heat Pump	317,528	91.00	315,583	45.66	5,049,324	99%	50%
Central AC	786,447	631.71	782,950	332.23	14,942,488	100%	53%
Ground Source Heat Pump	86,870	25.32	102,339	22.24	1,535,086	118%	88%
Insulation - Attic	122,314	74.09	124,381	74.69	2,487,625	102%	101%
Pool Pump	485,329	110.93	484,911	110.93	4,849,114	100%	100%
Mobile Home Duct Sealing	255,057	27.96	203,451	24.04	3,662,112	80%	86%
HVAC Tune-Up	44,201	33.72	55,963	33.72	559,627	127%	100%
Omnidirectional LED	2,424	0.69	2,632	0.27	47,378	109%	40%
Total	**2,100,170**	**995.42**	**2,072,210**	**643.78**	**33,132,753**	**99%**	**65%**

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 virtual site visits. Findings from virtual verifications determined a 100% ISR for all sampled measures in Single Upgrade for PY2020. All other measures not included in the virtual verification sample were assumed to have an ISR of 100% based on previous years' results.[84] A description of verified findings for each measure type is included below:

[84] No participants with omnidirectional LED lightbulbs were sampled for the virtual site visits. A default ISR of 97% was used in the calculations based on the deemed value from the AR TRM 7.0.

Heat Pumps: The energy savings for heat pumps had a 99% realization rate and the demand savings had a realization rate of 50%. 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 heat pump, 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).

The slight difference in kWh savings between the reported savings calculations and verified savings calculations are a result of the verified savings calculations using the 2016 federal minimum 14 SEER and 8.2 HSPF for all units in the program, while the reported savings calculations are using the old federal minimum baseline 12.44 SEER and 7.7 HSPF for one project in the program. The difference in kW savings between the reported savings calculations and verified savings calculations are a result of the verified savings calculations using the 2016 federal minimum EER of 11.8 for all units in the program, while the reported savings calculations are using the old federal minimum baseline EER of 10.8 for all units in the program.

Central Air Conditioner: The energy savings for central ACs had a 100% realization rate for the energy savings and 53% for demand savings. 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 as any additional oversized baseline would have a different EFLH.

There is no difference in kWh savings between the reported savings calculations and verified savings calculations. However, it is important to note that the verified savings calculations used the 2016 federal minimum SEER of 14 for all units in the program, while one project in the reported savings calculations used the old federal minimum baseline SEER value of 12.44. The difference in kW savings between the reported savings calculations and verified savings calculations are a result of the verified savings calculations using the 2016 federal minimum EER of 11.8 for all units in the program, while the reported savings calculations are using the old federal minimum baseline EER value of 10.8.

Ground Source Heat Pump: The energy savings for ground source heat pumps had a 118% realization rate and the demand savings 88%. The baseline used in both the reported and verified savings calculations matched the federal guidelines of 14 SEER and 8.2 HSPF, as the ground source heat pumps were replacing other types of HVAC equipment. However, the reported savings calculations used a baseline EER of 11.2 for all units rather than a 11.8 EER, which aligns with the 2016 federal minimum. The difference in the baseline EER values is affecting the kW savings between the reported savings calculations and verified savings calculations. Also, the reported savings calculations did not claim heating savings for some of the projects, while the verified savings calculations claimed heating savings for all projects in the program.

Attic Insulation: The energy savings for attic insulation had realization rate of 102% and the demand savings had a realization rate of 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% for approximately 56% of homes because they had final insulation levels between R-38 and R-49. For these homes, the reported savings calculations used the deemed values for R-38 while the verified savings calculations used the interpolated values.

Variable Speed Drive Pool Pumps: ADM calculated savings for each home with a variable speed drive pool pump (summer only and year-round) and determined the realization rate for energy savings to be 100% and the realization rate for demand savings to be 100%. ADM applied the same OKDSD deemed savings table values as the report energy savings. The verified savings calculations for the year-round pool pumps included the same annual operating days as the tracking data algorithm, although the AR TRM lists longer operating days for the year-round pumps.

Mobile Home Duct Sealing: Mobile home duct sealing involved sealing leaks in ducts of the distribution system of mobile homes with either a central AC or a ducted heating system. ADM utilized the AR TRM 7.0 algorithm and inputs from the PSO duct leakage reduction results to calculate measure savings along with OKDSD full load hours. The energy savings for mobile home duct sealing had a realization rate of 80% and the demand savings had a realization rate of 86%. Potential differences between reported and verified energy savings is that reported savings calculations used baseline condition SEER and HSPF values 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, the SEER and HSPF of the installed unit were used in the savings calculations. Additionally, the reported savings calculations used an efficient HSPF of 7.7, while the verified savings calculations used a HSPF of 8.2, as per the 2016 federal minimum code.

HVAC Tune-Ups: HVAC tune-ups were performed on existing units in the program. The energy savings for HVAC tune-ups had a 100% realization rate and the demand savings 100%. Deemed savings factors were based on the pre- and post- EER of the HVAC unit. The verified savings calculations utilized Method 2 from the AR TRM 7.0 algorithm and was based on a change in efficiency based on pre- and post- measurement of the system.

9-Watt Omnidirectional LED: In 2020, there were a total of 18 projects that included 9-watt omnidirectional LED lightbulbs. Although, this measure was not offered through the website, it was available on special request. The energy savings for omnidirectional LEDs had a 109% realization rate and the demand savings had a realization rate of 40%.

The verified savings calculations used the Illinois TRM (IL TRM) V9 for the baseline wattage, while the OKDSD was used for the savings algorithms. A default ISR of 97% was used in the verified savings calculations based on the deemed value from the AR TRM 7.0.

Single Upgrade NTG Estimation Results

Survey data from a total of 156 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 11%. 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%.

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). Fifty-four respondents said they had installed additional measures in 2020. Out of those 54 respondents, 12 had a high enough program influence score to indicate that the program was influential in their decision to install those additional measures. However, some were identified as gas saving measures, the lighting may have been incentivized through the retail channel, some participants claimed they already applied for a rebate for the measure, and other measures 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 3-125.

Table 3-125: Program Level Gross Energy and Demand Savings

Program	Reported Energy (kWh)	Reported Demand (kW)	Gross Verified Energy (kWh)	Gross Verified Demand (kW)	Lifetime Energy Savings (kWh)
New Homes	1,488,718	572.59	1,487,311	572.28	29,746,215
Multiple Upgrades	2,659,964	1,652.74	2,507,673	1,293.51	45,830,776
Single Upgrade	2,100,170	995.42	2,072,210	643.78	33,132,753
Total	**6,248,852**	**3,220.75**	**6,067,195**	**2,509.57**	**108,709,744**

Table 3-126 and Table 3-127 summarize the verified net impacts of the complete Home Rebates Program.

Table 3-126: Verified Gross and Net Energy Savings

Program	Free Ridership	Participant Spillover	NTG Ratio	Gross Verified Energy (kWh)	Net Verified Energy (kWh)
New Homes	32%	0%	68%	1,487,311	1,016,119
Multiple Upgrades	6%	0%	94%	2,507,673	2,359,341
Single Upgrade	11%	0%	89%	2,072,210	1,839,804
Total				**6,067,195**	**5,215,264**

Table 3-127: Verified Gross and Net Peak Demand Reduction

Program	Free Ridership	Participant Spillover	NTG Ratio	Gross Verified Demand (kW)	Net Verified Demand (kW)
New Homes	32%	0%	68%	572.28	391.23
Multiple Upgrades	6%	0%	94%	1,293.51	1,216.79
Single Upgrade	11%	0%	89%	643.78	571.69
Total				**2,509.57**	**2,179.70**

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:

- **The New Homes component experienced changes in program delivery due to COVID-19.** Although residential construction was declared an essential business in Oklahoma, COVID-19 affected the supply chain and labor workforce. Many people decided to buy homes during PY2020, however, there are not enough homes being built in part due to labor shortages. Additionally, the only two HERs Raters available for home audits have been overwhelmed by the recent demand, according to the interviewees.
- **Program staff suspended in-person inspection for New Homes during the early stages of the pandemic.** Program staff indicated they had to stop field work for a few months while they adapted to the new circumstances and social distancing protocols. In-person inspections were resumed by June.
- **Homebuilders indicated they are satisfied with the program.** For three of the six builders, PSO's financial incentive is very important for their company. On average, a PSO program-qualifying home can cost a builder from $3,000 to $10,000 (depending on the square footage) more compared to a house not built to program standards. All home builders trust PSO to provide reliable sources about energy efficient building techniques or practices.
- **Builders constructed many houses this year and expect to build more by the end of 2020 but unsure about future housing demands.** Homebuilders with smaller projects will build close to ten to 20 homes this year, while companies with more extensive projects expect to build 150 to 200 homes by the end of 2020. Yet, builders indicated they were unsure of the future state of the housing market for 2021. The economic ramifications of the COVID-19 pandemic have affected interest rates, supply chains, and the sector's labor force.
- **Most home builders indicated that constructing energy efficient homes is standard for their company.** In general, some of the builders noted that their clients are aware the houses are built to energy efficiency standards but are unsure if the buyers know about PSO's rebate. Furthermore, four out of the six builders indicated the number of eligible homes would increase, while one was unsure, and another interview believed the number would remain the same for 2020.
- **Most of the home builders indicated their home buyers consider a home's general appearance, location, and price as factors for buying a home.** Home buyers are also interested with maintenance cost as well as energy efficiency. The builders did suggest PSO would benefit from creating more marketing materials

that better educates homes buyers about energy efficiency and how that influences reducing costs to the public.

- **Home builders are satisfied with program outreach.** The main communication channel between the home builders and PSO or ICF is email. One interviewee expressed that their interactions with PSO staff are “very positive and helpful.”
- **Home builders benefit from including a HERs rating on their homes.** Three out of four builders who responded to the question stated that there was an advantage to providing home buyers with a rating. Some of the builders suggested PSO should emphasize the importance of a HERs rating and estimate an amount of dollar savings to the homeowners.

3.5.6.2 Single and Multiple Upgrades

The following summarizes the key findings of the process evaluation of the Multiple Upgrades component:

- **The Multiple Upgrades component underwent significant changes to program operations.** Before the pandemic, the process included having the service provider email PSO about a new project. PSO would register the new project in their system and then schedule a test-in inspection at the customer’s home. Afterwards, the service providers would go to the customer’s home and install the measure, and finally there would be a test-out inspection. Ultimately, PSO staff decided to suspend their test-ins indefinitely and rather use historical averages based on data gathered from 5,000 homes and HVAC types to conduct the home inspection.
- **The Multiple Upgrades component underwent significant changes to program delivery.** The change in program operations has allowed service providers to install more measures and increase their participation in the program. For in-home installations, PSO developed a best practices guideline that included the step-by-step installation procedure as well as recommended safety protocol. Interviewees indicated the change in process has increased participation among service providers, which is why PSO has decided to discontinue conducting in-person test-ins for next year.
- **The additional $500 bonus for HVACs had mixed results.** To ensure HVAC sales continued despite the pandemic, PSO decided to offer an additional $500 HVAC bonus from June 1st to July 15th, a total discount of $1,000 for an HVAC. Program staff indicated they used billboard and Facebook ads to promote the incentive. As a result, the HVAC sales doubled, and many customers purchased 16 SEERs.

- **Program staff did not expect to meet program goals for 2020**. Even though the additional $500 incentive bonus helped offset impacts of COVID-19 during those months, the budget depleted faster than anticipated. One interviewee indicated they had already spent 85% of the budget but had only met 65% of the goal. Yet, program staff were still hopeful to close the program by November with at least 85% of the goal met.
- **Program staff adopted new recruitment and communication strategies to adapt to the new circumstances.** Program staff indicated most of the HVAC contractor recruitment and training was done telephonically during the beginning of the pandemic. At the time of the interview, staff stated they have been able to revisit contractors in person.
- **Program staff indicated there are plans to launch an HVAC tune-up program for PY2021**. This year, the program conducted a pilot for HVAC tune-ups for mobile homes. The implementer indicated the pilot was successful and cost effective. There are plans to launch the program statewide for 2021.
- **Program staff plans to conduct a focus group with HVAC contractors.** Staff indicated they plan to conduct a focus group with HVAC contractors on November 11th to discuss current state of the sector and well as future marketing trends.
- **The rebates influenced about half of the program participants' decision to improve upon their home's energy efficiency.** Some customers mentioned that they could not have made their upgrades without the assistance of the rebates. Other customers did not participate in the program due to total cost of the equipment regardless of the rebates. A trade ally made an example that the rebate for the 16 SEER HVAC units were reduced, which may have made it less enticing for some customers to purchase such an upgrade.
- **The Home Rebates Program has opportunities to increase knowledge about energy efficiency in customer's homes.** Most participants have increased the amount of time they spend at home due to the coronavirus pandemic. They indicated that they were more aware of the advantages of energy efficiency since the upgrades were made to their homes, but most also reported that they have not changed their thermostats to save energy, nor have they visited the PowerForwardwithPSO.com website where they could learn more about energy saving and additional programs.
- **Trade allies have a great influence on the program participants.** The program participants primarily learned of the program through their contractor and were generally satisfied with them. Most of the contractors (trade allies) inferred that being involved with the program influenced their level of marketing and selling of

the energy efficient measures. The contractors shared with the program participants the benefits of the energy efficient equipment they were purchasing.

- **Overall, the program participants and trade allies are satisfied with the PSO Home Rebate Program.** Program participants were generally satisfied with their contractors and with PSO program staff. The trade allies, too, had positive feedback for the program staff and indicated that their communication with program staff was helpful. They also indicated that the program staff could be quicker in responding to questions. None of the trade allies had any issues with the Third-Party Verifiers (TPV), and they reported their program training in 2020 to be helpful.

The following summarizes the key findings of the process evaluation of the Single Upgrade component:

- **Program staff performed more desktop QA/QC procedures for the Single Upgrade component than in previous years.** To assess quality of Single Upgrade projects remotely, program staff indicated they utilized their Geo-tagging tool to verify the installations. The implementer indicated that desktop QA rose to almost 90% during PY2020. At the time of the interview, staff indicated technicians had been allowed to return to in-person inspections and that desktop versus in-person inspections were about 50% each.
- **The Home Rebates Program has opportunities to increase knowledge about energy efficiency in customer's homes.** Most participants have increased the amount of time they spend at home due to the coronavirus pandemic. They indicated that they were more aware of the advantages of energy efficiency since the upgrades were made to their homes, but most also reported that they did not visit the PowerForwardwithPSO.com website where they could learn more about energy saving and additional programs.
- **Overall, the program participants and trade allies are satisfied with the PSO Home Rebate Program.** Program participants were generally satisfied with their contractors and with PSO program staff. The trade allies, too, had positive feedback for the program staff and indicated that their communication with program staff was helpful. They also indicated that the program staff could be quicker in responding to questions. None of the trade allies had any issues with the Third-Party Verifiers (TPV), and they reported their program training in 2020 to be helpful.

3.5.7 Conclusions and Recommendations

The following recommendations are offered for continued improvement of the New Homes component:

- **Host a virtual gathering with homebuilders and HERs raters to discuss current issues and develop marketing strategies to meet future trends.** Because homebuilders expressed an interest in participating in future events, PSO could consider hosting a virtual event soon with New Homes participants. PSO could take this time to conduct a focus group and identify key trends that may improve sales of energy efficient homes.

The following recommendations are offered for continued improvement of the Single & Multiple Upgrades component:

- **Continue to collaborate with program stakeholders to maintain program success and find new strategies to save energy.** The effective and constant communication among program staff and service providers has allowed for the program to continue despite the challenges posed by the pandemic. Collaboration, cooperation, and even innovation has allowed for many to work remotely, return to in-person visits, and streamline operations.
- **Increase promotion of the PowerForwardwithPSO.com website to increase customer's knowledge of the rebates available for energy efficient upgrades.** Customers may be more inclined to upgrade additional equipment when they can see what all is included in the rebate programs. They also may learn to save more energy at home when reading the tips and tools that the website offers.
- **Increase advertisements for home improvement and energy savings tips and tools.** Home improvement and energy saving tips and tools can be advertised through a digital newsletter or other print ads such as bill inserts. Tip and tools will increase a customer's knowledge of how to save energy in their home and can emphasize the importance of a contractor's expertise and the need for energy efficiency home audits.
- **Investigate opportunities to reduce participant and/or trade ally question turnaround time.** Explore when trade allies are experiencing negative interactions or delayed responses to questions during their time in the program. Explore creating processes that will help PSO staff navigate through the challenges.
- **Improve contractor training for completion of the participant information.** Email and phone numbers were missing or contained the contractor contact information for many of the participants. Tracking data provided by the implementor should be complete and contain only the participants' information.

- **Increase QA/QC process in reviewing final ex-ante savings in the tracking data.** The reconciliation of the final reported values from the tracking data should be completed within the given deadlines after the end of the program year. Extra review processes should ensure that the reported savings calculations are correct, and that no erroneous values remain within the data.
- **Ensure final rebate/incentive amounts in tracking data reflect final reported values.** The per measure rebate/incentives amounts listed in final tracking data for Multiple Upgrades did not include bonuses and fees from the program, which caused them to not tie out to the final reported rebate/incentive amounts. Final tracking data should reflect all final values reported for the program.

3.5.8 Single and Multiple Upgrades 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 0 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

Financial Ability

Financial ability was assessed with the following question:

- PFR1: Because energy-efficient upgrades are higher in cost, would you have still purchased the [MEASURE] without the PSO rebate/discount?

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).

Prior Plans

The presence of plans prior to involvement with the program was assessed through the following questions:

- PFR2: Before learning about the PSO rebate program, did you have plans to purchase or install the [MEASURE]?
- PFR3: Did you purchase and install [a more efficient/more] [MEASURE] because of the PSO rebate/discount?
- PFR4: [For duct sealing and knee wall insulation measures] Before participating in the program, did you know that your [duct system was leaking/ knee walls were need of improved insulation]?
- PFR5: [For duct sealing and knee wall insulation measures] Were you aware that you could save energy by [sealing your ducts/insulating your knee walls] before you participated in the program?

For measures other than duct sealing and knee wall insulation, respondents who answered "Yes" to PFR2 and "No" to PFR3 were assigned a plans score of 1. All other respondents were assigned a plans score of 0. For duct sealing and knee wall insulation measures, respondents who said "Yes" to PFR4 and PFR5 were assigned a plans score of 1 and all other respondents were assigned a plans score of 0.

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: How likely is it that you would have purchased and installed the same [MEASURE] without the rebate/discount through PSO's Home Rebates Program?
- PFR7: How likely would you have been to purchase and install the [MEASURE] if you had not learned about PSO's Home Rebates Program from [SOURCE]?
- PFR8: [IF MULTIPLE UPGRADES OR RESPONDENT HAD AN ASSESSMENT] How likely would you have been to purchase and install the same [MEASURE] your home energy auditor had not recommended it?

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 = 0.25
- 3 = 0.5
- 4 = 0.75
- 5 (Very likely) = 1

The likelihood score was based on the lowest rating provided on questions PFR6 through PFR8.

Program Impact on Timing

The program effect on the timing was assessed with the following two questions:

- PFR9: Did you purchase and install the [MEASURE] sooner than you would have because of the PSO rebate/discount?
- PFR10: If you had not received a PSO rebate/discount, when would you have purchased and installed the [MEASURE]?

The information provided in the response to these questions is used in the following manner:

- If the respondent stated that they would have installed the measure in more than one year, the preliminary free ridership score is multiplied by 0, resulting in a final free ridership score of 0. This is 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 the respondent stated that they would have installed the measure in 6 months to one year, the preliminary free ridership score is multiplied by 0.25.
- If the respondent stated that they would have installed the measure within 6 months of when it was installed, the preliminary free ridership score is multiplied by 0.5.

3.5.9 Participant Questions to Assess Service Provider Influence on HVAC Installation

The participant survey asked participants:

- PFR11: Did the contractor or home energy auditor that you worked with recommend any additional energy saving upgrades?
- PFR12: How influential was the recommendation by your contractor or home energy auditor in your decision install the additional energy-efficient upgrades in your home?

A “Yes” response to PFR11 and rating of 5 for PFR12 indicates service provider influence.

3.5.10 Service Provider Free Ridership Questions

The service provider survey included two service providers free ridership (SPFR) questions:

- SPFR1: How important was the PSO Home Rebates Program, including the rebates and information provided through the program, in influencing your level of marketing and selling of energy efficient measures to PSO customers during [YEAR]?

- SPFR2: Would you have recommended different equipment types, quantities, or efficiency levels to customers if the program were not available?

The responses to SPFR1 were scored as following (where higher values indicated higher free ridership):

- 0 (Not at all important) = 1
- 1 = 0.9
- 2 = 0.8
- 3 = 0.7
- 4 = 0.6
- 5 = 0.5
- 6 = 0.4
- 7 = 0.3
- 8 = 0.2
- 9 = 0.1
- 10 (Very important) = 0

If the service provider answered “Yes” to question SPFR2, the score from SPFR1 is reduced by 50%.

3.5.11 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: Since participating in the program, have you purchased and installed any additional energy-saving equipment or home improvements, with or without receiving a program rebate or discount?”

Participants indicating that they have purchased and installed one or more energy efficiency projects since participating in the PSO Home Rebates Program were then asked two questions to determine whether the energy savings resulting from those measures may be attributed to the program:

SO3: How would you rate the importance of your experience with PSO's Home Rebates Program in your decision to install those additional energy-saving equipment or home improvements?

SO4: How likely would you have been to install those additional energy-saving equipment or home improvements if you had not participated in PSO's Home Rebates Program?

The responses to SO2 were scored as following (on a scale of 0 to 10, where higher values indicated higher spillover):

- 0 (Not at all important) = 1
- 1 = 0.9
- 2 = 0.8
- 3 = 0.7
- 4 = 0.6
- 5 = 0.5
- 6 = 0.4
- 7 = 0.3
- 8 = 0.2
- 9 = 0.1
- 10 (Very important) = 0

The responses to SO3 were scored as following (on a scale of 1 to 15, where higher values indicated higher spillover):

- 1 (Not at all likely) = 0
- 2 = 0.25
- 3 = 0.5
- 4 = 0.75
- 5 (Very likely) = 1

Participants responding to question SO3 with a rating of 7 or higher and responding to question SO4 with a rating of 3 or lower, were considered to have been motivated by the program to make these additional purchases, and the energy savings from these items were attributed to the program. Savings for spillover measures like those offered through the program were calculated and then extrapolated to the population of respondents.

3.6 Education

3.6.1 Program Overview

The PSO Education Program, known by teachers, students, and parents as the PSO Energy Saver Kits Program, provides educational materials and energy-efficient products to 5th grade students. The program provides students with the opportunity to learn about energy efficiency and provides energy efficient products to reduce home energy use. The PSO Education Program has operated continuously since 2010 but has only claimed savings since 2016. Table 3-128 summarizes PY2020 performance metrics for the PSO Education Program.

Table 3-128: Performance Metrics – Education Program

Metric	PY2020
Number of Customers	16,001
Budgeted Expenditures	$1,120,000
Actual Expenditures	$950,062
Energy Impacts (kWh)	
Projected Energy Savings	3,510,710
Reported Energy Savings	3,787,117
Gross Verified Energy-savings	3,595,976
Net Verified Energy-savings	3,595,976
Peak Demand Impacts (kW)	
Projected Peak Demand Savings	420.00
Reported Peak Demand Savings	728.72
Gross Verified Peak Demand Savings	737.06
Net Verified Peak Demand Savings	737.06
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	2.41
Utility Cost Test Ratio	2.52

The Education Program consists of three main components. (1) Education materials provided to teachers. (2) Kits with energy saving measures for students to install at home. (3) The PSO Education Program webpage.[85]

Educational materials were developed by the implementer to form a five-day curriculum to meet 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,

[85] https://www.pso-education.com/

teacher, or students. The ready-made curriculum includes documentation explicitly outlining the Oklahoma Academic Standards supported through the program in language arts, mathematics, and science.

Students are engaged through compelling stories and illustrated characters such as C.A.D.E. (the Champion And Defender of Energy). CADE goes on energy-saving adventures and teaches students about energy-saving habits and ways to be more energy-efficient at home.

Students return home with an Energy Saver Kit and install the measures from the kit at home. The measures provide energy savings to participating families and can reinforce concepts taught through the curriculum. Table 3-129 details kit contents and expected savings per measure.

The PSO Education Program website provides additional resources for teachers, students, and parents. Teachers can access additional resources and educational materials to enrich the students' experience in the program. Students can access additional information about kit contents and links to educational activities through sites such as the Department of Energy Kids and the Energy Information Administration (EIA) Kids. Parents can access installation instruction for kit contents and other energy-saving tips.

Table 3-129: Summary of Kit Contents and Verified Energy Savings and Demand Reduction

Kit Contents	Quantity	Verified kWh Savings Per Measure	Verified kW Reduction Per Measure	Verified kWh Savings Per Kit	Verified kW Reduction Per Kit
Energy Star® 9W LED	4	15.34	0.0017	61.34	0.0067
Advanced Power Strip	1	89.70	0.0104	89.70	0.0104
FilterTone® Alarm	1	53.41	0.0290	53.41	0.0290
LED Night Light	1	20.28	0.0000	20.28	0.0000
Digital Thermometer	1	0.00	0.0000	0.00	0.0000
Total				**224.73**	**0.0461**

Some of the available program literature for parents was developed in English and Spanish to 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.

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

ADM collaborated with the program implementers to develop two quizzes and two surveys to be conducted through the program. The quizzes assess the student's knowledge about electricity and energy use before and after participation in the program. The surveys collect information about the home, such as heating fuel and air conditioning system type, and information about program-related activities, such as measure installation and behavioral changes. Impact calculations use survey responses to inform the savings analysis. Teachers are eligible for a $50 gift card when 80% of student surveys are completed and returned.

PSO does not collect student contact information. Collecting any student contact information beyond the student's first name would be in violation of the Personal Information Protection Act (PIPA) and Family Educational Rights and Privacy Act (FERPA).

ADM conducted two in-depth interviews with program staff to gain insight into the program execution. ADM completed interviews in October 2020 with the PSO Program Coordinator who managed the program, and the implementation Program Manager. Table 3-130 summarizes the data collection activities and purpose.

Table 3-130: Data Collection and Sample Size Effort by Survey

Data Collection Activity	Data Use	Achieved Sample Size
Program Tracking Data	Impact/Process	16,001
PSO Student Survey	Impact/Process	2,051
ADM Teacher Survey	Process	115
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. Measure level In-Service Rates (ISR) were calculated from student surveys. The student surveys are provided with the kits and collected by the implementation team.

3.6.2.3 Gross Impact Methodologies

To calculate annual energy-savings (kWh) and peak demand impacts (kW), ADM conducted the following evaluation activities:

- Reviewed a census of program tracking data: ADM reviewed the tracking data for a census of kits.
- Reviewed program invoices: ADM conducted a review of program invoices to verify shipment of kits reported in program tracking data and reconcile program costs.

- Calculated verified savings: The sources for deemed savings algorithms are the 2016 Pennsylvania Technical Reference Manual (PA TRM) and Arkansas Technical Reference Manual v7.0 (AR TRM).
- Determined measure installation: ADM calculated the ISR for ENERGY STAR® LEDs, FilterTone® alarms, LED night lights, and the advanced power strip using data collected from a sample of program participants in the student surveys.

ENERGY STAR® LEDs

The algorithm used to determine energy-savings and demand reduction for ENERGY STAR® LEDs is in Appendix G, Section 1.5.1 based on the Arkansas Technical Reference Manual (AR TRM).

The AR TRM stipulated value for hours of use (HOU) for omnidirectional lamps is 792.6 hours per lamp. ADM conducted a lighting benchmarking study in PY2016 and found daily hours of use of 2.63 blended hours for indoor/outdoor applications, or 960.61 hours per year.[86] In-service rates, interactive effects, and coincident factors were determined from student surveys.

Advanced Power Strips

The algorithm used to determine energy-savings and demand reduction for advanced power strips in residential applications is based on the AR TRM and detailed in Appendix G, Section 1.5.2. In-service rates were determined from the student surveys. Due to the complexity of correctly installing advanced power strips, ADM calculated in-service rates based on the number of students who reported installing the power strip with parental help or supervision.

FilterTone® Alarm

The algorithm used to determine energy-savings and demand reduction for FilterTone® Alarms is based on the PA TRM and detailed in Appendix G, Section 1.5.3. In-Service Rate was determined from student surveys. Due to the complexity of correctly installing FilterTone® alarms, ADM calculated in-service rates based on the number of students who reported installing the alarm with parental help or supervision. The source for the equivalent full load hours (EFLH) for the FilterTone® alarms calculation was the PY2019 – PY2021 Demand Portfolio Model.

LED Night Light

The algorithm used to determine energy-savings for LED Night Lights is from the PA TRM and detailed in Appendix G, Section G.1.5.4. Measure In-Service Rate was determined from student surveys.

[86] ADM HOU Memo, 2016.

Digital Thermometer

PSO did not claim energy-savings or demand reduction for the digital thermometers distributed in the Education Program kits.

3.6.2.4 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 to participate. It is therefore not reasonable to assume that a parent or student was a free rider when they received the kit.

3.6.2.5 Lifetime Savings

Lifetime annual energy savings were calculated by multiplying the gross annual energy savings by the Effective Useful Life (EUL) for each measure type. EUL values for each measure were based on the assumptions in the AR TRM and PA TRM. Table 3-131 shows the EUL and source for each measure type.

Table 3-131: Per-Measure Estimated Useful Life (EUL)

Kit Contents	EUL	Source
Energy Star® 9W LED	19[87]	AR TRM
Advanced Power Strip	10	AR TRM
FilterTone® Alarm	14	PA TRM
LED Night Light	8	PA TRM

3.6.2.6 Process Evaluation

ADM's process evaluation activities will include a review of program materials and databases, interviews with PSO and implementer staff, School Kits survey data collected from students, and a survey of participating teachers.

Table 3-132 below summarizes the data collection activities and corresponding process evaluation research objectives.

[87] ADM followed the AR TRM algorithms for LED bulbs, and used EISA Tier 1 baselines for the first three years of the measure life (2020-2022), and EISA Tier 2 baselines thereafter.

Table 3-132: Process Evaluation Data Collection Activities Summary

Data Type	Process Evaluation Research Objectives
Review of Program Materials and Databases	Provide information on program design, implementation, and delivery. Provide school and teacher participation data to help interpret data from student surveys. Provide information to develop sample of teachers to survey.
PSO and Implementation Staff Interviews	Confirm program design, implementation, and delivery; identify any changes. Get perspective on successes, challenges, developments, progress toward goals, and barriers.
Assessment of Student Survey Data	Assess pre-post differences in energy quiz. Assess whether quiz performance is related to household or school characteristics. Determine whether assessed energy-saving activities, including installation of kit measures, are related to household characteristics, school characteristics, or quiz performance.
Teacher Survey	Assess teacher perceptions of the program, materials, and kits; use of materials in curriculum development; and level of teacher involvement in kit distribution.

3.6.3 Impact Evaluation Findings

Table 3-133 reports the verified gross annual energy-savings (kWh) of the 2020 Education Program by measure.

Table 3-133: Gross Energy-savings (kWh) Summary by Measure for PY2020

Measure	Number of measures	ISR	***Reported*** **Energy (kWh) Savings**	Verified Energy (kWh) Savings	Realization Rate	Verified Lifetime Energy Savings (kWh)
Advanced Power Strip	16,001	47%	1,471,132	1,435,298	98%	14,352,976
LED Night Light	16,001	77%	339,541	324,562	96%	2,596,498
FilterTone® Alarm	16,001	45%	801,170	854,604	107%	11,964,457
Energy Star® LED	64,004	50%	1,175,273	981,512	84%	8,025,304
Total			**3,787,117**	**3,595,976**	**95%**	**36,939,236**

Table 3-134 reports the peak demand reduction (kW) of the 2020 Education Program by measure.

Table 3-134: Gross Demand Reduction (kW) Summary by Measure for PY2020

Measure	Number of measures in Kit	ISR	*Reported* Demand (kW) Reduction	Verified Demand (kW) Reduction	Realization Rate
Advanced Power Strip	16,001	47%	169.13	165.94	98%
LED Night Light	16,001	77%	0.00	0.00	NA
FilterTone® Alarm	16,001	45%	435.66	464.69	107%
Energy Star® LED	64,004	50%	123.93	106.42	86%
Total			**728.72**	**737.06**	**101%**

Overall, the 2020 Education Program resulted in verified gross annual energy savings of 3,595,976 kWh with a demand reduction of 737.06 kW, and lifetime energy savings of 36,939,236 kWh. This represents a realization rate for energy-savings and demand reduction of 95% and 101%, respectively. Detailed descriptions of differences in the savings calculations are in the measure level findings below.

3.6.3.1 Program Tracking Data

ADM reviewed the program tracking data periodically throughout the year and worked with the implementation team to address any issues. The final program tracking data was verified to not contain any issues such as duplicate entries or missing data.

3.6.3.2 Advanced Power Strip

ADM confirmed the savings methodology was consistent between reported results and verified results. ADM used the student survey to determine the proportion of installed advanced power strips controlling home offices, home entertainment systems, or other devices, which was then applied to the energy-savings and demand reductions to create weighted average savings and demand reduction for advanced power strips. The verified average energy savings and demand reductions were found to be 192 kWh and 0.022 kW per power strip, slightly higher than the assumed values of 184 kWh and 0.021 kW.

ADM found an ISR of 47% for advanced power strips, compared to the assumed ISR of 50%. The realization rate for advanced power strips was found to be 98% due to differences in installation location from ex-ante assumptions and a verified in-service rate that was slightly lower than assumed.

3.6.3.3 LED Night Light

ADM confirmed the savings methodology was consistent between reported results and verified results. The program level realization rates for energy savings is 96%. Verified energy savings differ from reported due to the differences between the assumed ISR (81%) and verified in-service rate (77%).

3.6.3.4 *FilterTone® Alarm*

ADM confirmed the savings methodology was consistent between reported results and verified results. The program level kWh and kW realization rates for FilterTone® Alarms were 107%. Verified energy savings differ from reported due to the differences between the assumed ISR (42%) and verified in-service rate (45%).

3.6.3.5 *Energy Star® LED*

ADM confirmed the savings methodology was consistent between reported results and verified results. The program level realization rates for kWh and kW were 84% and 86%, respectively. ADM used student surveys to determine LED in-service rates, interactive effects, and coincidence factors. The differences in savings and demand reductions between ADM and the implementer were due to differences between the verified and assumed values for these inputs, as shown in Table 3-135.

Table 3-135: Differences Between Assumed and Verified Inputs for LED Light Bulb Calculations

Calculation Input	Assumed Value	Verified Value
In-Service Rate	58%	50%
Interactive Effect (Energy)	0.97	0.93
Interactive Effect (Demand)	1.25	1.24
Coincidence Factor (CF)	0.0786	0.0784

3.6.4 Process Evaluation Findings

ADM's process evaluation activities included student and teacher surveys as well as interviews with the PSO Program manager and program implementer. ADM provided a process evaluation memo to PSO after the completion of the 2020 program year.

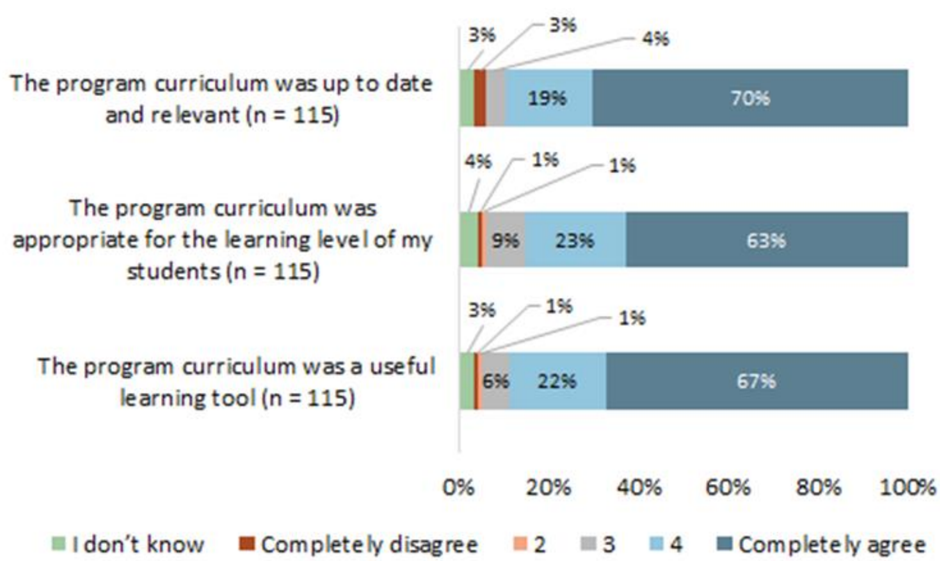
Table 3-136 provides an overview of the kit distribution among the top ten cities. The largest proportion of distributed kits occurred in the cities of Tulsa (26%), Broken Arrow (13%), Lawton (6%), Owasso (3%), and Bixby (3%).

Table 3-136: Kit Distribution Among Top Ten Cities

City	Number of Kits (n = 16,001)	Percentage of Kits
Tulsa	4,106	26%
Broken Arrow	2,147	13%
Lawton	913	6%
Owasso	549	3%
Bixby	534	3%
Jenks	448	3%
Bartlesville	437	3%
Duncan	340	2%
Sand Springs	246	2%
Collinsville	203	1%

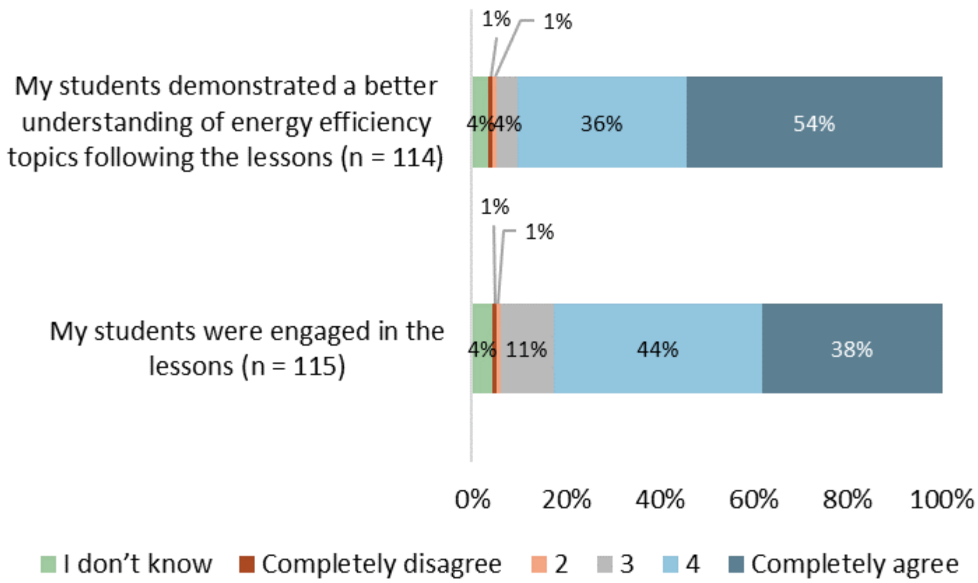
Most teachers agreed that the program curriculum was up to date and relevant, was appropriate for the learning level of their students, and was a useful learning tool (see Figure 3-32).

Figure 3-32 Teacher Perceptions of the Program Curriculum



Most teachers (83%) agreed that their students were engaged with the lessons and 90% agreed their students demonstrated a better comprehension of energy efficiency following the lessons (see Figure 3-33).

Figure 3-33 Perception of Student Experience



3.6.5 Conclusions and Recommendations

The following are the key conclusions from the evaluation of the Education Program.

- Program staff and implementers met program goals during PY2020. A total of 16,001 kits were sent to 490 different fifth grade teachers within the PSO territory for PY2020. According to the data, Franklin Energy sent 1,601 kits during the spring semester and 14,400 in the fall. The largest proportion of distributed kits occurred in the cities of Tulsa (26%), Broken Arrow (13%), and Lawton (6%).
- Program impacts did not differ greatly from previous years, and measure-level savings, demand reductions, and In-Service Rates are within the expected range for a kit program.
- Parents, teachers, and students were highly satisfied with the program. Parents indicated high levels of satisfaction with the program kit and curriculum and 92% of students rated the program "good" or "excellent". In addition, ADM's survey of teachers found that 98% of teachers would like to participate in the program again, while PSO's survey of teachers found that all the 72 teachers surveyed would recommend the program to others.
- The Program succeeded in educating students about energy and energy efficiency. Analysis of the scores on program quizzes found that student scores increased by an average of 22%, from an average of 60% before the teachers taught the curriculum, to an average of 82% after completing the curriculum.

