Public Service Company of Oklahoma 2024 Energy Efficiency & Demand Response Programs: Annual Report

Prepared for:

Oklahoma Corporation Commission

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165:35-41-7. Reporting

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Table of Contents

List of Tables

List of Figures

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 the Public Service Company of Oklahoma (PSO) in 2024. 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 filed a comprehensive portfolio of energy efficiency and demand response programs (Portfolio Filing) to the Oklahoma Corporation Commission (OCC) for Program Years 2022 - 2024. This portfolio was approved by the OCC in Cause No. PUD 2021000041. The focus of this report is participation during the third program year, 2024, of the implementation cycle, spanning from January 1, 2024, to December 31, 2024.[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 2022 – 2024 portfolio.[2]
- **Reported Impacts:** refer to energy savings (kWh) and peak demand (kW) reduction estimates based on customer participation in 2024.
- **Verified Impacts:** refer to energy savings (kWh) and peak demand (kW) reduction estimates for 2024 developed through independent program evaluation, measurement, and verification (EM&V).
    - **Realization Rate:** The difference between verified impacts and reported impacts is often referred to as the Realization Rate (RR). This is calculated as the verified impact divided by the reported impact. Therefore, an RR greater than 100% represents verified impacts greater than reported impacts.
    - **Gross Verified Impacts:** refer to energy savings (kWh) and peak demand (kW) reduction estimates developed through measurement and verification practices.

[1] All the programs represent program participation from January 1, 2023 – December 31, 2023, except the Energy Saving Products Program. The reported savings for LED retail discounts span the period of December 1, 2022 – November 30, 2023. This offset allows for the reconciliation of retail sales data and manufacturer/retailer invoices.
[2] Approved by the OCC in Cause No. PUD 2021000041.

- **Net Verified Impacts:** refer to gross verified energy savings (kWh) and peak demand (kW) reduction estimates which are the result of program influence.

PSO's independent, third-party evaluator, ADM Associates, Inc. (ADM), performed 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 and calculations, 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 1.2, Appendix B:, and 5.4.4Appendix C:, where 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, verified annual energy savings and peak demand reduction during 2024 are summarized in the following sections.

1.1 2024 Program Offerings

PSO offered customers a suite of residential energy efficiency subprograms under Residential Energy Services, a suite of commercial and industrial energy efficiency subprograms under Business Rebates, and a home weatherization program for low-income customers. The Residential Energy Services program consists of the following subprograms: Multifamily and Manufactured Homes, Energy Saving Products, Home Rebates, Behavioral Modification, and Education Kits. The Business Rebates program consists of the following subprograms: Custom and Prescriptive (including Oil & Gas, Agriculture, and Strategic Energy Management), Small Business Energy Solutions, Commercial Midstream, and Commercial Retail Sales.

PSO offered customers demand response programs, one residential (Power Hours) and one commercial/industrial (Peak Performers). Additionally, PSO performed energy efficiency in electric distribution for a reduction in meter-level energy consumption through the application of Conservation Voltage Reduction. Program names, program year start dates, and targeted customer sectors are shown in Table 1-1.

[3] A description of ADM and their commitment to safety is included in 5.4.4Appendix G:.

Table 1-1: Program Start Dates

Program	Sector	Start Date
Energy-Efficiency Programs		
Business Rebates	Commercial & Industrial, Small Business	January 1st, 2024
Residential Energy Services	Residential	January 1st, 2024
Home Weatherization	Limited-Income Residential	January 1st, 2024
Conservation Voltage Reduction	Multiple Classes	January 1st, 2024
Demand Response Programs		
Power Hours	Residential	January 1st, 2024
Peak Performers	Commercial & Industrial	January 1st, 2024

1.2 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 5.4.4Appendix B:. The methods used to calculate cost-effectiveness were informed by the California Standard Practice Manual.[4]

The specific tests used to evaluate cost-effectiveness for the Oklahoma Corporation 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 the Participant Cost Test are presented in Table 1-2. Detailed cost-effectiveness assumptions and findings are presented in 5.4.4Appendix B:.

[4] 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.

Table 1-2: 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	1.81	1.46	0.47	1.69	3.36
Residential Energy Services	1.81	2.06	0.43	2.39	5.08
Home Weatherization	2.02	3.40	0.66	4.06	5.10
Conservation Voltage Reduction	1.33	1.49	0.44	1.87	-
Total - EE Programs	**1.64**	**1.78**	**0.46**	**2.12**	**5.46**
Demand Response Programs					
Power Hours	2.15	3.48	2.11	3.48	-
Peak Performers	2.96	10.50	2.91	10.50	4.08
Total - DR Programs	**2.78**	**7.77**	**2.73**	**7.77**	**4.57**
Research and Development Programs					
Research and Development	4.27	0.79	1.36	0.98	0.50
Total - R&D Programs	4.27	0.79	1.36	0.98	0.50
Portfolio Total	**1.81**	**2.07**	**0.57**	**2.39**	**5.30**

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[5]

C = Total program costs

D = Annual kWh savings

Table 1-3 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) (7.32% discount rate) based calculations. The verified net lifetime energy savings in Table 1-3 are at the generator and include a line loss adjustment factor of 1.0586.

Table 1-3: Levelized $/kWh for Energy-Efficiency Programs[6]

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 (7.32%)	
2024 Residential[7]	$14,292,497	399,714,433	$0.036	347,516,720	$0.041
2024 Commercial[8]	$11,476,201	341,947,367	$0.034	300,489,978	$0.038
2024 CVR	$15,943,001	336,735,354	$0.047	270,584,071	$0.059
2024 EE Programs	**$41,711,700**	**1,078,397,153**	**$0.039**	**918,590,769**	**$0.045**

* To calculate levelized cost, a lifetime cost associated with CVR based on net present value was used, calculated at $15,943.001.

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 brief period, 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. Table 1-4 shows how PSO's portfolio of demand response programs (Peak Performers and Power Hours) performed on a $/kW reduction basis for the program year. The verified net peak demand reduction in Table 1-4 includes a line loss adjustment factor of 1.0781.

Table 1-4: $/kW for Demand Response Programs

Program Year	Total Costs	Verified Net Peak Demand Reduction from DR (kW)	$/kW
2024	$6,998,792	141,654	$49.41

[5] Calculated as described in 5.4.4Appendix B:.
[6] Lifetime savings reduced by 5% societal discount or weighted average cost of capital discount factor.
[7] Residential Programs include Home Weatherization and Residential Energy Services.
[8] Commercial Programs include Business Rebates.

1.3 Summary of Energy Impacts

Energy Impacts are presented as annual energy savings, peak demand reduction, and lifetime energy savings. Energy impacts are presented, in general, for projected impacts (goals prepared during portfolio planning), reported impacts (estimated impacts developed during implementation), verified gross impacts (confirmed impacts through evaluation efforts), and verified net impacts (confirmed program influenced impacts through evaluation efforts). Net impacts are the result of applying a Net-to-Gross (NTG) ratio representing the percentage of gross savings directly attributable to program influences. Program year results of annual energy savings, represented at the meter, are shown in Table 1-5.

Table 1-5: Summary of Gross Energy Impacts – 2024[9]

Program	Gross Annual Energy Savings (Meter, MWh)				Net Impacts (Meter)	
	Projected	Reported	Verified	Gross Realization Rate	NTG Ratio	Net Annual Energy Savings (MWh)
Energy-Efficiency Programs						
Business Rebates	38,609	41,060	42,012	102%	86%	36,208
Residential Energy Services	41,442	57,073	59,936	105%	90%	54,172
Home Weatherization	2,670	5,017	5,009	100%	100%	5,009
Conservation Voltage Reduction	34,794	24,704	22,570	91%	100%	22,570
Total – EE Programs	**117,515**	**127,854**	**129,527**	**101%**	**91%**	**117,958**
Demand Response Programs						
Power Hours	0	0	267	-	100%	267
Peak Performers	76	0	1,134	-	100%	1,134
Total - DR Programs	**76**	**0**	**1,401**	**-**	**100%**	**1,401**
Research and Development Programs						
Research and Development	196	54	153	283%	100%	153
Total – R&D Programs	**196**	**54**	**153**	**284%**	**100%**	**153**
Portfolio Totals	**117,787**	**127,908**	**131,081**	**102%**	**91%**	**119,513**

1.4 Summary of Peak Demand Impacts

Peak demand impacts, or coincident peak demand reduction, represent the reduction in consumption during the PSO peak period. When energy impacts are not available at the

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

hourly level, an average reduction across the peak demand period is used. Peak demand is reported for both gross and net impacts. Table 1-6 summarizes the peak demand impacts at the meter of PSO's energy efficiency and demand response programs during the program year.

Table 1-6: Summary of Demand Impacts – 2024[10]

Program	Gross Peak Demand Reduction (Meter, MW)				Net Impacts (Meter)	
	Projected	Reported	Verified	Gross Realization Rate	NTG Ratio	Net Peak Demand Reduction (MW)
Energy-Efficiency Programs						
Business Rebates	7.98	7.27	7.43	102%	79%	5.88
Residential Energy Services	7.35	12.43	13.37	108%	88%	11.77
Home Weatherization	0.98	2.73	2.72	100%	100%	2.72
Conservation Voltage Reduction	9.22	6.55	4.40	67%	100%	4.40
Total – EE Programs	**25.53**	**28.97**	**27.92**	**96%**	**89%**	**24.78**
Demand Response Programs						
Power Hours	25.25	21.35	22.74	107%	100%	22.74
Peak Performers	77.86	114.99	107.84	94%	100%	107.84
Total - DR Programs	**103.11**	**136.35**	**130.59**	**96%**	**100%**	**130.59**
Research and Development Programs						
Research and Development	0.25	0.003	0.16	4765%	4765%	0.16
Total – R&D Programs	**0.25**	**0.003**	**0.16**	**4765%**	**4765%**	**0.16**
Portfolio Total	**128.89**	**165.32**	**158.67**	**96%**	**98%**	**155.53**

Table 1-7 compares the verified net energy impacts to projected net savings for PSO's programs during the program year.

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

Table 1-7: Summary of Net Energy Impacts – 2024

Program	Projected Net		Verified Net		Percent of Verified/Projections	
	MWh	MW	MWh	MW	MWh	MW
Energy-Efficiency Programs						
Business Rebates	36,534	7.38	36,208	5.88	99%	80%
Residential Energy Services	39,215	6.80	54,172	11.77	138%	173%
Home Weatherization	2,527	0.91	5,009	2.72	198%	300%
Conservation Voltage Reduction	32,924	8.53	22,570	4.40	69%	52%
Total – EE Programs	**111,199**	**23.61**	**117,958**	**24.78**	**106%**	**105%**
Demand Response Programs						
Power Hours	0	23.35	267	22.74	-	97%
Peak Performers	72	72	1,134	107.84	1576%	150%
Total - DR Programs	**72**	**95.35**	**1,401**	**130.59**	**1946%**	**137%**
Research and Development Programs						
Research and Development	186	0.23	153	0.16	82%	70%
Total – R&D Programs	**186**	**0.23**	**153**	**0.16**	**82%**	**70%**
Portfolio Total	**111,456**	**119.19**	**119,513**	**155.53**	**107%**	**130%**

1.5 Summary of Overall Program Satisfaction

Participants from each program were surveyed about their overall experience with the program. In general, participant satisfaction for the program year is estimated at 90%.[11] Participant satisfaction results by subprogram are summarized in Table 1-8. Process evaluation findings by program are presented in Chapters 3 and 4 of this report.

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

Table 1-8: Overall Program Satisfaction Reported by Subprogram Participants

Program	Percent Satisfied
Business Rebates - Prescriptive and Custom	100%
Business Rebates - SBES	100%
Multi-Family	100%
Home Weatherization	93%
Energy Saving Products	66%
Homes Rebates - Single Upgrade	95%
Homes Rebates - Multiple Upgrades	93%
Homes Rebates - New Homes	100%
Education	94%
Behavioral	70%
Power Hours	89%
Business Demand Response	90%

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 2024. 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 165:35-41-4.

PSO contracted with ADM to perform comprehensive program evaluation, measurement, and verification (EM&V) for 2024. ADM's evaluation findings for each energy-efficiency program are provided in Chapter 3 of this report, and evaluation findings for the demand response program are provided in Chapter 4. Table 2-1 summarizes program-level participation, program contribution to portfolio-level savings, and number of measures offered.

Table 2-1: Program Level Participation

Program	% Of Portfolio Savings (Reported)	Participants*	Number of Measure Types
Business Rebates	32.10%	1,020	19
Residential Energy Services	44.62%	288,988	57
Home Weatherization	3.92%	1,971	10
Conservation Voltage Reduction	19.31%	55,644	1
Cumulative EE Totals	**99.96%**	**347,623**	**87**
Power Hours	0.00%	13,611	1
Business Demand Response	0.00%	1,867	1
Cumulative DR Totals	**0.00%**	**15,478**	**2**
Cumulative R&D Totals	**0.04%**	**31**	**1**
Cumulative Portfolio Totals	**100%**	**363,132**	**90**

*Participants represent a residence or business who participated as opposed to the number of measures or projects. For Energy Saving Products subprogram of Residential Energy Services, the actual number of customers is unknown and instead this count is of unique customers that received rebates for qualifying downstream measures.

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. Included in the eGRID 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 2024 values from eGRID non-baseload output emission rates for SPSO.

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)	1,508.42	95	13

Using emission rates from the United States Environmental Protection Agency (eGRID) and lifetime energy savings for measures installed through the PSO Demand Portfolio in 2024 results in the estimated emissions reductions listed in Table 2-3.

Table 2-3: Emission Reduction Estimates

Lifetime Energy Savings (Net at Generator) (MWh)	Carbon dioxide Reduction (CO_2) (tonnes)	Methane Reduction (CH_4) (tonnes)	Nitrous oxide Reduction (N_2O) (tonnes)
1,464,493	1,002,017.05	63.11	8.64

Reductions in water consumption at participant homes/facilities resulting from PSO's 2024 portfolio of programs were only tracked for the programs and measures in which deemed water savings values are available. The result was annual water savings of 61,238 gallons. Many of the energy efficiency measures commonly associated with water savings in the residential sector (faucet aerators, low flow shower heads, efficient clothes washers, 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 2024.

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 as of December 31, 2023, was made up of coal (~10%), natural gas (~25%), purchased power (~38%) and wind (~27%).[12]

A 2003 report by the National Renewable Energy Laboratory (NREL) 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 2024 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)
1,464,493	78%	510	582,575,510

2.2 Milestones Achieved in Market Transformation Programs

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

Education Kits: Program goals often reach beyond energy savings with programs such as the Education Program (known as Energy Saving Kits) providing education content to 5th grade students through their teachers. The kits provide content supporting 5th grade curriculum while educating youth on the benefits of energy efficiency. PSO has developed a website to accompany the Energy Saver Kits with online activities focused on educating students and their families. Over the past three years, at least 87% of teachers reported high student engagement with the lessons. Also, over 86% of teachers in this period found the curriculum to be current, relevant, and a beneficial learning tool, attesting to its effectiveness. The student survey involves a pre- and post-lesson energy efficiency knowledge test. The average quiz score increased by more than 25% after teachers utilized the Energy Saver Kit curriculum. Participant satisfaction for the kits goes beyond those in the program with a strong positive impact on local communities.

Energy Saving Products (ESP) Program: The ESP program includes retail markdowns of certain energy efficiency measures, such as door sweeps, door seals, air filters, and spray foam. The goal of the markdowns is to increase sales to customers who would have otherwise purchased less efficient options in the absence of a price discount. These types of programs have market transformation effects in terms of retailer stocking decisions and manufacturer shipment decisions.

[12] https://www.psoklahoma.com/lib/docs/company/about/PSO_2023_Fact_Sheet.pdf

The Program expanded their offerings through the years to include rebates for Level 2 electric vehicle chargers and limited time offerings of energy efficiency measures at discounts on PSO website. The addition of these measures and channel is an example of how PSO continues to transform the market by affecting customer purchasing decisions in preferred purchasing channels.

Home Rebates – New Homes: The program provides educational training for both builders and raters that influence energy efficiency offerings in building performance and new homes.

Business Rebates Commercial Midstream: PSO offers a commercial midstream program for both lighting and HVAC energy efficient products. Midstream programs provide opportunities for market transformation by increased 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.

Business Rebates Commercial Retail Sales: PSO created a product discount path in 2024 to influence stocking practices of commercial lighting equipment. This new offering runs in parallel to the residential retail sales for ESP.

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 program 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 Limited waiver OAC 165:35-41-4(b)(5) for Heat Pumps

PSO received a rule waiver allowing fuel switching for a limited number of air source heat pumps, new construction heat pump water heaters, and mini-split air source heat pumps annually. The request was driven by customer interest to remove natural gas fired equipment in homes and buildings for situations such as those with solar who wish to make the best use of their solar generation. Heat pump technology has advanced, and marketing heat pumps had to be limited before the waiver due to customers not understanding the fuel switching rule and disappointed when not eligible for a rebate. The quantities of units approved and incentivized by baseline fuel type is shown in Table 2-5.