- Program materials underwent some changes for PY2020. PSO staff stated they revamped the look of the school kits for this year, but the measures in the kit remained the same. Additionally, program staff stated they examined the workbooks and made any necessary updates. Implementers indicated they have provided teachers with digital materials if they needed or wanted to present the lessons and activities online.
- Many of the survey participants have previously participated in the program. Seventy-eight percent of respondents indicated they had participated in the School Kits program prior to the 2020 school year, with 20% indicating this was the first year they had participated. Among the teachers who responded to the survey, 69% indicated they had participated in the School Kits program for more than three years.
- The pandemic created some challenges for teachers. Teachers reported the pandemic affected their ability to complete all the lesson plans (46%), classroom activities (57%), or distribute kits (27%). Some teachers shared their experience with distance and virtual learning. Many expressed it was difficult to implement some of the activities.
- According to participants, the information in the kits complemented or enriched their curriculums. Most teachers (68%) reported teaching concepts that they normally teach in their regular curriculum. Many teachers indicated they would most likely have not taught students about energy efficiency or their instruction on the subject would have been limited. Many indicated the student kits are a great component that adds additional value to their own curriculum and instruction.
- Most teachers received positive feedback from their students regarding the program. Eighty-three percent of survey participants agreed that their students were engaged with the lessons and 90% agreed their students demonstrated a better comprehension of energy efficiency following the lessons.

The following recommendations are offered for continued improvement of the Education Program.

- Program impacts may be increased by further encouraging teachers to instruct their students on how to install the advanced power strips and FilterTone® alarm, which only approximately 3/4 of teachers did. Providing more instruction to teachers and students on how to install these measures could improve installation rates and result in higher savings.
- While each kit contained some materials in Spanish, PSO could consider expanding resources on the program website in other languages. Adding languages like Spanish may help reach more families and increase participation as well as home survey completions. Other languages to consider could include

American sign language (in the program videos) and languages spoken in the Asian or Indo-European territories.

- The virtual methods introduced in 2020 may be beneficial to continue into future years. Teachers expressed satisfaction with the digital resources provided, and several teachers expressed a desire for additional virtual activities and digital resources, including PowerPoint presentations and Google Classrooms integration. Virtual activities that require more group and interpersonal communication skills may help students adapt to unique situations where hands-on work is restricted and may reinforce the idea of personal and communal responsibility around conserving energy.
- The program website is a valuable resource for participants. Continuing to keep it relevant and up to date will benefit the program.
- Student engagement may be improved by customizing some aspects of the kits to reflect the different energy use among cities or counties within the PSO territory. According to the instructors, students benefitted from learning how energy efficiency affected their daily lives. Program staff could add a sheet of fun facts that informs what major economic sectors are in that county or city, what commercial buildings have done to be more energy efficient, how the home builders are creating more energy efficient homes where the students live, etc. The document could help expand the child’s understanding that energy efficiency is often a collaborative effort that involves everyone taking some sort of action.
- Program staff could explore adding new activities to the program. Several teachers suggested that the number of activities provided could be increased to improve student engagement. These activities could also serve to increase program participation. Program staff could consider adding an activity that asks the students of each cohort to leave a letter to the next cohort about their experience with the program. The activity could increase the sense of social responsibility and community among the students. Additionally, the activity may increase further participation from teachers and create a tradition in the school.

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 can choose to opt out if they no longer want to receive the emailed energy reports. In addition to receiving a report that encourages saving energy, participants are 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. The implementers focused on identifying single family homes within that pool of potential participants using a third-party data set. 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 implementer 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. Wave 1 participants started treatment by receiving energy reports via email only, and approximately 50,000 participants began also receiving paper reports in 2019. A second wave (wave 2) commenced on May 22, 2018. Like wave 1 participants, wave 2 began treatment with emailed reports, but started receiving mailed reports in 2019 as well. An additional wave (wave 3) was added on March 20, 2019, via paper reports and email reports when email contact information is available. These participants continued to receive energy reports in 2020. A fourth wave (wave 4) was added for 2020, and this group began receiving paper and emailed reports on March 1, 2020.

Paper energy reports were mailed to treatment participants in March, May, June, August, and November 2020. Additionally, monthly emailed energy reports are sent to participants in each wave where available. Program year 2020 included some participants who will only receive reports via email.

Table 3-137 shows the performance metrics achieved by the program.

Table 3-137: Performance Metrics – Behavioral Modification Program

Metric	PY2020
Number of Customers	193,195
Budgeted Expenditures	$1,273,750
Actual Expenditures	$1,271,000
Energy Impacts (kWh)	
Projected Energy Savings	22,008,294
Reported Energy Savings	19,980,019
Gross Verified Energy Savings	21,062,812
Net Verified Energy Savings	21,062,812
Peak Demand Impacts (kW)	
Projected Peak Demand Savings	2,512.36
Reported Peak Demand Savings	3,699.65
Gross Verified Peak Demand Savings	4,109.32
Net Verified Peak Demand Savings	4,109.32
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	1.26
Utility Cost Test Ratio	1.19

PSO’s Behavioral Program serviced 193,195 households during the 2020 program year. Table 3-138 shows the annual energy savings (kWh) per wave for PY2020.

Table 3-138: 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	74,771	0.29	106.1	7,933,203	7,933,203
Wave 2	32,549	0.47	172.0	5,598,428	5,598,428
Wave 3	42,654	0.24	87.8	3,745,021	3,745,021
Wave 4	43,221	0.24	87.6	3,786,160	3,786,160
Total	**193,195**	**0.30**[†]	**109.0**[†]	**21,062,812**	**21,062,812**

[†]*Reflects an average value weighted by the count of treatment group participants.*

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 energy savings (kWh) and peak demand reduction (kW), 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 2020 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 associated 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 differences in LED purchasing patterns, potential impacts of the coronavirus pandemic, and customer satisfaction.
- In-depth interviews with program staff to support the process evaluation.

3.7.2.2 Survey Sampling Plan

To ensure proper extrapolation of survey results to program participants, ADM surveys a statistically representative sample. For the calculation of sample size for survey completes, a coefficient of variation of 0.5 was assumed.[88] With this assumption, a minimum sample size of 68 participants was required, as shown in Equation 3-4 on the following page.

[88] 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 Objective

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, determining how participants' energy usage was affected by the COVID-19 pandemic, and to 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.

The survey was administered online with participation through an emailed link to a random group of participants and controls. A summary of survey goals by wave is shown in Table 3-139.

Table 3-139: Summary of Survey Targets and Responses

Wave	Control Group		Treatment Group	
	Number of Customers Targeted	Number of Completed Surveys	Number of Customers Targeted	Number of Completed Surveys
Wave 1	3,141	75	4,798	75
Wave 2	3,910	68	5,635	62
Wave 3	4,095	78	5,551	65
Wave 4	3,972	67	5,979	61
Total	**15,118**	**288**	**21,963**	**263**

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 2020.
2. Calendarized the billing data provided by PSO.

3. Cleaned the data by removing duplicate bills and string characters in the monthly consumption column.

4. Removed billing months with negative consumption on their monthly bill.

5. Removed billing readings with consumption less than 100 kWh or greater than 10,000 kWh.

6. Removed billing months with a reported number of billing days less than 25 or greater than 35. It is assumed that these values are in error.

7. Determined the appropriate pre-treatment time frame for all participants in the program and removed customers without sufficient pre-program billing data.
   - 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.
   - For wave 4, participants who started the program on March 1, 2020, the pre-treatment period is March 1, 2019 – February 29, 2020.

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 Saving 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 at a rate determined to be statistically different (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

$$AEC_{i,t} = \alpha_i \mathrm{Customer_i} + \beta_1 CDD_{i,t} + \beta_2 HDD_{i,t} + \beta_3 Post_{i,t} + \beta_4 Post_{i,t} * Treat_{i,t} + \beta_5 Post_{i,t} * CDD_{i,t} + \beta_6 Post_{i,t} * HDD_{i,t} + E_{i,t}$$

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 on the following page in Table 3-140.

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 above 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 under which it is assumed that a building needs no cooling). A minimum value of 0 is used for both HDD and CDD. A description of the variables used in the regression model is shown in Table 3-140 on the next page.

Table 3-140: 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 1 if the monthly period is after the customer received their first energy report and 0 if not
Treatment	Treatment is a dummy variable that is 1 if the customer is a member of the treatment group and a 0 if not
E_t	E_t is the error term

Table 3-141 describes the coefficients that were determined by using the mixed effects panel model shown in Equation 3-5.

Table 3-141: 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 for 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 heating.

3.7.2.7 Calculation of Annual Energy Savings

The average daily annual energy savings value for the post period treatment groups is defined as coefficient β_4 in the regression model. To determine per participant annualized savings, the annual energy savings value is multiplied by 366[89] days for waves 1, 2, and 3. Wave 4 annualized savings are calculated by multiplying the annual energy savings

[89] Since 2020 is a leap year, the savings calculations account for 29 days in February 2020 for a total of 366 days in the year.

value by 365 days, since treatment began March 1, 2020 and therefore does not include the February 2020 leap day. The verified annual energy savings for the program is determined by multiplying the annualized annual energy savings by the number of participants in the treatment group.

3.7.2.8 Calculation of Coincident Peak Demand Reduction

The peak demand reduction was determined by applying the program annual energy savings to a normalized hourly load shape that represents typical residential energy consumption, resulting in an 8,760 hourly annual savings curve. The selected load shape was the same used to determine estimates for the Behavioral Modification Program during portfolio planning. An average value across the peak demand window was drawn from the energy savings curve. The peak demand window is defined as consumption non-holiday weekdays between 2 PM and 6 PM in the months of June through September.

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.

3.7.2.10 Lifetime Energy Savings

The Behavioral Program is considered to have an effective useful life (or EUL) of 1.0 year. This is consistent with behavioral practices and the recommended value from the energy efficiency portfolio plan. Therefore, the lifetime savings total is equivalent to the annual verified energy savings.

3.7.3 Impact Evaluation Findings

The following section reports the findings for PY2020 annual energy savings and coincident peak demand 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 3-142.

Table 3-142: Pre-Treatment Average Daily Consumption

Wave	Control Group		Treatment Group		t test p value
	Number of Customers in Regression Model	Average Daily Pre-Treatment kWh	Number of Customers in Regression Model	Average Daily Pre-Treatment kWh	
Wave 1	16,124	42.69	70,207	42.72	0.69
Wave 2	13,394	48.37	31,443	48.53	0.12
Wave 3	18,050	36.91	36,043	36.88	0.65
Wave 4	11,199	40.10	38,782	40.16	0.46

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 control groups using a two-sample t test. Of these, ADM determined that there was a statistically different rate of participation between the wave 1 treatment and control groups with the Home Rebates Single Upgrade program. In addition, a difference was determined between the wave 3 participant groups' cross participation with the Home Weatherization Program. See Table 3-143 for the results of the t-tests for each group. The p values showing evidence of a statistically significant difference are bolded in the table following page.

Table 3-143: Cross Participation with other PSO Residential Programs

ESP Program					
Behavioral Program Wave	Control Group		Treatment Group		t-test
	n	%	n	%	p-value
1	81	0.47%	383	0.51%	0.564
2	47	0.34%	142	0.44%	0.147
3	64	0.30%	126	0.30%	0.980
4	37	0.30%	105	0.24%	0.347
Home Weatherization					
Behavioral Program Wave	Control Group		Treatment Group		t-test
	n	%	n	%	p-value
1	86	0.50%	375	0.50%	1.000
2	62	0.45%	185	0.57%	0.110
3	74	0.35%	221	0.52%	**0.003**
4	79	0.63%	233	0.54%	0.243

Home Rebates, Multiple Upgrades					
Behavioral Program Wave	Control Group		Treatment Group		t-test
	n	%	n	%	p-value
1	55	0.32%	215	0.29%	0.504
2	41	0.29%	73	0.22%	0.194
3	50	0.23%	83	0.19%	0.342
4	29	0.23%	101	0.23%	1.000
Home Rebates, Single Upgrade					
Behavioral Program Wave	Control Group		Treatment Group		t-test
	n	%	n	%	p-value
1	70	0.41%	422	0.56%	**0.015**
2	80	0.58%	171	0.53%	0.552
3	71	0.33%	171	0.40%	0.211
4	55	0.44%	158	0.37%	0.266
Power Hours					
Behavioral Program Wave	Control Group		Treatment Group		t-test
	n	%	n	%	p-value
1	1668	9.72%	7336	9.81%	0.853
2	1077	7.74%	2485	7.63%	0.722
3	880	4.13%	1663	3.90%	0.173
4	609	4.87%	2097	4.85%	0.925

Since the participants of the Energy Saving 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 3-144. The t-test shows that there was 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.

Table 3-144: 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	
12.26	231	12.44	233	1.00

3.7.3.3 Data Cleaning

Table 3-145 shows the number of accounts left after each step of data cleaning to determine the participants 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 3-145: Number of Accounts After Each Data Cleaning Step

Cleaning Step	Wave 1		Wave 2		Wave 3		Wave 4	
	Control Group	**Treatment Group**	**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	13,000	45,000
Participants not active PSO customers in the program year removed	17,152	74,771	13,912	32,549	21,305	42,654	12,505	43,221
Cross participants removed	17,060	74,248	13,901	32,504	21,213	42,392	12,543	43,384
Outliers removed	16,927	73,649	13,737	32,172	21,063	42,088	12,121	41,985
Accounts with insufficient data removed	16,124	70,207	13,394	31,443	18,050	36,043	11,199	38,782
Number of accounts in final model:	**16,124**	**70,207**	**13,394**	**31,443**	**18,050**	**36,043**	**11,199**	**38,782**

3.7.3.4 Calculated Annual Energy Savings (kWh)

Table 3-146 provides the results of the mixed-effects panel regression model. A negative coefficient indicates savings attributable to the program.

Table 3-146: Results of Mixed Effect Panel Regression Modeling

Wave	Post × Treat Coefficient	Standard Error	T-Statistic	P-Value	R-Squared
Wave 1	-0.29	0.05	-5.73	<0.001	0.71
Wave 2	-0.47	0.07	-6.50	<0.001	0.74
Wave 3	-0.24	0.04	-5.47	<0.001	0.60
Wave 4	-0.24	0.07	-3.48	<0.001	0.73

3.7.3.5 Total Annual Energy Savings (kWh)

The annual energy savings by wave are reported in Table 3-147 on the following page. Annual energy savings per customer were determined by multiplying the daily kWh savings value by 366[90] days for waves 1, 2, and 3, and by 365 days for wave 4. Then, the verified annual energy savings total for the program was determined by multiplying the annualized annual energy savings by the number of participants that were in the treatment group.

Table 3-147 Annual Energy 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	74,771	0.29	106.1	7,933,203	7,933,203
Wave 2	32,549	0.47	172.0	5,598,428	5,598,428
Wave 3	42,654	0.24	87.8	3,745,021	3,745,021
Wave 4	43,221	0.24	87.6	3,786,160	3,786,160
Total	**193,195**	**0.30†**	**109.0†**	**21,062,812**	**21,062,812**

†Reflects an average value weighted by the count of treatment group participants.

3.7.3.6 Coincident Peak Demand Reduction (kW)

The peak demand reduction results by wave are reported in Table 3-148.

[90] Since 2020 is a leap year, the savings calculations account for 29 days in February 2020 for a total of 366 days in the year.

Table 3-148: Coincident Peak Demand Reduction, by Wave

Wave	Number of Treatment Customers	Verified Net kW Peak Reduction
Wave 1	74,771	1,547.76
Wave 2	32,549	1,092.24
Wave 3	42,654	730.65
Wave 4	43,221	738.67
Total	**193,195**	**4,109.32**

3.7.3.7 Verified Gross Impacts

Verified and reported annual energy savings (kWh) and peak demand reduction (kW) in Table 3-149.

Table 3-149: Reported and Verified Annual Energy Savings and Peak Demand Reduction

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
19,980,019	3,699.65	21,062,812	4,109.32	105%	111%

3.7.3.8 Net and lifetime Evaluation Impacts

As described in the methodology section, net impacts are equivalent to gross impacts for the Behavioral Modification Program. The effective useful life of the Behavioral Modification Program is 1 year, making the lifetime energy savings equivalent to the annual energy savings.

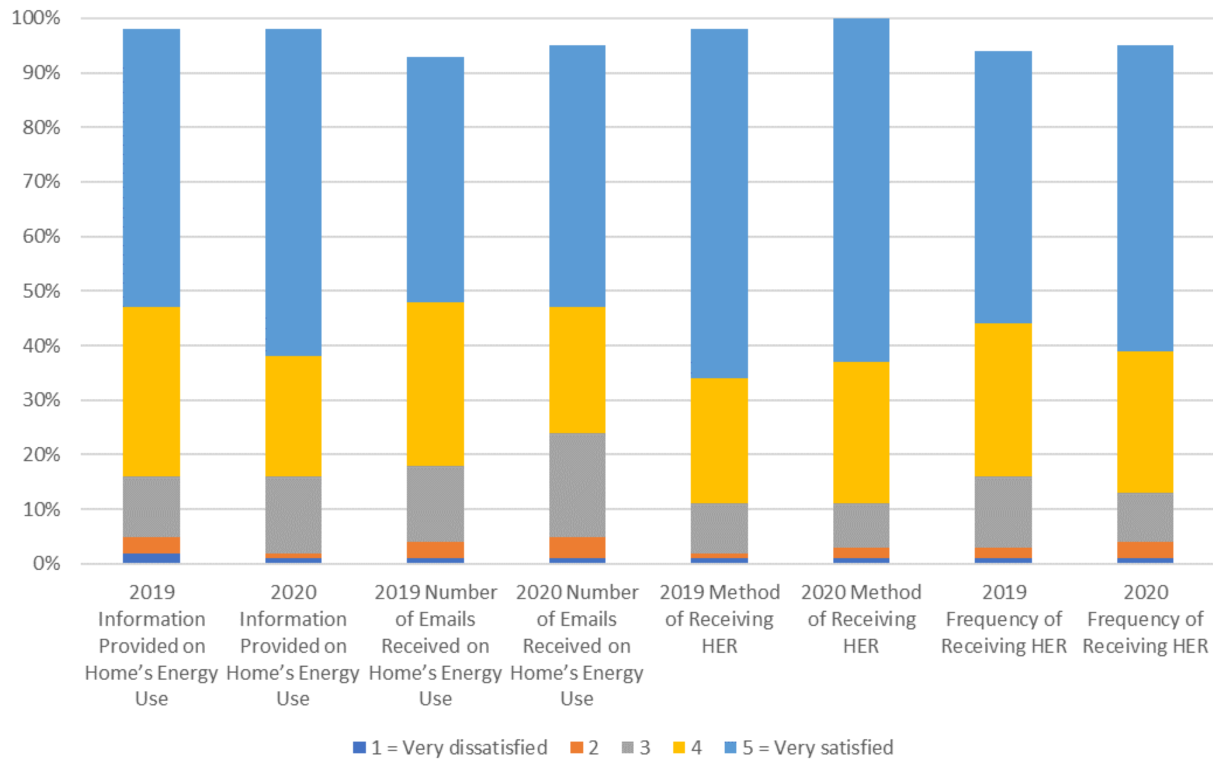
3.7.4 Process Evaluation Findings

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 2020. The following summarizes the key findings from the process evaluation of the Behavioral Modification Program.

The PSO Behavioral Program underwent several changes regarding customer engagement in 2020, including changes to the Energy Smart Rewards component, modifications to the report template, and adapting reports to reflect current conditions. Changes made in the previous program year persisted as well, such as the addition of mailed paper reports and a more regular schedule of report delivery.

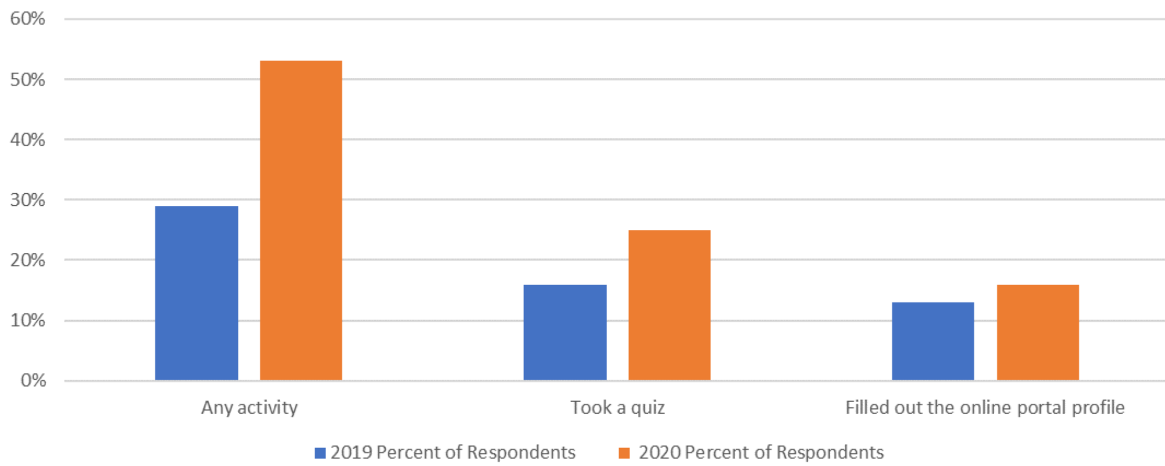
Participant satisfaction was reported for several program characteristics and has remained consistently high in both 2019 and 2020. Ratings on the information provided in the energy reports as well as the frequency and method of receiving the reports were high with over 80% of respondents reporting very satisfied or satisfied. Results are shown in Figure 3-34 on the following page.

Figure 3-34: Program Year Comparison of Satisfaction with HER Aspects



The amount of participant interactions with available online tools can be used as an indicator of interest in performing energy efficiency actions. Program year 2020 saw an increase in Smart Energy Rewards activity among participants based on survey results. Results are shown in Figure 3-35.

Figure 3-35: Program Year Comparison of Participation in Online Portal



3.7.5 Conclusions and Recommendations

This section presents conclusions and recommendations based on evaluation of the program for the 2020 program year.

3.7.5.1 Conclusions

The following conclusions were developed from the evaluation findings.

- Savings goals for PY2020 were met with an increase in annual energy savings from prior years. Final verified net annual energy savings and verified net peak demand reduction are 21,062,812 kWh and 4,109.32 kW, respectively.
- The Energy Smart Rewards component of the program was successful during 2020. The rewards program increased engagement and participant retention during the program year, according to staff. Based on survey results, the portal provided valuable information that enhanced energy savings actions. Opportunities may exist to further increase the program's impact if strategies can be devised to increase the use of the My Energy Advisor portal among program participants.
- Personalization can potentially impact the success of the program in upcoming years. Program staff expressed ideas about developing videos that help people find more ways to save energy or use software that can successfully project high energy bills for customers. Evidence appears to suggest that the HERs educate participants about energy-saving activities but do not necessarily induce adoption of them. Customization of messages may help increase the adoption of energy-saving activities.
- Majority of respondents reported buying LED bulbs in 2020. About one-quarter of respondents reported they had purchased or installed energy efficient equipment

or appliances other than lighting in 2020. The most common items were ENERGY STAR® appliances.

- Approximately three-quarters of survey respondents reported spending more time at home in 2020, and therefore using more energy overall. However, only about one-third had perceived an increase in their energy bill.

3.7.5.2 Discussion of Differences Between PY2019 and PY2020.

The Behavioral Program energy savings during 2020 exceed that of the PY2019 savings. This increase in savings is seen within each wave and at program level. Contributing factors could include an increase in usage overall and behavior changes due to the coronavirus pandemic. Despite the increase in savings, the values reported in this evaluation are consistent across the industry[91].

To determine the potential impact of the coronavirus pandemic on program savings in 2020, ADM included survey questions in both the control and treatment participant surveys. The questions inquired about behavioral and usage changes specific to related economic impacts and safety ordinances starting in Spring 2020. ADM performed a two-sample t-test on the treatment and control survey data results regarding these behavioral changes. The results are provided in Table 3-150. The results of the t-tests show no statistically significant differences between the control and treatment groups regarding these aspects of how participants' energy usage may have been affected by business closures and precautions in place during 2020.

Table 3-150: Coronavirus Pandemic Responses

Question	Percent Impacted		t test p value
	Control Group	Treatment Group	
How has the coronavirus pandemic changed the amount of time you spend at home?	78.7%	77.9%	0.89
Has the coronavirus pandemic affected your ability to participate in PSO's energy efficiency programs?	78.1%	83.8%	0.45
Have you noticed any change in your electricity bill since the coronavirus pandemic?	30.8%	28.8%	0.69

[91] Measured savings over 400 kWh/year have been verified in some instances. For an example of a compilation of Behavioral Program annual savings results, see Kane, R. and Srinivas, N. "Unlocking the Potential of Behavioral Energy Efficiency: Methodology for Calculating Technical, Economic, and Achievable Savings Potential," ACEEE Summer Study on Energy Efficiency in Buildings. 2014. Accessible via: https://www.aceee.org/files/proceedings/2014/data/papers/5-284.pdf

3.7.5.3 Recommendations

The following recommendations are offered for improvement of the Behavioral Program.

- Continue to explore opportunities to personalize the reports for customers. Adapting the language to fit the current social climate as well as tailoring questions to customers has increased engagement and participation this year. PSO could consider developing additional educational material that emphasizes the idea that energy efficiency is a constant practice. Implementing additional big data or machine learning to the program to improve the customization component of the reports could enhance the program and result in higher energy savings.
- Explore ways to make the mailed HERs more engaging. It may be possible to reduce barriers to logging on among populations who may not be online savvy. Consider using strategies that increase the call to action to some of the energy saving tips that were not so popular according to survey responses.

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 PY2020. This document is the Evaluation Report for the PY2020 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.[92] 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.

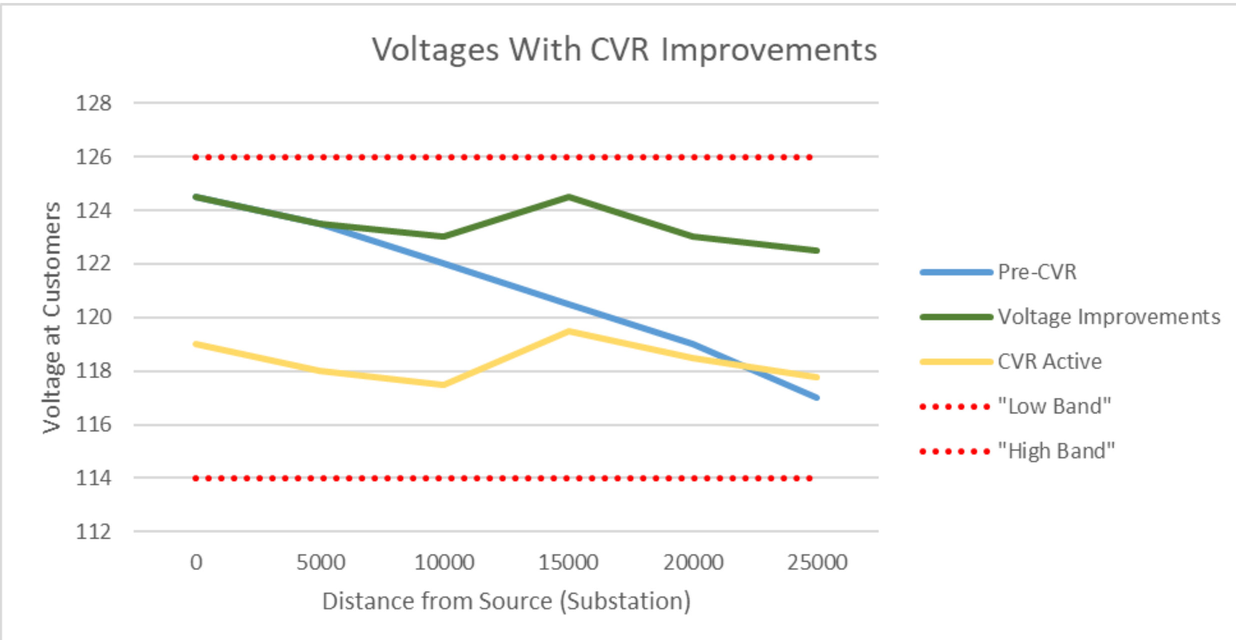
PSO approached the implementation of CVR in a holistic, system-wide manner, to fully optimize the energy efficiency potential. PSO considered the following three system configurations and decided on full implementation of these configurations.

- 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 the equipment is now communicating with a backend system (Yukon) and a fully implemented CVR system.

[92] https://www.tdworld.com/grid-opt-smart-grid/cvr-here-stay

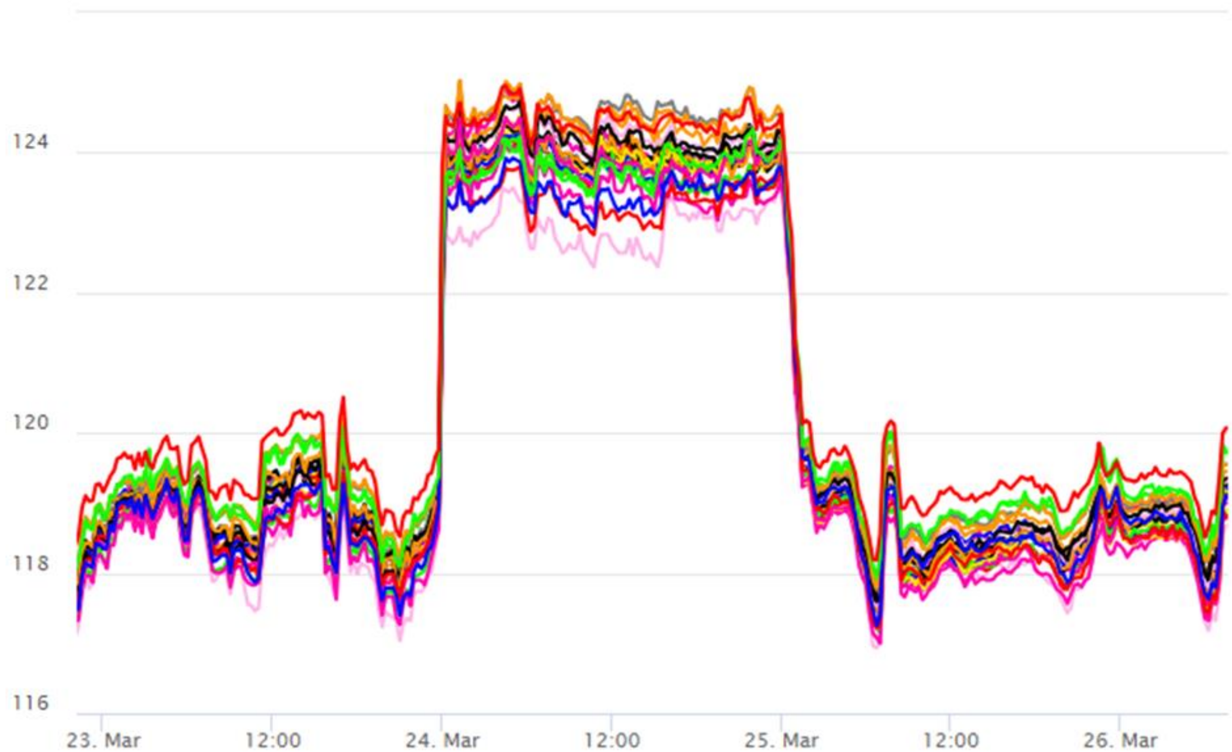
The inclusion of systematic upgrades results in a more consistent delivery of voltage to customers. As shown in Figure 3-36, blue represents voltage of a typical distribution system configuration, green represents a typical distribution system with equipment locations and settings optimized, and yellow 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 3-36: 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 3-37, 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 3-37: Example PSO Circuit with CVR and Upgrades during Evaluation Testing



To support CVR at this 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 PY2020 CVR program M&V evaluation consisted of 5 substations and 23 circuits (See Table 3-151). 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 3-151: CVR Deployment Timeline

Substation	Construction Start Date	Construction Complete Date	In Service Date
141st & Pine	19-Apr	19-May	19-Nov
46th Street North	19-May	19-Jun	19-Dec
53rd & Cache	19-Jun	19-Aug	19-Nov
Broken Arrow 81st	19-Jun	19-Aug	19-Dec
Lawton Sheridan	19-Apr	19-Jul	19-Dec

The additional equipment installed, by substation, is listed in Table 3-152.

Table 3-152: System Equipment Upgrades

Substation	Capacitors	Regulators	End Of Line Devices
141st & Pine	13	2	6
46th Street North	15	2	7
53rd & Cache	10	1	8
Broken Arrow 81st	24	2	5
Lawton Sheridan	31	0	11

Gross annual energy savings were reported to be 15,704,599 kWh for the circuits claimed in 2020. ADM's verified savings estimates for CVR are 14,425,878 kWh, resulting in an 92% realization rate for gross annual energy savings. Table 3-153 provides reported and verified program performance metrics.

Table 3-153: PY2020 CVR Program Overview

Metric	PY2020
Number of Customers	27,488
Budgeted Expenditures	$983,359
Actual Expenditures	$1,126,666
Energy Impacts (kWh)	
Projected Gross Energy Savings	18,123,755
Gross Verified Energy Savings	14,425,878
Net Verified Energy Savings	14,425,878
Peak Demand Impacts (kW)	
Projected Gross Peak Demand Savings	4,198
Gross Verified Peak Demand Savings	4,168.70
Net Verified Peak Demand Savings	4,168.70
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	1.84
Utility Cost Test Ratio	1.69

PSO implemented the program using Eaton's Yukon Integrated Volt/VAR Control (IVVC) automation software.[93] Voltage levels were controlled independently for each of the three phases for all evaluated circuits.

3.8.2 CVR EM&V Methodologies

For the PY2020 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. 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

[93] 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

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 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.[94] 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

[94] 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 2020 was 5 PM on August 28th.

3.8.2.6 Lifetime Energy Savings

Lifetime energy savings is calculated as the product of annual energy savings multiplied by the equipment's effective useful life (EUL). Associated expenses for CVR equipment and upgrades are only considered during its first year of operation. Therefore, an EUL of one year is applied for the CVR program. This equates to lifetime energy savings being equivalent to annual energy savings.

3.8.3 CVR Impact Evaluation Findings

The evaluation for CVR includes an impact evaluation 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. Net impacts are equivalent to gross impacts for the CVR program due to the nature of implementation at the distribution level with no incentives provided.

3.8.3.1 Gross Verified Annual Energy Savings (kWh)

The gross verified annual energy savings (kWh) for PY2020 are 14,425,878 kWh. This represents an overall annual percent savings of 2.88% relative to the evaluated circuit demand. Table 4 and Table 5 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.

Table 3-154: PY2020 CVR Cooling Season Gross Verified Energy Savings (kWh)

Substation	Circuit	Percent Savings	Cooling Season Energy Savings (kWh)	Cooling Season Energy Consumption (kWh)
141st & Pine	ET1	0.99%	208,028	21,100,669
	ET3	4.40%	549,464	12,501,184
53rd & Cache Rd	LC11	3.64%	664,555	18,277,587
	LC15	3.55%	417,280	11,740,274
	LC19	3.49%	417,398	11,968,807
Lawton Sheridan Rd	LS10	3.62%	335,850	9,274,337
	LS11	3.06%	476,810	15,600,673
	LS12	3.71%	42,110	1,133,909
	LS13	5.95%	633,588	10,652,867
	LS14	3.46%	402,959	11,638,809
	LS15	3.26%	366,963	11,272,669
	LS16	5.18%	569,379	10,997,926
	LS17	2.98%	661,583	22,202,610
46th Street North	ZD1	3.59%	290,028	8,068,280
	ZD2	1.45%	209,165	14,466,645
	ZD3	3.20%	217,526	6,799,506
	ZD4	2.80%	406,424	14,532,604
Broken Arrow 81st	ZV1	2.17%	317,708	14,623,371
	ZV2	4.12%	45,621	1,108,433
	ZV3	3.02%	484,380	16,032,554
	ZV4	4.05%	365,895	9,042,311
	ZV5	1.08%	63,931	5,909,544
	ZV6	3.31%	511,156	15,430,597
Total		**3.16%**	**8,657,799**	**274,376,168**

Table 3-155: PY2020 CVR Heating Season Gross Verified Energy Savings (kWh)

Substation	Circuit	Percent Savings	Heating Season Energy Savings (kWh)	Heating Season Energy Consumption (kWh)
141st & Pine	ET1	2.87%	550,465	19,169,861
	ET3	3.17%	381,028	12,010,853
53rd & Cache Rd	LC11	1.75%	218,226	12,482,266
	LC15	1.73%	132,192	7,641,639
	LC19	3.82%	352,454	9,237,282
Lawton Sheridan Rd	LS10	1.61%	119,649	7,418,702
	LS11	3.14%	304,826	9,701,794
	LS12	2.65%	23,998	907,262
	LS13	2.72%	325,692	11,964,561
	LS14	3.48%	375,088	10,791,069
	LS15	3.43%	291,032	8,495,632
	LS16	1.42%	122,591	8,656,152
	LS17	2.75%	470,702	17,117,481
46th Street North	ZD1	2.69%	273,783	10,169,001
	ZD2	1.05%	198,382	18,868,575
	ZD3	2.31%	193,054	8,372,398
	ZD4	2.02%	275,134	13,613,691
Broken Arrow 81st	ZV1	4.33%	434,740	10,040,523
	ZV2	2.38%	21,604	906,699
	ZV3	2.54%	212,985	8,398,637
	ZV4	1.59%	117,602	7,417,528
	ZV5	2.68%	104,588	3,899,904
	ZV6	2.76%	268,264	9,715,595
Total		**2.54%**	**5,768,079**	**226,997,104**

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. Circuit savings and characteristics split by phase are shown in Section 3.8.5.

3.8.3.2 Gross Verified Coincident Peak Demand Reduction (kW)

The gross verified coincident peak demand reduction (kW) for PY2020 is 4,168.70 kW. This represents 112% of the projected peak demand reduction. Results per circuit are shown in Table 3-156.

Table 3-156: PY2020 CVR Gross Verified Peak Demand Reduction (kW)

Substation	Circuit	Peak Demand Reduction
141st & Pine	ET1	72.68
	ET3	167.55
53rd & Cache Rd	LC11	321.46
	LC15	213.50
	LC19	191.98
Lawton Sheridan Rd	LS10	164.75
	LS11	209.64
	LS12	19.33
	LS13	438.14
	LS14	203.70
	LS15	161.32
	LS16	280.37
	LS17	249.34
46th Street North	ZD1	182.68
	ZD2	138.51
	ZD3	149.77
	ZD4	159.81
Broken Arrow 81st	ZV1	143.95
	ZV2	21.42
	ZV3	236.82
	ZV4	184.25
	ZV5	30.78
	ZV6	226.95
Total		**4,168.70**

3.8.3.3 Evaluation Methodology Comparison

Results between the industry standard on/off regression methodology and the transition test approach are compared in Table 3-157. 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 5.48% of one another between the two methodologies. Transition test annual savings results are shown in Table 8 and Table 9.

Table 3-157: CVR Methodology Summary Comparison

Season	Methodology	Daily Average Savings	Percent Savings	CVR Factor	Projected Full Season Savings
Cooling	On / Off	47,053	3.16%	0.73	8,657,799
	Transition Test	33,151	2.22%	0.51	6,099,695
Heating	On / Off	31,868	2.54%	0.54	5,768,079
	Transition Test	41,631	3.32%	0.73	7,535,223

Table 3-158: PY2020 CVR Cooling Season Transition Test Savings Summary

Substation	Circuit	Percent Savings	Cooling Season Energy Savings (kWh)	Cooling Season Energy Consumption (kWh)
141st & Pine	ET1	1.33%	281,619	21,100,669
	ET3	0.91%	113,452	12,501,184
53rd & Cache Rd	LC11	2.42%	442,561	18,277,587
	LC15	2.68%	314,794	11,740,274
	LC19	2.62%	313,252	11,968,807
Lawton Sheridan Rd	LS10	4.51%	418,466	9,274,337
	LS11	1.60%	250,044	15,600,673
	LS12	2.79%	31,600	1,133,909
	LS13	2.32%	246,834	10,652,867
	LS14	2.58%	300,360	11,638,809
	LS15	1.97%	222,347	11,272,669
	LS16	2.13%	234,351	10,997,926
	LS17	2.94%	653,458	22,202,610
46th Street North	ZD1	2.47%	199,101	8,068,280
	ZD2	2.72%	394,040	14,466,645
	ZD3	1.62%	110,084	6,799,506
	ZD4	0.21%	30,452	14,532,604
Broken Arrow 81st	ZV1	2.40%	350,983	14,623,371
	ZV2	2.04%	22,661	1,108,433

Substation	Circuit	Percent Savings	Cooling Season Energy Savings (kWh)	Cooling Season Energy Consumption (kWh)
	ZV3	2.59%	414,649	16,032,554
	ZV4	3.04%	274,933	9,042,311
	ZV5	2.57%	152,077	5,909,544
	ZV6	2.12%	327,579	15,430,597
Total		**2.22%**	**6,099,695**	**274,376,168**

Table 3-159: PY2020 CVR Heating Season Transition Test Savings Summary

Substation	Circuit	Percent Savings	Heating Season Energy Savings (kWh)	Heating Season Energy Consumption (kWh)
141st & Pine	ET1	2.97%	570,004	19,169,861
	ET3	-1.36%	(162,977)	12,010,853
53rd & Cache Rd	LC11	5.83%	727,217	12,482,266
	LC15	5.66%	432,298	7,641,639
	LC19	1.92%	177,026	9,237,282
Lawton Sheridan Rd	LS10	7.55%	560,002	7,418,702
	LS11	3.42%	331,516	9,701,794
	LS12	1.70%	15,420	907,262
	LS13	6.57%	786,590	11,964,561
	LS14	1.79%	192,713	10,791,069
	LS15	1.70%	144,646	8,495,632
	LS16	7.00%	605,956	8,656,152
	LS17	0.58%	99,575	17,117,481
46th Street North	ZD1	4.24%	431,157	10,169,001
	ZD2	3.36%	634,927	18,868,575
	ZD3	3.65%	305,606	8,372,398
	ZD4	1.88%	255,998	13,613,691
Broken Arrow 81st	ZV1	3.50%	351,766	10,040,523
	ZV2	4.45%	40,370	906,699
	ZV3	3.94%	330,997	8,398,637
	ZV4	3.70%	274,565	7,417,528
	ZV5	4.83%	188,233	3,899,904
	ZV6	2.49%	241,619	9,715,595
Total		**3.32%**	**7,535,223**	**226,997,104**

Circuit savings and characteristics split by phase for the transition test methodology evaluation are shown in Section 3.8.6.

3.8.4 Conclusions

PY2020 was the third 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 PY2019 found a percent difference of approximately 10.5%, and PY2020 saw a percent difference of 5.5%. In all 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 implementation on any new circuits will undergo the same evaluation testing.

The overall average reduction in distributed energy due to CVR across the evaluated circuits is 2.88% with an average CVR factor around 0.63. The previous year’s evaluation identified a 2.68% energy consumption reduction with a .66 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 to estimate typical year energy savings.

3.8.5 Detailed Circuit Level ON/OFF Results

Table 3-160: 141st & Pine Substation Savings by Phase

Substation	Season	Circuit	Phase	Baseline OFF Voltage	ON Voltage	Daily Avg kWh Savings	Daily Average Consumption	Percent Savings	CVR Factor
141st & Pine	Cooling	ET1	A	124.85	121.02	787	37,698	2.09%	0.68
			B	124.94	121.22	310	38,417	0.81%	0.27
			C	124.97	121.76	34	38,563	0.09%	0.03
		Total / Average		**124.92**	**121.33**	**1,131**	**114,678**	**0.99%**	**0.34**
		ET3	A	124.87	120.82	1,163	21,730	5.35%	1.65
			B	124.94	121.06	979	24,722	3.96%	1.27
			C	124.93	121.57	844	21,489	3.93%	1.46
		Total / Average		**124.92**	**121.15**	**2,986**	**67,941**	**4.40%**	**1.46**
	Total / Average			**124.92**	**121.24**	**4,117**	**182,619**	**2.25%**	**0.77**
	Heating	ET1	A	124.92	119.59	1,244	34,724	3.58%	0.84
			B	124.80	119.61	1,045	35,581	2.94%	0.71
			C	124.82	119.98	753	35,606	2.11%	0.55
		Total / Average		**124.85**	**119.73**	**3,041**	**105,911**	**2.87%**	**0.70**
		ET3	A	124.80	119.61	1,045	35,581	2.94%	0.71
			B	124.82	119.98	753	35,606	2.11%	0.55
			C	124.89	119.48	734	21,419	3.42%	0.79
		Total / Average		**124.84**	**119.69**	**2,531**	**92,606**	**2.73%**	**0.66**
	Total / Average			**124.84**	**119.71**	**5,572**	**198,516**	**2.81%**	**0.68**
Total / Average				**124.87**	**120.36**	**9,655**	**342,573**	**2.82%**	**0.78**

Table 3-161: 53rd & Cache Substation Savings by Phase

Substation	Season	Circuit	Phase	Baseline OFF Voltage	ON Voltage	Daily Avg kWh Savings	Daily Average Consumption	Percent Savings	CVR Factor
53rd & Cache	Cooling	LC11	A	125.18	119.07	1,064	34,567	3.08%	0.63
			B	125.91	119.78	1,173	32,218	3.64%	0.75
			C	125.75	119.83	1,375	32,550	4.22%	0.90
		Total / Average		**125.61**	**119.56**	**3,612**	**99,335**	**3.64%**	**0.75**
		LC15	A	125.18	119.05	756	20,228	3.74%	0.76
			B	125.91	119.81	785	23,923	3.28%	0.68
			C	125.75	119.85	726	19,655	3.70%	0.79
		Total / Average		**125.61**	**119.57**	**2,268**	**63,806**	**3.55%**	**0.74**
		LC19	A	125.18	119.09	840	21,534	3.90%	0.80
			B	125.91	119.80	620	20,092	3.08%	0.64

			C	125.75	119.85	809	23,422	3.45%	0.74
		Total / Average		**125.61**	**119.58**	**2,268**	**65,048**	**3.49%**	**0.73**
	Total / Average			**125.61**	**119.57**	**8,148**	**228,188**	**3.57%**	**0.74**
	Heating	LC11	A	125.18	118.56	331	24,671	1.34%	0.25
			B	125.91	119.39	356	22,620	1.57%	0.30
			C	125.75	119.57	519	21,672	2.39%	0.49
		Total / Average		**125.61**	**119.17**	**1,206**	**68,963**	**1.75%**	**0.34**
		LC15	A	125.18	118.55	234	13,425	1.75%	0.33
			B	125.91	119.41	311	15,382	2.02%	0.39
			C	125.75	119.55	185	13,412	1.38%	0.28
		Total / Average		**125.61**	**119.17**	**730**	**42,219**	**1.73%**	**0.34**
		LC19	A	125.18	118.55	682	17,343	3.94%	0.74
			B	125.91	119.39	627	15,526	4.04%	0.78
			C	125.75	119.56	638	18,166	3.51%	0.71
		Total / Average		**125.61**	**119.17**	**1,947**	**51,035**	**3.82%**	**0.74**
	Total / Average			**125.61**	**119.17**	**3,883**	**162,217**	**2.39%**	**0.47**
Total / Average				**125.61**	**119.37**	**12,031**	**390,405**	**3.08%**	**0.62**

Table 3-162: Lawton Sheridan (Bus 1) Substation Savings by Phase

Substation	Season	Circuit	Phase	Baseline OFF Voltage	ON Voltage	Daily Avg kWh Savings	Daily Average Consumption	Percent Savings	CVR Factor
Lawton Sheridan (Bus 1)	Cooling	LS10	A	124.84	119.15	726	24,551	2.96%	0.65
			B	126.58	119.73	367	8,398	4.37%	0.81
			C	126.33	119.64	732	17,456	4.20%	0.79
		Total / Average		**125.91**	**119.51**	**1,825**	**50,404**	**3.62%**	**0.71**
		LS12	A	124.84	119.16	84	2,557	3.30%	0.73
			B	126.58	119.75	69	1,702	4.07%	0.75
			C	126.33	119.64	75	1,904	3.95%	0.75
		Total / Average		**125.91**	**119.52**	**229**	**6,163**	**3.71%**	**0.73**
		LS14	A	124.84	119.13	487	20,135	2.42%	0.53
			B	126.58	119.73	1,094	24,082	4.54%	0.84
			C	126.33	119.65	609	19,038	3.20%	0.60
		Total / Average		**125.91**	**119.50**	**2,190**	**63,254**	**3.46%**	**0.68**
		LS17	A	124.84	117.02	1,530	37,580	4.07%	0.65
			B	126.58	123.69	761	44,774	1.70%	0.74
			C	126.33	118.00	1,304	38,313	3.40%	0.52
		Total / Average		**125.91**	**119.57**	**3,596**	**120,666**	**2.98%**	**0.59**
	Total / Average			**125.91**	**119.52**	**7,840**	**240,487**	**3.26%**	**0.64**
	Heating	LS10	A	124.84	118.72	358	20,311	1.76%	0.36
			B	126.58	119.39	142	6,613	2.15%	0.38
			C	126.33	119.56	160	14,064	1.14%	0.21

Substation	Season	Circuit	Phase	Baseline OFF Voltage	ON Voltage	Daily Avg kWh Savings	Daily Average Consumption	Percent Savings	CVR Factor
		Total / Average		**125.91**	**119.23**	**661**	**40,987**	**1.61%**	**0.30**
		LS12	A	124.84	118.79	40	2,072	1.92%	0.40
			B	126.58	119.42	55	1,317	4.14%	0.73
			C	126.33	119.61	38	1,624	2.35%	0.44
		Total / Average		**125.91**	**119.27**	**133**	**5,012**	**2.65%**	**0.50**
		LS14	A	124.84	118.69	708	21,442	3.30%	0.67
			B	126.58	119.36	801	20,248	3.95%	0.69
			C	126.33	119.55	563	17,929	3.14%	0.59
		Total / Average		**125.91**	**119.20**	**2,072**	**59,619**	**3.48%**	**0.65**
		LS17	A	124.84	116.67	1,053	29,161	3.61%	0.55
			B	126.58	123.25	623	34,018	1.83%	0.70
			C	126.33	117.91	925	31,393	2.95%	0.44
		Total / Average		**125.91**	**119.28**	**2,601**	**94,572**	**2.75%**	**0.52**
	Total / Average			**125.91**	**119.24**	**5,466**	**200,191**	**2.73%**	**0.52**
Total / Average				**125.91**	**119.38**	**13,306**	**440,678**	**3.02%**	**0.58**

Table 3-163: Lawton Sheridan (Bus 2) Substation Savings by Phase

Substation	Season	Circuit	Phase	Baseline OFF Voltage	ON Voltage	Daily Avg kWh Savings	Daily Average Consumption	Percent Savings	CVR Factor
Lawton Sheridan (Bus 2)	Cooling	LS11	A	125.97	119.71	801	25,511	3.14%	0.63
			B	126.74	121.02	833	26,586	3.13%	0.69
			C	126.64	121.06	958	32,690	2.93%	0.67
		Total / Average		**126.45**	**120.60**	**2,591**	**84,786**	**3.06%**	**0.66**
		LS13	A	125.97	116.33	1,180	18,054	6.54%	0.85
			B	126.74	116.77	1,184	19,299	6.14%	0.78
			C	126.64	117.21	1,079	20,543	5.25%	0.71
		Total / Average		**126.45**	**116.77**	**3,443**	**57,896**	**5.95%**	**0.78**
		LS15	A	125.97	119.74	704	19,170	3.67%	0.74
			B	126.74	121.03	544	19,544	2.78%	0.62
			C	126.64	121.13	747	22,550	3.31%	0.76
		Total / Average		**126.45**	**120.64**	**1,994**	**61,265**	**3.26%**	**0.71**
		LS16	A	125.97	119.69	1,274	20,559	6.19%	1.24
			B	126.74	121.02	1,038	21,690	4.79%	1.06
			C	126.64	121.10	783	17,522	4.47%	1.02
		Total / Average		**126.45**	**120.60**	**3,094**	**59,771**	**5.18%**	**1.12**
	Total / Average			**126.45**	**119.65**	**11,124**	**263,718**	**4.22%**	**0.78**
	Heating	LS11	A	125.97	119.00	456	15,230	2.99%	0.54

Substation	Season	Circuit	Phase	Baseline OFF Voltage	ON Voltage	Daily Avg kWh Savings	Daily Average Consumption	Percent Savings	CVR Factor
			B	126.74	120.06	645	16,816	3.84%	0.73
			C	126.64	120.33	583	21,555	2.71%	0.54
		Total / Average		**126.45**	**119.80**	**1,684**	**53,601**	**3.14%**	**0.60**
		LS13	A	125.97	116.14	858	20,472	4.19%	0.54
			B	126.74	116.68	627	22,034	2.84%	0.36
			C	126.64	117.22	314	23,597	1.33%	0.18
		Total / Average		**126.45**	**116.68**	**1,799**	**66,103**	**2.72%**	**0.35**
		LS15	A	125.97	118.97	571	14,804	3.86%	0.69
			B	126.74	120.04	483	14,677	3.29%	0.62
			C	126.64	120.34	553	17,456	3.17%	0.64
		Total / Average		**126.45**	**119.78**	**1,608**	**46,937**	**3.43%**	**0.65**
		LS16	A	125.97	118.97	237	17,520	1.35%	0.24
			B	126.74	120.07	257	16,721	1.54%	0.29
			C	126.64	120.35	183	13,583	1.35%	0.27
		Total / Average		**126.45**	**119.80**	**677**	**47,824**	**1.42%**	**0.27**
	Total / Average			**126.45**	**119.02**	**5,769**	**214,465**	**2.69%**	**0.46**
Total / Average				**126.45**	**119.33**	**16,892**	**478,183**	**3.53%**	**0.63**

Table 3-164: 46th Street North Substation Savings by Phase

Substation	Season	Circuit	Phase	Baseline OFF Voltage	ON Voltage	Daily Avg kWh Savings	Daily Average Consumption	Percent Savings	CVR Factor
46th Street North	Cooling	ZD1	A	123.82	118.64	699	17,152	4.08%	0.97
			B	124.40	119.14	370	12,990	2.85%	0.67
			C	124.42	119.18	507	13,708	3.70%	0.88
		Total / Average		**124.21**	**118.99**	**1,576**	**43,849**	**3.59%**	**0.85**
		ZD2	A	123.70	118.49	280	27,266	1.03%	0.24
			B	124.40	119.11	243	22,792	1.06%	0.25
			C	124.36	119.11	614	28,565	2.15%	0.51
		Total / Average		**124.15**	**118.91**	**1,137**	**78,623**	**1.45%**	**0.34**
		ZD3	A	123.89	118.64	247	8,639	2.86%	0.67
			B	124.38	119.11	400	12,121	3.30%	0.78
			C	124.07	118.81	536	16,194	3.31%	0.78
		Total / Average		**124.11**	**118.85**	**1,182**	**36,954**	**3.20%**	**0.75**
		ZD4	A	123.79	118.53	736	26,446	2.78%	0.65
			B	124.37	119.08	742	27,915	2.66%	0.63
			C	124.35	119.10	731	24,621	2.97%	0.70

Substation	Season	Circuit	Phase	Baseline OFF Voltage	ON Voltage	Daily Avg kWh Savings	Daily Average Consumption	Percent Savings	CVR Factor
		Total / Average		**124.17**	**118.90**	**2,209**	**78,982**	**2.80%**	**0.66**
	Total / Average			**124.16**	**118.91**	**6,104**	**238,408**	**2.56%**	**0.61**
	Heating	ZD1	A	124.16	118.96	750	24,790	3.03%	0.72
			B	124.66	119.41	308	14,631	2.10%	0.50
			C	124.60	119.40	455	16,761	2.71%	0.65
		Total / Average		**124.47**	**119.26**	**1,513**	**56,182**	**2.69%**	**0.64**
		ZD2	A	123.91	118.79	261	34,851	0.75%	0.18
			B	124.61	119.39	248	31,835	0.78%	0.19
			C	124.53	119.39	587	37,559	1.56%	0.38
		Total / Average		**124.35**	**119.19**	**1,096**	**104,246**	**1.05%**	**0.25**
		ZD3	A	124.11	118.98	242	11,668	2.07%	0.50
			B	124.59	119.39	370	15,361	2.41%	0.58
			C	124.25	119.17	455	19,227	2.37%	0.58
		Total / Average		**124.32**	**119.18**	**1,067**	**46,256**	**2.31%**	**0.56**
		ZD4	A	124.02	118.90	506	25,237	2.00%	0.49
			B	124.57	119.39	519	26,869	1.93%	0.46
			C	124.50	119.38	496	23,108	2.15%	0.52
		Total / Average		**124.36**	**119.22**	**1,520**	**75,214**	**2.02%**	**0.49**
	Total / Average			**124.38**	**119.21**	**5,195**	**281,899**	**1.84%**	**0.44**
Total / Average				**124.27**	**119.06**	**11,299**	**520,306**	**2.17%**	**0.52**

Table 3-165: Brokwn Arrow 81st Substation Savings by Phase

Substation	Season	Circuit	Phase	Baseline OFF Voltage	ON Voltage	Daily Avg kWh Savings	Daily Average Consumption	Percent Savings	CVR Factor
Broken Arrow 81st	Cooling	ZV1	A	124.14	119.01	559	30,553	1.83%	0.44
			B	124.78	119.51	497	19,760	2.51%	0.60
			C	124.64	119.45	671	29,162	2.30%	0.55
		Total / Average		**124.52**	**119.32**	**1,727**	**79,475**	**2.17%**	**0.52**
		ZV2	A	125.23	119.09	97	2,489	3.91%	0.80
			B	125.72	119.69	69	1,664	4.16%	0.87
			C	125.79	119.57	81	1,870	4.35%	0.88
		Total / Average		**125.58**	**119.45**	**248**	**6,024**	**4.12%**	**0.84**
		ZV3	A	124.13	119.02	914	31,246	2.93%	0.71
			B	124.75	119.55	872	28,387	3.07%	0.74
			C	124.64	119.48	846	27,501	3.08%	0.74
		Total / Average		**124.51**	**119.35**	**2,633**	**87,133**	**3.02%**	**0.73**
		ZV4	A	125.23	119.07	824	23,974	3.44%	0.70

Substation	Season	Circuit	Phase	Baseline OFF Voltage	ON Voltage	Daily Avg kWh Savings	Daily Average Consumption	Percent Savings	CVR Factor
			B	125.72	119.65	366	8,265	4.43%	0.92
			C	125.79	119.55	798	16,904	4.72%	0.95
		Total / Average		**125.58**	**119.43**	**1,989**	**49,143**	**4.05%**	**0.83**
		ZV5	A	124.15	119.04	80	11,419	0.70%	0.17
			B	124.75	119.55	177	11,586	1.52%	0.37
			C	124.70	119.54	91	9,113	0.99%	0.24
		Total / Average		**124.53**	**119.38**	**347**	**32,117**	**1.08%**	**0.26**
		ZV6	A	125.23	119.67	910	25,330	3.59%	0.81
			B	125.72	120.96	925	26,277	3.52%	0.93
			C	125.79	120.96	943	32,255	2.92%	0.76
		Total / Average		**125.58**	**120.53**	**2,778**	**83,862**	**3.31%**	**0.82**
	Total / Average			**125.05**	**119.58**	**9,721**	**337,754**	**2.88%**	**0.66**
	Heating	ZV1	A	124.15	118.80	836	20,817	4.02%	0.93
			B	124.42	119.03	626	13,655	4.59%	1.06
			C	124.51	119.12	940	21,000	4.48%	1.03
		Total / Average		**124.36**	**118.98**	**2,402**	**55,473**	**4.33%**	**1.00**
		ZV2	A	125.23	118.78	39	2,071	1.89%	0.37
			B	125.72	119.42	48	1,318	3.65%	0.73
			C	125.79	119.59	32	1,620	1.98%	0.40
		Total / Average		**125.58**	**119.26**	**119**	**5,009**	**2.38%**	**0.47**
		ZV3	A	124.15	118.83	412	16,857	2.44%	0.57
			B	124.40	119.08	390	14,907	2.62%	0.61
			C	124.50	119.16	374	14,638	2.56%	0.60
		Total / Average		**124.35**	**119.02**	**1,177**	**46,401**	**2.54%**	**0.59**
		ZV4	A	125.23	118.72	383	20,300	1.89%	0.36
			B	125.72	119.40	125	6,619	1.89%	0.37
			C	125.79	119.55	142	14,062	1.01%	0.20
		Total / Average		**125.58**	**119.23**	**650**	**40,981**	**1.59%**	**0.31**
		ZV5	A	124.14	118.84	192	7,604	2.52%	0.59
			B	124.41	119.08	215	7,662	2.81%	0.66
			C	124.55	119.21	171	6,281	2.72%	0.63
		Total / Average		**124.37**	**119.04**	**578**	**21,546**	**2.68%**	**0.63**
		ZV6	A	125.23	118.99	423	15,258	2.77%	0.56
			B	125.72	120.14	550	16,836	3.27%	0.74
			C	125.79	120.40	509	21,583	2.36%	0.55
		Total / Average		**125.58**	**119.84**	**1,482**	**53,677**	**2.76%**	**0.60**
	Total / Average			**124.97**	**119.23**	**6,408**	**223,088**	**2.87%**	**0.63**
Total / Average				**125.01**	**119.40**	**16,129**	**560,842**	**2.88%**	**0.64**

3.8.6 Detailed Circuit Transition Test Results

Table 3-166: 141st & Pine 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
141st & Pine	Cooling	ET1	A	124.85	121.02	539	37,698	1.43%	0.47
			B	124.94	121.22	563	38,417	1.46%	0.49
			C	124.97	121.76	429	38,563	1.11%	0.43
		Total / Average		**124.92**	**121.33**	**1,531**	**114,678**	**1.33%**	**0.46**
		ET3	A	124.87	120.82	192	21,730	0.89%	0.27
			B	124.94	121.06	318	24,722	1.29%	0.41
			C	124.93	121.57	106	21,489	0.49%	0.18
		Total / Average		**124.92**	**121.15**	**617**	**67,941**	**0.91%**	**0.30**
	Total / Average			**124.92**	**121.24**	**2,147**	**182,619**	**1.18%**	**0.40**
	Heating	ET1	A	124.92	119.59	1,112	34,724	3.20%	0.75
			B	124.80	119.61	1,156	35,581	3.25%	0.78
			C	124.82	119.98	881	35,606	2.47%	0.64
		Total / Average		**124.85**	**119.73**	**3,149**	**105,911**	**2.97%**	**0.72**
		ET3	A	124.80	119.61	1,156	35,581	3.25%	0.78
			B	124.82	119.98	881	35,606	2.47%	0.64
			C	124.89	119.48	(328)	21,419	-1.53%	-0.35
		Total / Average		**124.84**	**119.69**	**1,709**	**92,606**	**1.85%**	**0.45**
	Total / Average			**124.84**	**119.71**	**4,858**	**198,516**	**2.45%**	**0.60**
Total / Average				**124.87**	**120.36**	**6,576**	**342,573**	**1.92%**	**0.53**

Table 3-167: 53rd & Cache 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
53rd & Cache	Cooling	LC11	A	125.18	119.07	644	34,567	1.86%	0.38
			B	125.91	119.78	929	32,218	2.88%	0.59
			C	125.75	119.83	832	32,550	2.56%	0.54
		Total / Average		**125.61**	**119.56**	**2,405**	**99,335**	**2.42%**	**0.50**
		LC15	A	125.18	119.05	699	20,228	3.45%	0.71
			B	125.91	119.81	641	23,923	2.68%	0.55
			C	125.75	119.85	372	19,655	1.89%	0.40
		Total / Average		**125.61**	**119.57**	**1,711**	**63,806**	**2.68%**	**0.56**
		LC19	A	125.18	119.09	616	21,534	2.86%	0.59
			B	125.91	119.80	495	20,092	2.46%	0.51

			C	125.75	119.85	592	23,422	2.53%	0.54
		Total / Average		**125.61**	**119.58**	**1,702**	**65,048**	**2.62%**	**0.55**
	Total / Average			**125.61**	**119.57**	**5,819**	**228,188**	**2.55%**	**0.53**
	Heating	LC11	A	125.18	118.56	590	24,671	2.39%	0.45
			B	125.91	119.39	1,944	22,620	8.60%	1.66
			C	125.75	119.57	1,484	21,672	6.85%	1.39
		Total / Average		**125.61**	**119.17**	**4,018**	**68,963**	**5.83%**	**1.14**
		LC15	A	125.18	118.55	850	13,425	6.33%	1.20
			B	125.91	119.41	1,121	15,382	7.28%	1.41
			C	125.75	119.55	418	13,412	3.12%	0.63
		Total / Average		**125.61**	**119.17**	**2,388**	**42,219**	**5.66%**	**1.10**
		LC19	A	125.18	118.55	547	17,343	3.15%	0.60
			B	125.91	119.39	(5)	15,526	-0.03%	-0.01
			C	125.75	119.56	436	18,166	2.40%	0.49
		Total / Average		**125.61**	**119.17**	**978**	**51,035**	**1.92%**	**0.37**
	Total / Average			**125.61**	**119.17**	**7,384**	**162,217**	**4.55%**	**0.89**
Total / Average				**125.61**	**119.37**	**13,203**	**390,405**	**3.38%**	**0.68**

Table 3-168: Lawton Sheridan (Bus 1) 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
Lawton Sheridan (Bus 1)	Cooling	LS10	A	124.84	119.15	705	24,551	2.87%	0.63
			B	126.58	119.73	675	8,398	8.04%	1.49
			C	126.33	119.64	894	17,456	5.12%	0.97
		Total / Average		**125.91**	**119.51**	**2,274**	**50,404**	**4.51%**	**0.89**
		LS12	A	124.84	119.16	44	2,557	1.73%	0.38
			B	126.58	119.75	70	1,702	4.10%	0.76
			C	126.33	119.64	58	1,904	3.03%	0.57
		Total / Average		**125.91**	**119.52**	**172**	**6,163**	**2.79%**	**0.55**
		LS14	A	124.84	119.13	472	20,135	2.34%	0.51
			B	126.58	119.73	677	24,082	2.81%	0.52
			C	126.33	119.65	484	19,038	2.54%	0.48
		Total / Average		**125.91**	**119.50**	**1,632**	**63,254**	**2.58%**	**0.51**
		LS17	A	124.84	117.02	1,330	37,580	3.54%	0.56
			B	126.58	123.69	707	44,774	1.58%	0.69
			C	126.33	118.00	1,515	38,313	3.95%	0.60
		Total / Average		**125.91**	**119.57**	**3,551**	**120,666**	**2.94%**	**0.58**
	Total / Average			**125.91**	**119.52**	**7,630**	**240,487**	**3.17%**	**0.63**
	Heating	LS10	A	124.84	118.72	1,330	20,311	6.55%	1.34
			B	126.58	119.39	820	6,613	12.40%	2.19

Substation	Season	Circuit	Phase	Baseline OFF Voltage	ON Voltage	Daily Avg kWh Savings	Daily Average Consumption	Percent Savings	CVR Factor
			C	126.33	119.56	944	14,064	6.71%	1.25
		Total / Average		**125.91**	**119.23**	**3,094**	**40,987**	**7.55%**	**1.42**
		LS12	A	124.84	118.79	6	2,072	0.31%	0.06
			B	126.58	119.42	45	1,317	3.40%	0.60
			C	126.33	119.61	34	1,624	2.09%	0.39
		Total / Average		**125.91**	**119.27**	**85**	**5,012**	**1.70%**	**0.32**
		LS14	A	124.84	118.69	(170)	21,442	-0.79%	-0.16
			B	126.58	119.36	1,215	20,248	6.00%	1.05
			C	126.33	119.55	20	17,929	0.11%	0.02
		Total / Average		**125.91**	**119.20**	**1,065**	**59,619**	**1.79%**	**0.33**
		LS17	A	124.84	116.67	296	29,161	1.02%	0.16
			B	126.58	123.25	64	34,018	0.19%	0.07
			C	126.33	117.91	190	31,393	0.60%	0.09
		Total / Average		**125.91**	**119.28**	**550**	**94,572**	**0.58%**	**0.11**
	Total / Average			**125.91**	**119.24**	**4,794**	**200,191**	**2.39%**	**0.45**
Total / Average				**125.91**	**119.38**	**12,424**	**440,678**	**2.82%**	**0.54**

Table 3-169: Lawton Sheridan (Bus 2) 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
Lawton Sheridan (Bus 2)	Cooling	LS11	A	125.97	119.71	194	25,511	0.76%	0.15
			B	126.74	121.02	602	26,586	2.27%	0.50
			C	126.64	121.06	562	32,690	1.72%	0.39
		Total / Average		**126.45**	**120.60**	**1,359**	**84,786**	**1.60%**	**0.35**
		LS13	A	125.97	116.33	564	18,054	3.13%	0.41
			B	126.74	116.77	279	19,299	1.45%	0.18
			C	126.64	117.21	498	20,543	2.42%	0.33
		Total / Average		**126.45**	**116.77**	**1,341**	**57,896**	**2.32%**	**0.30**
		LS15	A	125.97	119.74	603	19,170	3.15%	0.64
			B	126.74	121.03	123	19,544	0.63%	0.14
			C	126.64	121.13	482	22,550	2.14%	0.49
		Total / Average		**126.45**	**120.64**	**1,208**	**61,265**	**1.97%**	**0.43**
		LS16	A	125.97	119.69	542	20,559	2.64%	0.53
			B	126.74	121.02	843	21,690	3.89%	0.86

Substation	Season	Circuit	Phase	Baseline OFF Voltage	ON Voltage	Daily Avg kWh Savings	Daily Average Consumption	Percent Savings	CVR Factor
			C	126.64	121.10	(112)	17,522	-0.64%	-0.15
		Total / Average		**126.45**	**120.60**	**1,274**	**59,771**	**2.13%**	**0.46**
	Total / Average			**126.45**	**119.65**	**5,182**	**263,718**	**1.97%**	**0.37**
	Heating	LS11	A	125.97	119.00	472	15,230	3.10%	0.56
			B	126.74	120.06	726	16,816	4.32%	0.82
			C	126.64	120.33	633	21,555	2.94%	0.59
		Total / Average		**126.45**	**119.80**	**1,832**	**53,601**	**3.42%**	**0.65**
		LS13	A	125.97	116.14	437	20,472	2.13%	0.27
			B	126.74	116.68	949	22,034	4.31%	0.54
			C	126.64	117.22	2,960	23,597	12.54%	1.69
		Total / Average		**126.45**	**116.68**	**4,346**	**66,103**	**6.57%**	**0.85**
		LS15	A	125.97	118.97	49	14,804	0.33%	0.06
			B	126.74	120.04	281	14,677	1.91%	0.36
			C	126.64	120.34	470	17,456	2.69%	0.54
		Total / Average		**126.45**	**119.78**	**799**	**46,937**	**1.70%**	**0.32**
		LS16	A	125.97	118.97	907	17,520	5.18%	0.93
			B	126.74	120.07	1,212	16,721	7.25%	1.38
			C	126.64	120.35	1,228	13,583	9.04%	1.82
		Total / Average		**126.45**	**119.80**	**3,348**	**47,824**	**7.00%**	**1.33**
	Total / Average			**126.45**	**119.02**	**10,324**	**214,465**	**4.81%**	**0.82**
Total / Average				**126.45**	**119.33**	**15,507**	**478,183**	**3.24%**	**0.58**

Table 3-170: 46th Street North 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
46th Street North	Cooling	ZD1	A	123.82	118.64	219	17,152	1.28%	0.31
			B	124.40	119.14	466	12,990	3.59%	0.85
			C	124.42	119.18	397	13,708	2.90%	0.69
		Total / Average		**124.21**	**118.99**	**1,082**	**43,849**	**2.47%**	**0.59**
		ZD2	A	123.70	118.49	903	27,266	3.31%	0.79
			B	124.40	119.11	638	22,792	2.80%	0.66
			C	124.36	119.11	601	28,565	2.10%	0.50
		Total / Average		**124.15**	**118.91**	**2,142**	**78,623**	**2.72%**	**0.64**

Substation	Season	Circuit	Phase	Baseline OFF Voltage	ON Voltage	Daily Avg kWh Savings	Daily Average Consumption	Percent Savings	CVR Factor
		ZD3	A	123.89	118.64	208	8,639	2.40%	0.57
			B	124.38	119.11	37	12,121	0.30%	0.07
			C	124.07	118.81	354	16,194	2.19%	0.52
		Total / Average		**124.11**	**118.85**	**598**	**36,954**	**1.62%**	**0.38**
		ZD4	A	123.79	118.53	(4)	26,446	-0.01%	0.00
			B	124.37	119.08	78	27,915	0.28%	0.07
			C	124.35	119.10	91	24,621	0.37%	0.09
		Total / Average		**124.17**	**118.90**	**165**	**78,982**	**0.21%**	**0.05**
	Total / Average			**124.16**	**118.91**	**3,987**	**238,408**	**1.67%**	**0.40**
	Heating	ZD1	A	124.16	118.96	1,021	24,790	4.12%	0.98
			B	124.66	119.41	700	14,631	4.79%	1.14
			C	124.60	119.40	661	16,761	3.94%	0.95
		Total / Average		**124.47**	**119.26**	**2,382**	**56,182**	**4.24%**	**1.01**
		ZD2	A	123.91	118.79	1,072	34,851	3.08%	0.74
			B	124.61	119.39	1,174	31,835	3.69%	0.88
			C	124.53	119.39	1,261	37,559	3.36%	0.81
		Total / Average		**124.35**	**119.19**	**3,508**	**104,246**	**3.36%**	**0.81**
		ZD3	A	124.11	118.98	472	11,668	4.04%	0.98
			B	124.59	119.39	603	15,361	3.92%	0.94
			C	124.25	119.17	614	19,227	3.19%	0.78
		Total / Average		**124.32**	**119.18**	**1,688**	**46,256**	**3.65%**	**0.88**
		ZD4	A	124.02	118.90	504	25,237	2.00%	0.48
			B	124.57	119.39	462	26,869	1.72%	0.41
			C	124.50	119.38	448	23,108	1.94%	0.47
		Total / Average		**124.36**	**119.22**	**1,414**	**75,214**	**1.88%**	**0.45**
	Total / Average			**124.38**	**119.21**	**8,993**	**281,899**	**3.19%**	**0.77**
Total / Average				**124.27**	**119.06**	**12,980**	**520,306**	**2.49%**	**0.60**

Table 3-171: Broken Arrow 81st 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
Broken Arrow 81st	Cooling	ZV1	A	124.14	119.01	667	30,553	2.18%	0.53
			B	124.78	119.51	484	19,760	2.45%	0.58
			C	124.64	119.45	757	29,162	2.59%	0.62

Substation	Season	Circuit	Phase	Baseline OFF Voltage	ON Voltage	Daily Avg kWh Savings	Daily Average Consumption	Percent Savings	CVR Factor
		Total / Average		**124.52**	**119.32**	**1,908**	**79,475**	**2.40%**	**0.58**
		ZV2	A	125.23	119.09	51	2,489	2.04%	0.41
			B	125.72	119.69	22	1,664	1.35%	0.28
			C	125.79	119.57	50	1,870	2.68%	0.54
		Total / Average		**125.58**	**119.45**	**123**	**6,024**	**2.04%**	**0.42**
		ZV3	A	124.13	119.02	732	31,246	2.34%	0.57
			B	124.75	119.55	708	28,387	2.50%	0.60
			C	124.64	119.48	814	27,501	2.96%	0.71
		Total / Average		**124.51**	**119.35**	**2,254**	**87,133**	**2.59%**	**0.62**
		ZV4	A	125.23	119.07	608	23,974	2.54%	0.52
			B	125.72	119.65	272	8,265	3.29%	0.68
			C	125.79	119.55	614	16,904	3.63%	0.73
		Total / Average		**125.58**	**119.43**	**1,494**	**49,143**	**3.04%**	**0.62**
		ZV5	A	124.15	119.04	282	11,419	2.47%	0.60
			B	124.75	119.55	241	11,586	2.08%	0.50
			C	124.70	119.54	303	9,113	3.32%	0.80
		Total / Average		**124.53**	**119.38**	**827**	**32,117**	**2.57%**	**0.62**
		ZV6	A	125.23	119.67	608	25,330	2.40%	0.54
			B	125.72	120.96	417	26,277	1.59%	0.42
			C	125.79	120.96	756	32,255	2.34%	0.61
		Total / Average		**125.58**	**120.53**	**1,780**	**83,862**	**2.12%**	**0.53**
	Total / Average			**125.05**	**119.58**	**8,385**	**337,754**	**2.48%**	**0.57**
	Heating	ZV1	A	124.15	118.80	724	20,817	3.48%	0.81
			B	124.42	119.03	546	13,655	4.00%	0.92
			C	124.51	119.12	674	21,000	3.21%	0.74
		Total / Average		**124.36**	**118.98**	**1,943**	**55,473**	**3.50%**	**0.81**
		ZV2	A	125.23	118.78	97	2,071	4.67%	0.91
			B	125.72	119.42	58	1,318	4.44%	0.89
			C	125.79	119.59	68	1,620	4.18%	0.85
		Total / Average		**125.58**	**119.26**	**223**	**5,009**	**4.45%**	**0.89**
		ZV3	A	124.15	118.83	587	16,857	3.48%	0.81
			B	124.40	119.08	630	14,907	4.22%	0.99
			C	124.50	119.16	612	14,638	4.18%	0.97
		Total / Average		**124.35**	**119.02**	**1,829**	**46,401**	**3.94%**	**0.92**
		ZV4	A	125.23	118.72	705	20,300	3.47%	0.67
			B	125.72	119.40	254	6,619	3.84%	0.76
			C	125.79	119.55	558	14,062	3.97%	0.80
		Total / Average		**125.58**	**119.23**	**1,517**	**40,981**	**3.70%**	**0.73**
		ZV5	A	124.14	118.84	340	7,604	4.47%	1.05

Substation	Season	Circuit	Phase	Baseline OFF Voltage	ON Voltage	Daily Avg kWh Savings	Daily Average Consumption	Percent Savings	CVR Factor
			B	124.41	119.08	398	7,662	5.20%	1.22
			C	124.55	119.21	301	6,281	4.80%	1.12
		Total / Average		**124.37**	**119.04**	**1,040**	**21,546**	**4.83%**	**1.13**
		ZV6	A	125.23	118.99	477	15,258	3.12%	0.63
			B	125.72	120.14	341	16,836	2.02%	0.46
			C	125.79	120.40	518	21,583	2.40%	0.56
		Total / Average		**125.58**	**119.84**	**1,335**	**53,677**	**2.49%**	**0.54**
	Total / Average			**124.97**	**119.23**	**7,887**	**223,088**	**3.54%**	**0.77**
Total / Average				**125.01**	**119.40**	**16,272**	**560,842**	**2.90%**	**0.65**

4 Demand Response Programs

PSO's demand response (DR) portfolio in the program year 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 demand response 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	Verified Lifetime Savings	Gross Realization Rate	NTG Ratio	Net Annual Energy Savings (MWh)
Power Hours	2,047	2,134	2,773	30,262	130%	88%	2,438
Business Demand Response	131	0	37	37	NA	100%	37
Demand Response Totals	**2,178**	**2,134**	**2,810**	**30,300**	**132%**	**88%**	**2,475**

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	17.98	16.40	6.24	0.38	0.99	6.19
Business Demand Response	52.28	68.04	47.41	0.70	1.00	47.41
Demand Response Totals	**70.25**	**84.45**	**53.65**	**0.64**	**1.00**	**53.60**

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 providing full rebates for the purchase of a new smart thermostat. DLC events reduce energy usage when demand is highest by communicating with registered Wi-Fi enabled thermostats installed in the homes of participants. Smart thermostats help lower electricity usage by providing customers with improved real-time information about HVAC usage and cost, improved user interfaces, and algorithm optimization (such as occupancy detection and prediction).

Table 4-3 shows the performance metrics achieved by the program. Over two gigawatt-hours (GWh) of energy was saved annually by this program because of the smart thermostats and DLC events. From the DLC events, a peak demand reduction of over six megawatts (MW) was realized. On average, a customer in the Power Hours Program saved 102.94 kWh during program year 2020 (PY2020).