Table 2-5: Heat Pump Participation

Heat Pump Technology	Residential	Residential	Multifamily	Residential
	ASHP	GSHP	ASHP	HPWH
Approved Qty of fuel switching conversions from natural gas	**70**	**NA**	**50**	**10**
Actual Qty Converted from natural gas	**0**	**1**	**0**	**2**
Actual Qty converted from propane	0	2	0	0
Actual Qty with natural gas backup replaced with same source	236	1	0	0
Actual Qty with electric backup replaced with same source	193	6	63	21
New Construction Heat Pump Installations	50	1	NA	NA
Actual Incentivized Total	**479**	**11**	**63**	**23**

2.4 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 2-6 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 2-6: Utility Growth Rates 2022 – 2024

Year	Net Sales (GWh)	Sales Growth	Energy at Generator (GWh)	Energy Growth	Peak Demand (MW)	Demand Growth
2022	18,617	1.67%	19,750	1.93%	4,196	-0.56%
2023	18,562	-0.29%	19,681	-0.35%	4,192	-0.11%
2024	19,112	2.96%	20,243	2.92%	4,349	3.75%
Compound Growth Rate	**1.32%**		**1.24%**		**1.81%**	

Table 2-7 and Table 2-8 show weather-normalized annual growth rates and 2021 - 2023 compound growth rates (CPGR) for utility energy sales by customer class.

Table 2-7: 2022 – 2024 Weather Normalized Retail Meter Sales

	Residential		Commercial		Industrial		Other Retail		Total Retail		FERC	
Year	**GWh**	**%Chg**	**GWh**	**%Chg**	**GWh**	**%Chg**	**GWh**	**%Chg**	**GWh**	**%Chg**	**GWh**	**%Chg**
2022	6,269	0.89%	5,035	2.10%	6,069	4.01%	1,269	3.69%	18,641	1.79%	9	2.08%
2023	6,216	0.84%	5,209	3.47%	5,939	2.13%	1,253	1.23%	18,619	0.12%	8	5.40%
2024	6,268	0.82%	5,623	7.94%	5,878	-1.03%	1,266	1.04%	19,036	2.24%	8	3.61%
CPGR	0.01%		5.68%		1.58%		0.10%		1.05%		0.99%	

Table 2-8: 2022 – 2024 Total System Weather Normalized Retail Meter Sales

Year	Total System	
	GWh	**%Change**
2022	18,641	1.79%
2023	18,619	-0.12
2024	19,112	2.24%
Compound Growth Rate	**1.05%**	

Table 2-9 shows 2024 Demand Portfolio funding as a percent of total annual electricity revenue.

Table 2-9: 2024 Demand Portfolio Funding

Funding	Value
2024 Demand Portfolio Program Cost ($M)	$35
2024 Operating Revenues ($M)	$1,860
Program Cost as % of Utility Operating Revenue	1.9%

Table 2-10 shows 2024 Demand Portfolio net energy savings as a percent of total annual energy sales.

Table 2-10: 2024 Demand Portfolio Energy Savings

Metric	Value
2024 Demand Portfolio Net Energy Savings (GWh)	127
2024 Metered Energy Sales (GWh)	19,112
Savings as % of Utility Sales	0.66%

2.5 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 is shown in Table 2-11.

Table 2-11: High-Volume Electricity User Opt-Out – Energy Efficiency

Metric	2024	
	Opt-Out Eligible	Chose to Opt-Out -EE
Number of accounts	7,653	5,103
2024 Electric Sales (GWh)	7,380	7,114
Aggregate load as a percentage of total sales	38.6%	37.2%

Table 2-12 provides a summary of high-volume customers who opted out of demand response programs.

Table 2-12: High-Volume Electricity User Opt-Out – Demand Response

Metric	2024	
	Opt-Out Eligible	Chose to Opt-Out -DR
Number of accounts	7,653	4,850
2024 Electric Sales (GWh)	7,380	6,318
Aggregate load as a percentage of total sales	38.6%	33.0%

2.6 Program Implementation & Strategic Alliances

PSO has eight full-time employees dedicated to the implementation of energy efficiency and demand response programs. Additionally, PSO entered into 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 Program and most of the Residential Energy Services Program (Energy Saving Products Program, Multifamily and Manufactured Homes and Home Rebates Programs). The Home Weatherization Program was largely implemented by Titan ES, LLC, with some program participation also coming through Revitalize T-Town, working to preserve and revitalize low-income homes and communities. PSO contracted with AM Conservation to provide energy-efficiency kits distributed through the Education Program. Home Energy Reports were administered to select residential customers by Oracle. Conservation Voltage Reduction is implemented “in-house” with assistance of multiple contract vendors when necessary to deploy equipment.

Through EnergyHub’s Mercury platform, PSO directs and initiates residential load management events. Finally, the Peak Performers 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 Medium Giant. Examples of customer outreach 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 72 training and outreach events:

- 41 PowerForward Overview Events
- 4 Service Provider Trainings
- 27 PSO/AEP Customer Service & Marketing and External Affairs

2.8 Summary of Process Evaluation Findings

ADM completed surveying and interview efforts throughout the program year to inform the impact and process evaluations. Program participants, service providers, and program staff were 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

The business rebates program includes Prescriptive and Custom, Small Business Energy Solutions, Commercial Midstream, and Commercial Retail Sales.[13]

2.8.1.1 Prescriptive and Custom

- PSO and ICF excel in communication with trade allies and customers. All trade allies who interacted with ICF staff reported receiving timely, knowledgeable responses, while all trade allies who engaged with PSO staff noted their strong program knowledge and professionalism. These robust communication channels drive program success through satisfied trade allies who actively promote the program, with all surveyed trade allies informing customers about offerings during sales visits and including incentives in project proposals. Customer satisfaction was high in 2024, consistent with past years. Beyond satisfaction, the program benefits from word-of-mouth recommendations, with 51% of participants recommending it and 88% likely to do so.

2.8.1.2 Small Business Energy Solutions

- SBES program participants and trade allies are satisfied overall. All SBES survey respondents were satisfied with their experience and 87% either would not change anything about the program or did not know what they would change to improve the program. All four of the interviewed trade allies ADM said they were satisfied with the steps required to participate in the offering, the range of equipment that qualifies, the amount of time it takes to receive the rebate, and SBES overall. Furthermore, trade ally comments indicate satisfaction with the application tool and participation process.
- Trade ally comments indicated increased interest in specific project types or trends in 2024. Specifically, one lighting trade ally noted that manufacturing customers have shown increased interest in LED lighting controls. The refrigeration trade ally noted that online monitoring has become more popular with companies that have larger refrigeration setups. The other two lighting trade allies did not notice any

[13] Process Evaluation was not conducted on Commercial Retail Sales as it was new in 2024, started as a pilot partway through the year.

overall increase or notable interest in any services or products from small businesses. Moreover, one of these allies pointed out that small business owners generally only consider energy saving projects or potential for savings upon receiving project proposals.

2.8.1.3 Commercial Midstream

- HVAC and Lighting distributor representatives are satisfied overall though findings from the interviews suggest opportunities to increase program support. Three distributor representatives were interested in more proactive engagement with and support from program staff.
- HVAC distributor interview findings from 2024 and service provider interview findings from 2023 suggest distributors and rebate processing companies take differing rebate processing fees. Distributors estimated holding back approximately 10% of the incentive, however, they do not have a set percentage, and the amount held back varied from project to project.
- Findings from the service provider and distributor interviews indicated opportunities to increase the promotion of the program. The HVAC service provider and one of the three interviewed HVAC distributors estimated that almost none of their customers were aware of the Midstream HVAC offering before they informed them of it. Two distributors specifically noted that they do not have marketing materials for the program.
- There is an interest in expanding HVAC offerings. Two distributor representatives voiced interest in expanding the range of equipment eligible for Midstream incentives.

2.8.2 Residential Energy Services

The Residential Energy Services program includes Multifamily and Manufactured Homes, Home Rebates, Energy Savings Products, Education, and Behavioral Modifications.

2.8.2.1 Multifamily & Manufactured Homes

- Decision-maker satisfaction varies depending on their service provider or the measures implemented. High satisfaction was recorded from the five decision-makers that received weatherization measures. They expressed satisfaction with the quality of work completed, performance of improvements, wait time, the program overall, and their interactions with PSO staff. Satisfaction with AC tune-ups was mixed, with two out of four decision-makers that received AC tune-ups expressing dissatisfaction. These decision-makers cited issues with service quality, lack of communication about work completed, and problems with AC equipment arising after program participation.