Table 4-3: Performance Metrics – Power Hours Program

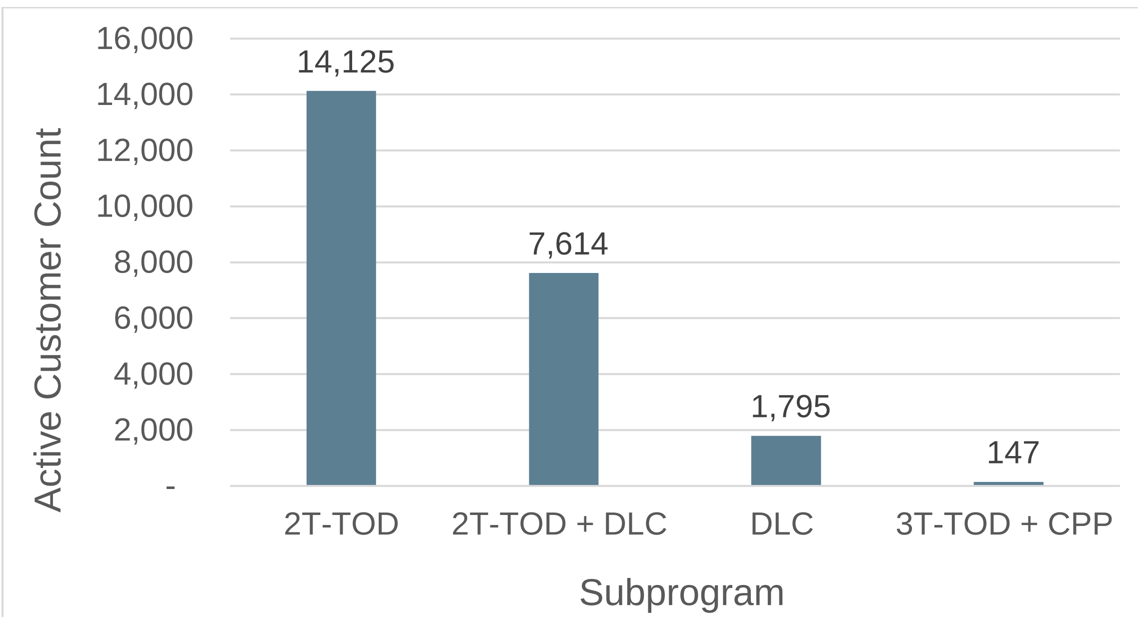
Metric	PY2020
Number of Customers	23,681
Budgeted Expenditures	$2,330,169
Actual Expenditures	$1,910,328
Energy Impacts (kWh)	
Projected Energy Savings	2,046,870
Reported Energy Savings	2,134,314
Gross Verified Energy Savings	2,772,995
Net Verified Energy Savings	2,437,623
Peak Demand Impacts (kW)	
Projected Peak Demand Savings	18,923.60
Reported Peak Demand Savings	16,401.46
Gross Verified Peak Demand Savings	6,235.74
Net Verified Peak Demand Savings	6,186.76
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	1.58
Utility Cost Test Ratio	1.35

Annual energy efficiency savings (kWh) were calculated for all new customers that joined the program in PY2020 and used program rebates to purchase a smart thermostat. Peak demand reduction (kW) and annual energy savings (kWh) for each DLC event were calculated for customers in the DLC and DLC + 2T-TOD subprograms. Details on subprogram paths are described later in this chapter.

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, active 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.

PY2020 was the fifth year PSO administered the program. At the end of PY2020 there were 23,681 active participants, with 3,369 new customers joining the program in 2020. 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 Honeywell, allowing them to receive a load curtailment signal. There are two load curtailment strategies used for DLC events; temperature offset, and duty-cycling described as:

- 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 is on or off during the event period. All duty-cycling events this year used a 50% cycling ratio with a 60-minute cycling period; meaning the A/C compressor is shut off for 30 minutes, then turned back on for the next 30 minutes. This pattern repeats until the event is over.

Only one DLC event occurred in PY2020, on July 14, 2020. That event used a temperature offset curtailment strategy, with an offset of three degrees.

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" mobile application or by manually changing the setpoint on the thermostat. During 2020, all customers in the subprogram received a bill 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 program. The rate was broken into two tiers, with each tier having 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. This rate tariff charges different rates for electricity during the billing months of June through October. The rates were as follows:

- A rate of 2.334₵/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 14.100₵/kWh was applied to hours from 2 p.m. to 7 p.m. on non-holiday weekdays.
- A rate of 0.750₵/kWh is typically applied during hours when PSO called a critical peak event. This had no effect in PY 2020, however, as no critical peak events were called.

4.1.2 EM&V Methodologies

The impact of the Power Hours Program is measured in two parts. The first is measuring the peak reduction (kW) and annual energy savings (kWh) during DLC events. The second is measuring the annual energy savings from the smart thermostat incentives. The following section defines how these savings are calculated.

4.1.2.1 Direct Load Control Events

The impact of DLC events is analyzed using 15-minute interval AMI billing consumption data provided by PSO. Software written in the statistical programming language R is used to process and analyze the data. Various data processing steps are applied to the data before analyzed. These steps include:

- Validating that the files are 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 are validated, the data is cleaned and prepared for analysis. This includes:

- Performing data completeness checks on all data.
- Aggregating 15-minute consumption data to 30-minute consumption data. This is done for a better match with weather data and to improve statistical model effectiveness.

Local temperature data was 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

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 are converted to CDD using the hypothetical CDD base.
- A linear regression model is 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 is the value chosen. In PY2020, the optimal CDD base temperature for the participant population was determined to be 67°. All weather data is retrieved from airports in the following Oklahoma cities: Tulsa, Lawton, Bartlesville, Chickasha, Elk City, and Okmulgee. Each household is matched with weather data from the location it was nearest to geographically.

Once the necessary data is processed, the devices that participate in the DLC events are identified. Two Power Hours subprograms include a direct load control component: DLC and DLC + 2T-TOD. Tracking data for these subprograms, provided by PSO, is used to identify which devices are available to participate in each event. An available device is defined as a device registered with Honeywell 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 participates in the events. Thus, devices that are non-responsive to the called events need to be identified so that the calculation of energy savings included only devices that actually participate 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 are 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

$$x = (i_1, i_2, i_3, \ldots, i_{48})$$

$$CSUM(x) = (i_1, i_1 + i_2,\ i_1 + i_2, + i_3, \ldots, i_1 + \ldots + i_{48})$$

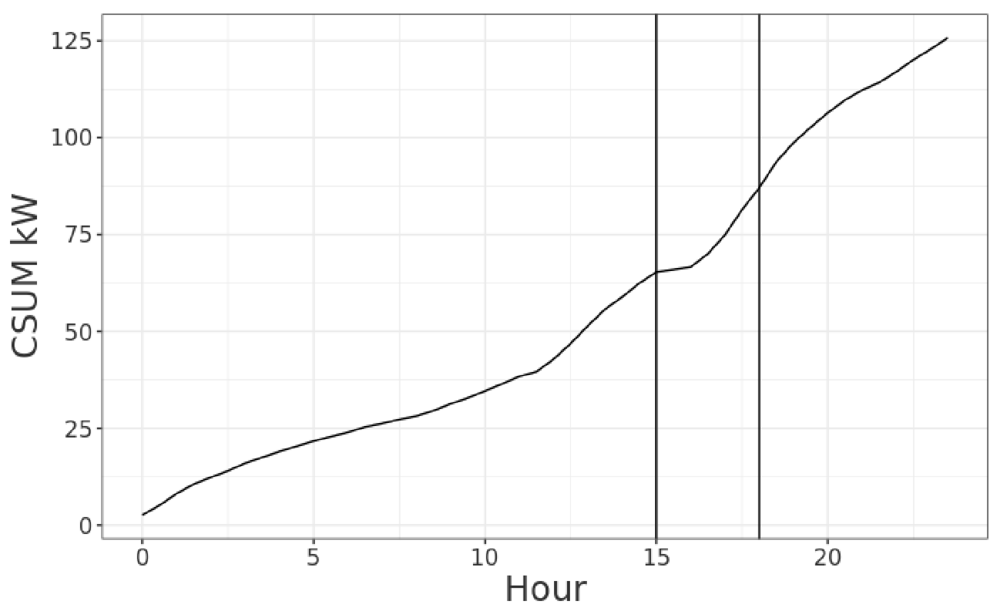
Where:

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 providing 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 a DLC event. 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 changes once the event started, a slope ratio is 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 is created for each site using the average hourly consumption of the previous seven non-event weekdays. Next, the slope ratio is calculated for the actual CSUM curve and the site normal CSUM curve. If the slope ratio for the actual curve is greater than or equal to the slope ratio for the site-normal curve, the device is 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 tests for a 10% reduction in hourly consumption. For each device, the consumption one hour before the event started and the consumption one hour after the event started are tested for a drop greater than 10% (Equation 4-6Equation 4-6). The value of 10% 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 are developed. These are used to estimate what energy usage would have been during an event day had the event not occurred. For each event, this counterfactual baseline is 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 k-means clustering algorithm is used to identify similar weather days to each event day. Average daily temperature and humidity is calculated for every non-holiday weekday from June to August. Then the k-means clustering algorithm is applied to the daily weather data. This method splits 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 is used to calculate that event's baseline.

When determined what data is used to calculate each event's baseline curve, a linear regression model is calculated using that data (Equation 4-7).

Equation 4-7: Baseline Energy Usage Curve Regression Model

$$kW_t = CDD_t + CDD_{t-2} + t$$

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 one hour before t

To ensure the baseline curves are as accurate as possible, a normalizing factor is 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

With the baseline curve determined, demand reduction can be calculated. Demand reduction represents the average decrease in energy usage that occurs for the average event participant during a given time interval. Demand reduction is 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 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 is then used to calculate average annual energy savings for each event. The equation is shown in Equation 4-10.

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 is calculated for each event, representing the maximum drop in energy usage that occurred for the average event participant. The equation is shown in Equation 4-11.

Equation 4-11: 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 Thermostats

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 are calculated for customers that joined the program in PY2020 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)[95] or if the thermostat model was listed as an EnergyStar® certified smart thermostat at any point in PY2020.[96] Table 4-4 lists every thermostat model incentivized by the program, as well as which of those models qualify as a smart thermostat.

Table 4-4: Thermostat Models Incentivized by the Program

Thermostat Model	Qualifies as Smart
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

Savings are calculated as deemed value for each new participant, based on the methodology offered for smart thermostats in the AR TRM.

4.1.2.3 Net-to-Gross Estimation

A net-to-gross ratio is 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 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.

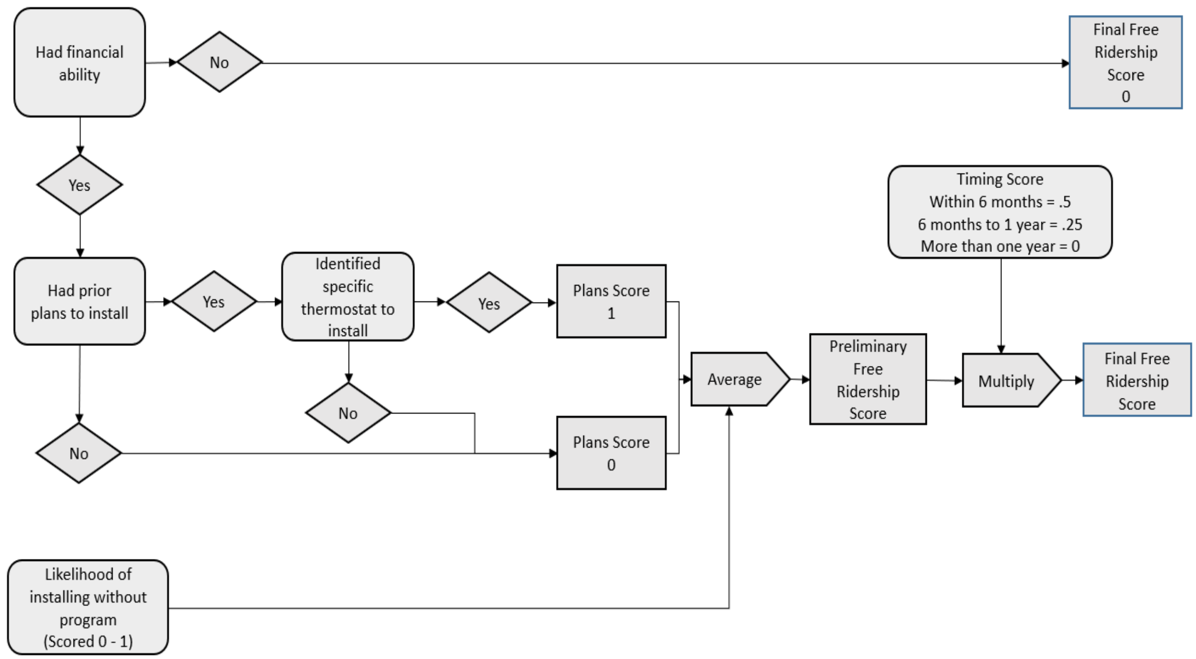
Information collected from a sample of participant decision makers is used to estimate the net savings resulting from the rebated smart thermostats. Information is collected through online survey efforts with the number of respondents representing a statistically

[95] Arkansas Technical Reference Manual, version 7.0 volume 1: See Section 2.1.12
[96] Accessible via: https://www.energystar.gov/products/certified-products/detail/set

representative sample of the population. 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 is 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. 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



4.1.2.4 Process Evaluation

ADM's process evaluation activities include a review of program materials, participant surveys and interviews with program staff (at PSO and implementation firms). The participant surveys will be implemented as online surveys with telephone follow-up as needed.

Table 4-5 below summarizes the data collection activities and corresponding process evaluation research objectives.

Table 4-5: Process Evaluation Data Collection Activities Summary

Data Collection Activity	Process Evaluation Research Objectives
Program Materials Review	Review reports and support materials for clarity and consistency with program objectives.
Program Staff Interviews	Assess program staff perspectives regarding program operations, strengths, weaknesses, barriers to success, and opportunities for improvement.
Participant Survey	Assess participant's reasons for participating and experience with the program, including satisfaction.

4.1.3 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.

4.1.3.1 Direct Load Control Event Impact

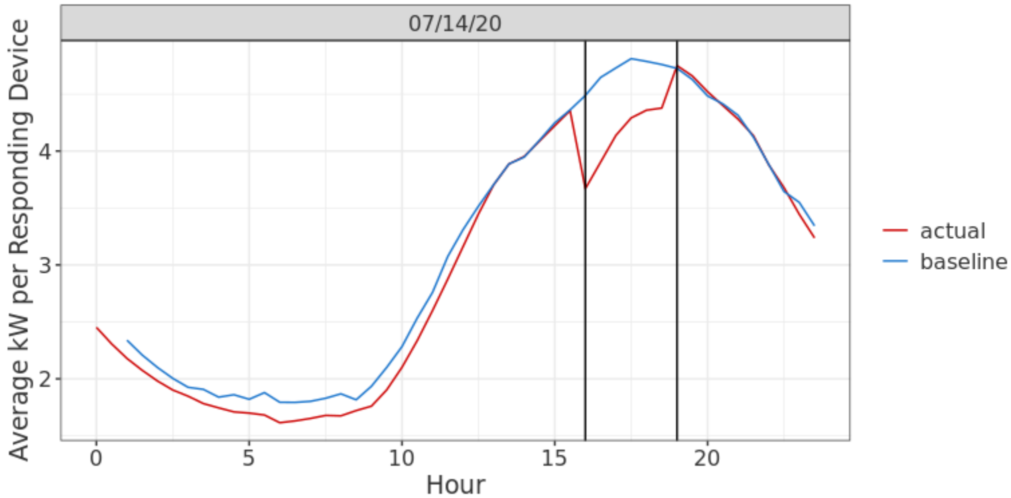
In 2020, one Direct Load Control (DLC) event was called on July 14. This event is summarized in Table 4-6.

Table 4-6: Summary of Events

Date	Event Start Hour	Event End Hour	Duration (Hours)	Curtailment Strategy
07/14/2020	16	19	3	Temperature Offset

A baseline curve was developed for the event day. These were used to estimate what energy usage would have been during the event day had the event not occurred. The baseline curve used for the demand reduction calculations are shown in Figure 4-4. Vertical lines represent the start and end time of the 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 for the event was removed from the analysis. The response rate is defined as the percentage of available devices that were not identified as an NRD. Table 4-7 shows the response rates for each event.

Table 4-7: Active and responsive Device Counts per Event

Date	Available Devices	Responsive Devices	Response Rate
07/14/2020	9,104	7,115	78.15%

Demand reduction was calculated by comparing the hourly consumption predicted by the baseline curve to the actual hourly consumption during the event. Results include 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 4-8. Each column represents the average kW reduction per responding device during the specified time interval. Time intervals during the snapback period are identified with grey cells.

Table 4-8: Demand Reduction (kW) per 30-Minute Interval

Date	16	16.5	17	17.5	18	18.5	19	19.5	20	20.5
07/14/2020	0.82	0.74	0.59	0.52	0.43	0.38	-0.02	-0.03	-0.04	-0.01

Note that, compared to previous years, the performance during the single 2020 event was impacted by several variables. The average demand reduction per device for the single 2020 event was 0.82. In 2019 there were 10 events and on average, the average demand reduction per device was 1.70 on average. The worst performing event, occurring on July 10 2019, achieved an average demand reduction per device of 1.06.

The event in 2020 was rather unique. DLC events in 2019 used a temperature offset of four degrees, whereas the 2020 event used a temperature offset of three degrees. Additionally, COVID-19 likely led more people to be home during the DLC event when they previously would not have. It is possible this led to more people adjusting their thermostat's setpoint after the event began, resulting in less of a demand reduction than if they had not been home and thus unlikely to make that adjustment. These reasons, combined with the fact that there was only one event's worth of data in 2020, make it difficult to compare performance between this year and previous years.

Average annual energy savings per responding device was calculated for each event, using the demand reduction results above. Total energy savings for each event was calculated by multiplying the average energy savings per responding device by the number of responding devices for that event. Table 4-9 shows average annual energy savings per device and total savings for each event.

Table 4-9: 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)
07/14/2020	7,115	3.48	-0.10	3.38	24,048

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 4-10.

Table 4-10: Program-Level Peak Reduction (kW) per Event

Date	Responsive Devices	Peak Reduction per Device (kW)	Peak Reduction per Event (kW)
07/14/2020	7,115	0.82	5,834.30

Peak reduction was calculated by taking the average peak reduction per event. Typically, max peak reduction is calculated by finding the maximum peak reduction per event, and potential max peak reduction represents the max peak reduction possible if each event had reached the max response rate from the year, max number of available devices, and maximum peak reduction per device. With there being only one event during PY2020, the max peak reduction and potential max peak reduction were identical to the verified peak reduction.

4.1.3.2 Smart Thermostat Rebates Impact

The annual energy savings for the Power Hours Program was calculated based on the savings associated with the smart thermostat program incentive. Savings from smart thermostats are derived 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 PY2020 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 PY2020, 3,357 new smart thermostats were purchased by new program participants using rebates from the program.

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 87.8%. This is slightly higher than the net-to-gross ratio in 2019, which was 84.0%. Net savings are shown in Table 4-11.

Table 4-11: Thermostat Incentive Energy Savings

Rebated Smart Thermostats	Gross Energy Savings (kWh)	Net-to-Gross Ratio	Net Energy Savings (kWh)
3,357	2,748,947	87.8%	2,413,575

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 4.1.3.1). 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. Peak demand reduction is shown in Table 4-12.

Table 4-12: Smart Thermostat Incentive Peak Reduction

Rebated Smart Thermostats Purchased by New 2T-TOD Customers	Verified Peak Reduction per Device (kW)	Gross Verified Peak Reduction (kW)	Net-to-Gross Ratio	Net Verified Peak Reduction (kW)
1,544	0.26	401.44	87.8%	352.46

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	5,834.30
Thermostat Incentives	352.46
Total	**6,186.76**

4.1.3.3 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	24,048
Thermostat Incentives	2,413,575
Total	**2,437,623**

4.1.3.4 Total Lifetime Savings (kWh)

According to the AR TRM, the effective useful life (EUL) of a new smart thermostat is 11 years[97]. Lifetime savings were calculated by multiplying the net annual energy savings from smart thermostats with the EUL. The total lifetime savings for all smart thermostats installed in PY2020 is shown in Table 4-15.

Table 4-15: Total Lifetime Savings

Source	Expected Useful Life (Years)	Total Lifetime Savings (kWh)
Smart Thermostats	11	26,549,325

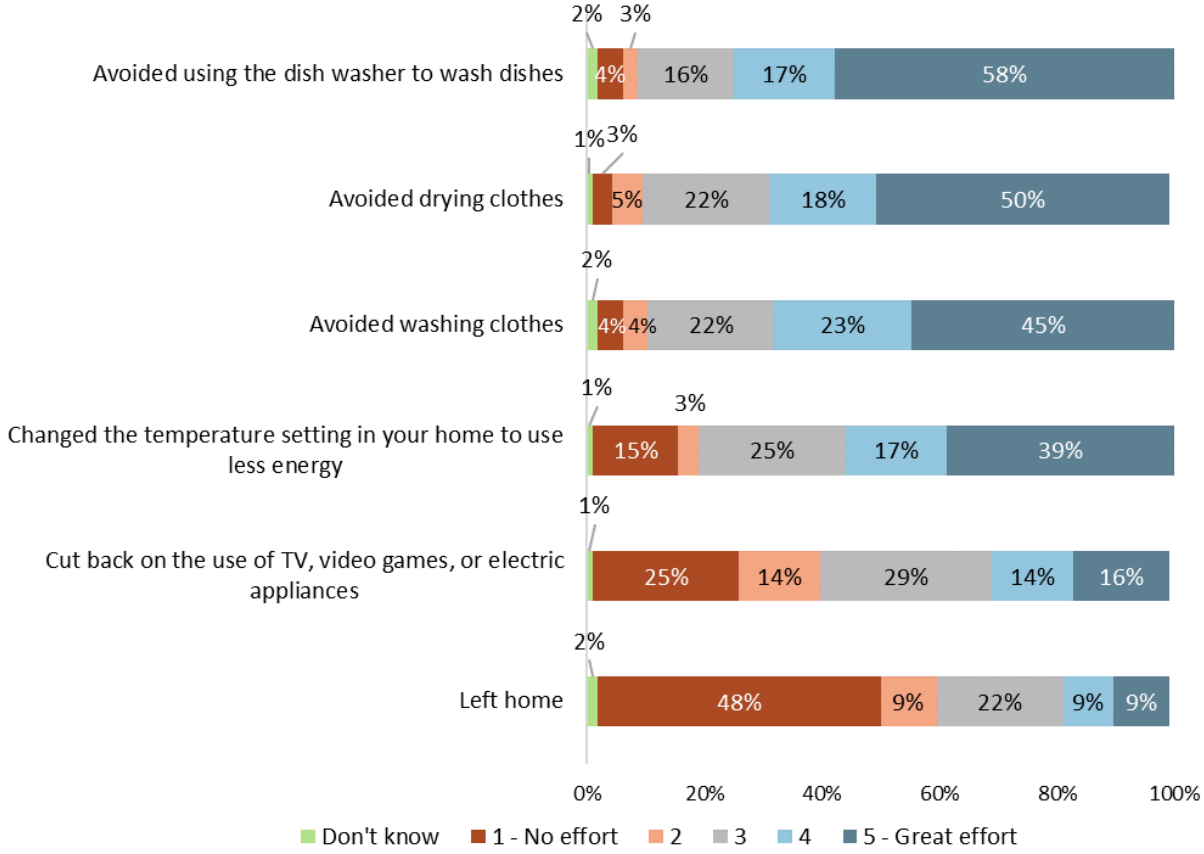
4.1.4 Process Evaluation Findings

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 2020 program year.

[97] Arkansas Technical Reference Manual, version 7.0 volume 1: See Section 2.1.12

Participants made the greatest efforts to reduce energy during peak periods by avoiding drying clothes (68% made a great or moderate effort), avoiding washing clothes (68% made a great or moderate effort), and avoiding washing dishes (75% made a great or moderate effort). The strategies with the least effort included leaving home or reducing TVs and video games during peak periods. Figure 4-5 summarizes the effort participants made for all rated strategies.

Figure 4-5: Strategies to Avoid Using Electricity During Peak Periods



The following summarizes the key finding from the process evaluation of the Power Hours Program.

- The program has exceeded the enrollment goal for PY2020. Program staff indicated the program exceeded the enrollment goal of 3,000 participants for this year. According to staff, most PSO customers have become very familiar with Power Hours.
- The program underwent significant updates to program website and educational videos. Program staff indicated they revamped their website and added a new feature to the online enrollment process. They posted more how-to videos on the program's website, changed some of the wording used in their messages,

improved the impact of network traffic on the Power Hours website, and included more tips for customers about saving energy. To improve enrollment completion rates, staff indicated the online application now has a new feature where the customer can see the completion percentage during their application process.

- COVID-19 did not affect program operations or delivery overall. Program staff indicated the program operates mainly online, so COVID-19-related restrictions did not affect the program in general.
- The program stopped hosting community events during the pandemic. Program staff indicated they usually host community events to promote the Power Hours Program as part of their marketing and education strategies. For PY2020, the staff was able to participate in several pre-COVID-19 community events.
- Marketing strategies implemented for 2020 improved participant engagement overall. Program staff and Honeywell sent a variety of email campaigns that varied in objective and target audience. Program staff indicated they received positive feedback from all their campaigns.
- The program did not call many events in 2020. Staff indicated they had one event the entire summer because of mild weather patterns.
- QA/QC processes have been streamlined for PY2020. Because Honeywell tracks program data, program staff can quickly identify people who have not registered their thermostats online. If a participant requests credit claims, the program staff investigates and grants the credits when applicable. Program staff also indicated they fixed some quality control issues in the system for 2020.
- The program staff anticipates some changes for PY2021. Staff indicated that Honeywell would be using a new DR platform. At the time of the interview, Honeywell was still negotiating with the platform vendor and assured PSO the change would not affect the utility company’s IT infrastructure.
- Program staff continues to improve the program for current and future participants. One interviewee stated that the program could have up to 12,000 registered smart thermostats online on any given event. PSO staff hopes to expand their event time range and create a centralized platform to manage all the different thermostat brands during an event.

4.1.5 Conclusions and Recommendations

The following summarizes the key findings from the evaluation of the Power Hours Program:

- The verified net annual energy savings for PY2020 was 2,437,623 kWh, and the verified peak demand reduction was 6,186.76 kW.

- The program has exceeded the enrollment goal for PY2020. Program staff indicated the program exceeded the enrollment goal of 3,000 participants for this year.
- The program did not call many events in 2020. Staff indicated they had one event the entire summer because of mild weather patterns.
- COVID-19 did not affect program operations or delivery overall. Program staff indicated the program operates mainly online, so COVID-19-related restrictions did not affect the program in general.

The following recommendations are offered for continued improvement of the Power Hours Program:

- Increase collaboration among evaluation and implementation to ensure program data is consistent across all data sources.
- Continue to invest time in maintaining the program website and portal for customer use. Program staff indicated they experienced a high traffic volume according to their analytics, and customers reported they frequently engaged with the website. Most customers enrolled online during this 2020 program year and utilized many of the how-to videos for installation and other educational purposes.
- Explore other features that program staff and customers can engage with online. As new technology continues to influence customer behavior and energy use, program staff could explore new software or platforms supporting streamlining processes and quality control.

4.2 Peak Performers Program

4.2.1 Program 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. 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 event season in 2020 test events were used for incentive payments and reported impacts. A total of 1,858 premise account numbers representing 245 customers, participated in a DR test event. Each participant participated in one of four test event days. The test event lasted from 4 PM - 5 PM on 6/9/2020 and from 2 PM - 3 PM on 6/11/2020, 6/16/2020, and 9/24/2020.

ADM’s evaluation developed verified demand reduction estimates that were lower than reported values. The kW realization rate was 70%. Both reported and verified peak demand reduction represent the average kW reduction for each customer over the test event hour, summed across participants.

Table 4-16 Performance Metrics – Peak Performers

Metric	PY2020
Number of Customers	245
Premise Account Numbers	1,858
Budgeted Expenditures	$3,318,516
Actual Expenditures	$2,525,586
Energy Impacts (kWh)	
Projected Energy Savings	138,346
Reported Energy Savings	0
Gross Verified Energy Savings	37,127
Net Verified Energy Savings	37,127
Peak Demand Impacts (kW)	
Projected Peak Demand Savings	56,358
Reported Peak Demand Savings	68,045
Gross Verified Peak Demand Savings	47,413
Net Verified Peak Demand Savings	47,413
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	8.02
Utility Cost Test Ratio	2.87

4.2.2 Impact Evaluation

The section below covers ADM's impact evaluation methodology and results for the 2020 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 represent what participants' usage would have been if the event had not occurred. In 2020, 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 4-17: Peak Performers Baseline Models

Model Name	Description
3 of 10 Unadjusted	Model described in Section G.2.2.1 without the adjustment described in step 5.
3 of 10 Scalar Adjusted	Model described in Section G.2.2.1 but allows for a ±30% day of adjustment.
3 of 10 Additive Adjusted	Model described in Section G.2.2.1 but allows an adjustment of the actual demand difference in kW between *B(h)* and *D(h)* described in Section G.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 G.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 G.2.2.1, but with 5 baseline days selected and allows for a ±30% adjustment.
5 of 10 Additive Adjusted	Model described in Section G.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 G.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 G.2.2.1, but with 7 baseline days selected and allows for a ±30% adjustment.
7 of 10 Additive Adjusted	Model described in Section G.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 G.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 G.2.2.1, but with 9 baseline days selected and allows for a ±30% adjustment.
9 of 10 Additive Adjusted	Model described in Section G.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 matched test event day usage to the five most similar event eligible non-event days. The days selected serve as a good proxy for the test event days and will be referred to as proxy event days. The proxy event days were then used to identify baseline “best fits” for each premise ID using residual root mean squared error (RRMSE) scores.

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.

Baseline Methodology for Small Sites

All models with less than or equal to 550 kW reported reduction were compared to the proxy test event days using RRMSE with the three best fitting models being selected and weighted in the way described in the previous section.

Baseline Methodology for Large Sites

For the twenty sites with the largest kW reductions in the program (greater than 550 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 test 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 4-18: Large Site Model Selection

Premise Name	Reported kW	Weather Dependent Energy Usage?	Abnormal Pre-Event Usage?	What Models were Added/Removed
P	7,988	No	No	Drop weather models
Q	3,805	No	No	Drop weather models
AF	3,661	Yes	No	No change
R	2,265	No	Yes	Drop weather models and drop adjusted models
I	2,111	No	Yes	Drop weather models and drop adjusted models
X	1,932	No	No	Drop weather models
K	1,768	No	Yes	Drop weather models and drop adjusted models
H	1,537	No	No	Drop weather models
E	1,470	No	No	Drop weather models
AG	1,395	No	Yes	Drop weather models and drop adjusted models
J	1,178	No	Yes	Drop weather models and drop adjusted models
B	1,160	No	No	Drop weather models
F	1,136	No	Yes	Drop weather models and drop adjusted models
N	1,018	No	Yes	Drop weather models and drop adjusted models
AD	939	No	Yes	Drop weather models and drop adjusted models
Z	935	No	Yes	Drop weather models and drop adjusted models
S	860	No	No	Drop weather models
AH	588	No	No	Drop weather models
AI	581	No	No	Drop weather models
AJ	551	No	Yes	Drop weather models and drop adjusted models

4.2.2.3 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.

4.2.2.4 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.

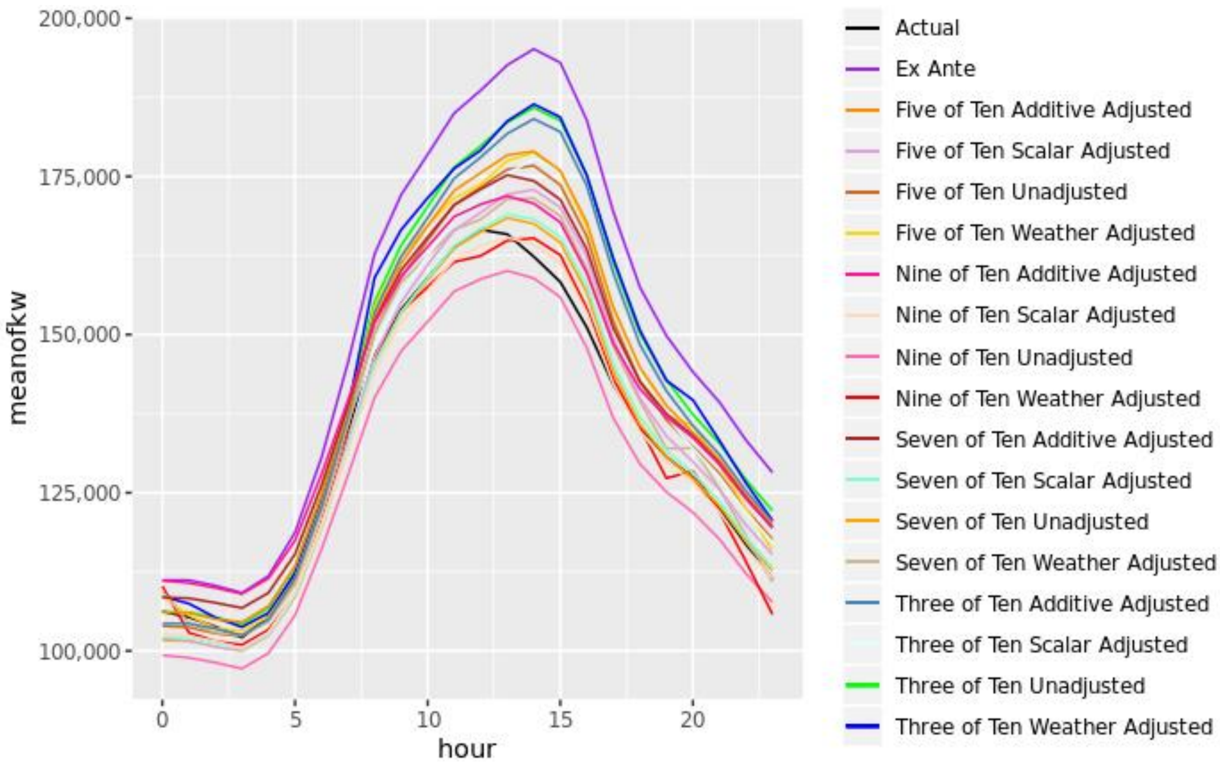
4.2.2.5 *Impact Evaluation Results*

This section presents the results of ADM's impact evaluation of the Peak Performers Program. The impact evaluation determines gross and net annual energy savings as well as peak demand reduction.

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 weekdays.

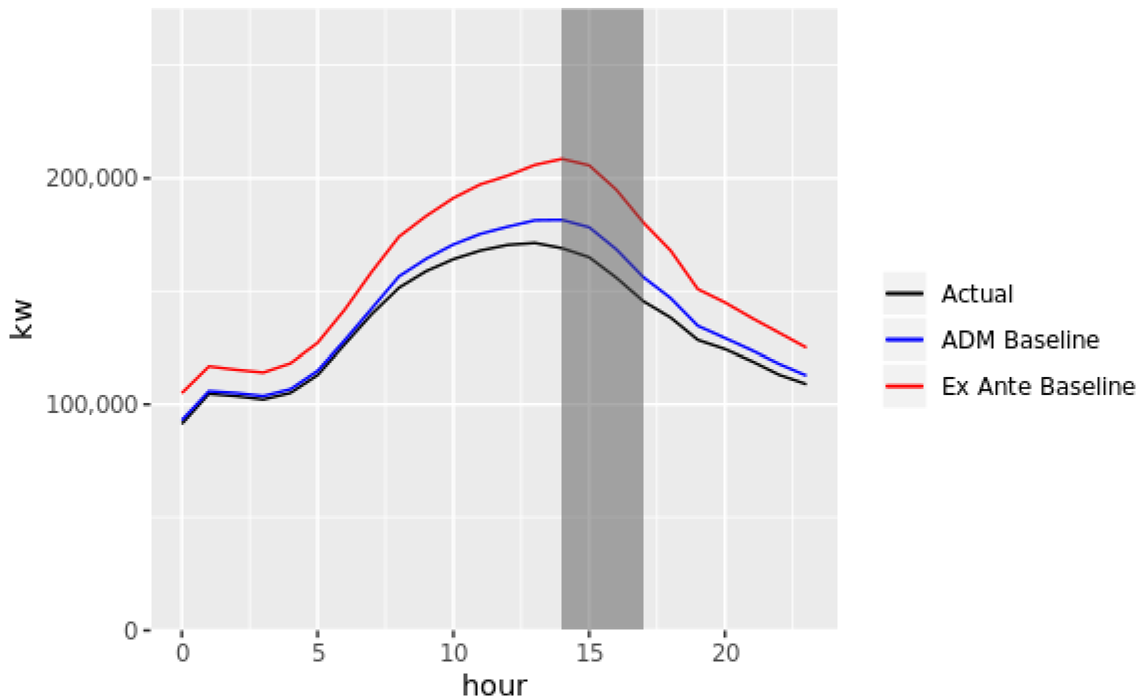
Figure 4-6: Average June Weekday Usage for All Models



The seven of ten and the nine of ten models appear to perform the best compared to the average June day while the reported (ex-ante) model appears to overestimate more than other models.

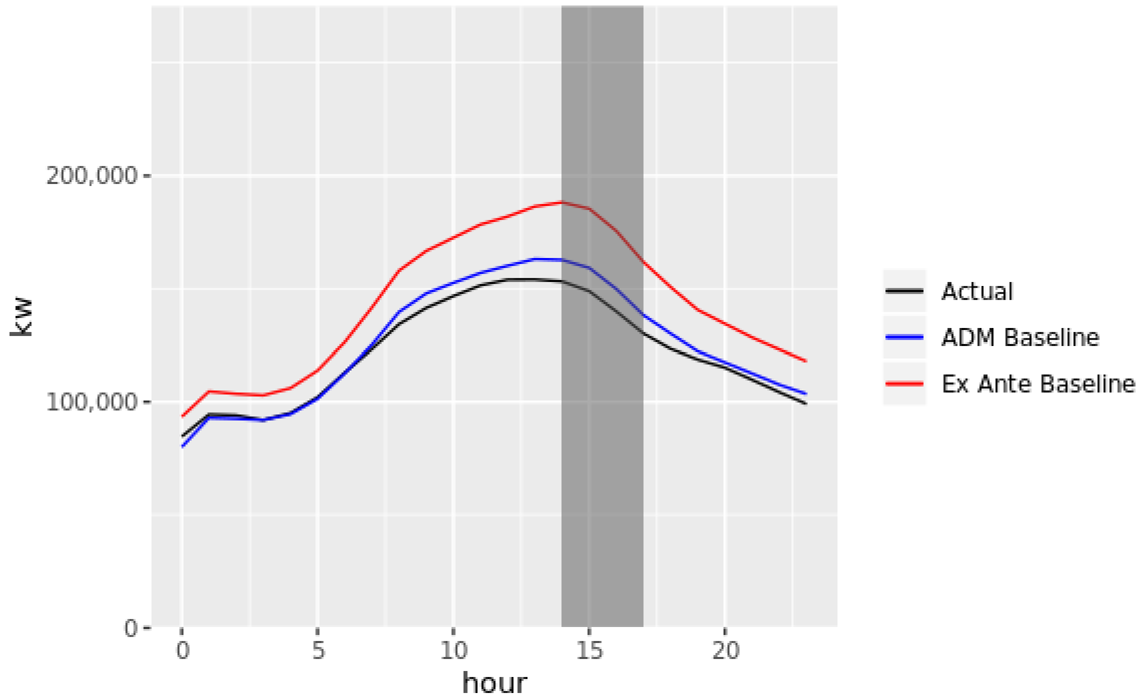
Figure 4-7, below, presents the aggregated results of actual usage, reported modeled usage, and verified modeled usage for all non-event, non-holiday June through September weekdays.

Figure 4-7: Average Actual, Reported, Verified Weekday Usage



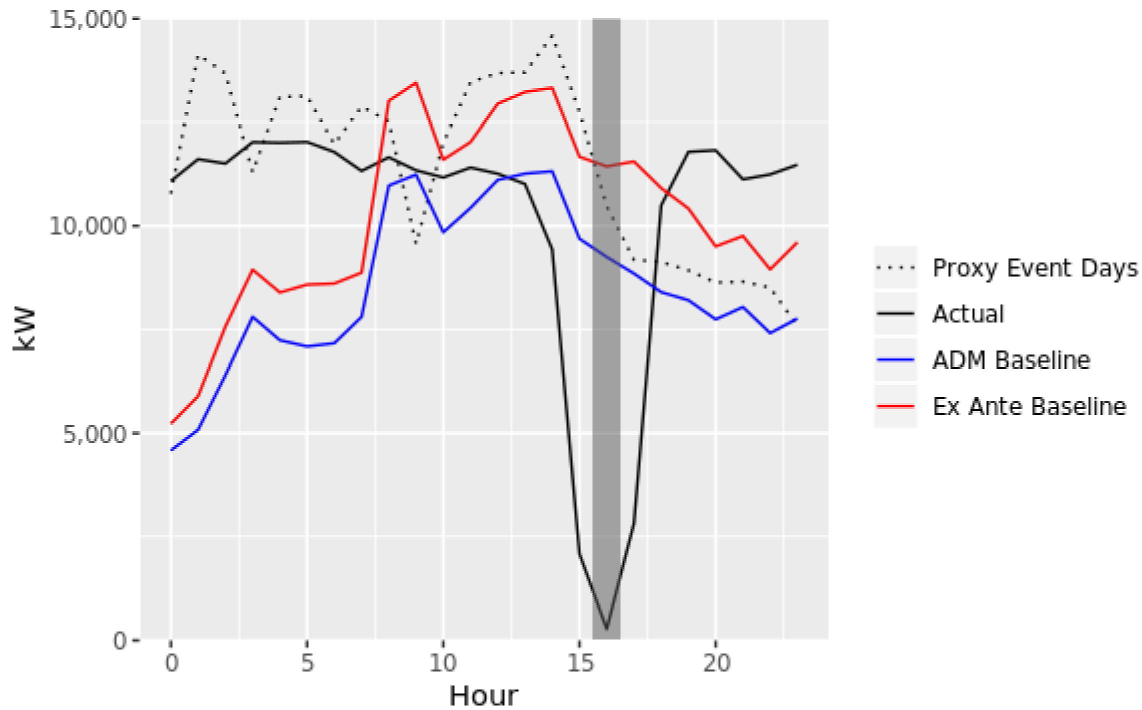
For the average summer non-event day, ADM's baseline performs better than the reported model, but would appear to overestimate energy usage. However, as noted previously, comparing the models to the most similar days of all non-event days, can provide a more relevant proxy. Below, in Figure 4-8, the 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 provides a good fit for actual usage.

Figure 4-8: Proxy Event Day Average Actual, Reported, Verified Weekday Usage



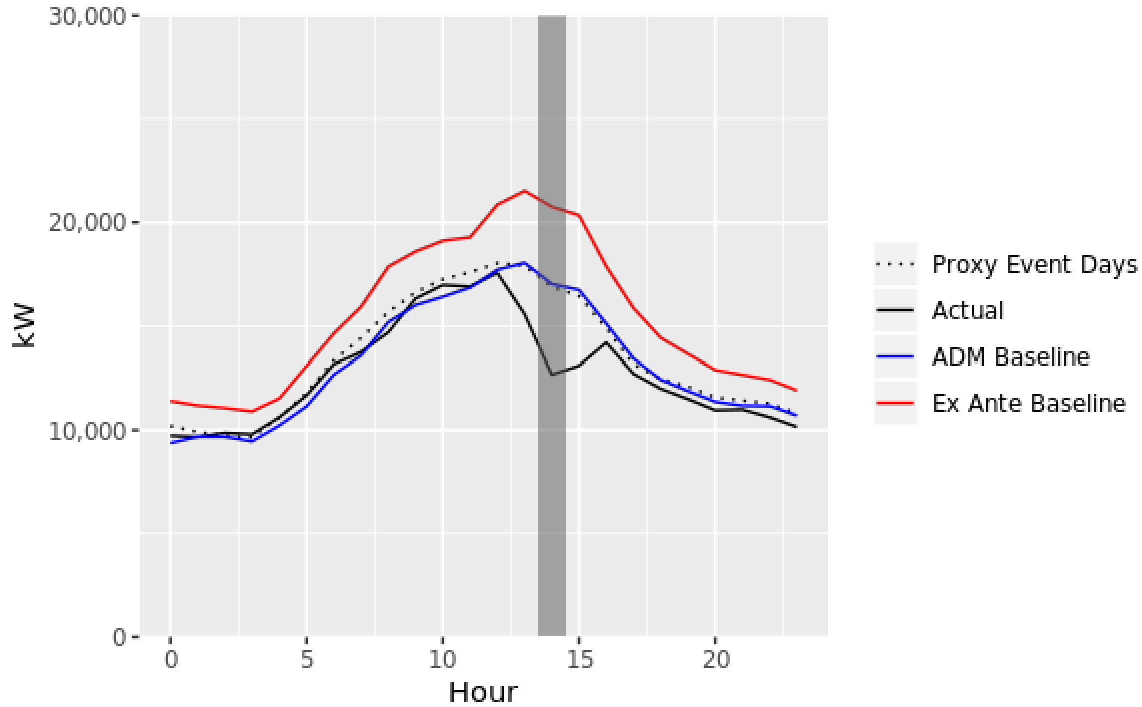
The following figures compare actual, reported, and verified usage for each of the three DR events that were called in 2020. The RRMSE comparing the ADM baseline to actual proxy event day usage is 4.6%. The following graph presents aggregated results of actual usage, reported modeled usage, and verified modeled usage for first test event on 6/9/2020.

Figure 4-9: Actual, Reported, and Verified Usage for Test Event 1, 6/9/2020



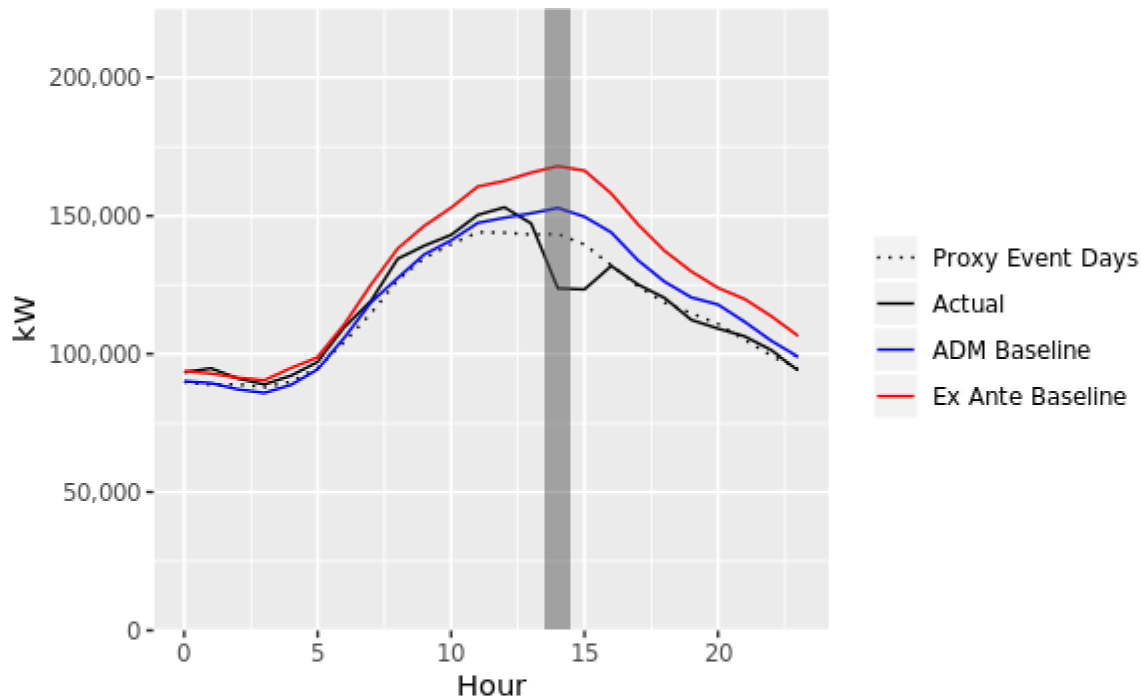
One high usage customer with five premise IDs participated in the first event. Their usage is irregular and being industrial, they are process-driven. The variability in consumption is evident when comparing actual energy consumption during the event to average values from proxy event days. For test event one, the ADM model fit improves in the hours prior to the event and is a reasonable estimate for the three hours preceding the event. Figure 4-10 presents aggregated results of actual usage, reported modeled usage, and verified modeled usage for event two on 6/11/2020.

Figure 4-10: Actual, Reported, Verified Usage for Event 2, 6/11/2020



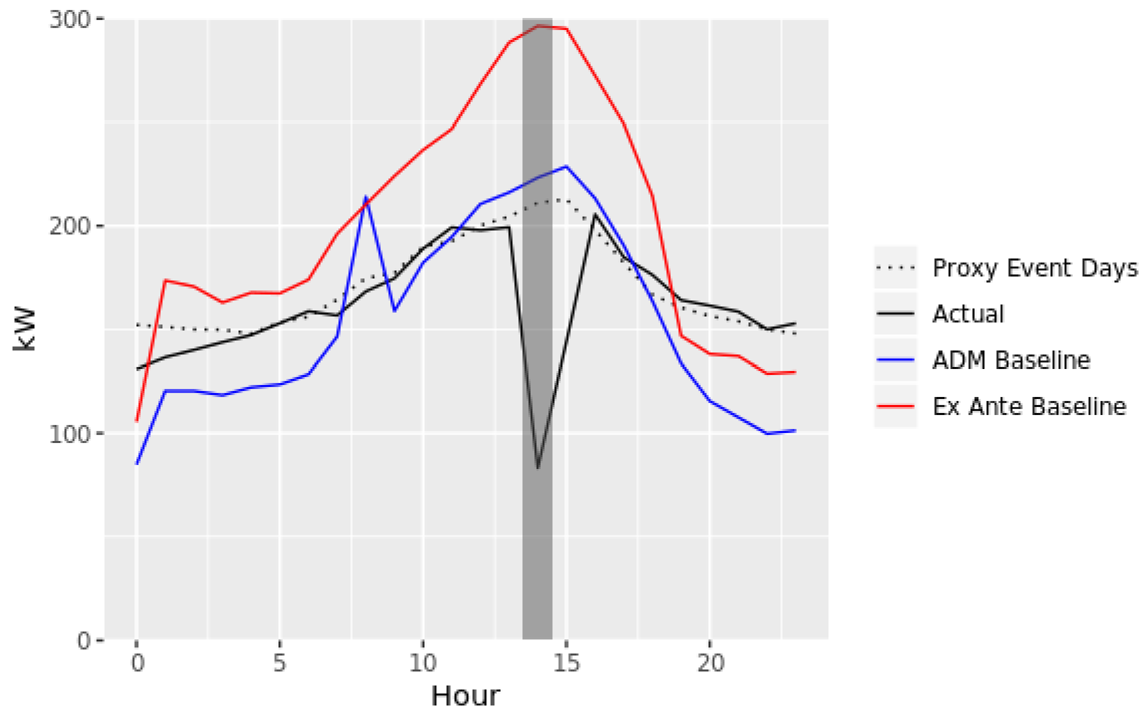
Test event two was participated in by 284 premise IDs. During test event two, the ADM model fits the actual event day usage well during non-event periods. The estimated usage during the event hour tracks the overall usage of the proxy event days. Figure 4-11 presents aggregated results of actual usage, reported modeled usage, and verified modeled usage for event three on 6/16/2020.

Figure 4-11: Actual, Reported, Verified Usage for Event 3, 6/16/2020



Test event three was participated in by 1561 premise IDs. For test event three, the ADM model fits the actual test event day usage well during non-event periods. The estimated usage during the event hour is a reasonable estimate. Figure 4-11 presents aggregated results of actual usage, reported modeled usage, and verified modeled usage for event four on 9/24/2020.

Figure 4-12: Actual, Reported, Verified Usage for Event 4, 9/24/2020



Test event four was participated in by 8 premise IDs. Fewer participants led to irregular load shapes compared to events two and three. For test event four, the ADM model does not fit actual test event day usage well during non-event periods but represents estimated usage during the event hour.

Peak Performers Peak Demand Reductions

Demand response event impacts were estimated by comparing the test 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 G.2.2.1, ADM used hourly interval data to recreate baseline estimations to determine reported impacts. The process was then repeated, this time using ADM's baseline methodology described in Section G.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 2020.

Table 4-19: 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	56.36	68.05	47.41	70%	100%	47.41

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 test event day to evaluate kWh savings for 2020 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 test event day. It is possible that some facilities shifted event related load outside of the test 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 2020.

Table 4-20 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	138.34	0.00	37.13	N/A	100%	37.13

Lifetime Energy Savings

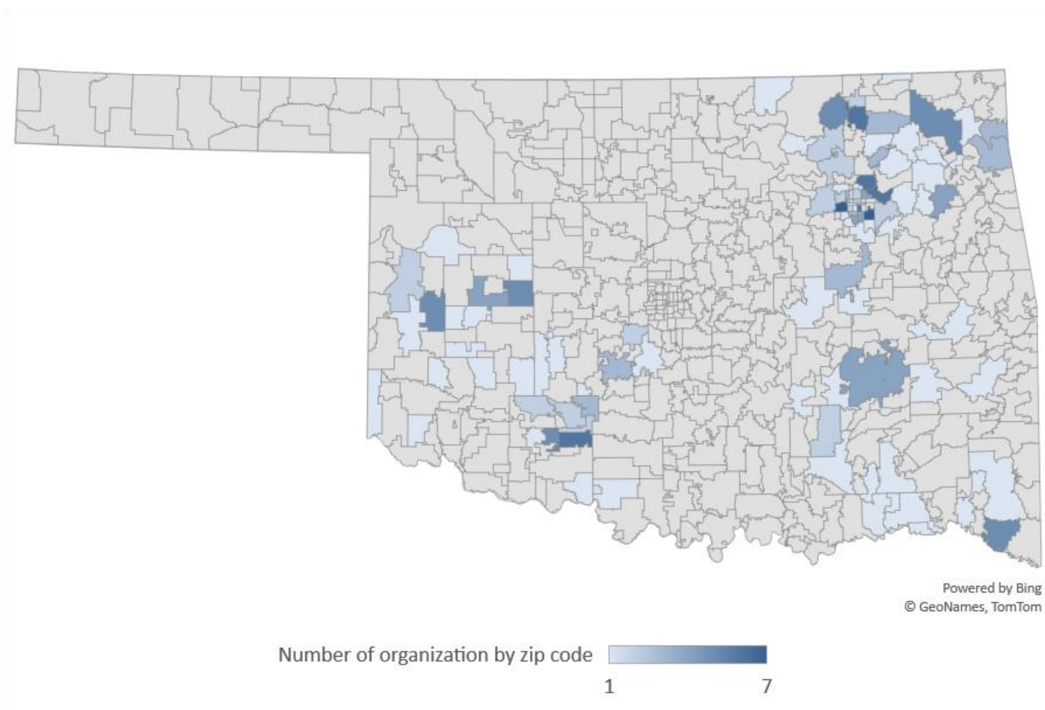
Annual energy savings are determined each year and therefore an effective useful life of one year is applied to quantify the lifetime savings of participants for any given program year.

4.2.3 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 2020 program year. The following summarizes key finding from the process evaluation of the Peak Performers Program.

Most of the current program participants are located throughout the PSO territory (see Figure 4-13). Most of the organizations are operating in Wagoner (21%), Tulsa (17%), and Comanche counties (eight percent).

Figure 4-13 Program Participant Location by Zip Code



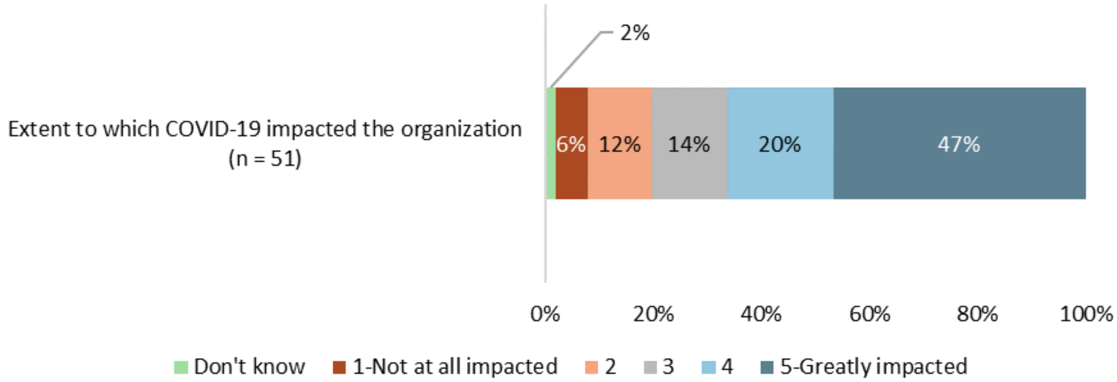
Each organization varies in size and by industry sector. The top three facility types that participated during PY2020 were K-12 schools (29%), offices (23%), and industrial/ manufacturing facilities (11%). See Table 4-21 for more details.

Table 4-21 Program Participants by Organization Type

Organization Types	Percentage of Responses (n = 246)
K-12 School	29%
Office	23%
Industrial / Manufacturing	11%
Religious worship	6%
Retail	6%
Warehouse	6%
Recreation / Sports facility	3%
Entertainment and Hospitality	2%
University	2%
Mining	2%
Health Facility	1%
Library	1%
Public Services	1%
Grocery / Convenience store	1%
Multifamily	1%
Restaurant not fast food	1%
Transportation	1%
Multi-use (offices and apartments)	< 1%
Other	3%

Organizations provided feedback about how the coronavirus pandemic impacted their operations. According to program staff, peak event season typically occurs between May 15th and September 30th. Although there were no peak events due to the mild weather, 85% of survey respondents indicated the coronavirus pandemic did affect them during that time-period (May 15 – September 30). Among organizations affected by the pandemic, 67% indicated they had been impacted or greatly impacted.

Figure 4-14 Impact of COVID-19 on Organizations



As illustrated in Figure 4-15, participants are satisfied with the program (97%). Most survey respondents indicated the event notification process (93%), incentive amount (87%), and the energy usage data available to them while participating in the program (73%) were satisfactory (see Figure 4-16).

Figure 4-15: Satisfaction with Peak Performers

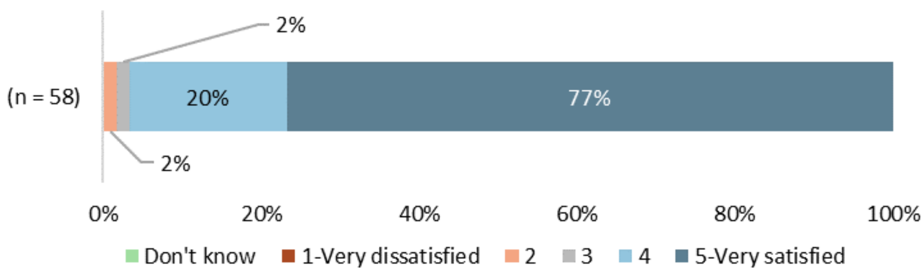
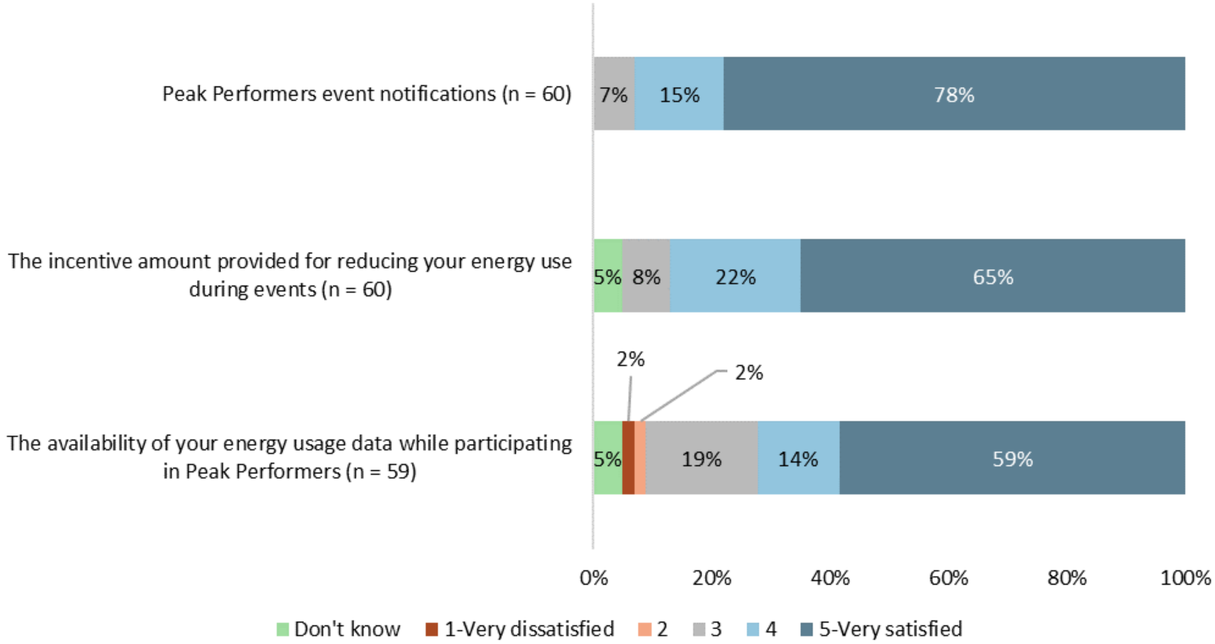


Figure 4-16 Participant Satisfaction



4.2.4 Conclusions and Recommendations

The following summarizes the key findings of the evaluation of the Peak Performers Program.

- **During PY2020, PSO only called test events**. Oklahoma experienced a mild summer, according to program staff, so they conducted test events rather than peak events. There was a total of four test events. Each organization had the liberty of choosing the date. They also could tailor the date to their specific needs. Organizations needed to participate in one of those dates.
- **Most of the current program participants are located throughout the PSO territory**. Most of the organizations are in Wagoner (21%), Tulsa (17%), and Comanche counties (8%). The businesses also vary in size and industry sector. The top three facility types that participated during PY2020 were K-12 schools (29%), offices, and industrial/ manufacturing facility (11%).
- **Program staff utilized different communication channels to market during PY2020**. According to program staff, the program's online coordinator managed all their social media accounts and posted information on Facebook, LinkedIn, and YouTube. They also bought advertisement space in Tulsa People Magazine and sent eblasts.

- **QA/QC procedures have updated participant status records**. According to program staff, when Vision processed and checked participant status, their algorithms would mistakenly count as "active" participants who had discontinued the program or "cancelled." This year, they updated the algorithm and created a new status to distinguish between active and nonactive participants.
- **The coronavirus pandemic impacted many of the program participants.** Although there were no peak events due to the mild weather, 85% survey respondents indicated the coronavirus pandemic did affect them during that time-period. Of the organizations affected by the pandemic, 67% indicated they had been impacted or greatly impacted. Yet, COVID-19 did not affect the organizations' abilities to reduce energy during a test event (68%).
- **Overall, 97% of participants were satisfied with the program in PY2020.** Peak Performer participants indicated the event notification process (93%), incentive amount (87%), and the energy usage data available to them while participating in the program (73%) were satisfactory. Seventy-four percent have already recommended the program to others, and 95% stated they plan to participate in the Peak Performers for PY2021.

The following recommendations are offered for continued improvement of the Power Hours Program.

- **Explore expanding marketing materials to attract new participants.** Create more videos that emphasize cost-effectiveness of participating in the program and of practicing more energy efficient habits in the workplace. Promote the videos on social media platforms and send them as links in email blasts.
- **Explore a refer-a-friend campaign to attract new participants and engage with current enrollees.** Develop a campaign that motivates companies to refer other business owners to the program. Analyze the cost-effectiveness of offering a type of incentive to the business who referred the new participant. Send reminders of the campaign before peak event season begins.

5 Research & Development Pilot Programs

PSO is performing three energy efficiency and demand response pilot program studies. The three pilots included a pool pump demand response pilot, a smart street lighting pilot and a non-wires solutions pilot. Activities during 2020 for these pilot programs are discussed in this chapter.

5.1 Pool Pump Demand Response

For this study, PSO installed remote triggering electrical switches on pool pump wiring to investigate the demand response potential during period of high electricity demand. Ten participants were identified for the pilot with four events during the summer peak period window. Switch installation did not include any changes to the pool pump such as pool pump settings or additional controls. The switches leverage the same network and technology as PSO’s existing AMI meter network.

ADM performed a preliminary impact evaluation effort to determine the potential peak demand reduction based on the demand response events. PSO collected information from each site (meter ID, pool pump size, event date, event start time, and event end time). ADM used this data along with customer AMI consumption data to determine peak demand reduction estimates.

5.1.1 Evaluation Methodology

For each of the ten sites, a baseline consumption model was calculated by training a linear regression model to predict consumption during non-event weekdays. This model was used to predict the expected consumption during each event day (counterfactual baseline). Demand reduction is determined by calculating the difference between the baseline predicted consumption and the actual consumption during the event. Data is reviewed for two hours after the event to investigate any potential post-event influence on consumption.

5.1.2 Evaluation Findings

The dates and times of the four events that took place in 2020 are shown in Table 5-1.

Table 5-1: Pool Pump Demand Response Events

Date	Start Time	End Time
July 7, 2020	4:00 PM	7:00 PM
August 10, 2020	4:00 PM	6:00 PM
September 14, 2020	4:00 PM	6:00 PM
September 16, 2020	4:00 PM	6:00 PM

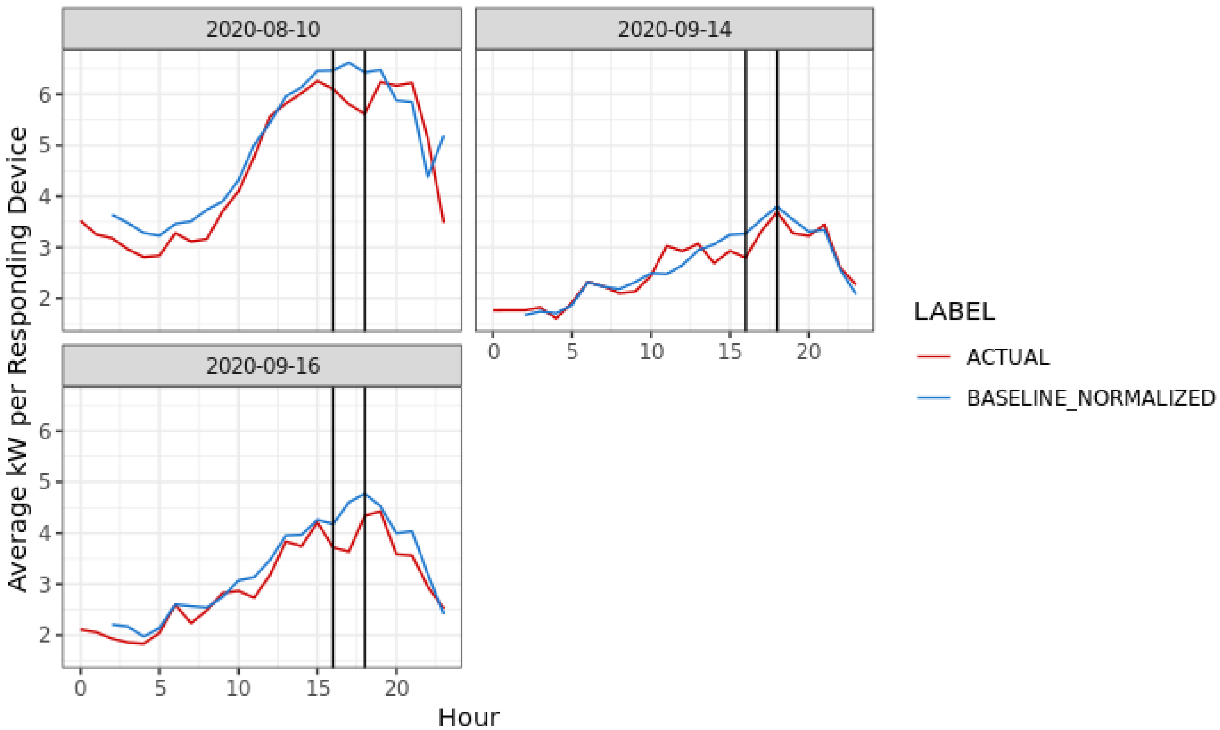
The event in July was not considered for the impact evaluation. Only five sites participated in this event and the event also coincided with a Power Hours demand response event. The average demand reduction per device was estimated for the remaining three events for each hour during the events. Results are shown in Table 5-2.

Table 5-2: Average Demand Reduction (kW)

Date	4:00 PM	5:00 PM	6:00 PM	7:00 PM
August 10, 2020	0.365	0.815	0.815	0.237
September 14, 2020	0.469	0.232	0.107	0.266
September 16, 2020	0.462	0.964	0.430	0.099

With an average pool pump load per site at 1.49 kW, the study shows a significant decrease in demand reduction at approximately 30% on average. The shape of the consumption curves (average across participants) did not indicate the expected initial reduction at the beginning of each event. On August 10th and September 16th, the reduction was most notable in the hours after the event. On September 14th, a reduction occurred before the event began. It is possible that consumption was impacted by other variables that could not be accounted for. Therefore, it is difficult to accurately quantify the magnitude of avoided consumption with ten participants. This analysis is preliminary. With 15-minute interval data by customer, analysis with this detail will be completed. Also, more sites in 2021 would support additional accuracy in the savings estimate. Profiles of average consumption and average normalized baseline are shown in Figure 5-1.

Figure 5-1: Average consumption profile on event days



5.2 Smart Street Lighting

As part of the smart street lighting pilot study, PSO installed smart controls on streetlights at four schools, with approximately 135 Telecells. Some of the lights are in parking lots, while others are on the street. The smart system provides the benefit of remote operation and feedback from each streetlight as well as smart controls for multiple dimming conditions. The equipment and provided software is made by Telensa.

The "Telecell" is a wireless control node for a given streetlight that includes revenue grade metering, on-board dimming, low power requirement of 0.8W, integral GPS, and runs without network connection. The "UNB" acronym, regarding the UNB base station, stands for Ultra Narrow Band radio system, which has the unique combination of low cost, long range, long battery life, and 2-way communication for massive numbers of devices. The Central System used to remotely manage the streetlights is called "PLANet" and is accessible via an online interface.

Energy savings are generated from two aspects of this smart street lighting. Installation of the new equipment required a lamp upgrade to LED fixtures, and the controls component results in reduced consumption during hours of operation. The dimming schedule used is called "Photocontrol stepped 100% full on-80%-60%-80%-off". This schedule results in the lights turning on at 100% power using photocontrol at sunset, then dimming to 80% power at 20:00, 60% at 22:00, 80% at 05:00, and off using photocontrol at sunrise. All (135) retrofitted lights utilize this schedule.

5.2.1 Evaluation Methodology

ADM collaborated with PSO and Telensa over the course of several months to learn about the scope of work, gain clarity on savings components, attend training for navigating the PLANet system, develop an M&V Plan, and obtain data including make and model of retrofitted light fixtures, as well as quantities. ADM used the make and model information to download specification sheets for each pre-and post-implementation fixture, including power requirements. ADM also obtained a data export from Telensa which contained information about each Telecell, including lamp type and power readings. This information was cross-referenced with the retrofit fixture tally provided by PSO.

Energy savings from lighting efficiency projects can generally be formulated as follows:

$$Savings(kWh) = \sum_{i=1}^{All\ Portions} \Big((kW_{Base} \times hours_{Base}) - (kW_{Efficient} \times hours_{Efficient}) \Big)_i \times IEF_{E,i}$$

$$Demand\ Reduction(kW) = \sum_{i=1}^{All\ Spaces} \Big((kW_{Base} \times CF_{Base}) - (kW_{Efficient} \times CF_{Efficient}) \Big)_i \times IEF_{D,i}$$

Where:

i denotes the *i*th portion involved in the lighting project. For M&V purposes, a project *must* be broken down into *i* distinct portions, with the portion generally defined by separate hours of use, separate spaces, or separate fixture types.

All parameters defined below may take on separate values for each of the *i* portions of the project:

kW_{Base} is the total connected lighting load in the base case. For retrofit projects this is the product of the quantity of base (pre-retrofit) fixtures, and the per-fixture alternating current wattage[98]. For new construction, it is usually the product of the lighting wattage allowance and the area (though sometimes length or enumeration) of the affected space.

$kW_{Efficient}$ is the total connected lighting load in the efficient case. This is the product of the quantity of efficient (post-retrofit, or new construction) fixtures, and the per-fixture alternating current wattage.

[98] We emphasize that the wattage to be used is inclusive of wattage requirements of ballasts or direct current drivers for solid state lighting.

$hours_{Base}$ is the total annual hours of operation for the given fixture group in the base case. The hours of use must account for the control type (e.g., for pre-existing occupancy sensors or other controls).

$hours_{Efficient}$ is the total annual hours of operation for the given fixture group in the efficient or "as-built" case. The hours of use must account for the control type (e.g., for occupancy sensors or other controls).

CF_{Base} is the peak demand coincidence factor for the given fixture group in the base case. The hours of use must account for the control type (e.g., for pre-existing occupancy sensors or other controls).

$CF_{Efficient}$ is the peak demand coincidence factor for the given fixture group in the efficient or "as-built" case. The hours of use must account for the control type (e.g., for occupancy sensors or other controls).

IEF_E is the average annual heating and cooling interactive effect for the space.

5.2.2 Evaluation Findings

ADM used available consumption and schedule data from Telensa's software to determine annual energy savings (kWh) and peak demand reduction (kW). Power requirements for the new LEDs were taken from acquired specification sheets. Baseline fixture wattages were sourced from the Arkansas TRM based on information gathered from PSO staff.

Data collected on each light fixture from mid-November through early January was used to determine a dimming schedule to represent the reduction in consumption based on the programmed schedule. A reduction in annual operating hours of 1,135 hours was determined out of the deemed annual operating hours (based on a photocell) provided by the AR TRM. Based on these findings, preliminary energy savings for the retrofit and controls installation for each fixture was determined. Results are shown in Table 5-3.

Table 5-3: Estimated Annual Energy Savings by Fixture

Fixture Type	Quantity	Retrofit Annual Energy Savings per Fixture (kWh)	Controls Annual Energy Savings per Fixture (kWh)	Total Annual Energy Savings per Fixture (kWh)
295W HPS to 44W LED	44	691	138	829
465W HPS to 28W LED	28	1,275	165	1,440
1100W HPS to 45W LED	45	3,209	336	3,545
138W HPS to 16W LED	16	396	44	440
138W HPS to 2W LED	2	292	74	365
Total	**135**	**1,611**	**198**	**1,808**

Energy impacts from lighting retrofit and smart street lighting controls are summarized in Table 5-4.

Table 5-4: Estimated Energy Impacts from Smart Street Lighting

Project Savings	Verified Results
Retrofit Energy Savings (kWh)	217,418
Controls Energy Savings (kWh)	26,692
Total Energy Savings (kWh)	244,110
Summer Peak Coincident Demand Reduction (kW)	0

ADM will continue to analyze the energy savings impacts from the smart street lighting pilot program as more seasonal data becomes available.

5.3 Non-Wires Solution

Under contract with PSO, ADM is performing evaluation, measurement, and verification (EM&V) activities to confirm the annual energy savings (kWh), summer peak demand reductions (kW), and winter morning ramp-up reduction (kW) being realized through the Non-Wires Solutions Pilot program that PSO is implementing in 2020-2021.

This pilot program seeks to implement site-specific energy efficiency measures using recommendations from the implementer team’s Phase 2 Non-Wires Solutions (NWS) Study to reduce the demand peak on circuit 83831 in the Boswell, Soper, Hugo area. The Phase 2 report suggests that a 588 peak winter lead reduction (kW) is feasible and cost effective through traditional energy efficiency and demand response solutions compared to a $4 million distribution investment. Energy efficiency measures will be implemented based on current program offerings and additional measures. These include:

- Residential Weatherization (air sealing, duct sealing, attic insulation, low-flow showerheads, faucet aerators, hot water pipe insulation)
- Residential LED light bulbs (through the Residential Weatherization Program)
- Efficient heat pumps (through the Home Rebates Single Upgrades Program)
- Small Business Lighting and Refrigeration (through the Small Business Energy Solutions Program)
- Commercial and Industrial Measures (targeting lighting, refrigeration seals, and strip curtains through the Business Rebates Program)
- Energy Coaching
- Residential HVAC Tune-Up

Evaluation of these measures will result in verification of net annual energy savings, net peak demand reduction, and net winter ramp-up demand reduction.

5.3.1 Evaluation Methodology

Measures incorporated into energy efficiency programs will be evaluated through those program evaluations. Measure implemented for this pilot have been included in Home Weatherization, Home Rebates (Single Upgrades), and Business Rebates (Small Business Energy Solutions as well as Custom and Prescriptive). For evaluation purposes, these measures were comparable to program offerings and therefore were included within sampling practices of each program. Details on evaluation methodologies can be found within each program's evaluation chapter within this report.

Energy impacts reported on include gross and net annual energy savings, summer peak demand reduction, and lifetime energy savings. In addition, the magnitude of the winter peak demand reduction (kW) is to be determined in the spring of 2021 after the winter peak demand season has ended.

A final report for this pilot program will be prepared in 2021 to include verified findings during the winter demand season. This report will include findings from ADM's process evaluation which are applicable to the NWS pilot study.

5.3.1.1 Winter Peak Demand Reduction (kW)

Based on demand from the utility substation, winter peak reduction (kW) is defined as the average hourly consumption between 6 AM and 11 AM on non-holiday weekdays in December to February.

Verified gross winter peak reduction will be determined based on energy savings curves. An energy savings curve is developed by applying annual energy savings to an 8,760 electrical load profile representing each energy efficiency measure. The load shape is dependent on the climate zone and sector.

A billing regression analysis will be performed for project sites in which the ex-ante annual energy savings meet the necessary criteria based on ASHRAE Guide 14-2014 and IPMVP protocols. When applicable, a billing regression analysis using AMI customer data can provide a more accurate representation of consumption changes during the specific winter peak demand period. Billing regression analyses will be normalized for weather to represent typical year winter peak demand reduction to ensure the magnitude of reduction is consistent from year to year.

A net-to-gross value will not be determined for winter peak demand reduction as the goal of the pilot is to determine the reduction in consumption at the substation. To represent the reduction at the substation, ADM may be able to include line losses with support from PSO.

5.3.2 Evaluation Findings

ADM worked with PSO and the implementation team to target energy efficiency measures and potential within the geographical territory of the electrical circuit in question. Estimates of winter peak demand reduction are not typical within energy efficiency and therefore estimates had to be determined for each measure. Estimates were determined using energy simulations and load shape analysis.

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.[99] Reported impacts refer to energy savings and peak demand reduction estimates based on actual program participation in PY2020, before program evaluation activities. Finally, verified impacts refer to energy savings and demand reduction estimates for PY2020 developed through independent program evaluation, measurement, and verification (EM&V).

[99] 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 energy savings (kWh), 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 2020 energy efficiency and demand response portfolio from January 1, 2020 through December 31, 2020.

The cost-effectiveness of PSO's 2020 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.[100]

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 2020 programs were estimated by ADM as part of the portfolio impact evaluation. Verified energy savings estimates at the meter were adjusted to account for line losses using a line loss adjustment factor of 1.0586 for energy savings and 1.0781 for peak reduction. 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.[101] 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.

[100] 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

[101] 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)[102] 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).[103]
- 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 PY2020, PSO's overall portfolio is cost-effective based on both the UCT and TRC.

[102] The UCT is also referred to as the Program Administrator Cost Test (PACT).
[103] http://www.occeweb.com/rules/CH35finalrules111819.pdf.

Table B-1: Projected by Program, 2020 (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	7,269	39,674,299	-196,767	$11,389,217
Multi-Family	308	1,699,927	14,283	$970,698
Home Weatherization	1,203	2,464,670	169,969	$3,409,467
Energy Saving Products	2,397	19,378,992	-181,174	$2,831,582
Home Rebates	2,526	6,558,210	288,278	$7,431,058
Education	420	3,510,710	-12,064	$1,120,000
Behavioral	4,075	22,008,294	602,316	$1,273,750
Conservation Voltage Reduction	4,526	19,185,807	0	$983,359
Total – EE Programs	**22,725**	**114,480,908**	**684,842**	**$29,409,132**
Power Hours	19,383	1,625,112	128,745	$2,330,169
Business Demand Response	56,358	138,346	0	$3,318,516
Total – DR Programs	**75,741**	**1,763,458**	**128,745**	**$5,648,685**
Total – R&D Programs	**341**	**144,347**	**0**	**$331,219**
Total	**98,807**	**116,388,714**	**813,587**	**$35,389,035**

Table B-2: Cost-Effectiveness by Program, 2020 (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	7,542	8,011	44,396,059	47,159,612	$10,952,859	2.58	4.11
Multi-Family	817	868	3,106,403	3,299,769	$1,497,183	2.29	1.74
Home Weatherization	2,245	2,385	4,239,629	4,503,536	$3,316,716	2.87	1.97
Energy Saving Products	5,934	6,303	33,255,910	35,326,015	$3,113,265	7.95	7.82
Home Rebates	2,217	2,355	5,312,912	5,643,628	$8,269,131	1.41	0.92
Education	737	783	3,595,976	3,819,817	$950,062	2.41	2.52
Behavioral	4109	4,365	21,062,812	22,373,924	$1,271,000	1.26	1.19
Conservation Voltage Reduction	4,169	4,429	14,425,878	15,323,856	$1,126,666	2.50	2.65
Total – EE Programs	**27,770**	**29,499**	**129,395,579**	**137,450,159**	**$30,496,882**	**2.39**	**2.53**
Power Hours	6,187	6,572	2,437,623	2,589,360	$1,910,328	1.58	1.35
Business Demand	47,413	51,430	37,127	40,272	$2,535,586	8.02	2.87
Total – DR Programs	**53,600**	**58,001**	**2,474,750**	**2,629,632**	**$4,445,914**	**3.87**	**2.24**
Total – R&D Programs	**-**	**-**	**-**	**-**	**$269,537**	**-**	**-**
Total	**81,370**	**87,500**	**131,870,329**	**140,079,790**	**$35,212,333**	**2.47**	**2.50**

B.2 Energy Efficiency Programs

PSO’s energy efficiency portfolio in 2020 consisted of eight programs with a verified net peak demand reduction of 29,499 kW and verified net annual energy savings of 137,450,159 kWh (including line-loss estimates of 5.86%). Total spending in 2020 equaled $35,212,333. 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 2020.