- Service providers generally express satisfaction with the program's design and implementation. All four interviewed service providers were satisfied with the measures offered through the program and the timeliness of rebate payment.
- Participating contractors are the primary drivers of program awareness. Six out of eight surveyed decision-makers learned about the program from a service provider. Service providers noted promoting the program by searching for potential participants and performing in-person marketing or outreach visits to market the program.
- The program is enabling improvements at multi-family properties that might not have occurred otherwise. Six of the seven decision-makers said they did not have prior plans to install the measures.

2.8.2.2 Energy Saving Products

- New marketing strategies connect thermostat campaigns with Power Hours and promote heat pump water heaters, with an end of the year focus on targeted EV charger marketing.
- The Limited Time Offering (LTO) online provided customers with confidence in the product quality and convenience. The discount through the LTO was the primary motivation for participants to purchase products such as smart thermostats.
- Most LTO (80%) and downstream rebate (87%) participants were satisfied with the program and program staff. Participants were pleased with the equipment and downstream rebate process. Respondents were overwhelmingly satisfied with the Level 2 EV charger offerings.

2.8.2.3 Home Rebates

The Home Rebates Program consists of energy-efficient New Homes, Single Upgrades, and Multiple Upgrades.

New Homes

- Limited program awareness among home buyers: The New Homes Program remains largely unknown to home buyers until they engage with a builder or real estate agent. Survey results indicate that 84% of home buyers were unaware of the program before purchasing their home. Additionally, most builders noted that fewer than half of their customers knew about the program before engaging with them.
- Builders find value in energy-efficient construction but face market challenges: Builders participating in the program see the benefits of constructing energy-efficient homes, with 60% reporting that their building practices have improved even for non-qualifying homes. However, the higher cost of program-compliant homes remains a challenge, as 80% of builders indicated that price is the most important factor for buyers, and 26-50% of potential buyers are unwilling to pay the additional cost for energy-efficient homes.
- The program's marketing initiatives, including bill inserts, Parade of Homes magazine ads, and the St. Jude home sponsorship, have increased outreach. However, survey results show that only 31% of home buyers are satisfied with PSO's marketing efforts, and many buyers do not fully understand the benefits of energy-efficient homes.

Single and Multiple Upgrades

- Overall, 95% of respondents were satisfied with the Single Upgrade Program and 93% for the Multiple Upgrades Program. Many respondents reported benefits such as improved home comfort and lower utility bills. However, concerns about rebate amounts, unclear rebate explanations, and the usability of installed equipment indicate areas where program processes and contractor training could be refined to improve customer satisfaction further.
- Despite the introduction of the heat pump water heater measure in PY2023 and a targeted educational campaign, there have been no confirmed projects under the Single Upgrade Program.[14] This suggests that additional barriers, such as contractor awareness, customer understanding, or financial constraints, may be limiting participation.
- Contractors are the primary source of program awareness (77% of participants learned about the rebates for Single Upgrades and 77% for Multiple Upgrades), highlighting their critical role in program success. However, customer feedback suggests some contractors lack clarity on rebate processes, leading to dissatisfaction.

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[14] 20 heat pump water heaters were rebated in the Energy Saving Products Program.

2.8.2.4 Education Program

- The program has explored ways to provide digital resources without significantly increasing costs, reflecting a commitment to ensuring materials are accessible. There is an increasing demand for digital content, particularly multilingual resources, to cater to a diverse audience. While translating digital materials is feasible, managing physical inventory in multiple languages could pose challenges.
- The program has adopted more interactive and data-driven outreach strategies, including webinars, in-person events, and feedback collection through conferences. The use of HubSpot has enhanced tracking of teacher engagement and communication effectiveness. The program has developed digital materials, such as games and Google Slides, aligned with educational standards. Teacher engagement remains a focus, and the program plans to further develop resources based on teacher feedback and continue refining its outreach strategies.
- Teachers found the program's curriculum was up-to-date, relevant, and a useful teaching tool. 96% of teachers indicated they would participate again, highlighting the value they find in the program.
- The program successfully increased students' knowledge of energy efficiency concepts, indicating its effectiveness as an educational tool. The program significantly improved students' knowledge of energy efficiency, as evidenced by a 25% increase in average quiz scores from pre-test (58%) to post-test (83%), with all questions showing statistically significant gains in correct responses.

2.8.2.5 Behavioral Modification

- The HERs program has maintained a consistent design, with a few targeted enhancements aimed at boosting engagement and data quality. One improvement has been the addition of video messaging.
- Overall participant satisfaction with HERs remains high, with positive feedback on information clarity, delivery frequency, and content relevance. Over 70% of respondents found the HERs easy to understand, with 30% stating they gained substantial knowledge about energy efficiency, suggesting that HERs deliver tangible educational value. Participants appreciate the provided modules on neighbor comparisons, air conditioning, and weatherization.
- Over half of the participants adopted new energy-saving practices, with 67% crediting HERs as an influential factor. Notably, participants in the Behavioral program are adopting these behaviors at a higher rate than non-participants

2.8.3 Home Weatherization

- The program provides value to PSO customers through improved home comfort and reduced energy bills for income-eligible residents. Program staff are dedicated to ensuring widespread program availability, with 88% of participants gaining program awareness from program stakeholders and word of mouth.
- PSO implemented a home readiness strategy to increase eligibility for the program's weatherization measures. This enabled additional participation through 23 make-ready projects in 2024.
- Participants are satisfied with the measures they received (85% to 94%), the quality of the contractor's work (84%), interactions with program staff (87% to 93%), and their overall experience (93%).

2.8.4 Power Hours

- Cross promotion through thermostat sales in other programs has increased customer awareness of the program in addition to the bill inserts, mailers, emails, mobile app alerts, and Power Hours webpage available to customers. The enrollment incentive was the main motivator for participating in program events, with a 5% increase in participants from the previous year.
- Participants stated satisfaction with the ease of enrollment, program staff, and program overall, with 89% of respondents somewhat or very satisfied.
- Precooling was administered for a subset of participants across several demand response events. Those who observed its effects noted them as generally positive, although some expressed concerns about potential increases in energy usage due to precooling.

2.8.5 Peak Performers

- Three events occurred in 2024, aligning with many participants' expectations regarding event frequency. Although some organizations indicated interest in either increasing or decreasing their participation, the consensus was that the level of involvement was manageable.
- Most Participant survey findings indicate a strong overall satisfaction with the program (90%), with 100% satisfaction in their interactions with program staff.
- Communication about peak events was appreciated, though some wanted earlier notice to prepare staff. While most found the incentive adequate, a few felt it didn't justify the discomfort of participation. Despite this, the program’s communication was effective and well-received.

3 Energy-Efficiency Programs

This chapter reports on evaluation findings of the 2024 PSO energy-efficiency programs. Chapter 4 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	38,609	41,060	42,012	445,376	102%	86%	36,208
Multifamily	1,715	3,518	3,556	53,852	99%	97%	3,439
Home Weatherization	2,670	5,017	5,009	84,708	100%	100%	5,009
Energy Saving Products	5,594	19,676	17,495	132,575	89%	73%	12,743
Home Rebates	4,439	7,172	7,344	115,978	104%	88%	6,448
Education	2,877	3,470	3,355	35,025	97%	100%	3,355
Behavioral	26,816	23,237	28,187	28,187	121%	100%	28,187
Conservation Voltage Reduction	34,794	24,704	22,570	564,241	91%	100%	22,570
Energy-Efficiency Totals	**117,515**	**127,854**	**129,527**	**1,459,942**	**101%**	**91%**	**117,958**

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	7.98	7.27	7.43	102%	79%	5.88
Multi-Family	0.41	1.14	1.14	98%	98%	1.10
Home Weatherization	0.98	2.73	2.72	100%	100%	2.72
Energy Saving Products	0.85	4.09	2.94	72%	60%	1.77
Home Rebates	1.43	3.02	3.28	109%	88%	2.89
Education	0.45	0.52	0.52	100%	100%	0.52
Behavioral	4.22	3.66	5.49	150%	100%	5.49
Conservation Voltage Reduction	9.22	6.55	4.40	67%	100%	4.40
Energy Efficiency Totals	**25.53**	**28.97**	**27.92**	**96%**	**89%**	**24.78**

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

3.1 Residential Energy Services programs

This section presents findings from the impact and process evaluation of the 2024 Residential Energy Services program year. The Residential Energy Services Program includes the subprograms of Home Rebates, Energy Saving Products, Education Kits, Multifamily and Manufactured Homes, and Behavioral Modification. Program performance metrics are summarized in Table 3-3.

Table 3-3: Performance Metrics – Residential Energy Services Program

Metric	2024
Number of Participants	288,988
Budgeted Expenditures	$9,470,842
Actual Expenditures	$10,834,238
Energy Impacts (kWh)	
Projected Energy Savings	41,442,000
Reported Energy Savings	57,072,840
Gross Verified Energy Savings	59,936,346
Net Verified Energy Savings	54,171,551
Peak Demand Impacts (kW)	
Projected Peak Demand Savings	7,350.18
Reported Peak Demand Savings	12,432.05
Gross Verified Peak Demand Savings	13,367.59
Net Verified Peak Demand Savings	11,772.88
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	2.06
Utility Cost Test Ratio	1.81

3.1.1 Home Rebates

This chapter presents findings from the impact and process evaluation of the 2024 program year for the Home Rebates Program.

3.1.1.1 Program Overview

The Home Rebates Program offered by the Public Service 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. Eligible homes require the following standards:

- 95% LED 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 – SEER2 14.3 Air Conditioner
- Home infiltration (6 air changes per hour at 50 pascals)
- Duct infiltration (6 cfm25 /100 sq. ft. of conditioned floor area)
- 100% ENERGY STAR® certified windows

The program was promoted to builders of single-family dwellings and to customers buying new homes. Key program activities included:

- Training homebuilders, sales staff, trade contractors and other market allies.
- Increasing consumer awareness of and demand for ENERGY STAR® qualified homes through various consumer outreach channels.
- Increasing homebuilder promotion of Home Rebates or ENERGY STAR® qualified homes through program-provided collateral items and encouraging the use of the ENERGY STAR® brand.

Home Rebates performance metrics are summarized in Table 3-4.

Table 3-4: Performance Metrics – Home Rebates Program

Metric	2024
Number of Participants	3,918
Budgeted Expenditures	$4,667,703
Actual Expenditures	$6,814,076
Energy Impacts (kWh)	
Projected Energy Savings	4,439,202
Reported Energy Savings	7,172,494
Gross Verified Energy Savings	7,343,924
Net Verified Energy Savings	6,448,056
Peak Demand Impacts (kW)	
Projected Peak Demand Savings	1,425.25
Reported Peak Demand Savings	3,024.09
Gross Verified Peak Demand Savings	3,284.87
Net Verified Peak Demand Savings	2,894.21
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	1.62
Utility Cost Test Ratio	1.24

The EM&V methodologies and findings for the Home Rebates Program are presented in the next sections. The New Homes, Multiple Upgrades, and Single Upgrade components are reported in Section 3.1.1.2, Section 3.1.1.3, and Section 3.1.1.4, respectively.

3.1.1.2 New Homes

This section presents the findings and results of the evaluation of the 2024 New Homes portion of the Home Rebates Program. Evaluation methodologies can be found in a supplemental document.

3.1.1.2.1 Impact Evaluation Activities

ADM employed a site-specific evaluation approach to quantify electric impacts for the New Homes Program. The impact evaluation for this program included the following steps:

- Program tracking data review for completeness, clerical errors, outliers, and accuracy.
- Establishing a sample design and selecting a random sample of homes for evaluation.

- Data collection activities (including on-site verifications, HERS rater documentation, building drawings, and builder provided documentation).
- Gross Impact analysis. Engineering analysis of site-level and program level impacts using energy simulation with post-installation consumption calibration.
- Net Impact analysis. ADM used survey results from online builder surveys to determine the level of free ridership in the program.

3.1.1.2.2 Process Evaluation Activities

ADM performed a process evaluation assessing the 2024 New Homes Program operations and delivery. The program design, operations, and delivery were assessed for the New Homes Program through builder surveys, home buyer surveys, and a facilitated discussion with program and implementation staff at PSO. Table 3-5 summarizes the data collection activities.

Table 3-5: New Homes - 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 Facilitated Discussion	Assess past program year recommendations and implementation strategies
Builder Survey	Assess program support, training, satisfaction, program influence on building practices, and suggestions for improvements
Home Buyer Survey	Investigate buyers' reasons for buying the home they did, importance of energy efficiency in their decision, as well as how well builders explained the energy-efficient characteristics of the homes

The process evaluation addressed the following research questions:

- Has the underlying program theory of how the program affects energy saving behaviors changed since the previous program years? If so, how and why?
- How have the program implementation and delivery changed, if at all, since the previous program years? How are these changes related to previous evaluation results and how are they expected to change program impacts going forward?
- Did the program implementation reflect its current design? In what ways did it deviate and how did that affect program success?
- Do program utility and implementation contractor staff effectively coordinate to deliver the program?
- Are there ways to improve the design or implementation process?

- Is the New Homes component of the program motivating builders to build energy efficient homes? Why or why not? What could be done to motivate them more?
- How are builders selling energy-efficiency benefits to buyers? Are they getting the training they need to do this effectively? How can the program help them?
- What are new home buyers' motives for buying these homes? How important is the homes' energy efficiency status in their decisions? How important are the homes' non-energy benefits in their decisions?

3.1.1.2.3 Program Material Review

An element of the evaluation includes a review of the program tracking data and program documentation. The program tracking data is reviewed for completeness, systematic issues, and inconsistencies prior to any evaluation work.

ADM reviewed program tracking data and found no data issues. In this review ADM found that one HERS rater accounted for 47% of program savings and the top two HERS raters accounted for 86% of program savings.

3.1.1.2.4 Sampling Plan

Samples are developed separately for the process and impact evaluations. Samples are developed in a manner such that results from analysis of the sample represent the population with ± 10% precision at the 90% confidence interval based on annual energy savings. In some instances, such as survey designs, a census of home buyers/builders is necessary to maximize the sample, which may not always meet the precision target. Table 3-6 summarizes the sample size for each primary data collection activity.

Table 3-6: New Homes - Sample Sizes for Data Collection Efforts

Data Collection Activity	Achieved Sample Size
Builder Surveys Completed	5
Home Buyer Surveys Completed	45
Facilitated Discussion with Program Staff	1
On-Site Verifications	26
Impact Evaluation Analysis Sample	55

The impact evaluation sample design employed reported annual energy savings estimates to determine sample sizes per stratum and precision. The population of projects is broken out into strata such that sampled projects represent like projects in the population when results are extrapolated. It was determined that the metric used to stratify the sample is based on the HERS rater as they are responsible for confirming and reporting the energy savings measures. Sampled projects are selected randomly. Precision is then recalculated with verified annual energy savings to determine a verified precision. Sample design precision at the 90% confidence interval was ±8.86% for estimated annual energy savings. Table 3-7 below summarizes the sample framework exceeding the targeted 10% precision.

Table 3-7: New Homes - Sample Design

Strata	Measure	Reported Energy Savings (kWh)	Population Size	C.V.	Sample Size	Relative Precision
Stratum 1	Rater 1 Small	295,438	330	0.32	10	17%
Stratum 2	Rater 1 Large	308,218	125	0.32	12	15%
Stratum 3	Rater 2 Small	154,718	116	0.17	7	10%
Stratum 4	Rater 2 Large	350,439	144	0.67	17	25%
Stratum 5	Rater 3	137,086	45	0.35	3	30%
Stratum 6	Other	47,771	19	1.32	6	73%
Total	**-**	**1,293,670**	**779**		**55**	**9.53%**

3.1.1.2.5 Data Collection

Data collection activities supporting the evaluation included builder surveys, home buyer surveys, a facilitated discussion with PSO program staff and implementation staff, and primary data collection through on-site verifications.

Builder Survey

For the New Homes Program, contact information for all builders was requested from the implementation contractor. Any new builder who participated in the program in 2024 or builders who had previously participated in the program but did not complete an online survey in the previous program year was emailed a survey link in November 2024. A total of 21 home builders were emailed the online survey, which resulted in 5 survey completes.

Home Buyer Survey

For the New Homes Program, a sample of New Homes participants were pulled from the tracking data and included in the survey sample list. The home buyer contact information was requested from PSO and the home buyers in the survey sample list were emailed a survey link in August 2024. A total of 274 participants were emailed the online survey, which resulted in 45 survey completes.

Program Staff Facilitated Discussion

ADM conducted a facilitated discussion of the Home Rebates – New Homes Program with PSO program and implementation staff in September 2024. The facilitated discussion involved a group discussion with key personnel responsible for discussing past program year recommendations and brainstorming implementation strategies.

On-Site Verification Visits

On-site verification visits were performed through recruitment by the implementation team. On-Site visits occurred during post inspections with as many locations recruited as were feasible. Field data collection forms were completed to verify attic insulation thickness and type, percentage of LEDs installed, and appliance model numbers. Additionally, photographs were taken to confirm the collected data. This information provided verification for simulation model inputs.

3.1.1.2.6 Gross Impact Methodology

Energy impacts are calculated through energy simulation using Ekotrope.[15] The simulation tool determines the difference in energy consumption between a residence built to Oklahoma energy codes and the as-built residence. ADM uses information obtained from on-site visits and application documents to confirm the as-built conditions. Energy simulation consumption was compared and calibrated (as needed) to billing consumption data. A detailed description of this methodology can be found in a supplemental document.