Table B-3: Energy-Efficiency Programs – Verified Impacts (Net, at Generator)

Program	Number of Participants in 2020	Verified Peak Demand Reduction (kW)	Verified Annual Energy Savings (kWh)	Verified Gas Savings (Therms)
Business Rebates	1,284	8,011	47,159,612	0
Multi-Family	112	868	3,299,769	139,730
Home Weatherization	2,163	2,385	4,503,536	477,379
Energy Saving Products	1,233,128[104]	6,303	35,326,015	0
Home Rebates	3,522	2,355	5,643,628	541,647
Education	16,001	783	3,819,817	-5,181
Behavioral	193,195	4,365	22,373,924	0
Conservation Voltage Reduction	27,488	4,429	15,323,856	0
Total – EE Programs	**243,765**	**29,499**	**137,450,159**	**1,153,575**

Table B-4: Energy-Efficiency Programs – Reported Costs

Program	Annual Non-EM&V Admin Costs ($)[105]	Annual EM&V Admin Costs ($)	Annual Cash Inducement Costs ($)[106]	Annual Non-Cash Inducement Costs ($)[107]
Business Rebates	$347,813	$280,311	$6,585,458	$3,739,277
Multi-Family	$14,073	$64,685	$1,167,871	$250,555
Home Weatherization	$101,481	$56,476	$2,960,855	$197,904
Energy Saving Products	$133,631	$152,051	$2,019,881	$807,703
Home Rebates	$184,980	$211,883	$5,735,832	$2,136,436
Education	$54,377	$47,793	$774,520	$73,372
Behavioral	$31,019	$73,979	$74,435	$1,091,567
Conservation Voltage Reduction	$14,837	$67,180	$0	$1,044,649
Total – EE Programs	**$882,212**	**$954,357**	**$19,318,851**	**$9,559,048**

[104] Energy Saving Products participants are the total number of upstream and downstream measures rebated.
[105] Non-EM&V Admin Costs include PSO staff labor costs and overhead costs.
[106] Cash inducement costs refer to customer rebate costs.
[107] 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 measures 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	CVR
	Tier 1	Tier 2								
LED Night Light	8	0						x		
FilterTone® Furnace Filter Alarm	14	0						x		
9-watt LED	3	16						x		
Air Sealing	11	0		x						
Attic Insulation	20	0		x			x			
Duct Replacement	18	0		x						
Faucet Aerator	10	0		x	x					
Heat Pump	16	0		x						
Low Flow Shower Head	10	0		x						
Pool Pump	10	0		x			x			
Windows	20	0		x						
Residential Lighting (DI)	3	17		x						
Residential Lighting (Non-DI)	3	17		x						
Commercial Lighting (DI)	9	0		x						
Commercial Lighting (Non-DI)	9	0		x						
NC Lighting	11	0		x						
Lighting Controls	8	0		x						
Washing Machine	14	0		x						
Dryer	14	0		x						
8760 Lighting	14.14	0	x							
Agriculture	9.618	0	x							

Measure	Measure life		Business Rebates	Multi-Family	Home Weatherization	Energy Saving Products	Homes Rebates	Education	Power Hours	CVR
	Tier 1	Tier 2								
Custom	13.42	0	x							
Exterior Lighting	13.06	0	x							
HVAC	13.42	0	x							
Kitchen & Appliances	13.24	0	x							
NC Lighting	11.5	0	x							
Oil & Gas	14.84	0	x							
Refrigeration	10.59	0	x							
Retrofit Lighting	13.5	0	x							
Lighting	10.62	0	x							
HVAC	12.28	0	x							
Exit Signs	14.53	0	x							
Exterior Lighting	14.53	0	x							
Interior Lighting	14.53	0	x							
Non-Lighting	14.53	0	x							
Air Sealing Package	11	0					x			
Central AC	19	0					x			
Duct Replacement	20	0					x			
Duct System Sealing	18	0		x	x		x			
Ground Source Heat Pump Bonus	25	0					x			
Air Source Heat Pumps	16	0					x			
Heating System ECM-type Blower Fan	15	0					x			
Insulation - Basement/Enclosed Crawlspace	20	0					x			

Measure	Measure life		Business Rebates	Multi-Family	Home Weatherization	Energy Saving Products	Homes Rebates	Education	Power Hours	CVR
	Tier 1	Tier 2								
Insulation - Exterior Wall	20	0					x			
Insulation - Kneewalls/Vertical Attic Wall	20	0					x			
Air Source Heat Pumps	16	0					x			
Ground Source Heat Pumps	25	0					x			
Insulation - Attic	25	0					x			
Mobile Home Duct Sealing	18	0					x			
HVAC Tune-Up	10	0					x			
9-watt Omnidirectional LED	3	17					x			
New Homes	20	0					x			
Air Infiltration	11	0			x					
Attic Insulation	20	0			x					
Water Heater Jacket	7	0			x					
Water Heater Pipe Insulation	13	0			x					
Showerheads - Mobile	10	0			x					
LED-Mobile	3	16			x					
APS - Mobile	10	0			x					
Conservation Voltage Reduction	25	0								x
DLC Events	1	0							x	
Smart Thermostat Incentive	11	0							x	
Air Filters	1	0				x				

Measure	Measure life		Business Rebates	Multi-Family	Home Weatherization	Energy Saving Products	Homes Rebates	Education	Power Hours	CVR
	Tier 1	Tier 2								
Advanced Power Strips	10	0				x		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	3	17				x				
Lighting - Omni-directional LED - DG	3	17				x				
Lighting - Omni-directional LED - FB	3	17				x				

In the tables that follow, total costs and benefits, and cost-effectiveness test results are provided for each energy efficiency program in the program year.

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	**4.11**	**2.58**	**0.76**	**2.95**	**3.65**
Net Benefits ($000s)	25,649.00	22,868.17	-10,772.91	28,340.09	27,594.19
Total Benefits ($000s)	33,902.56	37,381.74	33,902.56	42,853.66	38,008.64
Total Costs ($000s)	8,253.56	14,513.57	44,675.47	14,513.57	10,414.45

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	**1.74**	**2.29**	**0.58**	**2.86**	**4.42**
Net Benefits ($000s)	1,127.65	1,966.08	-1,952.38	2,840.28	4,107.32
Total Benefits ($000s)	2,659.95	3,495.19	2,659.95	4,369.39	5,307.91
Total Costs ($000s)	1,532.30	1,529.11	4,612.34	1,529.11	1,200.59

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	**1.97**	**2.87**	**0.75**	**3.45**	**3.97**
Net Benefits ($000s)	3,204.28	6,201.68	-2,122.62	8,137.72	8,781.58
Total Benefits ($000s)	6,520.99	9,518.40	6,520.99	11,454.43	11,742.43
Total Costs ($000s)	3,316.72	3,316.72	8,643.62	3,316.72	2,960.86

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	**7.82**	**7.95**	**0.64**	**12.30**	**22.49**
Net Benefits ($000s)	18495.23	14163.66	-11893.43	23021.92	28868.11
Total Benefits ($000s)	21208.91	16200.65	21208.91	25058.90	30211.31
Total Costs ($000s)	2713.69	2036.98	33102.34	2036.98	1343.20

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	**0.92**	**1.41**	**0.49**	**1.71**	**2.97**
Net Benefits ($000s)	-609.15	3222.55	-7554.39	5628.99	11186.27
Total Benefits ($000s)	7344.79	11115.69	7344.79	13522.13	16860.25
Total Costs ($000s)	7953.94	7893.14	14899.18	7893.14	5673.98

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	**2.52**	**2.41**	**0.59**	**3.02**	**4.8**
Net Benefits ($000s)	1,441.01	1,338.43	-1,673.49	1,915.66	2,941.23
Total Benefits ($000s)	2,391.07	2,288.49	2,391.07	2,865.72	3,715.75
Total Costs ($000s)	950.06	950.06	4,064.57	950.06	774.52

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	**1.19**	**1.26**	**0.43**	**1.26**	**-**
Net Benefits ($000s)	240.68	315.12	-1,981.38	315.12	2,434.82
Total Benefits ($000s)	1,511.68	1,511.68	1,511.68	1,511.68	2,434.82
Total Costs ($000s)	1,271.00	1,196.56	3,493.06	1,196.56	-

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	**1.69**	**1.84**	**0.67**	**2.31**	**-**
Net Benefits ($000s)	8152.95	9860.96	-9722.60	15487.83	15126.92
Total Benefits ($000s)	19958.48	21666.50	19958.48	27293.37	15126.92
Total Costs ($000s)	11805.54	11805.54	29681.08	11805.54	0.00

B.3 Demand Response Programs

PSO's demand response portfolio in 2020 consisted of two demand response programs with a verified net energy savings of 2,629,632 kWh and a verified net peak demand reduction of 58,002 kW.[108] Total spending in 2020 equaled $4,445,915. Table B-14 provides a summary of program participation and verified net impacts for the 2020 demand response portfolio. Table B-15 provides a summary of 2020 program costs.

Table B-14: Demand Response Programs – Verified Impacts (Net, at Generator)

Program	Number of Participants in 2020	Verified Peak Demand Reduction (kW)	Verified Annual Energy Savings (kWh)	Gas Savings (Therms)
Power Hours	23,681	6,572	2,589,360	0
Business Demand Response	232	51,430	40,272	0
Total – DR Programs	**23,913**	**58,002**	**2,629,632**	**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	$250,114	$73,096	$483,723	$1,103,394
Business Demand Response	$136,952	$49,648	$2,173,111	$175,876
Total – DR Programs	**$387,067**	**$122,744**	**$2,656,834**	**$1,279,270**

In the table that follows, total costs and benefits, and full cost-effectiveness test results are provided for the Business Demand Response program.

108 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	**1.35**	**1.58**	**0.60**	**1.70**	**8.03**
Net Benefits ($000s)	629.14	946.37	-1,595.56	1,142.48	2,280.85
Total Benefits ($000s)	2,425.73	2,583.46	2,425.73	2,779.57	2,605.06
Total Costs ($000s)	1,796.59	1,637.09	4,021.29	1,637.09	324.22

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	**2.87**	**8.02**	**2.86**	**8.02**	**4.01**
Net Benefits ($000s)	4,732.92	6,362.75	4,729.94	6,362.75	1,632.99
Total Benefits ($000s)	7,268.50	7,268.50	7,268.50	7,268.50	2,176.27
Total Costs ($000s)	2,535.59	905.75	2,538.56	905.75	543.28

B.4 Avoided Costs

The avoided costs in the table below (Table B-18) were developed for energy, capacity, transmission and distribution (T&D), and CO_2 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).[109]

[109] 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	CO_2	Natural Gas
	$/MWh	$/MW-day	$/kW-yr	$/kW-yr	($/metric tonne)	($/Mcf)
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. Summary of the 2019-2021 Demand Portfolio Energy Efficiency & Demand Response Programs

C.1 Introduction

Public Service Company of Oklahoma (PSO) received approval of the 2019 - 2021 Demand Portfolio, by the Oklahoma Corporation Commission on December 18, 2018 in Cause No. PUD201800073, Order No. 688452. The first two years of the 3-year Demand Portfolio achieved GWh savings of 283.8 GWh or 126% of the energy savings goal and 183 MW savings or 96% of the demand saving goal while maintaining total spending under budget at $68,699,896 or 97% of the filed approved budget. Of the total spending, $42,931,355 or 62% was in the form of cash inducements (e.g., incentives and rebates) to participating customers. The total utility benefit of the portfolio was $86,319,331 with a Utility Cost Test of 2.81.

The following sections discuss the Demand Portfolio goals and actuals for energy savings (kWh), peak demand reduction (kW), program cost, cash inducements and cost effectiveness for each year.

C.1.1 Savings Summary

The savings summary of the first two years of PSO's 2019-2021 Demand Portfolio is calculated based on verified energy savings and peak demand reduction for each of the energy efficiency and demand response programs. All spending values were provided by PSO. All energy savings and demand reduction values were taken directly from the portfolio tracking data provided by PSO. The verified energy savings and demand reductions reflect Evaluation, Measurement and Verification (EM&V) findings determined by ADM for each program year. Reported costs, verified annual energy savings, and verified peak demand reduction by program is shown in Table C-1. The peak demand reduction (kW) and annual energy savings (kWh) presented throughout this report represent net savings at the generator by applying program level net-to-gross (NTG) ratios and adjusting for line losses.

C.1.2 kWh Energy Savings

The annual energy savings (kWh) presented in Table C-1 represent net savings at the generator by applying program level net-to-gross (NTG) ratios and adjusting for line losses (a line loss adjustment factor of 5.86%).

Table C-1: Net kWh Savings by Program (Impacts are Net, at Generator)

Program	2019	2020	2019-2020	2-Year Goal	% to Goal
Energy Efficiency Programs					
Business Rebates	65,983,221	47,159,612	113,142,833	80,226,965	141%
Multi-Family	3,828,352	3,299,769	7,128,122	3,215,706	222%
Home Weatherization	3,976,252	4,503,536	8,479,788	5,029,976	169%
Energy Saving Products	38,696,169	35,326,015	74,022,183	42,973,249	172%
Home Rebates	4,645,422	5,643,628	10,289,050	13,111,239	78%
Education	3,725,951	3,819,817	7,545,769	7,021,419	107%
Behavioral	9,003,535	22,373,924	31,377,459	42,015,834	75%
Conservation Voltage Reduction	11,089,332	15,323,856	26,413,188	27,826,098	95%
Energy Efficiency Totals	**140,948,234**	**137,450,159**	**278,398,392**	**221,420,487**	**126%**
Demand Response Programs					
Power Hours	2,150,471	2,589,360	4,739,831	3,250,225	146%
Business Demand Response	590,885	40,272	631,157	273,317	231%
Demand Response Totals	**2,741,356**	**2,629,632**	**5,370,987**	**3,523,542**	**152%**
Research and Development				**270,069**	**0%**
Total	**143,689,589**	**140,079,790**	**283,769,380**	**225,214,098**	**126%**

C.1.3 kW Demand Savings

The annual demand reduction (kW) presented in Table C-2 represents net savings at the generator by applying program level net-to-gross (NTG) ratios and adjusting for line losses (a line loss adjustment factor of 7.81%).

Table C-2: Net kW Savings by Program (Impacts are Net, at Generator)

Program	2019	2020	2019-2020	2-Year Goal	% to Goal
Energy Efficiency Programs					
Business Rebates	10,791	8,011	18,802	14,751	127%
Multi-Family	1,024	868	1,892	589	321%
Home Weatherization	2,201	2,385	4,585	2,455	187%
Energy Saving Products	6,168	6,303	12,472	5,314	235%
Home Rebates	2,604	2,355	4,960	5,051	97%
Education	717	783	1,500	841	178%
Behavioral	1,028	4,365	5,393	7,780	69%
Conservation Voltage Reduction	2,192	4,429	6,621	6,437	103%
Energy Efficiency Totals	**26,725**	**29,499**	**56,224**	**43,219**	**130%**
Demand Response Programs					
Power Hours	13,021	6,572	19,593	35,847	55%
Business Demand Response	55,761	51,430	107,191	111,341	96%
Demand Response Totals	**68,782**	**58,001**	**126,784**	**147,188**	**86%**
Research and Development				**552**	**0%**
Total	**95,507**	**87,500**	**183,007**	**190,959**	**96%**

C.1.4 Program Costs

The program costs presented in Table C-3 represent total spending of the demand portfolio. The portfolio is under budget at $68,699,896 or 97% of the filed approved budget.

Table C-3: Total Program Cost by Program

Program	2019	2020	2019-2020	2-Year Goal	% to Goal
Energy Efficiency Programs					
Business Rebates	$10,788,034	$10,952,859	$21,740,894	$22,581,011	96%
Multi-Family	$951,182	$1,497,183	$2,448,366	$1,944,297	126%
Home Weatherization	$3,659,104	$3,316,716	$6,975,821	$6,977,574	100%
Energy Saving Products	$3,613,293	$3,113,265	$6,726,558	$6,127,422	110%
Home Rebates	$7,008,892	$8,269,131	$15,278,023	$14,855,884	103%
Education	$873,910	$950,062	$1,823,971	$2,264,000	81%
Behavioral	$1,116,829	$1,271,000	$2,387,829	$2,562,500	93%
Conservation Voltage Reduction	$801,114	$1,126,666	$1,927,780	$1,624,680	119%
Energy Efficiency Totals	**$28,812,360**	**$30,496,882**	**$59,309,241**	**$58,937,369**	**101%**
Demand Response Programs					
Power Hours	$1,952,166	$1,910,328	$3,862,494	$4,622,838	84%
Business Demand Response	$2,721,470	$2,535,586	$5,257,056	$6,556,092	80%
Demand Response Totals	**$4,673,636**	**$4,445,914**	**$9,119,550**	**$11,178,930**	**82%**
Research and Development	**$1,568**	**$269,537**	**$271,105**	**$637,250**	**43%**
Total	**$33,487,563**	**$35,212,333**	**$68,699,896**	**$70,753,548**	**97%**

C.1.5 Cash Inducements

Cash inducements are presented in Table C-4. Cash inducements are generally direct payments to customers or trade allies on behalf of customers, namely rebates and incentives.

Table C-4: Cash Inducements by Program

kWh Savings	2019	2020	2019-2020	2-Year Goal	% to Goal
Energy Efficiency Programs					
Business Rebates	$6,527,767	$6,585,458	$13,113,225	$13,113,507	100%
Multi-Family	$703,272	$1,167,871	$1,871,143	$1,261,321	148%
Home Weatherization	$3,260,805	$2,960,855	$6,221,661	$6,158,072	101%
Energy Saving Products	$2,404,318	$2,019,881	$4,424,199	$4,137,435	107%
Home Rebates	$4,475,056	$5,735,832	$10,210,888	$9,527,649	107%
Education	$719,189	$774,520	$1,493,709	$1,808,000	83%
Behavioral	$49,849	$74,435	$124,284	$200,000	62%
Conservation Voltage Reduction	$0	$0	$0	$0	0%
Energy Efficiency Totals	**$18,140,257**	**$19,318,851**	**$37,459,109**	**$36,205,984**	**103%**
Demand Response Programs					
Power Hours	$480,312	$483,723	$964,035	$1,482,839	65%
Business Demand Response	$2,333,926	$2,173,111	$4,507,037	$5,163,750	87%
Demand Response Totals	**$2,814,238**	**$2,656,834**	**$5,471,072**	**$6,646,589**	**82%**
Research and Development	**$0**	**$1,175**	**$1,175**	**$267,000**	**0%**
Total	**$20,954,495**	**$21,976,860**	**$42,931,355**	**$43,119,573**	**100%**

C.1.6 Cost Effectiveness

Figure C-1 shows the Demand Portfolio's Total Resource Cost Test (TRC) results and Utility Cost Test (UCT)[110] results for each year. The reported impacts are net-at-generator, reflecting NTG assumptions and line losses as described in each year Annual Report. These results adhere to the stipulations set forth by the Oklahoma Corporate Commission for the Demand Side Management Cost Recovery Rider. 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).

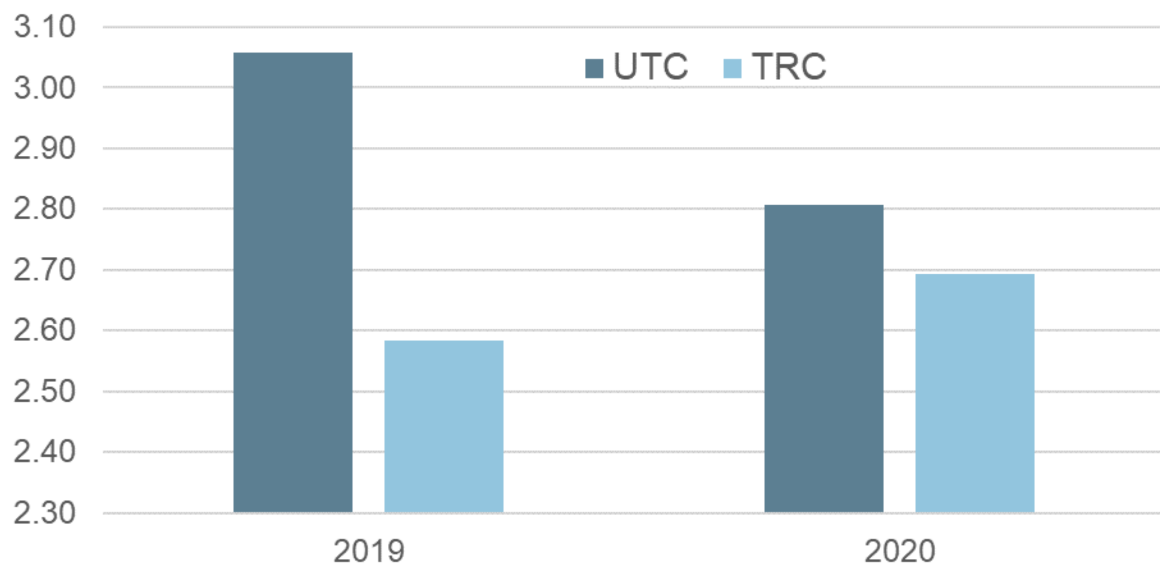
In addition to TRC and UCT results, results from the Ratepayer Impact Measure (RIM), Participant Cost Test (PCT) and Societal Cost Test (SCT) are included in each year's

[110] The UCT is also referred to as the Program Administrator Cost Test (PACT)

Annual Report. Based on reported program impacts and spending through December 31, 2020, PSO's overall portfolio is cost-effective based on both the TRC and UCT.

Figure C-1 shows the changes in cost effectiveness ratios over the portfolio period. The ratios greater than one emphasizes the significant benefit provided customers over cost incurred.

Figure C-1: Demand Portfolio Cost Effectiveness by Year



C.2 Energy Efficiency Programs

PSO's portfolio of energy efficiency portfolio offering consisted of eight programs.

C.2.1 Business Rebates Program

PSO's Business Rebates Program seeks to generate energy and demand savings for large and small commercial and industrial customers through promotion of high efficiency electric end use products including (but not limited to) lighting, HVAC, and motors. The program provides PSO's commercial and industrial customers with flexibility in choosing how to participate, by either self-sponsoring or by working through a third-party service provider to leverage technical expertise.

C.2.2 Multi-Family

PSO's Multifamily Program seeks to generate energy savings for owners, operators, and service providers of Multi-family facilities through promotion of high efficiency electric end use products. The program seeks to combine provision of financial inducements with access to technical expertise to maximize program penetration across the range of potential Multifamily customers. Prescriptive rebate amounts are provided to participating customers for some measures including certain types of lighting, lighting controls, HVAC equipment, water-related equipment, and other equipment. Custom projects (e.g. chillers) that do not fall into prescriptive measure categories are rebated on a per kWh and kW impact basis.

C.2.3 Home Weatherization Program

PSO's Home Weatherization Program seeks to generate energy and demand savings for limited income residential customers through the installation of a wide range of cost-effective weatherization and other measures in eligible dwellings. The purpose of the Home Weatherization Program is to provide PSO's limited income residential customers the financial assistance they need to make their homes more energy efficient, increase comfort levels, and reduce their utility bills.

C.2.4 Energy Saving Products Program

PSO's Energy Saving Products Program seeks to generate energy and demand savings for residential customers through the promotion of energy saving cooling equipment, electric water heaters, CFLs, LEDs, window/glass door replacements, solar screens, advanced power strips, and attic insulation. The purpose of this program is to provide PSO residential customers inducements for purchasing products that meet high efficiency standards. The program included three components:

1) downstream instant rebates for such measures as attic insulation and ENERGY STAR® cooling equipment and window/glass door replacements; 2) upstream discounts for CFLs, LEDs, advanced power strips, and room air conditioners; and 3) CFL/LEDs distributed free-of-charge through community food banks.

C.2.5 Home Rebates Program

PSO's Home Rebates Program 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 homes and retrofits. The purpose of the Home Rebates Program is to provide PSO residential customers with inducements for increasing building envelope efficiencies and installing items such as high efficiency appliances and HVAC equipment.

C.2.6 Education Program

PSO's Education Program seeks to generate energy and demand savings for residential customers by providing elementary school students with easy self-install energy efficiency measures, such as LEDs and Advanced Power Strips. The purpose of the Education

Program is to provide PSO residential customers with an educational experience on how to make their homes more efficient. A lesson plan is provided to the classroom teacher, which engages the students in learning about energy efficiency while also practicing mathematics and science. The students are then provided the take-home energy efficiency kit. Energy savings are achieved when these measures are installed in homes, however PSO does not claim any kW or kWh savings associated with these kits. Additionally, there may be energy savings and other benefits associated with behavioral changes the program induces with students, parents, and teachers.

C.2.7 Behavioral

The Behavioral Modification program provides monthly 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 emailed energy report. The energy report provides customers with energy conservation tips. It is expected that through this education, customers will adopt energy conservation tips that will lead to more efficient energy use in their homes.

C.2.8 Conservation Voltage Reduction

PSO's Conservation Voltage Reduction (CVR) Program seeks to generate energy and demand savings by using a system of devices, controls, software, and communications equipment to manage reactive power flow and lower voltage level for implemented distribution circuits at substations. The purpose of the CVR Program is to achieve energy efficiency savings by managing the voltage and power factor along the distribution circuit and lower the voltage profile within an acceptable bandwidth.

C.3 Demand Response Program

PSO's portfolio consisted of two demand response programs.

C.3.1 Business Demand Response Program

The Business Demand Response program is designed to incentivize commercial and industrial facilities for curtailing their energy usage during periods of high electrical demand. Nonresidential PSO customers enroll in the program and are notified when a load reduction event is initiated. Participants have the option of participating in each event individually, and are paid incentives based on average reduction over the course of all events. Incentives are set at $32 per average kW reduction over all event hours, and participants receive a 5% payment bonus if they opt to participate in all reduction events throughout the year. There is no direct penalty for opting out of specific event days. The program is active during summer months when average demand typically approaches designated capacity thresholds.

C.3.2 Power Hours

The Power Hours Program provides 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 providing full rebates for the purchase of a new smart thermostat. DLC events reduce energy usage when demand is highest by communicating with registered Wi-Fi enabled thermostats installed in the homes of participants. Smart thermostats help lower electricity usage by providing customers with improved real-time information about HVAC usage and cost, improved user interfaces, and algorithm optimization (such as occupancy detection and prediction).

Appendix D. Identification of Program Implementers

Table D-1 identifies program implementation contractors and associated contact information by 2020 program.

Table D-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	Andrea.palmer@icf.com
Education	AM Conservation Group	Lee Moran	Senior Program Manager	976 United Circle, Sparks, NV 89431	888-438-9473	LMoran@amconservationgroup.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 E. Training and Customer Outreach

During the program year, PSO conducted several service provider recruitment and training events. Additionally, PSO sponsored various customer outreach events and stakeholder presentations. Table E-1 summarizes the in-store retail lighting promotional events. Table E-2 summarizes service provider recruitment and training events, customer outreach events, and other non-lighting promotion events throughout the program year.

Table E-1: Summary of In-Store Retail Lighting Promotional Events

Date	Event Name	Location	Training/Education Type	Number of Attendees
1/5/2020	Other - Broken Arrow	Broken Arrown	Contractor	31 - 40
1/11/2020	Other - Hobart	Hobart	Contractor	21 - 30
1/25/2020	Other - Lawton	Lawton	Contractor	21 - 30
1/25/2020	Other - Tulsa	Tulsa	Contractor	41 - 50
1/25/2020	Other - Owasso	Owasso	Contractor	21 - 30
1/26/2020	Other - Tulsa	Tulsa	Contractor	31 - 40
2/8/2020	Other - Lawton	Lawton	Contractor	21 - 30
2/8/2020	Other - Bartlesville	Bartlesville	Contractor	41 - 50
2/22/2020	Other - Broken Arrow	Broken Arrow	Contractor	41 - 50
2/23/2020	Other - Tulsa	Tulsa	Contractor	41 - 50
2/29/2020	Other - Elk City	Elk City	Contractor	21 - 30
3/6/2020	Other - Lawton	Lawton	Contractor	21 - 30
3/7/2020	Other - Hobart	Hobart	Contractor	21 - 30
3/7/2020	Other - Tulsa	Tulsa	Contractor	41 - 50
7/11/2020	Other - Lawton	Lawton	Contractor	11 - 20
7/18/2020	Other - Tulsa	Tulsa	Contractor	21 - 30
7/24/2020	Other - Lawton	Lawton	Contractor	11 - 20
7/25/2020	Other - Broken Arrow	Broken Arrow	Contractor	31 - 40
8/8/2020	Other - Lawton	Lawton	Contractor	11 - 20
8/14/2020	Other - Owasso	Owasso	Contractor	31 - 40
8/15/2020	Other - Bartlesville	Bartlesville	Contractor	31 - 40
8/16/2020	Other - Grove	Grove	Contractor	21 - 30
8/21/2020	Other - Tulsa	Tulsa	Contractor	11 - 20
8/22/2020	Other - Tulsa	Tulsa	Contractor	11 - 20
9/4/2020	Other - Lawton	Lawton	Contractor	11 - 20
9/11/2020	Other - Tulsa	Tulsa	Contractor	31 - 40
9/12/2020	Other - McAlester	McAlester	Contractor	11 - 20
9/12/2020	Other - Tulsa	Tulsa	Contractor	31 - 40
9/13/2020	Other - Owasso	Owasso	Contractor	31 - 40
9/26/2020	Other - Lawton	Lawton	Contractor	11 - 20

Date	Event Name	Location	Training/Education Type	Number of Attendees
10/2/2020	Other - Tulsa	Tulsa	Contractor	11 - 20
10/3/2020	Other - Lawton	Lawton	Contractor	11 - 20
10/3/2020	Other - Tulsa	Tulsa	Contractor	21 - 30
10/4/2020	Other - Owasso	Owasso	Contractor	11 - 20
10/16/2020	Other - Lawton	Lawton	Contractor	11 - 20
10/17/2020	Other - Lawton	Lawton	Contractor	11 - 20
11/1/2020	Other - Grove	Grove	Contractor	31 - 40
11/14/2020	Other - Owasso	Owasso	Contractor	31 - 40
11/14/2020	Other - Lawton	Lawton	Contractor	11 - 20
11/20/2020	Other - Lawton	Lawton	Contractor	11 - 20
11/21/2020	Other - Lawton	Lawton	Contractor	11 - 20
11/21/2020	Other - Bartlesville	Bartlesville	Contractor	11 - 20
12/4/2020	Other - Owasso	Owasso	Contractor	31 - 40
12/5/2020	Other - Lawton	Lawton	Contractor	11 - 20
12/5/2020	Other - Broken Arrow	Broken Arrow	Contractor	41 - 50
12/6/2020	Other - Tulsa	Tulsa	Contractor	21 - 30
12/11/2020	Other - Lawton	Lawton	Contractor	11 - 20
12/12/2020	Other - Lawton	Lawton	Contractor	11 - 20

Table E-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
1/9/2020	Clinton SC	Clinton	Contractor, Other	11 - 20
1/16/2020	Other	Tulsa	Contractor	61 - 70
1/22/2020	Other - Metro Technology Centers	Oklahoma City	Contractor	100+
1/29/2020	Other - Virtual training event	Virtual training event	Contractor	71 - 80
1/29/2020	Tulsa General Office	Tulsa	Contractor	21 - 30
1/30/2020	Other	Other	Contractor	21 - 30
1/30/2020	Tulsa Alsuma Garage	Tulsa	Contractor	0 - 10
2/3/2020	OSU Tulsa	Tulsa	Contractor	0 - 10
2/6/2020	Other - McKeon Center for Creativity	Tulsa	Contractor	71 - 80
2/8/2020	Other	Grove	Contractor	100+
2/11/2020	Tulsa Mid Metro SC	Tulsa	Contractor	0 - 10
2/19/2020	Other - Virtual training event	Virtual training event	Contractor	91 - 100
2/19/2020	Tulsa General Office	Tulsa	Contractor	0 - 10
2/20/2020	Other - University of Tulsa, Allen Chapman Student Union	Tulsa	Contractor	100+
2/20/2020	Tulsa General Office	Tulsa	Contractor	0 - 10

Date	Event Name	Location	Training/Education Type	Number of Attendees
3/3/2020	Bartlesville SC	Bartlesville	Contractor	0 - 10
3/4/2020	Chickasha SC	Chickasha	Other	11 - 20
3/4/2020	Tulsa Alsuma SC	Tulsa	Contractor	0 - 10
3/4/2020	Tulsa Alsuma Garage	Tulsa	Contractor	0 - 10
3/5/2020	Other - Jay Chamber of Commerce	Jay	Contractor	21 - 30
3/11/2020	Atoka SC	Atoka	Other	11 - 20
3/12/2020	Other - Tulsa Fairgrounds	Tulsa	Contractor	100+
3/17/2020	Other - Over the Phone	Over the Phone	Contractor	0 - 10
4/13/2020	Other - Over the Phone	Over the Phone	Contractor	0 - 10
4/14/2020	Other - Over the Phone	Over the Phone	Contractor	0 - 10
4/15/2020	Other - Over the Phone	Over the Phone	Contractor	0 - 10
4/22/2020	Other - Virtual outreach event	Virtual outreach event	Contractor	71 - 80
5/7/2020	Other - Over the Phone	Over the Phone	Contractor	0 - 10
5/11/2020	Other - Over the Phone	Over the Phone	Contractor	0 - 10
6/4/2020	Tulsa General Office	Tulsa	Other	0 - 10
6/9/2020	Tulsa General Office	Tulsa	Other	11 - 20
6/10/2020	Other - Over the Phone	Over the Phone	Contractor	0 - 10
6/16/2020	Tulsa General Office	Tulsa	Other	11 - 20
6/19/2020	McAlester SC	McAlester	Other	0 - 10
6/22/2020	Tulsa General Office	Tulsa	Other	21 - 30
6/23/2020	Tulsa General Office	Tulsa	Other	21 - 30
6/25/2020	Tulsa General Office	Tulsa	Other	21 - 30
6/30/2020	Tulsa General Office	Tulsa	Other	21 - 30
7/14/2020	Tulsa General Office	Tulsa	Other	11 - 20
7/23/2020	Oklahoma City	Oklahoma City	Other	0 - 10
7/31/2020	Other - Over the Phone	Over the Phone	Contractor	0 - 10
9/24/2020	Tulsa General Office	Tulsa	Other	11 - 20
10/14/2020	Weatherford SC	Tipton	Other	0 - 10
10/15/2020	Other - Over the Phone	Over the Phone	Contractor	0 - 10
10/23/2020	Other	Other	Other	0 - 10
10/28/2020	Other - Virtual webinar	Virtual webinar	Contractor, Other	100+
10/29/2020	Tulsa General Office	Tulsa	Other	0 - 10
11/6/2020	Other	Tulsa	Contractor	100+
11/18/2020	Tulsa General Office	Tulsa	Other	0 - 10
12/11/2020	Other	Tulsa	Contractor	100+
12/17/2020	Tulsa General Office	Tulsa	Contractor	100+

Appendix F. Marketing Synopsis

The following pages of this appendix provide examples of marketing materials used to promote PSO's Demand Side Management portfolio in the program year.

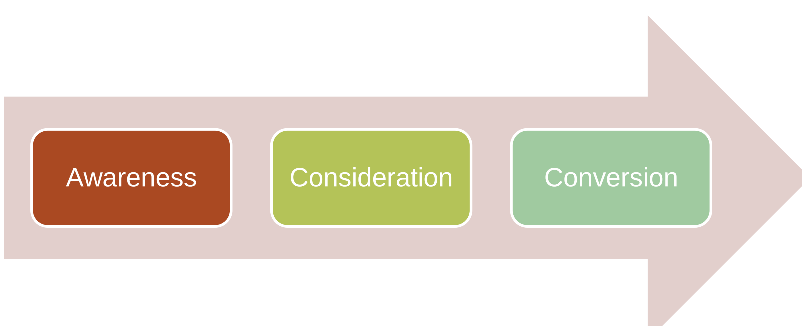
PSO continues to utilize a variety of marketing strategies for attracting, engaging, and educating customers on energy efficiency. Multichannel marketing includes multiple customer touchpoints to increase awareness and program participation to achieve energy-saving goals. PSO's centralized marketing function ensures strategic planning and execution across all energy efficiency programs, delivering a consistent message and experience for customers regardless of program.

F.1 COVID-19 Impacts

- Program marketing efforts were not significantly impacted; however, adjustments were made to both messaging and paid media placements to reach customers across media tactics they were more likely to consume while at home.
- Out-of-home ad placements were reduced and streaming video, audio, and social were utilized to reach more customers.
- Removed geotargeting for home improvement stores while businesses were shut down.
- Added messaging to promote energy efficiency tips for working from home.
- Increased program marketing in Q3 and Q4 to help increase participation and help achieve energy-saving goals.
- Business Mechanical Energy Efficiency Seminar was conducted virtually in October.
- On-site community engagement events were postponed in March 2020.

F.2 2020 Program Marketing Goals

Program marketing goals consist of awareness, consideration, and conversion.



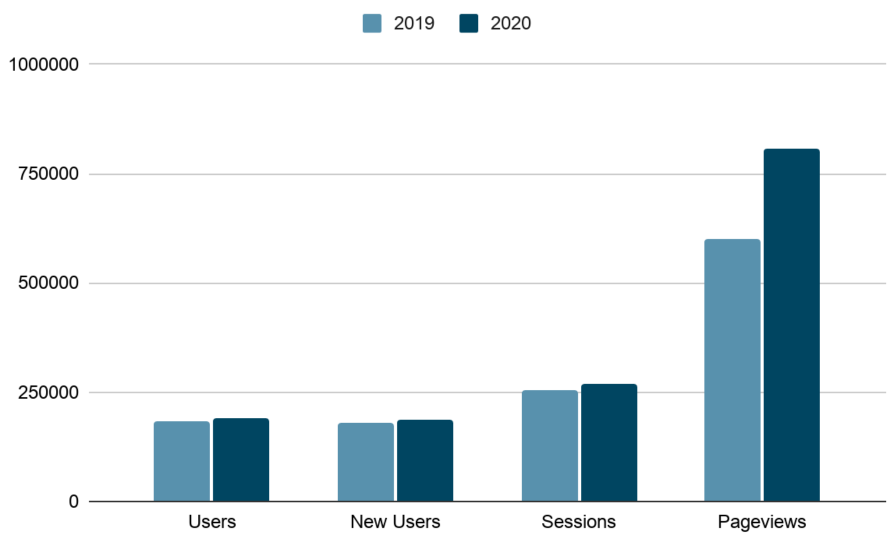
F.3 Strategies and Tactics

- 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 paid media toward highest performing creative.
- Become a go-to resource for customers for energy-related decisions.

F.4 Overall Website Performance

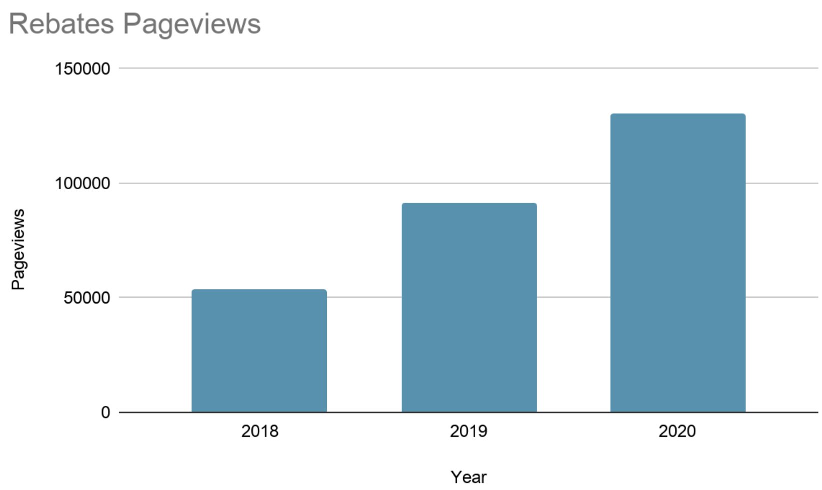
Compared to 2019 there were increases in each category of Users, New Users, Sessions and Pageviews.