3.1.1.2.7 Net-to-Gross (NTG) Estimation Methodology

Net impacts of the New Homes Program were evaluated using participating builder survey responses for free ridership. 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 align with industry standard methodology and can be found in a supplemental document.

3.1.1.2.8 Verified Gross Savings Results

This section details the verified gross and net savings impacts for the New Homes portion of the Home Rebates Program.

[15] https://www.ekotrope.com/

Program Activity

Participation and reported savings estimates by builder are shown in Table 3-8. The top six participating builders accounted for 77% of New Homes estimated annual energy savings.

Table 3-8: New Homes - Participation and Savings per Builder

Builder	Number of Homes	Reported Energy (kWh)	Reported Demand (kW)	Percent of Program Energy Savings
Simmons Homes LLC	141	232,162	96.30	17.98%
Executive Homes	89	229,351	108.98	17.76%
Rausch Coleman Homes	214	164,962	80.93	12.77%
Capital Homes Residential Grp., LLC	88	143,690	67.26	11.13%
Shaw Homes	92	120,391	56.81	9.32%
Sunview Construction, LLC	35	107,388	9.53	8.31%
True North Homes LLC	10	48,657	23.16	3.77%
Home Creations	27	36,028	17.44	2.79%
Texoma Building Services, LLC	10	29,698	3.48	2.30%
SPECTACULAR HOMES	13	21,626	9.38	1.67%
Cobblestone Homes, Inc.	4	20,398	9.56	1.58%
Concept Builders	11	16,865	8.09	1.31%
J. Madden Homes LLC	1	16,174	2.23	1.25%
Matt Rogers	1	15,846	1.99	1.23%
Bgreen Homes, LLC	7	15,478	6.49	1.20%
Abbey Homes LLC	3	14,590	6.99	1.13%
Archway Homes, LLC	3	11,674	5.47	0.90%
Tulsa Habitat for Humanity	7	9,537	4.09	0.74%
Homes By Classic Properties LLC	7	9,189	4.58	0.71%
TRADITION HOMES	6	7,800	3.76	0.60%
Ideal Homes	4	5,781	2.70	0.45%
Homeowner	1	4,518	1.89	0.35%
Malibu Homes	2	3,988	1.84	0.31%
Hensley Custom Homes, LLC	1	3,077	1.54	0.24%
Capron Construction, Inc.	1	2,870	1.19	0.22%
Epic Custom Homes	1	1,932	0.84	0.15%
Total	**779**	**1,293,670**	**536.51**	**100%**

Verified Gross Savings

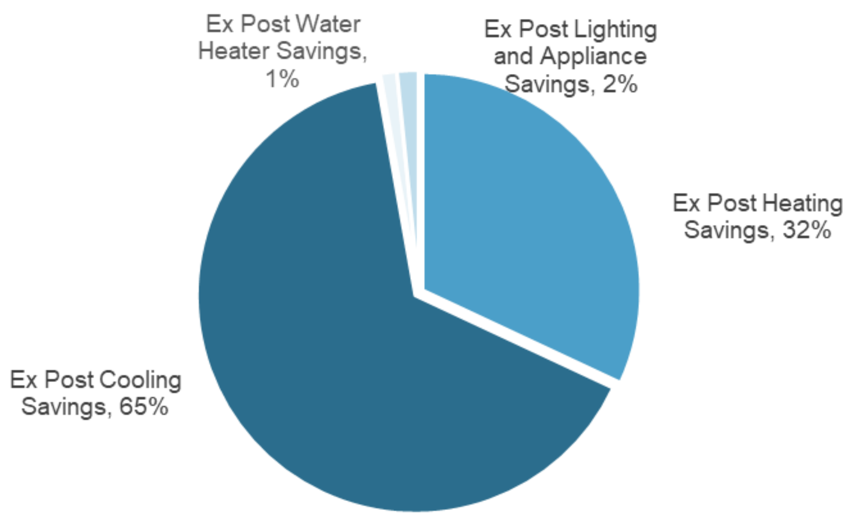
ADM performed on-site data collection for seven sampled projects. Findings from these data collection activities matched energy simulation inputs used by the HERs raters.

Differences Between Reported and Verified Simulation Inputs

The baseline conditions in Ekotrope are pre-determined for all models based on the Oklahoma energy code. The current Oklahoma energy code follows the 2009 International Residential Code. The impact analysis found reported simulation models reflected the building characteristics verified during engineering desk reviews.

Figure 3-1 shows the annual energy savings by end-use from the evaluation sample. As shown, the highest energy savings are realized with energy efficiency upgrades to electric heating systems, followed by upgrades to lighting and appliances.

Figure 3-1: New Homes - Energy Savings of Aggregated Sample by End Use



Adjustments to mechanical systems were made to the models for verified savings resulting in a 1.1% difference from estimated savings. The evaluation sample results by strata and sample precision with verified annual energy savings is shown in Table 3-9.

Table 3-9: New Homes Evaluation Sample Results

Strata	Measure	Sample Reported Energy Savings (kWh)	Sample Evaluated Energy Savings (kWh)	Population Size	Sample Size	Relative Precision
Stratum 1	Rater 1 Small	10,625	10,659	330	10	17%
Stratum 2	Rater 1 Large	36,179	37,192	125	12	15%
Stratum 3	Rater 2 Small	8,595	8,602	116	7	10%
Stratum 4	Rater 2 Large	66,388	65,655	144	17	25%
Stratum 5	Rater 3	9,648	9,108	45	3	30%
Stratum 6	Other	26,819	26,674	19	6	73%
Total		**158,254**	**157,889**	**779**	**55**	**9.53%**

The program achieved a 100% realization rate for the program year 2024. Reported and verified energy impacts are presented in Table 3-10.

Table 3-10: New Homes - Gross Impact Results by Strata

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
Rater 1 Small	295,438	145.95	296,381	146.29	5,927,621	100%	100%
Rater 1 Large	308,218	143.53	316,851	144.13	6,337,027	103%	100%
Rater 2 Small	154,718	68.71	154,842	68.68	3,096,832	100%	100%
Rater 2 Large	350,439	149.35	346,570	148.42	6,931,403	99%	99%
Rater 3	137,086	13.02	129,406	10.01	2,588,128	94%	77%
Other	47,771	15.96	47,511	15.92	950,222	99%	100%
Total	**1,293,670**	**536.51**	**1,291,562**	**533.45**	**25,831,232**	**100%**	**99%**

Program level reported and gross annual energy savings are summarized in Table 3-11. An effective useful life (EUL) of 20 was applied to program lifetime savings. A 20-year EUL is based on typical measures installed in new home construction.

Table 3-11: New Homes - Reported and Gross Impacts

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
1,293,670	536.51	1,291,562	533.45	25,831,232	100%	99%

3.1.1.2.9 Net-to-Gross (NTG) Estimation Results

Five builders contributing 33% of the program's annual energy savings participated in online surveys for 2024. Builder surveys were used to estimate free ridership ratios for the New Homes Program. Free ridership ratios (ranging from zero to one, zero for complete free ridership and one for no free ridership) were determined for each surveyed homebuilder and applied to the verified annual energy savings and peak demand reduction for homes built by that homebuilder. If a homebuilder was not available for the survey in 2024, the previous free ridership scores were considered for the calculation of NTG.

Average free ridership ratios for the program were weighted by the builder's verified savings contributions (shown in Table 3-12). No spillover was identified for the 2024 program. The magnitude of energy impacts due to free ridership and spillover are presented in Table 3-12.

Table 3-12: New Homes - Free Ridership and Spillover Impacts

Free Ridership (kWh)	Free Ridership kWh Ratio	Free Ridership (kW)	Free Ridership kW Ratio	Spillover (kWh)	Spillover (kW)
223,547	17.31%	101.02	18.94%	0	0.00

Based on impact evaluation results, the total verified net energy and demand savings are presented in Table 3-13 below.

Table 3-13: New Homes - Gross and Net Savings Impacts

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)
1,291,562	533.45	82.69%	81.06%	1,068,014	432.43	21,360,287

3.1.1.3 Multiple Upgrades

This section presents the findings and results of the evaluation of the Multiple Upgrades portion of the Home Rebates Program. A supplemental document provides detailed evaluation methodologies.

3.1.1.3.1 Impact Evaluation Activities

Data collection included online participant and trade ally surveys and a facilitated discussion with program and implementation staff. Additional sources of data to inform the impact evaluation were a census of program tracking data from the implementor's tracking and reporting system, along with project documentation obtained from the implementation online tool. 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. The impact evaluation for this program included the following activities:

- Determination of the number of customers participating in the program by types of measures installed.
- Determination of the gross energy savings and peak demand reduction per project based on engineering algorithms.
- Estimation of the net-to-gross ratios to determine the percentage of gross savings directly attributable to the program.
- Documentation of incremental costs for benefit-cost analysis.

3.1.1.3.2 Process Evaluation Activities

ADM performed a process evaluation assessing the 2024 Home Rebates Program operations and delivery. The program design, operations, and delivery were assessed for the Multiple Upgrades Program through participant surveys, trade ally surveys, and a facilitated discussion with PSO program staff and implementation staff. Table 3-14 summarizes the data collection activities.

Table 3-14: Multiple Upgrades - 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 Facilitated Discussion	Assess past program year recommendations and implementation strategies
Participant Survey	Assess participant experiences, including satisfaction.
Trade Ally Survey	Assess program support, training, satisfaction, program influence on trade ally practices, and suggestions for improvements.

The process evaluation addressed the following research questions:

- Has the underlying program theory of how the program affects energy saving behaviors changed since the previous program years? If so, how and why?

- How have the program implementation and delivery changed, if at all, since the previous program years? How are these changes related to previous evaluation results and how are they expected to change program impacts going forward?
- Did the program implementation reflect its current design? In what ways did it deviate and how did that affect program success?
- Do program utility and implementation contractor staff effectively coordinate to deliver the program?
- Are the program customer engagement materials effective at advertising the Single Upgrade and Multiple Upgrades components of the program? Could they be improved in any way?
- Are there ways to improve the design or implementation process?
- What is the experience of participants in the Single Upgrades and Multiple Upgrades components of the program?
- Is the program customer engagement content effective? What is working particularly well and what could be improved?
- Is the program reaching all segments of the target market? Is anyone under-represented or left out?

3.1.1.3.3 Sampling Plan

Sampling was conducted to ensure survey responses represent the program population. Table 3-15 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 3-15: Multiple Upgrades - Sample Sizes for Data Collection Efforts

Data Collection Activity	Achieved Sample Size
Participant Surveys Completed	119
Trade Ally Surveys Completed	9
Facilitated Discussion with Program Staff	1

Online Participant Surveys

For the calculation of sample size for survey completes for the online participant survey, a sample size of 68 was desired for the results to represent the program within ±10% precision at the 90% confidence interval.

3.1.1.3.4 Data Collection

Data collection activities supporting the evaluation included participant surveys, trade ally survey, a facilitated discussion with PSO program staff and implementation staff, and collection of all program documentation to complete an engineering analysis.

Participant Survey

ADM conducted a participant survey of PSO customers who participated in the Multiple Upgrades Program in 2024. 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 a link to the online survey. The survey was emailed in monthly waves to participants from April through November 2024. Participants were offered a monetary incentive if they completed the questionnaire. ADM sent the online survey to a total of 611 participants, which resulted in 119 survey completes.

Trade Ally Survey

ADM conducted a survey of all trade allies who participated in the Single & Multiple Upgrades Program in 2024. All trade allies with contact information were pulled from the tracking data and included in the survey sample list. Any trade ally with a valid email address was emailed a link to the online survey in December 2024. ADM sent the online survey to a total of 77 Trade Allies, which resulted in 9 survey completes.

Program Staff Facilitated Discussion

ADM conducted a facilitated discussion of the Home Rebates - Single Upgrade and Multiple Upgrades Program with PSO program staff and implementation staff in September 2024. The facilitated discussion involved a group discussion with key personnel responsible for discussing past program year recommendations and brainstorming implementation strategies.

3.1.1.3.5 Gross Impact Methodologies

The method used to calculate annual energy savings (kWh) and peak 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 collected from the online participant survey and on-site 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 program tracking data were used as inputs to the savings algorithms listed in the Arkansas Technical Reference Manual, Version 8.1 (AR TRM 8.1) and the Oklahoma Deemed Savings Document (OKDSD).

Detailed explanations of the prescriptive algorithms used to determine energy impacts can be found in a supplemental document.

Lifetime kWh Savings

Lifetime energy savings (kWh) were calculated by multiplying the gross annual energy 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 3-22 shows the EUL and source for each measure type.

Table 3-16: Multiple Upgrades – Per Measure Estimated Useful Life (EUL)

Measure Type	EUL (Years)
Air Sealing Package	11
Duct Replacement	20
Duct Sealing	18
Central AC	19
Heat Pump	16
Ductless Mini-Split Heat Pump	13
Ground Source Heat Pump	25
Attic Insulation	20
Floor Insulation	20
Knee Wall Insulation	20
Wall Insulation	20
WiFi Thermostat	11

3.1.1.3.6 Net-to-Gross (NTG) Estimation Methodology

Net impacts of the program were determined through the methodology and calculations of free ridership and spillover as described in a supplemental document. The algorithms are based on self-claimed information gathered during participant survey efforts.

3.1.1.3.7 Verified Gross Savings Results

This section details findings from the impact evaluation of the Multiple Upgrades Program.

Program Activity

The Multiple Upgrades portion of Home Rebates in 2024 had 902 total applications. Final energy savings were based on a total of 2,054 energy saving measures. See Table 3-17 below for a breakdown of total quantities for each energy saving measure in the program.

Table 3-17: Multiple Upgrades - Per Measure Equipment Quantities

Measure	Quantity in Program
Air Sealing Package	20
Duct Replacement	159
Duct Sealing	810
Central AC	684
Heat Pump[16]	220
Ground Source Heat Pump	0
Attic Insulation	99
Floor Insulation	1
Knee Wall Insulation	12
Wall Insulation	2
WiFi Thermostat	47
Total	**2,054**

[16] Measure includes air source heat pumps and ductless mini-split heat pumps.

Reported and Verified Gross Savings

Table 3-18 presents the gross verified savings by measure, lifetime energy savings (kWh), and realization rates by measure.

Table 3-18: Multiple Upgrades - 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 Package	4,163	4,163	2.39	2.35	45,797	100%	98%
Duct Replacement	424,923	455,954	204.88	261.05	9,119,076	107%	127%
Duct Sealing	1,893,409	2,021,137	971.75	1,185.87	36,380,458	107%	122%
Central AC	661,868	657,725	297.93	295.14	12,496,783	99%	99%
Heat Pump	585,256	568,714	64.85	60.47	8,927,337	97%	93%
Attic Insulation	85,602	88,926	59.92	61.79	1,778,526	104%	103%
Floor Insulation	156	156	0.04	0.04	3,120	100%	100%
Kneewall Insulation	5,554	5,554	3.40	3.40	111,085	100%	100%
Wall Insulation	1,465	1,465	0.68	0.68	29,300	100%	100%
WiFi Thermostat	45,288	45,288	0.00	0.00	498,166	100%	100%
Total	**3,707,684**	**3,849,082**	**1,605.83**	**1,870.77**	**69,389,647**	**104%**	**116%**

The gross impact analysis consisted of verifying measure installation using self-reported data from the participant survey results and checking the program tracking data to ensure that deemed savings algorithms were appropriately applied. In-Service Rates (ISRs) for each measure type were developed based on the findings from the online participant survey data and then extrapolated to the population. Findings from the participant survey determined a 100% ISR for all sampled measures in Multiple Upgrades. A description of verified gross findings for each measure type is included below.

Air Sealing (Infiltration Reduction): This measure reduces air infiltration into the residence, using pre- and post-treatment blower door air pressure readings to quantify the air leakage reduction. ADM utilized deemed values from the AR TRM 8.1 for all infiltration reduction projects. There were 20 air sealing projects in the Multiple Upgrades Program in 2024. The realization rates for air sealing were 100% for energy savings and 98% for the demand savings. The difference in demand savings is likely due to reported savings using the wrong DSF factor for one project's location.

Duct Replacement (Insulation): This measure consists of replacing/adding duct insulation to uninsulated metal supply and return ductwork, located in unconditioned space that previously had no existing insulation. ADM utilized the method in the AR TRM

8.1 that requires duct leakage testing using either a duct pressurization device (e.g., Duct Blaster), or a combination duct pressurization and blower door. The realization rates for duct replacement were 107% for energy savings and 127% for the demand savings. The difference between the reported and verified savings was due to the verified savings calculations following the AR TRM's calculations for a home with a heat pump as its heating and cooling system.

Duct Sealing: This measure involves sealing leaks in supply and return ducts of the distribution systems of homes or converted residences with either central air conditioning or a ducted heating system. The realization rates for duct sealing were 107% for energy savings and 122% for demand savings. The difference between the reported and verified savings was due to the verified savings calculations following the AR TRM's calculations for a home with a heat pump as its heating and cooling system.