Figure F-1: Website comparison from 2019 to 2020



190,140 **Users** 4.34%	188,600 **New Users** 5.11%	269,490 **Sessions** 5.49%	807,786 **Pageviews** 34.82%

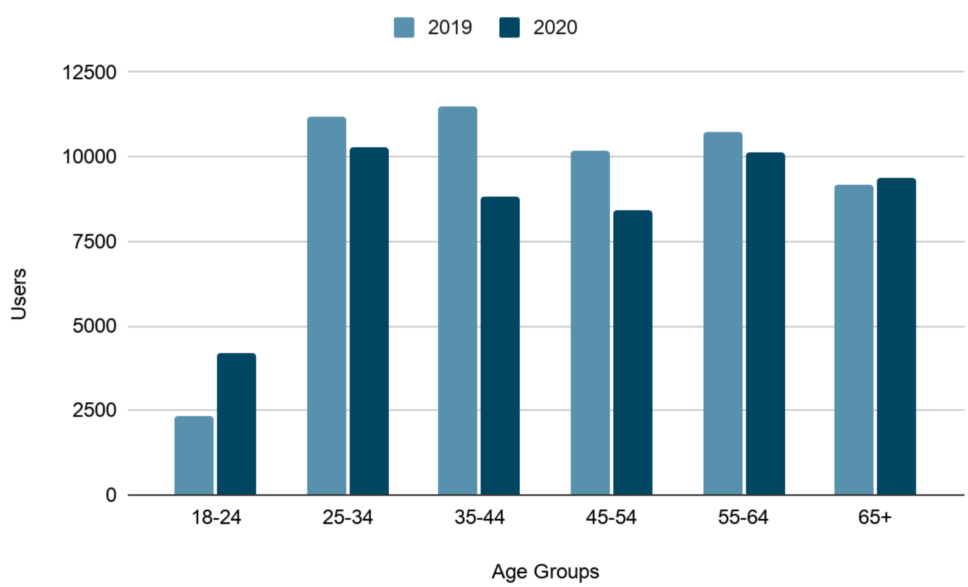
Figure F-2: Rebates Pageviews 2018 - 2020



F.4.1 Site Visitors: By Age

Website visitors by age had a few changes from 2019 to 2020. We saw a decrease in all age groups in sessions besides 18-24 and 65+.

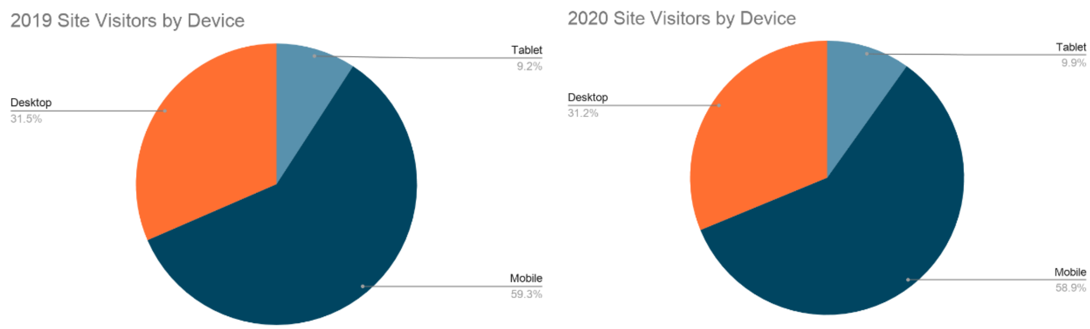
Figure F-3: Age Group Comparison 2019 - 2020



F.4.2 Site Visitors: By Device

More people are using their mobile devices compared to the traditional desktop. We see from 2019 to 2020 that our Desktop access has decreased and both Tablet and Mobile device access are increasing.

Figure F-4: 2019 - 2020 Site Visitors by Device



F.4.3 Website Events

Event tracking was adjusted to capture the most relevant website actions. The data below represents the top events by number of events though 2020.

Table F-1: Website Events 2020

EVENT TYPE	# OF EVENTS
Find a Retailer/Provider – Home Rebates	10,186
My PSO Account – Footer Link	4,080
Power Hours Sign Up	4,074
Weatherization Form	2,817
Find a Builder	141
Peak Performers Call Now	734
Peak Performers Enroll Now (external)	155
Small Business Energy Audit Request Form	406
Schedule a Consultation – Business – Contact Form	225
Small Business Energy Consult - Link	54
My Energy Advisor - Create Your Energy Profile	1,150

F.4.4 Website Engagement

The following pages have the most engagement – determined by total pageviews.

Table F-2: Website Engagement 2020

PAGE DESCRIPTION	PAGEVIEWS
Homepage - Residential	141,649
Rebates – Residential	130,345
Save the Watts Landing Page	53,642
Tips & Tools - Residential	37,969
Weatherization Assistance	36,417
Peak Performers	31,495

F.5 Paid Search Results

Paid search is being utilized to capture customers at the bottom of the sales funnel. In 2020, we consistently 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.

Table F-3: Paid Search Results

PAID SEARCH IMPRESSIONS	
Residential	27,313
Commercial	66,928

Top Search Terms: PSO energy, powerforwardwithpso, saving energy, energy efficiency, energy star rebate, home rebates, Energy Saving Rebates, heating & A/C, PSO Rebates

F.6 Web Traffic - Social

Social media continues to be a strong driver of traffic to the website. In 2020, we added NextDoor and Reddit into the media mix in order to diversify and reach customers across a variety of platforms where content is consumed.

Table F-4: Social Web Referrals

SOCIAL WEB REFERRALS	Count
Users	11,138
Sessions	12,636
Conversions	0

The top referral channels were from Facebook, Pinterest, and LinkedIN.

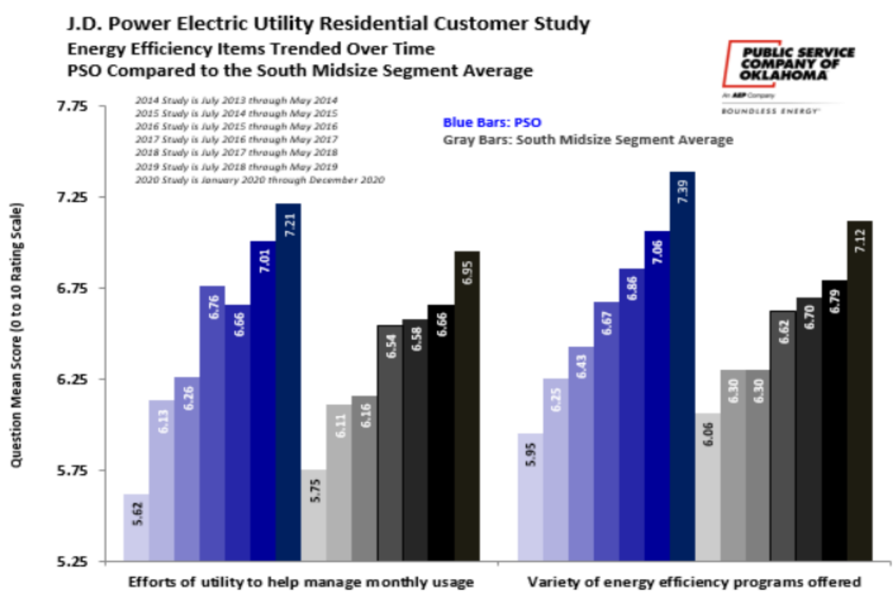
Table F-5: Top Referral Channels

TOP REFERRAL CHANNELS	USERS
Facebook	5,877
Pinterest	6,397
LinkedIn	192

F.7 J.D. Power Scores

J.D. Power provides electric utility customer satisfaction scores that PSO uses for marketing purposes. The figure below shows satisfaction scores from residential customers. PSO has 63% energy efficiency program awareness among residential customers which is above segment average and near best in class of 70%.

Figure F-5: PSO's J.D. Power Scores



F.8 Video Performance

In 2020, PSO continued the marketing strategy of utilizing multiple vendors to reach a wider customer base. We continue to add new vendors that can help us reach our audience with the unique message for them.

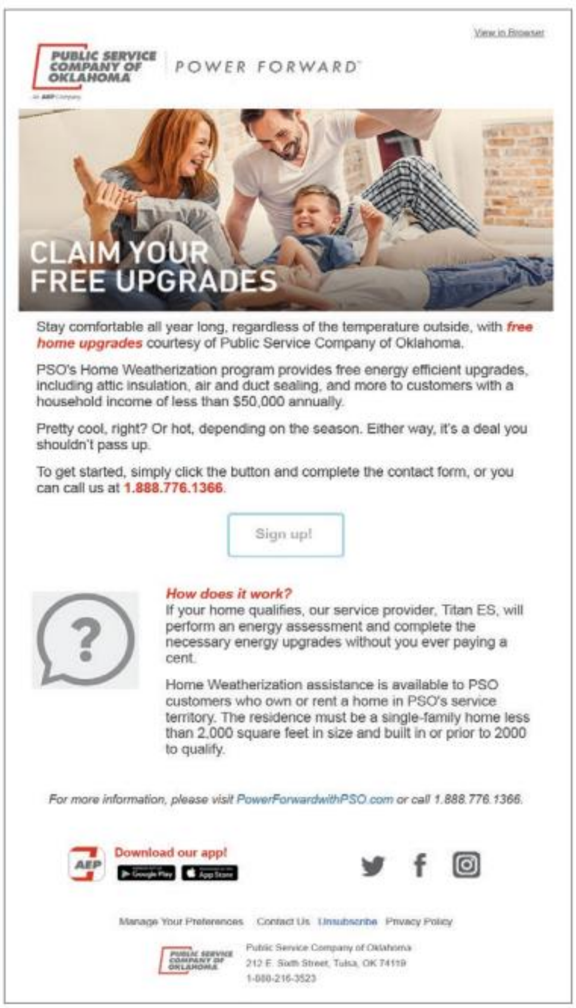
Table F-6: YouTube Channel Performance

Video Type	Impressions	Views	Clicks
Residential	820,610	122,959	1,048
Commercial	1,682,234	117,213	2,548

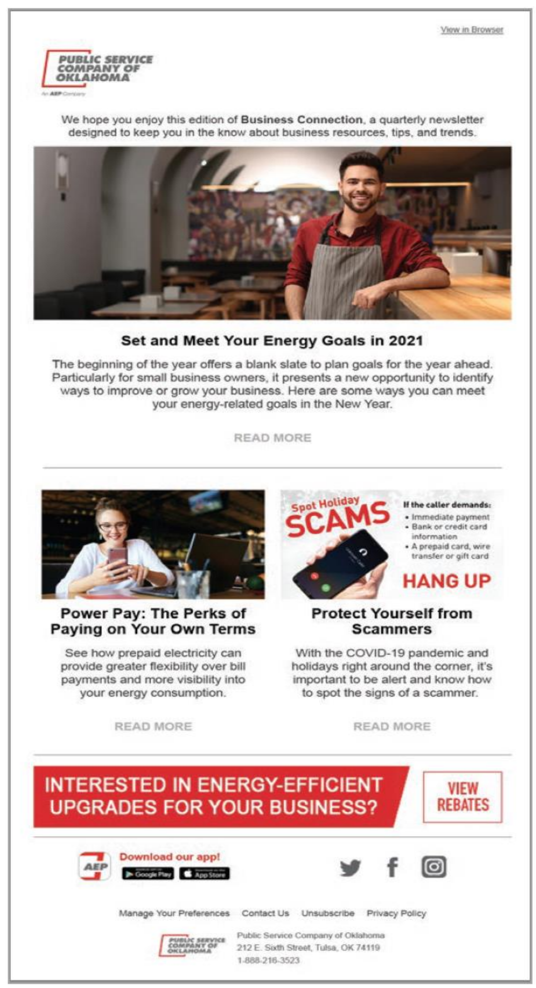
F.9 Email Marketing

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. In 2020, a quarterly newsletter was created to share energy efficiency tips with small business customers.

Targeted e-mail campaigns resulted in 1,575 Weatherization requests & 150+Small Business audit requests. Examples are shown below.



Free Upgrades Email



Business Connection E-Newsletter

F.10 Residential Newsletter

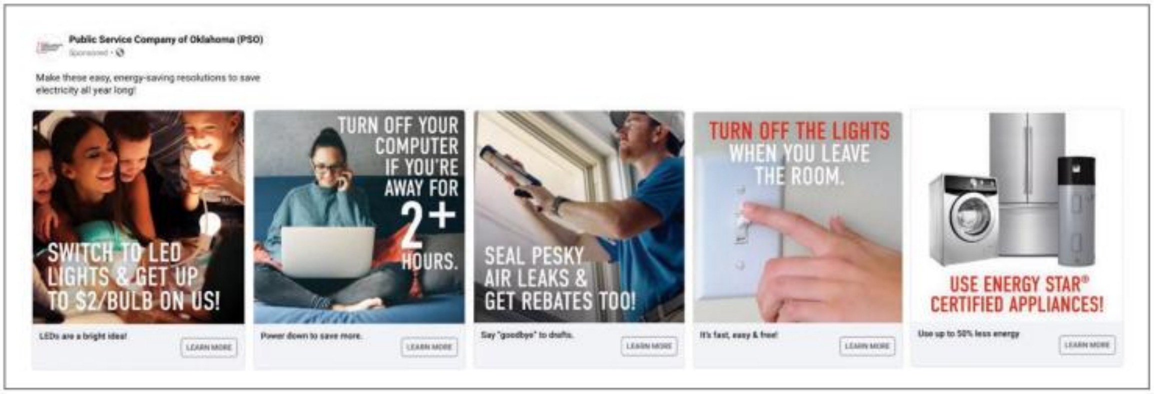
A residential newsletter was sent to approximately 310,000 customers monthly. Content highlights energy-saving blog content, energy tips and available rebates. Customers are encouraged to visit the Power Forward with PSO website.

Monthly E-Newsletters

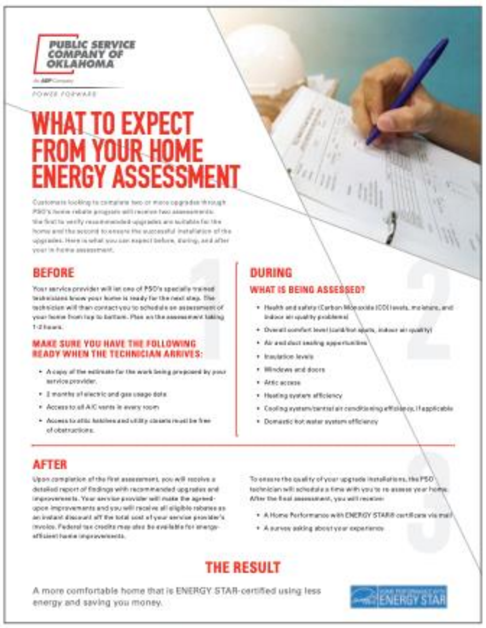
Clicks from the newsletter account for 33,498 visits to the website for 2020. A 28% increase from 2019.

F.11 Creative Examples: ENERGY STAR

Examples of additional online marketing materials are shown below.



Facebook - Tips Carousel



COVID Home Energy Assessment Flyer

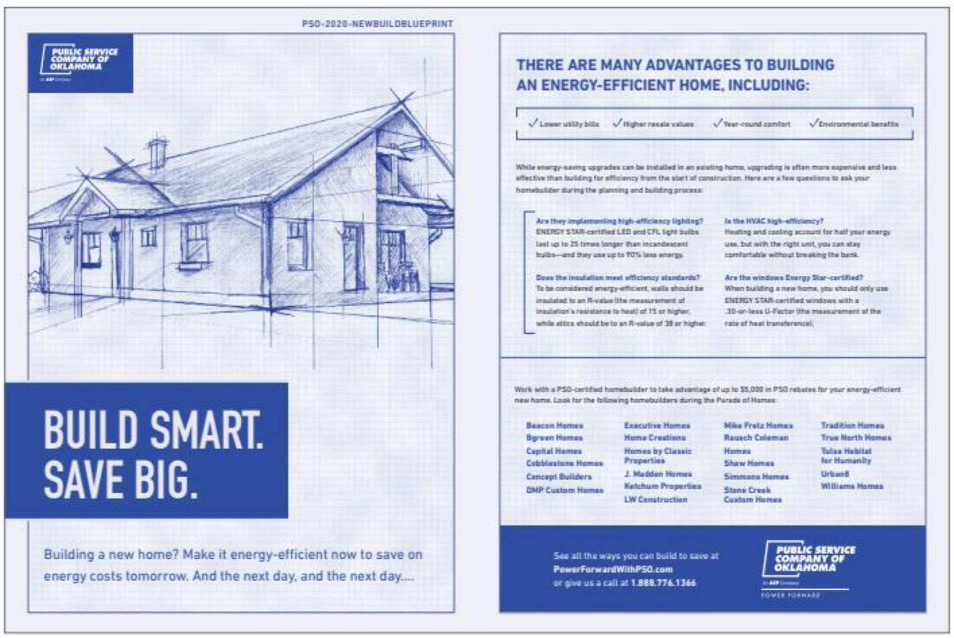
Parade of Homes New Home Flyer

F.12 Creative Examples: Residential Programs

Examples of additional marketing material are shown below.

NWS Weatherization Postcard - A

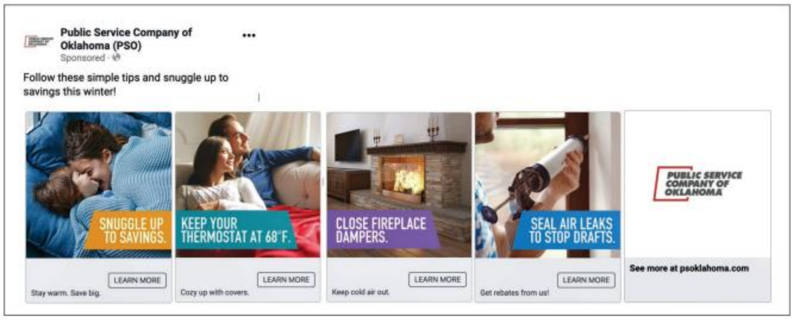
Weatherization Postcard Update - Front



Parade of Homes Print Ad

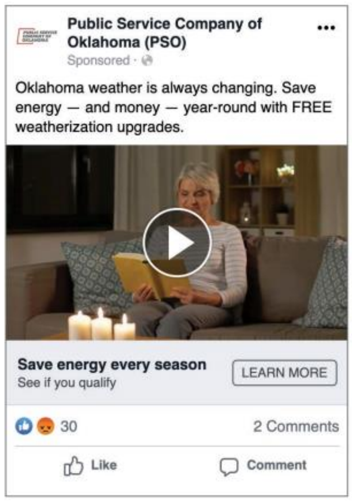
March Bill Insert

F.12.1 SOCIAL



Facebook - Tips Carousel

Reddit - Weatherization



Pinterest - Working From Home Tips - A

Facebook - Shine-A-Light - A

Facebook - Shine-A-Light - B

Pinterest - Working From Home Tips - B

Pinterest - Tips Carousel

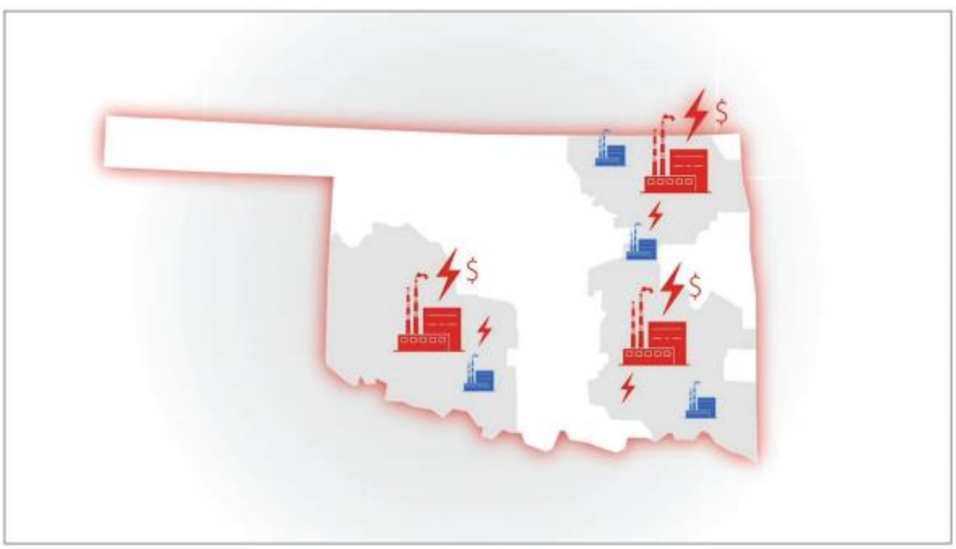
F.12.2 VIDEO

Fall Tips

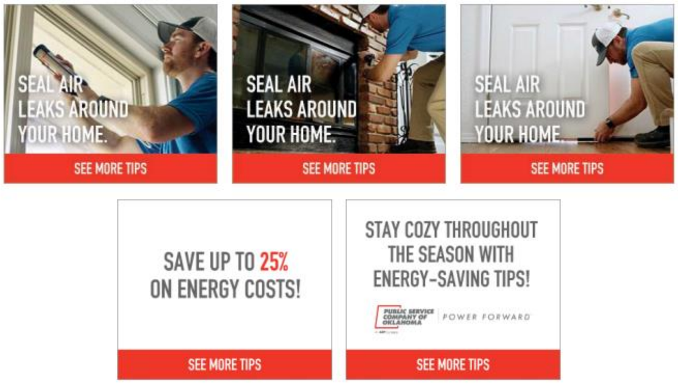
New Home Construction Rebates

Spring Preroll - A

Holiday/Winter Tips

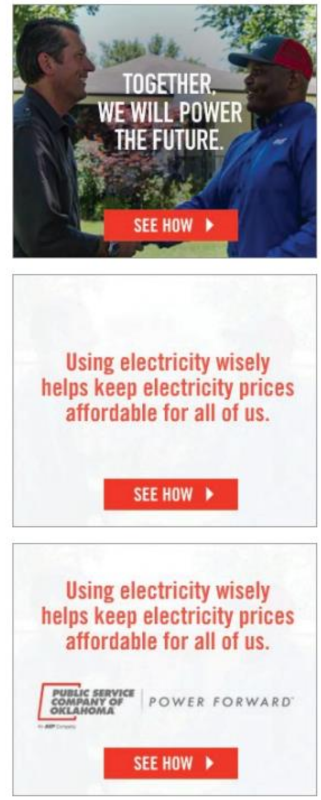

Energy Efficiency

F.12.3 DIGITAL BANNER ADS



Air Leaks

AARP - Digital Display



Winter Tips

Centro Energy Efficiency - A

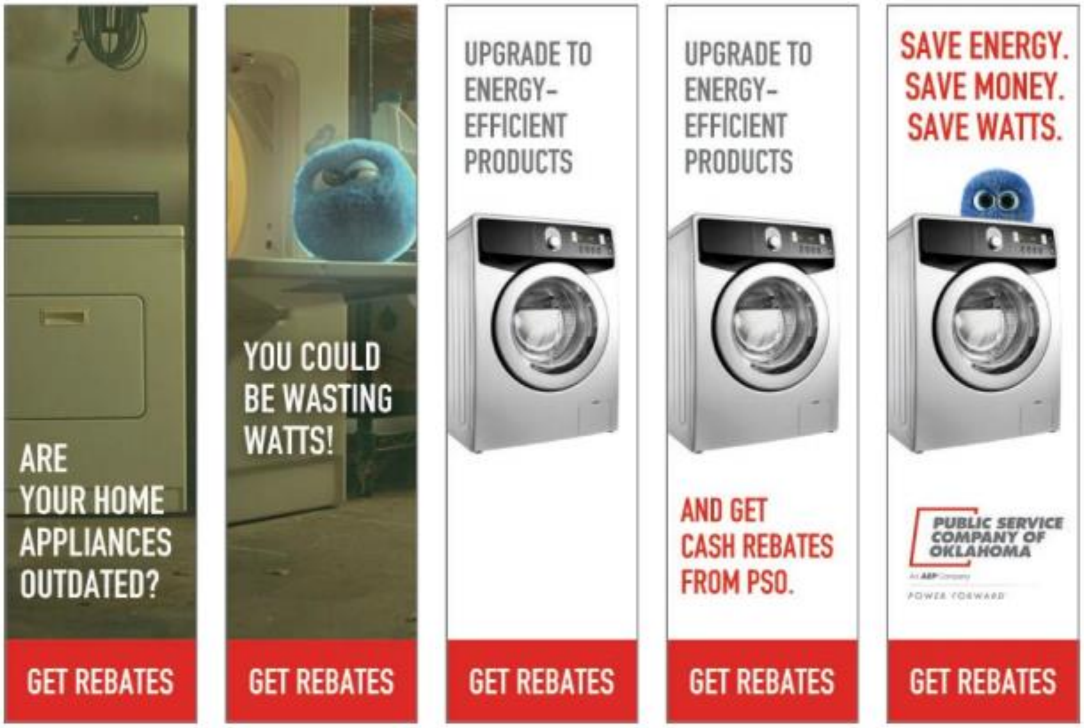
La Semana

Centro Energy Efficiency - B

New Home Construction Rebates

F.13 Creative Examples: Residential Watts

In 2020, PSO expanded the "Watts" campaign, which focused primarily on educating customers about how inefficient equipment in their homes is wasting electricity.

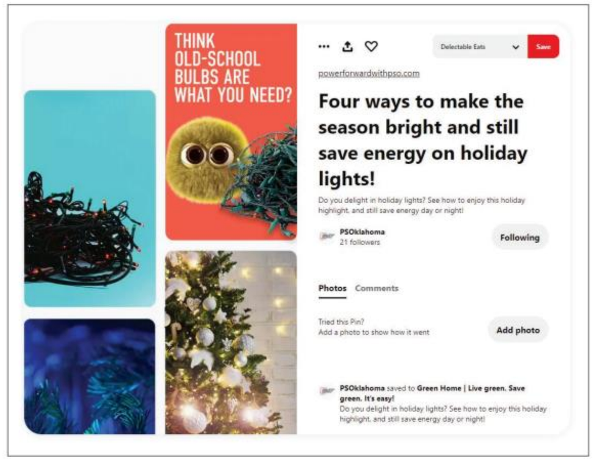


Watts - Appliances

Watts - Appliance Upgrades

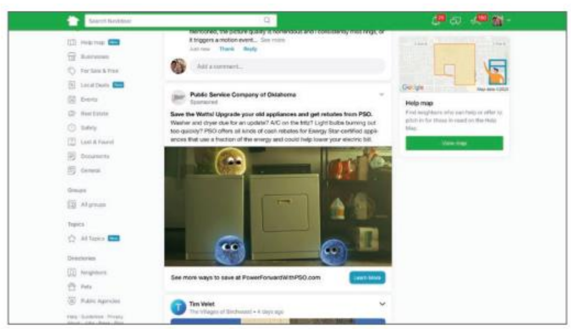
Facebook - Air Leaks Instant Experience

Facebook - Appliances Instant Experience



Pinterest - Holiday Tips Video Ad

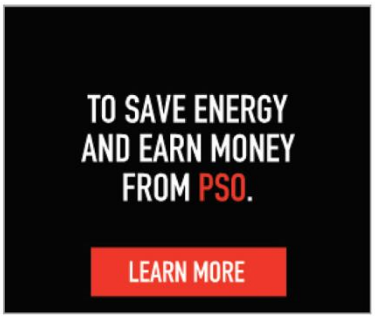
Watts Window Clings



Nextdoor - Watts - Appliance Upgrades

F.14 Creative Examples: Commercial Programs

F.14.1 DIGITAL BANNER ADS



Oil & Gas/Agriculture Rebates - B

Industry-Specific Rebates

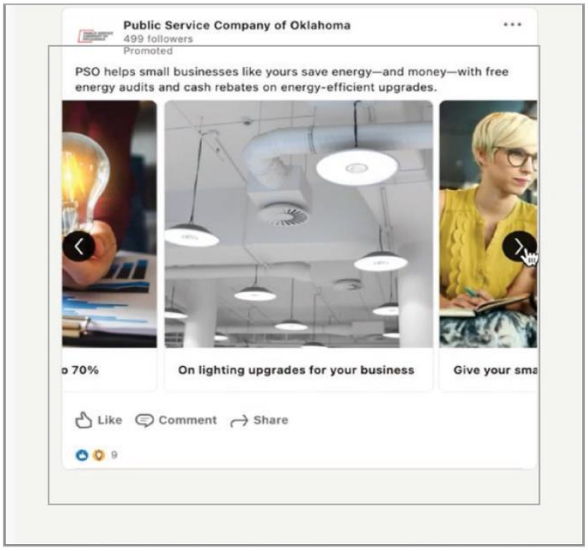
Tulsa Chamber - Memo Monday Static Display

F.14.2 PRINT / OUT OF HOME

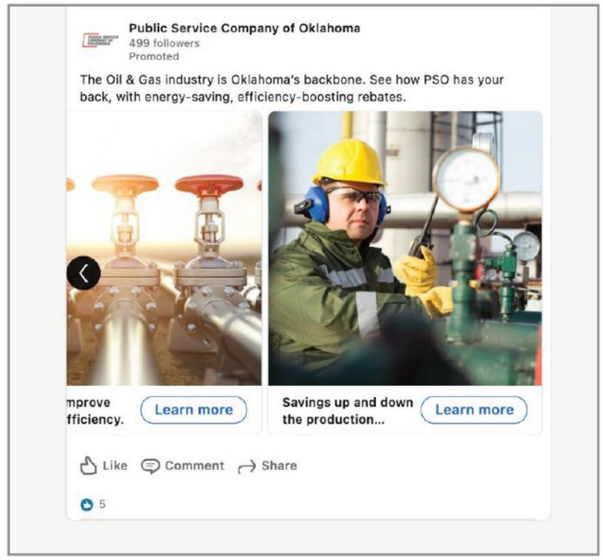
Tulsa People - Peak Performers

Tulsa People - Commercial Lighting Upgrades

F.14.3 SOCIAL / LINKEDIN



LinkedIn - Carousel



LinkedIn - Oil & Gas Carousel

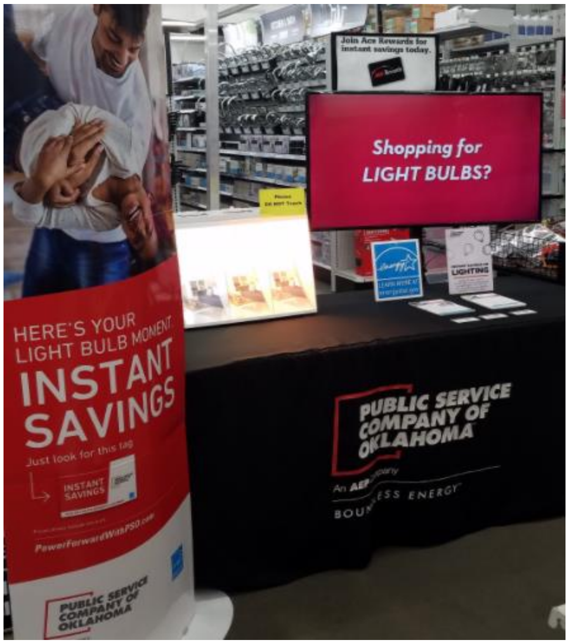
F.14.4 Video

Commercial Rebates Update

F.15 Community Engagement

Traditionally, PSO participates in a variety of community events, including tradeshows, lighting demonstrations, program presentations, seminars and more. However, due to the pandemic PSO in-person events were suspended beginning in March 2020. Instead, PSO used marketing materials and non-manned booths to help educate customers on rebate and program offerings.

- 27 internal training presentations
- 24 training/promotional events
- 48 in-store retailer lighting promotions



Appendix G. OKDSD, AR, & IL TRM Deemed Savings and Algorithms

G.1 Energy Efficiency Programs

G.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[111] (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:

G.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 determined through M&V practices but may be 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.

[111] 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.

G.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 is prepared. Calibration is based on actual billed usage during actual weather conditions. Once the analysis model has been calibrated for a particular facility, there are 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 is analyzed at the facility with all conditions the same but with the energy efficiency measures now installed. Third, the results are 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.

G.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) makes 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 in order to obtain the data needed on operating schedules. The data thus collected is 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.

G.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 energy management system data collection or 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.

For large projects, a billing regression analysis is often the most accurate representation of consumption changes due to energy efficiency measures. ADM adheres to ASHRAE Guide 14 to ensure the results are statistically representative. In addition, ADM will interview the site contact to ensure that no other operational changes or other energy efficiency measures are impacting consumption.

G.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 are more involved based on the additional data and documentation that is included in the savings calculations.

Methods include the range of International Performance Measurement & Verification Protocols, as shown in Table G-1 below. An emphasis is 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 are used for retro-commissioning projects as well.

Table G-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.

G.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.

G.1.2.1 Infiltration Reduction

ADM utilized the AR TRM for the savings algorithms. 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 G-1: Annual Energy Savings

$$kWh_{Savings} = CFM\ X\ ESF$$

Equation G-2: 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 G-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

G.1.2.2 Duct Sealing

ADM utilized the Oklahoma Deemed Savings Document (OKDSD) in conjunction with the duct leakage reduction results in order to calculate 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 G-3: Cooling Savings

$$kWH_{savings,C} = \frac{(DL_{pre} - DL_{\mathbf{post}}) X\ EFLH_C\ X\ (h_{out}\rho_{out} - h_{in}\rho_{in})\ X\ 60}{1000\ X\ SEER}$$

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 G-3

h = Outdoor/Indoor seasonal specific enthalpy (Btu/lb), from Table G-4

ρ_{out} = Density of outdoor air (lb/ft3) from Table G-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[112]

Table G-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

[112] Average of US DOE minimum allowed SEER for new air conditioners from 1992-2006 (10 SEER) and after January 23,2006 (13 SEER).

Table G-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 G-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 G-4: 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 G-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 G-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 G-5: Heating Savings (Electric Resistance)

$$kWH_{savings,C} = \frac{(DL_{pre} - DL_{\boldsymbol{post}})\ X\ 60\ X\ 0.77\ X\ HDD\ X\ 24\ X\ .018}{3{,}412}$$

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 G-6

0.018 = Volumetric heat capacity of air (Btu/ft3°F)

3,412 = Constant to convert from Btu to kWh

G.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 G-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

G.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 G-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

G.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 G-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

G.1.2.6 Low Flow Showerheads

This measure consists of removing existing showerheads and installing low flow showerheads in homes with electric water heating. The deemed savings are per low flow showerhead installed. The newly installed showerheads should not be easily modified to increase the flow rate in order for the unit to be eligible. The baseline flow rate is 2.5 gallons per minute (gpm) and the efficient showerhead is 1.5 gpm which saves 3,246 gallons of water per year and has a ratio of 0.000104 peak kW demand reduction to annual kWh savings.

ADM used AR TRM 7.0 to determine savings for four weather zones (see Table G-10).

Table G-10: Savings for Low Flow Showerheads (1.5 gpm)[113]

• Weather Zone	Average water main temperature (°F)	Mixed water temperature (°F)	Gross kWh savings	Gross Peak kW Demand Savings
• 9	65.6	103.7	308	0.032
• 8	66.1	103.9	306	0.032
• 7	67.8	104.4	296	0.031
• 6	70.1	105.1	283	0.029

G.1.2.7 Faucet Aerators

This measure involves the retrofit of aerators on kitchen and bathroom water faucets. The deemed savings are per faucet aerator installed. The baseline faucet flow rate is 2.2 gallons per minute (gpm) and the efficient faucet aerators is 1.5 gpm.

The AR TRM 7.0 provides deemed savings for four weather zones (see Table G-11).

Table G-11: Savings for Faucet Aerators (1.5 gpm)[114]

• Weather Zone	Average water main temperature (°F)	Mixed water temperature (°F)	Gross kWh savings	Gross Peak kW Demand Savings
• 9	65.6	102.0	35	0.004
• 8	66.1	102.2	34	0.004
• 7	67.8	102.7	33	0.003
• 6	70.1	103.5	32	0.003

G.1.2.8 Advanced Power Strips

This measure involves the installation of a 5-plug Advanced Power Strip (APS) that can automatically disconnect related equipment loads (i.e., speakers, video games, Blu-ray, etc.) depending on when the “master” device (i.e., television) is turned off. The baseline condition for this measure is the absence of an APS, where the devices are connected to a traditional power strip or wall outlet.

The AR TRM provides average whole system deemed savings for home office and home entertainment systems. It is most likely that APS will be installed for home entertainment purposes; therefore, ADM will apply the following deemed savings equation that pertains

[113] AR TRM 7.0 Table 160 and Table 162.
[114] AR TRM 7.0 Table 155 and Table 157.

to home entertainment systems using APS. These systems can typically include a television, media player (DVD, Blu-Ray), gaming console (Xbox, PlayStation, Nintendo), and audio equipment. The APS deemed savings are as follows:

$$kWh = 252.2\ kWh$$

$$kW = 0.030\ kW$$

G.1.2.9 ENERGY® STAR Omni-Directional LEDs

ADM will use AR TRM 7.0 to assess savings and demand reduction for the installation of ENERGY STAR® Omni-Directional LEDs (9.5W). The AR TRM v7.0 specifies the following formula for use in calculating energy and demand impacts of ENERGY STAR Omni-Directional LEDs measures.

Equation G-6: ENERGY® STAR Omni-Directional LED Energy Savings

$$LED\ kWh\ savings\ = \left(\frac{\Delta Watts}{1000}\right) * ISR * Hours * IEF_E$$

Where:

∆Watts	= Average delta watts for specified measure. The baseline wattage for PY2020 is 43W according to EISA 2007 Baselines. The installed LED lightbulb wattage for PY2020 is 9.5W.
ISR	= In-Service Rate. The percentage of LEDs distributed that are installed within one year of purchase. = 0.97 (Table 219 in AR TRM 7.0)
Hours	= Average hours of use per year = 365 days in year * Daily usage (hours/day) for residential lamps. ADM has reviewed all well-regarded and recent metering studies and calculated an unweighted average across HOU per lamp across all studies to reduce the possibility of bias. ADM will use a value of 2.63 hours * 365.25 days in year. = 960.61 hours
IEFE	= Interactive Effects Factor to account for cooling energy savings and heating energy penalties (Table 220 in AR TRM 7.0).

Equation G-7: ENERGY® STAR Omni-Directional LED Summer Peak Demand Savings

$$LED\ kW_{savings} = (\frac{\Delta Watts}{1000}) \times CF \times ISR \times IEF_D$$

Where:

CF = Summer peak coincidence factor for measure, 10% indoor and 0% outdoor (Table 221 in AR TRM v7.0)

IEFD = Interactive Effects Factor to account for cooling demand savings and heating demand penalties; this factor also applies to outdoor and unconditioned spaces (Table 222 in AR TRM v7.0).

Table G-12: ENERGY STAR Omni-Directional LED – Interactive Effects Factor, Gross kWh Savings, and Peak kW Demand Reduction[115]

Heating Type	IEF_E	IEF_D	Gross kWh savings	Gross Peak kW Demand Savings
Gas Heat with AC	1.10	1.29	34	0.0042
Gas Heat with no AC	1.00	1.00	31	0.0032
Electric Resistance Heat with AC	0.83	1.29	26	0.0042
Electric Resistance Heat with no AC	0.73	1.00	23	0.0032
Heat Pump	0.96	1.29	30	0.0042
Heating/Cooling Unknown	0.97	1.25	30	0.0041

G.1.2.10 Mobile Home Air Infiltration

The prescriptive like savings were calculated using the AR TRM 7.0. The savings are typically calculated by multiplying the leakage improvement (CFM) by the deemed kWh savings. The deemed kWh savings are dependent on heating and cooling type along with the weather zone.

ADM calculated average savings per square feet (kWh/sq.ft.) in an effort to adjust savings for each mobile home while minimizing inputs needed (heat/cool type, weather zone, etc). This allows for the implementer to calculate air infiltration savings by simply gathering the homes' square footage.

The proposed air infiltration algorithms are as follows.

$$kWh = 0.416\ \frac{kWh}{sq.ft}\ x\ Homes\ sq.ft.$$

[115] AR TRM 7.0 Table 220 and Table 222.

$$kW = 0.00014\ \frac{kW}{sq.ft}\ x\ Homes\ sq.ft.$$

Where:

$$0.416\ \frac{kWh}{sq.ft} = Average\ savings\ per\ sq.ft., calculated\ as\ follows;$$

$$0.416\ \frac{kWh}{sq.ft.} = \frac{Average\ Air\ Infiltration\ Savings}{Average\ Home\ Sq.ft.}$$

$$0.416\ \frac{kWh}{sq.ft} = \frac{544\ kWh}{1{,}307\ sq.ft.}$$

$$Homes\ sq.ft. = Square\ footage\ of\ home\ being\ serviced\ by\ non\ profit$$

G.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.[116] 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)[117], the Texas TRM v6.0 (TX TRM)[118], or the 2016 Pennsylvania TRM (PA TRM).[119]

G.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 G-6 above.

Peak demand savings for LEDs discounted through the program were also calculated using the algorithm from the OKDSD, shown in Equation G-7 above.

---

[116] Residential Oklahoma Deemed Savings, Installation & Efficiency Standards, *prepared by* Frontier Associates, LLC; November 27, 2013.
[117] Illinois Statewide Technical Reference Manual for Energy Efficiency, version 7.0 volume 3: Residential Measures, September 28, 2018.
[118] Texas Technical Reference Manual, version 6.0 volume 2: Residential Measures, November 7, 2018.
[119] 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 PY2019-2021, ADM utilized the AR TRM Protocol K: Leakage 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. 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 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.

G.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.[120] Thus, kWh energy savings for RAPs were calculated via Equation G-8, below.

Equation G-8: 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 G-13 below

[120] 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.

kWh_{ESTAR} = ENERGY STAR® kWh consumption per year; based on Table G-13 below

Table G-13: kWh per Year Usage Based on Clear Air Delivery Rate[121]

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 G-9, shown below:

Equation G-9: 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[122]

CF = Summer Peak Coincidence Factor for measure

= 0.667[123]

Table G-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

[121] Reproduced after lookup table on pg. 7 of the IL TRM.
[122] 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.
[123] Assumes appliance use is evenly spread throughout the year. As stipulated in the IL TRM, see footnote 8 on pg. 7 of the TRM.

G.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 G-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

G.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 G-10: 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[124]

[124] As stipulated by the IL TRM for standard usage with an unknown minimum and maximum CFM, see pg. 125 of the TRM.

$\eta_{Baseline}$ = Average efficacy for baseline fan

= 2.2[125]

$\eta_{Efficient}$ = Average efficacy for efficient fan

= 5.3[126]

$Hours$ = Assumed annual run hours for continuous ventilation

= 1,089[127]

Demand savings (kW) were calculated via the following formula, and is set at 0.0034 kW:

Equation G-11: 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[128]

$\eta_{Baseline}$ = Average efficacy for baseline fan

= 2.2[129]

$\eta_{Efficient}$ = Average efficacy for efficient

= 5.3[130]

CF = Summer peak coincidence factor for standard usage

= 0.135[131]

---

[125] As stipulated by the IL TRM for standard usage with an unknown minimum and maximum CFM, see pg. 125 of the TRM.
[126] As stipulated by the IL TRM for standard usage with an unknown minimum and maximum CFM, see pg. 125 of the TRM.
[127] As stipulated by the IL TRM for standard usage with an unknown minimum and maximum CFM, see pg. 125 of the TRM.
[128] As stipulated by the IL TRM for standard usage with an unknown minimum and maximum CFM, see pg. 125 of the TRM.
[129] As stipulated by the IL TRM for standard usage with an unknown minimum and maximum CFM, see pg. 125 of the TRM.
[130] As stipulated by the IL TRM for standard usage with an unknown minimum and maximum CFM, see pg. 125 of the TRM.
[131] As stipulated by the IL TRM for standard usage with an unknown minimum and maximum CFM, see pg. 125 of the TRM.

G.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 G-16.

Table G-16: Default Savings for ENERGY STAR® Water Dispensers[132]

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

G.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.[133] 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 G-12: Energy Savings (WM)

$$WM\ kWh\ savings\ = \mathrm{D}kWh_{cooling} + \mathrm{D}kWh_{heating}$$

Equation G-13: Cooling Energy Savings (WM)

$$\mathrm{D}kWh_{cooling} = \frac{1.08 \times \mathrm{D}CFM_{50} \quad \times CDD \times 24 \times LM \times DUA}{N \times \eta_{cool} \times 1{,}000}$$

Equation G-14: Heating Energy Savings (WM)

$$DkWh_{heating} = \frac{1.08 \times DCFM_{50} \times HDD \times 24}{N \times \eta_{heat} \times 3{,}412}$$

Equation G-15: Peak Demand Savings (WM)

$$WM\ kW\ savings = \frac{\mathrm{D}kWh_{cooling} \times PCF}{1{,}000}$$

132 Reproduced after Table 2-95, pg. 165 of the PA TRM.

133 Addendum document to the 2016 Pennsylvania TRM[119] for weather stripping, caulking, and outlet gaskets.

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)[134]

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[135]

CDD = Cooling degree-days per year

= 2,095 [136]

HDD = Heating degree-days per year

= 3,971[137]

η_{cool} = Cooling system efficiency

= 13[138]

η_{heat} = Heating system efficiency

= 2.3[139]

DUA = Discretionary use adjustment (accounts for uncertainty in residential occupants' cooling system usage patterns)

= 0.75[140]

LM = Latent multiplier for conversion of sensible load to total (sensible and latent) load

---

[134] 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.

[135] As stipulated by the PA TRM Weather Stripping IMP, see Table 1-1, pg. 3 of the IMP.

[136] 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.

[137] 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.

[138] Assuming central air conditioning installed after 1/23/2006 – see Table 1-4 on pg. 5 of the PA TRM Weather Stripping IMP.

[139] Assuming air-source heat pumps installed after 1/23/2006 – see Table 1-5 on pg. 5 of the PA TRM Weather Stripping IMP.

[140] As stipulated by the PA TRM Weather Stripping IMP, see Table 1-1, pg. 3 of the IMP.

	= Total load ÷ sensible load = 8.5 ÷ 2.0 = 4.3[141]
$1{,}000$	= Conversion factor between kilowatts and watts
$3{,}412$	= Conversion factor between kilowatt hours and Btu
PCF	= Peak demand savings conversion factor
	= 0.017[142]

G.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 G-16 and Equation G-17, respectively.

Equation G-16: 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 G-17: 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 G-17
η_{post}	= Energy efficiency rating (EER) of the installed cooling equipment, see Table G-17
RAF	= Room AC adjustment factor
	= 0.49[143]
$EFLH_C$	= Equivalent full-load cooling hours, see Table G-18.

[141] 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*.
[142] As stipulated by the PA TRM Weather Stripping IMP, see Table 1-1, pg. 3 of the IMP.
[143] As stipulated by the AR TRM, see derivation described in Table 67, pg. 75 of the TRM.

CF = Coincidence factor

= 0.87[144]

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 G-17.

Table G-17: RAC Replacement – Baseline and Efficiency Standards[145]

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 G-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 G-18: RAC Replacement – Equivalent Full-Load Cooling Hours[146]

Weather Zone	$EFLH_C$
9	431
8b	490
7	555
6	573

[144] As stipulated by the AR TRM, see pg. 74 and footnote 80 in the TRM.
[145] Reproduced after Table 65, pg. 73 of the AR TRM.
[146] Reproduced after Table 61, pg. 64 of the OKDSD; values shown are pertinent to room air conditioners.

G.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 G-18 and Equation G-19, respectively.

Equation G-18: 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 G-19: 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[147]
	= 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[148]
EER_{post}	= Deemed cooling efficiency of the equipment following tune-up
	= 11.2[149]
$EFLH_C$	= Equivalent full load hours for cooling based on weather zone (see Table G-19*)*
DF_C	= Cooling demand factor
	= 0.87[150]
FL	= Factor to account for air filter useful life
	= 0.16667

[147] As stipulated by the TX TRM, pg. 2-345.
[148] As stipulated by the TX TRM, pg. 2-58.
[149] As stipulated by the TX TRM, pg. 2-58 and 2-60.
[150] As stipulated by the TX TRM, see footnote 122 on pg. 2-61 of the TRM.

Table G-19: Equivalent Full Load Hours[151]

Weather Zone	$EFLH_C$
6	1,738
7	1,681
8a	1,436
8b	1,486
9	1,305

G.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 G-20:

Equation G-20: 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 G-21 below)

$T_{SetPoint}$ = Water heater set point

= 120°F[152]

[151] Reproduced after Table 61 of the OKDSD, pg. 64.
[152] As stipulated by the AR TRM, pg. 128.

T_{Supply} = Average supply water temperature, determined based on storage volume and draw pattern[153] (shown in Table G-22 below)

EF_{pre} = Baseline energy factor, determined based on storage volume and draw pattern[154]

EF_{post} = Energy Factor of new HPWH

$PA\%$ = Performance adjustment to account for ambient air temperature per DOE guidance

$= 0.00008 \times T_{amb}^3 + 0.0011 \times T_{amb}^2 - 0.4833 \times T_{amb} + 0.0857$[155]

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 G-25 below.

Table G-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

153 As stipulated by look up Table 138, pg. 122-123 of the AR TRM.
154 As stipulated by look up Table 138, pg. 122-123 of the AR TRM.
155 As stipulated by the AR TRM, pg. 128.

Table G-21: Estimated Annual Hot Water Use (gal)[156]

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

Table G-22: Average Water Main Temperature[157]

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 G-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 G-24: Average Ambient Temperatures (T_{amb}) by Installation Location[158]

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

[156] Reproduced after Table 142, pg. 125 of the AR TRM.
[157] Reproduced after Table 143, pg. 126 of the AR TRM.
[158] Reproduced after Table 144, pg. 128 of the AR TRM.

Table G-25: HPWH Adjustment[159]

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 G-21: Peak Demand Savings (HPWH)

$$kWsavings = kWh_{savings} \times Ratio_{Annual\ kWh}^{Peak\ kW}$$

Where:

$\mathrm{Ratio}_{\mathrm{Annual\ kWh}}^{\mathrm{Peak\ kW}}$ = 0.0000877[160]

[159] Reproduced after Table 145, pg. 129 of the AR TRM.
[160] As stipulated by the AR TRM, pg. 130.

G.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 of 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 G-22: 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)[161]

$\mathrm{CEF_{base}}$ = 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 G-26: Combined Energy Factor$_{base}$ by Product Class[162]

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.

[161] As stipulated by the IL TRM, see pg. 46 and footnote 115 of the TRM.
[162] Reproduced after CEF$_{base}$ look up table on pg. 46 of the IL TRM.

Table G-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[163]

$\%Electric$ = The percent of overall savings coming from electricity

= 100% (electric dryers) or 16% (gas dryers)[164]

Demand savings were calculated via the following formula:

Equation G-23: Peak Demand Savings (CD)

$$CD\ kWsavings = \frac{kWh_{savings}}{Hours} \times CF$$

Where:

$Hours$ = Annual run hours of clothes dryer

= 283[165]

CF = Summer peak coincidence factor

=0.038[166]

G.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 G-28* Since some configurations produce 0 kWh savings, ADM computed a weighted average

[163] As stipulated by the IL TRM, see pg. 46 and footnote 120 of the TRM.
[164] As stipulated by the IL TRM, see pg. 47 and footnote 121 of the TRM.
[165] As stipulated by the IL TRM, see pg. 47 and footnote 122 of the TRM.
[166] As stipulated by the IL TRM, see pg. 47 and footnote 123 of the TRM.

savings value for clothes washers and applied that single value to all clothes washers rebated through the program.

Table G-28: ENERGY STAR® Clothes Washer – Deemed Savings in Retrofit or New Construction Applications[167]

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

[167] Reproduced after Tables 172 and 173, pg. 167 of the AR TRM with additional entries calculated via savings equations provided in the TRM.

G.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 G-24.

Equation G-24: 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 G-29

kWh_{ES} = ENERGY STAR® average energy usage, Table G-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 G-25. 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 G-26.

Equation G-25: Energy Savings for RUL (RF)

$$RF\ kWhsavings_{ER} = (kWh_{manf} \times (1 + PDF)^{n}\ \times SLF) - kWh_{ES}$$

Equation G-26: 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[168]

PDF = Performance degradation factor

= 0.0125 per year[169]

n = Age of replaced refrigerator (years)

SLF = Site/Lab Factor

= 0.81[170]

---

[168] As stipulated by the AR TRM, see pg. 179 and footnote 240 in the TRM.
[169] As stipulated by the AR TRM, see pg. 179 and footnote 241 in the TRM.
[170] As stipulated by the AR TRM, see pg. 179 and footnote 242 in the TRM.

TAF = Temperature adjustment factor

= 1.188[171]

$LSAF$ = Load shape adjustment factor

= 1.074[172]

Table G-29: Example Formulas to Calculate the ENERGY STAR® Criteria for Each Refrigerator Product Category by Adjusted Volume[173]

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

171 As stipulated by the AR TRM, see pg. 180 and footnote 244 in the TRM.
172 As stipulated by the AR TRM, see pg. 180 and footnote 245 in the TRM.
173 Reproduced, in part, after Table 177 on pg. 176-177 of the AR TRM.

G.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 measure (no appreciable demand savings (kW) were recorded). For each unit rebated through the program, energy savings was calculated using Equation G-27.

Equation G-27: 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[174]

$avgMPG_e$ = Average MPG_e (kWh/100 miles) of electric vehicles currently on the market

= 32[175]

EER_{base} = Energy efficiency rating of the base technology (Level 1 EVC)

= 0.822[176]

$EER_{efficient}$ = Energy efficiency rating of the efficient technology (Level 2 EVC)

= 0.853[177]

ES_{gain} = Efficiency gain of an ENERGY STAR® certified Level 2 EVC[178]

= 56

---

[174] 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

[175] 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.

[176] 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*.

[177] 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*.

[178] Environmental Protection Agency (2013) ENERGY STAR® Market and Industry Scoping Report: Electric Vehicle Supply Equipment.

G.1.4 Home Rebates Program – Single Upgrade and Multiple Upgrades Components

This section includes the measure level algorithms and deemed savings values utilized for the verified gross kWh and kW savings calculations.

G.1.4.1 Infiltration Reduction

ADM utilized the AR TRM for the savings algorithms and deemed savings values shown in Section G.1.2.1, Equation G-1 and Equation G-2.

G.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 G.1.2.2: Equation G-3, Equation G-4, and Equation G-5.

G.1.4.3 Duct Replacement

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 G-30: Duct Replacement 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 G-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

G.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 G-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

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
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 G-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

G.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 G-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

G.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 G-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

G.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 G-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

G.1.4.8 Air Conditioner and Air Source Heat Pump Retrofits

ADM utilized the OKDSD for the savings algorithms.

Equation G-28: 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 G-29: 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 G-30: 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)[179]

$SEER_{Base}$ = Season Energy Efficiency Ratio of existing cooling equipment

$SEER_{post}$ = Season Energy Efficiency Ratio of installed cooling equipment

[179] Rated capacity of the new unit shall not exceed capacity of the existing unit; if completing this with other measures, use existing unit capacity.

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)

G.1.4.9 Ground Source Heat Pumps

ADM utilized the savings algorithms found in the OKDSD for units that meet the minimum efficiency requirements.

Equation G-31: Annual Energy Savings (Ground Source Heat Pump)

$$kWh_{\boldsymbol{savings,Clg}} = Cap\ X\ \frac{1\ kW}{1{,}000\ W}\ X\ EFLH_C\ X\ \left(\frac{1}{EER_{Base}} - \frac{1}{EER_{GSHP}}\right)$$

$$kWh_{\boldsymbol{savings,Htg}} = Cap\ X\ \frac{1\ kW}{3{,}412\ Btu}\ X\ EFLH_H\ X\ \left(\frac{1}{COP_{Base}} - \frac{1}{COP_{GSHP}}\right)$$

Equation G-32: Peak Demand Reduction (Ground Source Heat Pump)

$$kW_{\boldsymbol{savings}} = CAP\ X\ \frac{1\ kW}{1{,}000\ W}\ X\left(\frac{1}{EER_{Base}} - \frac{1}{EER_{post,AC/HP}}\right) X\ CF$$

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

G.1.4.10 Omni-directional LEDs

ADM utilized the OKDSD for the savings algorithms and deemed savings values shown in Section G.1.2.6: Equation G-6 and Equation G-7.

G.1.4.11 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 G-37: 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

G.1.4.12 Mobile Home 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 G.1.2.2: Equation G-3, Equation G-4, and Equation G-5.

G.1.4.13 HVAC Tune-Ups

ADM used Method 2[180] from the AR TRM v7 algorithm and is a change in efficiency based on pre- and post- measurement of the system. This measure involves tuning up existing HVAC units and deemed savings factors were based on the pre and post EER of the HVAC unit. For each unit rebated through the program, energy savings and peak demand reduction were calculated using Equation G-33 and Equation G-34.

[180] Calculation of savings based on pre or pre and post measurement of system efficiency, and age of equipment.

Equation G-33: Annual Energy Savings (HVAC Tune-Up)

$$kWh_{savings,c} = CAP_c \times \frac{1\ kW}{1{,}000\ W} \times EFLH_c \times \left(\frac{1}{EER_{pre}} - \frac{1}{EER_{post}}\right)$$

$$kWh_{savings,H} = CAP_H \times \frac{1\ kW}{1{,}000\ W} \times EFLH_H \times \left(\frac{1}{HSPF_{pre}} - \frac{1}{HSPF_{post}}\right)$$

$$kWh_{savings,HP} = kWh_{savings,C} + kWh_{savings,H}$$

Where:

CAP_C	= Rated or calculated equipment cooling capacity (Btu/hr)
CAP_H	= Rated or calculated equipment heating capacity (Btu/hr)
EER_{pre}	= Calculated or measured efficiency of the equipment for cooling before tune-up
EER_{post}	= Measured or calculated efficiency of the existing equipment for cooling; if unknown, use 11.2 EER (default)
$HSPF_{pre}$	= Calculated or measured efficiency of the equipment for heating before tune-up
$HSPF_{post}$	= Measured or calculated efficiency of the existing equipment for heating; if unknown, use 7.7 HSPF (default)
$EFLH_C$	= Equivalent full-load cooling hours
$EFLH_H$	= Equivalent full-load heating hours

Equation G-34: Peak Demand Reduction (HVAC Tune-Up)

$$kW_{savings,} = CAP_c \times \frac{1\ kW}{1{,}000\ W} \times \left(\frac{1}{EER_{pre}} - \frac{1}{EER_{post}}\right) \times CF$$

Where:

CF	= Coincidence Factor
	= 0.87 (default)

Other variables as define above.

G.1.4.14 New Home Construction RESNET Standards

The New Homes Construction savings methodology is followed by the Residential Energy Services Network (RESNET) standards. RESNET standards are industry wide standards that are recognized for verification of building energy performance by the EPA. Savings methodology that is in conformance with these standards are built into the Ekotrope modeling software and approved by RESNET.

G.1.5 Education Program

G.1.5.1 ENERGY STAR® LEDs

The energy savings for ENERGY STAR® LEDs were calculated by using the following equations as specified in the AR TRM, 7.0. 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 G-35: Energy Savings for LED bulbs

$$kWh_{savings} = \left(\frac{\Delta Watts}{1{,}000}\right) x\ Hours\ x\ ISR\ x\ IEF_E$$

Equation G-36: Demand Reduction LED bulbs

$$kW_{demand\ reduction} = \left(\frac{\Delta Watts}{1{,}000}\right) x\ CF\ x\ ISR\ x\ IEF_D$$

Where:

$\Delta Watts$ = The difference in watts between a baseline bulb and the distributed LED. Baseline wattages will be determined based on the wattage and brightness (lumen) of the measure and the EISA baseline standards.

$Hours$ = Average hours of use per year

= 960.61 hours[181]

ISR = In-service rate, the percentage of LEDs distributed that are installed.

CF = Summer Peak Coincidence Factor for measure.[182] An average coincident factor is calculated based on the reported installation location from student survey.

Lamp Location	CF
Indoor	10%
Outdoor	0%

IEF_E = Interactive effects factor to account for cooling energy savings and heating energy penalties as specified in the AR TRM, based on home heating and cooling condition reported in student survey responses.

[181] Based on the ADM 2016 benchmarking study.
[182] As stipulated in the AR TRM Version 7.0, Vol. 2, page 220.

IEF_D = Interactive effects factor to account for cooling demand savings as specified in the AR TRM, based on home heating and cooling condition reported in student survey responses.

G.1.5.2 Advanced Power Strips (APS)

ADM utilized the deemed savings values for "residential" applications from the AR TRM, version 7.0.

Table G-38: Demand and Annual Energy Savings for Advanced Power Strips[183]

System Type	kW Demand Reduction	kWh Savings
Residential		
Home Entertainment System	0.030	252.2
Home Office	0.008	82.5
Average APS	0.019	167.4

G.1.5.3 FilterTone® Alarm

The energy savings and peak demand reductions for FilterTone® Alarms were calculated by using the following equations from the PA TRM. Inputs to algorithms were determined from the data from the participant surveys in combination with algorithms and inputs found in the PA TRM.[184]

Equation G-37: Energy Savings for FilterTone® Alarms

$$kWh_{savings} = (EFLH_{Heat} + EFLH_{Cool})\ x\ kW_{motor}\ x\ EI\ x\ ISR$$

Equation G-38: Peak Demand Reduction for FilterTone® Alarms

$$kW_{demand\ reduction} = kW_{motor}\ x\ EI\ x\ ISR\ x\ CF$$

Where:

$EFLH_{Heat}$ = Assumed to be 800 hours[185]

$EFLH_{Cool}$ = Assumed to be 800 hours

[183] As stipulated in the AR TRM, Version 7.0, Vol. 2, page 188.
[184] As stipulated in the 2016 PA TRM, pg 70.
[185] $EFLH_{Heat}$ and $EFLH_{Cool}$ based on PSO's 2019-2021 DSM Portfolio Plan

kW_{motor}	= Average motor full load electric demand (kW), assumed to be 0.5 kW.[186]
EI	= Efficiency improvement
	= 15%[187]
CF	= Coincidence factor for peak demand reduction
	= 0.87[188]
ISR	= In-service rate, or percentage of units that get installed, from student survey.

G.1.5.4 LED Night Light

ADM utilized the following equation for calculating the kWh savings from the PA TRM.[189] There are no peak demand reductions associated with LED night lights.

Equation G-39: Energy Savings for LED Night Lights

$$kWh_{savings} = \left[\left(W_{base} - W_{post} \right) \times \left(\frac{Hours \times 365 \frac{days}{year}}{1000 \frac{W}{kW}} \right) \right] \times ISR$$

Where:

W_{base}	= Baseline wattage, assume incandescent night light
	= 7 W[190]
W_{post}	= Wattage of installed LED night light
	= 1 W[191]
$Hours$	= Number of hours per day the nightlight is assumed to operate
	= 12 hours[192]
ISR	= In-Service Rate, or percentage of delivered units that get installed, based on student survey responses.

---

186 As stipulated in the 2016 PA TRM, pg 71
187 As stipulated in the 2016 PA TRM, page 72.
188 Coincidence factor for demand reduction HVAC systems, as stipulated in the AR TRM Version 8.1, Vol 2, page 542.
189 2016 PA TRM, page 28.
190 2016 PA TRM, page 27.
191 Ibid
192 Ibid

G.1.6 Multifamily Program

G.1.6.1 Air Infiltration

ADM utilized the AR TRM for the savings algorithms shown in Section G.1.2.1: Equation G-1 was used annual energy savings (kWh) and Equation G-2 was used to calculate peak demand savings (kW).

G.1.6.2 Ceiling Insulation

ADM utilized the AR TRM for the deemed savings shown in Section G.1.2.3: Table G-7.

G.1.6.3 Duct Sealing

ADM utilized the OKDSD for the savings algorithms shown in Section G.1.2.2: Equation G-3 is used to determine annual cooling savings, and Equation G-4 and Equation G-5 are used to determine heating savings for electric resistance heat and gas heat, respectively.

G.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 G-40: 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 = 0.000104

Table G-39

T_{Supply} = Average supply water temperature, see = 0.000104

Table G-39

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 G-41: 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 G-39: 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**

G.1.6.5 Heat Pump

ADM utilized the OKDSD for the savings algorithms shown in Section G.1.4.8, Equation G-28 and Equation G-29 are used to calculate annual energy savings (kWh) and Equation G-30 for peak demand reduction (kW).

G.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 G-42: 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 0.000104

Table G-40

T_{Supply} = Average supply water temperature, see 0.000104

Table G-40

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 G-43: 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 G-40: 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

G.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 G-44: 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 G-41)

$hours_{HS,VS}$ = 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 G-42)

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 G-41)

$PFR_{HS,VS}$ = 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 G-42)

$PFR_{HS,MS}$ = ENERGY STAR® multi-speed pump low speed flow rate (gal/min) (Table G-42)

EF_{conv} = Conventional single-speed pump energy factor (gal/W·hr) (Table G-41)

$EF_{HS,VS}$ = 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 G-42)

$EF_{LS,MS}$ = ENERGY STAR® multi-speed pump low speed energy factor (gal/W·hr) (Table G-42)

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 G-42)

60 = Constant to convert between minutes and hours

1000 = Constant to convert W to kW

Table G-41: 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 G-42: 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 G-45: Peak Demand Savings (Pool 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

G.1.6.8 Clothes Dryer

For the Multifamily program, ADM utilized the deemed values for energy savings and algorithm for demand reduction from the Mid-Atlantic TRM. Energy savings are made available for ENERGY STAR® certified Clothes Dryers.

Table G-43: ENERGY STAR® Windows Deemed Savings

Product Class	Algorithm	ΔkWh
Vented or Ventless Electric, Standard (≥ 4.4 ft^3)	= ((8.45/3.11 – 8.45/3.93) * 311 * 100%	176.3
Vented or Ventless Electric, Compact (120V) (< 4.4 ft^3)	= ((3/3.01 – 3/3.80) * 311 * 100%	64.4
Vented Electric, Compact (240V) (< 4.4 ft3)	= ((3/2.73 – 3/3.45) * 311 * 100%	71.3
Ventless Electric, Compact (240V) (< 4.4 ft3)	= ((3/2.13 – 3/2.68) * 311 * 100%	89.9
Vented Gas	= ((8.45/2.84 – 8.45/3.48) * 311 * 16%	27.2

Demand reduction were derived using the following equation:

Equation G-46: Peak Demand Savings (Poop Pumps)

$$\Delta kW = \frac{\Delta kWh}{Hours} * CF$$

Where:

ΔkWh = Energy Savings

Hours = Annual run hours of clothes dryer.

= 290 hours per year.

CF = Summer Peak Coincidence Factor for measure

= 2.9%

G.1.6.9 ENERGY STAR® Clothes Washers

ADM utilized the AR TRM for the deemed savings values shown in section G.1.3.11: *Table G-28*.

G.1.6.10 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 G-44: 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

G.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 G.1.1.1.

G.1.8 Behavioral Modification Program

G.1.8.1 Calculation of Average Daily kWh Savings

ADM utilized the mixed effects panel regression model specified in *Equation G-47* to determine daily average electricity savings for treatment group members.

Equation G-47: Mixed Effects Panel Regression Model

$$AEC_{i,t} = \alpha_i \mathrm{Customer_i} + \beta_1 CDD_{i,t} + \beta_2 HDD_{i,t} + \beta_3 Post_{i,t} + \beta_4 Post_{i,t} * Treat_{i,t} + \beta_5 Post_{i,t} * CDD_{i,t} + \beta_6 Post_{i,t} * HDD_{i,t} + E_{i,t}$$

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 on the following page in Table G-45.

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 above 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 under which it is assumed that a building needs no cooling). A minimum value of 0 is used for both HDD and CDD.

Table G-45: 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 1 if the monthly period is after the customer received their first energy report and 0 if not
Treatment	Treatment is a dummy variable that is 1 if the customer is a member of the treatment group and a 0 if not
E_t	E_t is the error term

Table G-46 describes the coefficients that were determined by using the mixed effects panel model shown in Equation G-47.

Table G-46: 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 for 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 heating.

G.1.8.2 Calculation of Annual Energy Savings

The average daily annual energy savings value for the post period treatment groups is defined as coefficient β_4 in the regression model. To determine per participant annualized savings, the annual energy savings value is multiplied by 366[193] days for waves 1, 2, and 3. Wave 4 annualized savings are calculated by multiplying the annual energy savings

[193] Since 2020 is a leap year, the savings calculations account for 29 days in February 2020 for a total of 366 days in the year.

value by 365 days, since treatment began March 1, 2020 and therefore does not include the February 2020 leap day. The verified annual energy savings for the program is determined by multiplying the annualized annual energy savings by the number of participants in the treatment group.

G.1.8.3 Calculation of Coincident Peak Demand Reduction

The peak demand reduction was determined by applying the program annual energy savings to a normalized hourly load shape that represents typical residential energy consumption, resulting in an 8,760 hourly annual savings curve. The selected load shape was the same used to determine estimates for the Behavioral Modification Program during portfolio planning. An average value across the peak demand window was drawn from the energy savings curve. The peak demand window is defined as consumption non-holiday weekdays between 2 PM and 6 PM in the months of June through September.

G.2 Demand Response Programs

G.2.1 Power Hours Program

The impact of the Power Hours Program is measured in two parts. The first is measuring the peak reduction (kW) and energy savings (kWh) during DLC events. The second is measuring the annual energy savings from the smart thermostat incentives. The following section defines how these savings are calculated.

G.2.1.1 Direct Load Control Events

Two Power Hours subprograms include a direct load control component: DLC and DLC + 2T-TOD. Tracking data for these subprograms, provided by PSO, is used to identify which devices are 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 participates in the events. Thus, devices that are non-responsive to the called events need to be identified so that the calculation of energy savings included only devices that participate in the event.

Once non-responsive devices have been filtered out of the analysis, savings can be calculated. Usage data along with local weather data are used to calculate each event's baseline curve using a linear regression model (Equation 4-7).

Equation G-48: Baseline Energy Usage Curve Regression Model

$$kW_t = CDD_t + CDD_{t-2} + t$$

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 one hour before t

To ensure the baseline curves are as accurate as possible, a normalizing factor is calculated and applied to the baseline curve of each event day (Equation 4-8).

Equation G-49: 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

With the baseline curve determined, demand reduction can be calculated. Demand reduction represents the average decrease in energy usage that occurs for the average event participant during a given time interval. Demand reduction is calculated for the event period and the snapback period. Equation 4-9 shows the formula for calculating demand reduction.

Equation G-50: 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 is then used to calculate average annual energy savings for each event. The equation is shown in Equation 4-10.

Equation G-51: 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 is calculated for each event, representing the maximum drop in energy usage that occurred for the average event participant. The equation is shown in Equation 4-11.

Equation G-52: 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

G.2.1.2 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 G-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

G.2.2 Peak Performers Program

G.2.2.1 PSO Methodology for Estimating Customer Baselines

For the purposes of financial settlement with Peak Performer participants, PSO uses a "top 3-oG-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:

6. For an event day *D*, *D(h)* is the participant's actual electric demand at hour h on *D*.
7. Starting with the day before *D*, the eligible baseline days are the most recent 10 non-weekend, non-holiday, non-Peak Event days.
8. 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.

9. The hourly loads are averaged for the top three days identified in the previous step. This is the unadjusted baseline, *B(h)*.
10. 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-oG-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.

G.2.2.2 ADM Baseline Methodology

In the case of evaluating demand reduction impacts associated with the Peak Performers Program baselines or counterfactuals represent what participants' usage would have been if the event had not occurred. In 2020, 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 G-48: Peak Performers Baseline Models

Model Name	Description
3 of 10 Unadjusted	Model described in Section G.2.2.1 without the adjustment described in step 5.
3 of 10 Scalar Adjusted	Model described in Section G.2.2.1 but allows for a ±30% day of adjustment.
3 of 10 Additive Adjusted	Model described in Section G.2.2.1 but allows an adjustment of the actual demand difference in kW between *B(h)* and *D(h)* described in Section G.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 G.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 G.2.2.1, but with 5 baseline days selected and allows for a ±30% adjustment.
5 of 10 Additive Adjusted	Model described in Section G.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 G.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 G.2.2.1Section G.2.2.1, but with 7 baseline days selected and allows for a ±30% adjustment.
7 of 10 Additive Adjusted	Model described in Section G.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 G.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 G.2.2.1, but with 9 baseline days selected and allows for a ±30% adjustment.
9 of 10 Additive Adjusted	Model described in Section G.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 matched test event day usage to the five most similar event eligible non-event days. The days selected serve as a good proxy for the test event days and will be referred to as proxy event days. The proxy event days were then used to identify baseline “best fits” for each premise ID using residual root mean squared error (RRMSE) scores.

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.

G.2.2.3 Baseline Methodology for Small Sites

All models with less than or equal to 550 kW reported reduction were compared to the proxy test event days using RRMSE with the three best fitting models being selected and weighted in the way described in Section G.2.2.2.

G.2.2.4 Baseline Methodology for Large Sites

For the twenty sites with the largest kW reductions in the program (greater than 550 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 test event days using RRMSE with the three best fitting models selected and weighted in the way described in Section G.2.2.2.

Appendix H. 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 (Reno) and the California Bay Area (Fremont). ADM has remote staff located throughout the country. 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 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 I. Lighting Discounts Price Response Model Details

I.1 Introduction

To develop one estimate of free ridership for discounted LED bulb sales for the Energy Savings and Products Program (ESP), 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.

I.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 PY2020 (48 weeks) and a portion of PY2019 (4 weeks). Additional records regarding dates and retail locations of in-store promotional events were 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 I-1: Count of SKUs by Bulb Type and Store Type

Bulb Type	Discount	DIY	Mass Merchant	Total
LED Directional	9	77	52	**138**
LED Omni-Directional	14	124	43	**181**
Total	**23**	**200**	**95**	**318**

Table I-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	188,160	138	$10.18	$2.94
LED Omni-Directional	65,885	181	$13.11	$4.13
Total	**254,045**	**318**	**$11.56**	**$3.50**

I.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[194] and Michigan.[195] 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[196] 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

[194] http://www.efficiencymaine.com/docs/Efficiency-Maine-Residential-Lighting-Program-Final-Report_FINAL.pdf

[195] http://www.nmrgroupinc.com/wp-content/uploads/2013/10/Consumers-Energy_2013-ES-Lighting_Price-Elasticity-Model.pdf

[196] 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.[197] Seasonal effects on sales quantities were controlled for through a set of monthly dummy variables.

After determining the general modeling approach,[198] 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 I-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
LargeDiscountDummy = a binary variable equaling 1 if the discount on the pack is greater than $10; 0 otherwise

---

[197] 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.

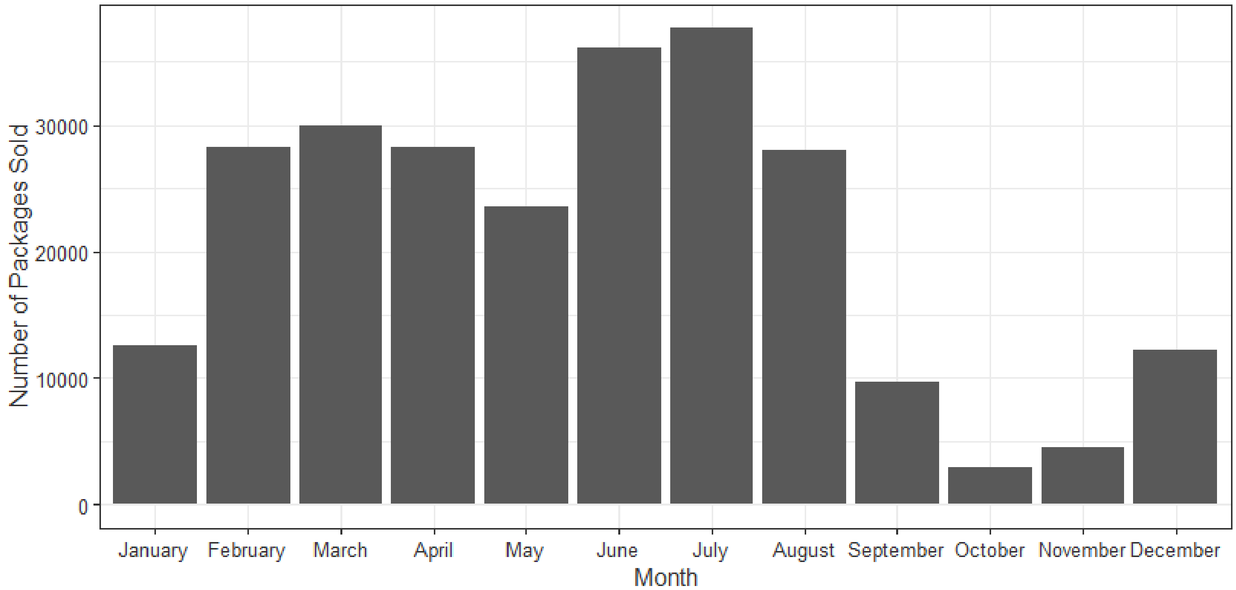
[198] Hurdle models, Poisson models, and zero-inflation models were all considered. However, the nature of the "zero" sales quantities eliminated hurdle and zero-inflation models. Overdispersion eliminated the Poisson model from consideration.

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 I-1 shows total package sales by during each month of PY2020 and demonstrates clear demand fluctuation across months.

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 I-1: PY2020 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 I-3: Negative Binomial Regression - Price Response Model for Standard LEDs (Dependent Variable: Bulb Packages Sold / Week)

Variable	Coefficient	Standard Error	z	p-value
Constant	5.27	0.29	18.45	< 0.01
ln(Price)	-0.19	0.016	-11.65	< 0.01
EventDummy	-0.08	0.11	0.75	0.46
August	-0.18	0.05	-3.48	< 0.01
December	0.05	0.06	0.80	0.42
February	-0.15	0.05	-2.93	< 0.01
January	-0.26	0.07	-3.92	< 0.01
July	-0.10	0.05	-1.85	0.06
June	-0.24	0.05	-4.70	< 0.01
March	-0.15	0.05	-2.97	< 0.01
May	-0.14	0.05	-2.79	0.01
November	0.27	0.10	2.66	0.01

Variable	Coefficient	Standard Error	z	p-value
October	0.02	0.11	0.23	0.82
September	-0.31	0.07	-4.79	< 0.01
LargeDiscountDummies	0.38	0.15	2.49	0.01
ModelNumberDummies	OMITTED			

Table I-4: Negative Binomial Regression - Price Response Model for Specialty LEDs (Dependent Variable: Bulb Packages Sold / Week)

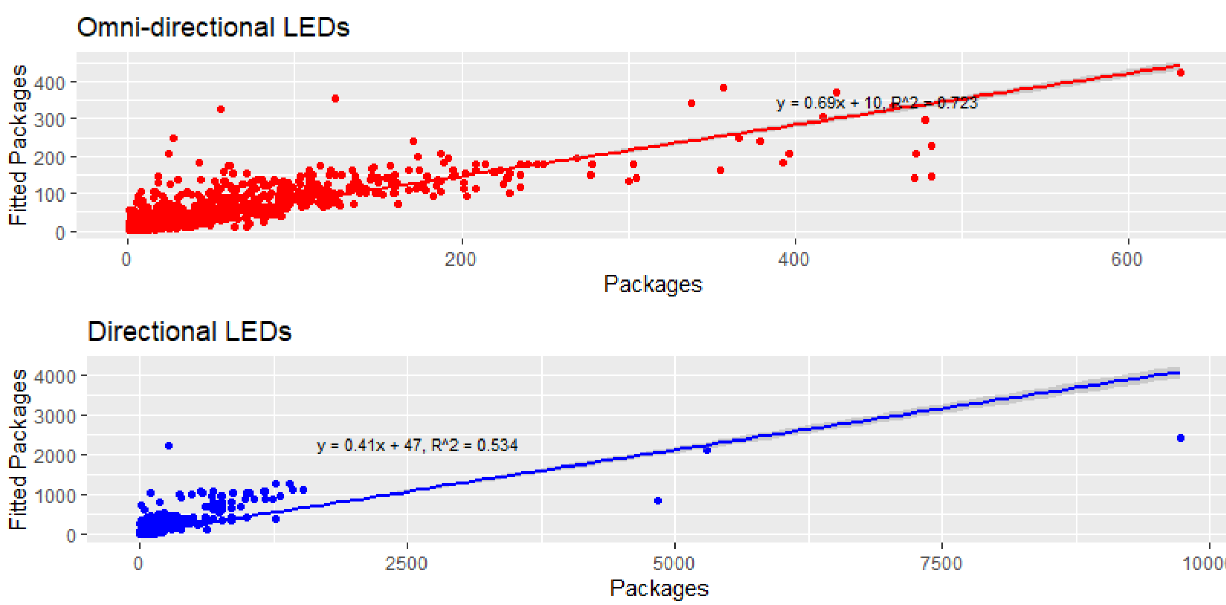
Variable	Coefficient	Standard Error	z	p-value
Constant	7.81	0.35	22.24	< 0.01
ln(Price)	-0.11	0.02	-6.18	< 0.01
EventDummy	0.10	0.17	0.61	0.54
August	-0.12	0.07	-1.63	0.10
December	0.08	0.08	1.01	0.31
February	-0.07	0.06	-1.20	0.23
January	-0.23	0.09	-2.55	0.01
July	0.10	0.07	1.37	0.17
June	-0.04	0.06	-0.54	0.59
March	0.02	0.06	0.29	0.77
May	-0.26	0.06	-3.97	< 0.01
November	0.34	0.09	3.90	< 0.01
October	0.12	0.09	1.30	0.19
September	-0.44	0.07	-6.33	< 0.01
Packsize	-1.72	0.17	-10.05	< 0.01
LargeDiscountDummies	0.16	0.22	0.74	0.46
ModelNumberDummies	OMITTED			

Table I-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
Directional LED	18,629.48	2,196	-18,331.48	18,631.48	19,485.71	2,245.08	2,048
Omni-directional LED	10,149.97	1,923	-13,901.73	14,289.73	15,368.79	1,968.22	1,731

Figure I-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 I-2: Actual Packages vs. Fitted Package Sales – Price Response Model



I.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.[199] A free ridership ratio was calculated using the following formula:

Equation I-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).
$E[Bulbs_{Program_i}]$	= 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 42.2%, as shown in the table below.

Table I-6: Price Response Model Free Ridership Estimates

Bulb Type	Estimated Free Ridership	Estimated Net-to-Gross
Directional LEDs	0.420	0.580
Omni-Directional LEDs	0.431	0.569
Overall	**0.422**	**0.578**

I.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:

[199] 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.

- Estimate is developed from actual sales data as opposed to customer selG-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-oG-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.