Central Air Conditioners: This measure involves the installation of a new central air conditioning system in a residential home (packaged unit, or split system consisting of an indoor unit with a matching remote condensing unit). 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). The realization rates for central air conditioners were 99% for energy savings and 99% for demand savings. The difference in energy and demand savings is due to rounding.

Heat Pumps:[17] This measure consists of the installation of a new central heat pump system in a residential home (central unit, packaged unit, split system consisting of an indoor unit with one or more matching remote condensing units, or mini-split system). The realization rates for heat pumps were 97% for energy savings and 93% for demand savings. The gross verified savings also included the "right sizing" for units that were similar in size (for example, a 1-ton heat pump replacing a 1.5-ton air conditioner). In those cases, the same capacity was used for the baseline and efficient capacity when upsizing. Projects for mini-split heat pump installation often replaced a room or 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. The difference in energy and demand savings is due to the difference between the baseline SEER/EER values used in the reported and verified savings calculations. The baseline values are based on the installation year, the type of the unit (packaged or split), and whether the unit was an air source heat pump or ductless mini-split heat pump. The reported and verified savings calculations have baseline SEER/EER/HSPF values that differ for some of the projects. This could have been from the reported savings calculations using different installation

[17] Measure includes air source heat pumps and ductless mini-split heat pumps.

dates/type of unit than the verified savings calculations for the baseline SEER/EER/HSPF values.

Ground Source Heat Pumps: There were no ground source heat pump projects in the Multiple Upgrades Program for 2024.

Attic Insulation: This measure requires adding ceiling insulation above a conditioned area in a residential home of existing construction to a minimum ceiling insulation value of R-38. The realization rates for attic insulation were 104% for energy savings and 103% for demand savings. The verified savings calculations used deemed values from the AR TRM 8.1 based on whether the insulation was attic or roof deck. The reported savings calculations used deemed values for attic for all projects. The difference in energy and demand savings is due to the reported savings calculations not including extra inches of insulation that provide an R value beyond the R-49 table, as the heat transfer rate diminished with each extra R value past R-49. These extra savings in the verified savings calculations are from homes that had final insulation levels between R-38 and R 49. The verified savings calculations used the deemed values for R 38 while the reported savings calculations used the interpolated values.

Floor Insulation: This measure presents two eligible scenarios for retrofitting a crawlspace underneath an uninsulated floor, one which includes insulating the underside of the floor (above the vented crawlspace), where the floor previously had no insulation, and the other includes “encapsulating” the crawlspace (sealing and insulating the vented perimeter skirt or stem wall between the ground (finished grade) and the first floor of the house, leaving the underside of the first floor structure uninsulated). There was one floor insulation project in the Multiple Upgrades Program in 2024. The realization rates for floor insulation were 100% for energy savings and 100% for demand savings.

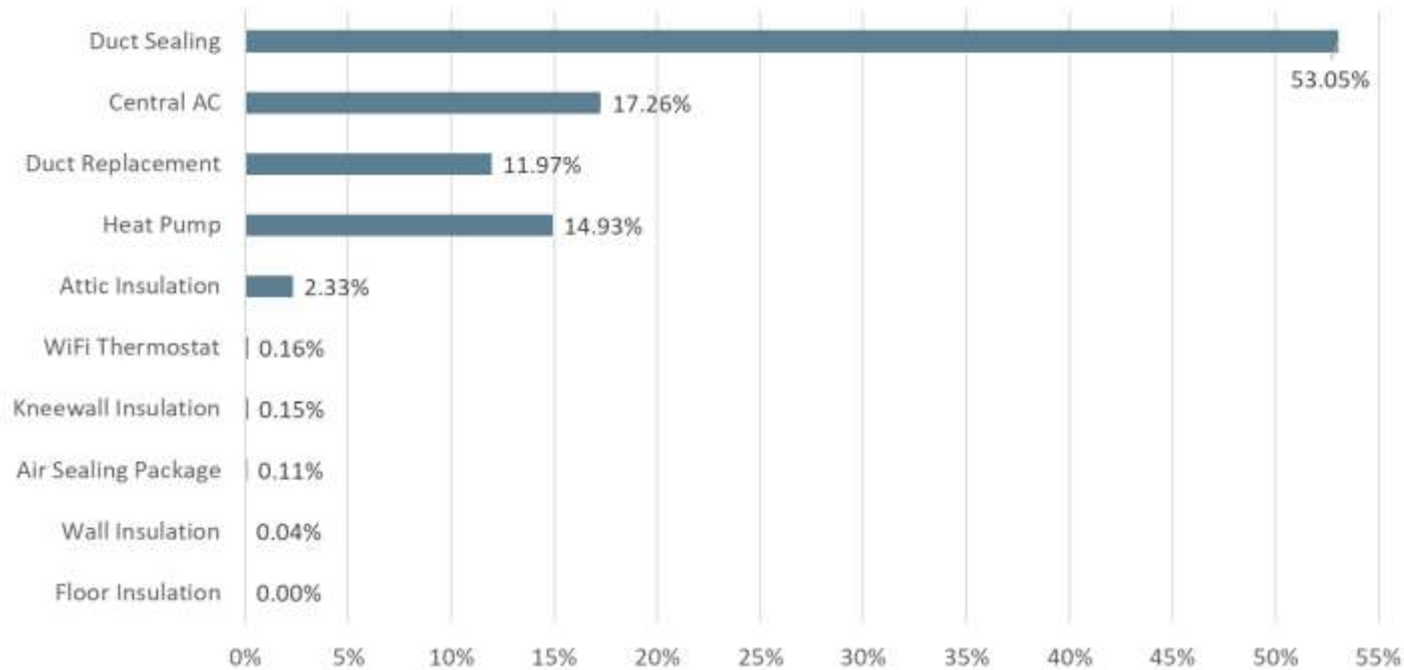
Knee Wall Insulation: This measure involves adding attic knee wall insulation to knee wall areas in a residential home of existing construction. The realization rates for knee wall insulation were 100% for energy savings and 100% for demand savings.

Exterior Wall Insulation: This measure consists of adding wall insulation in the wall cavity in a residential home of existing construction. There were two wall insulation projects in the Multiple Upgrades Program in 2024. The realization rates for wall insulation were 100% for energy savings and 100% for demand savings.

WiFi Thermostat: A desk review of energy impacts for WiFi Thermostats found a 100% realization rate.

The percent of gross verified energy savings reported by measure for the 2024 Multiple Upgrades Program are detailed in Figure 3-2 below.

Figure 3-2: Multiple Upgrades – Percent of Gross Verified Energy Savings per Measure



3.1.1.3.8 Net-to-Gross (NTG) Estimation Results

Survey data from a total of 119 Multiple Upgrades participants were used to determine the NTG ratio for this program. Survey respondents were asked a series of questions aimed at determining 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 measure-level free ridership of each survey participant was then weighted by the measure energy savings and averaged to determine the project-level free ridership score. This score was applied to the other measures where a survey response was not obtained.

Survey respondents were also asked a series of questions to determine if they had installed any additional, non-rebated, energy-efficiency measures as a direct influence of their participation in the program, which is referred to as spillover. Out of 120 survey completes, two respondents provided specific details of additional energy-efficient equipment[18] they purchased in 2024 that was directly influenced by their participation in the program. These two responses were considered spillover as the participants rated the influence of the program high enough to claim added savings in the NTG estimation. This additional energy-efficient equipment resulted in 1.20% spillover for the Multiple Upgrades Program in 2024.

[18] The energy-efficient equipment reported on the participant survey was only included as spillover if it was similar to the measures offered in the Home Rebates Program.

The average free ridership score was 9.07%. 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 an NTG ratio of 92.12% for energy and demand savings. Based on the impact evaluation results, the total verified net energy savings for the Multiple Upgrades Program are 3,509,974 kWh, and the total verified net peak demand savings are 1,727.67 kW. A summary of Multiple Upgrades' net impact findings is shown in Table 3-19.

Table 3-19: Multiple Upgrades - Gross/Net Verified Energy & Demand Savings

Gross Verified Energy (kWh)	Gross Verified Demand (kW)	Net Verified Energy (kWh)	Net Verified Demand (kW)	NTG Ratio
3,849,082	1,870.77	3,545,955	1,727.67	92.12%

3.1.1.4 Single Upgrade

This section presents the findings and results for evaluation of the Single Upgrade portion of the Home Rebates Program. Detailed evaluation methodologies are available in a supplemental document.

3.1.1.4.1 Impact Evaluation Activities

The primary data collection activities for the impact evaluation of the Single Upgrade Program consisted of online participant and trade ally surveys and a facilitated discussion with program and implementation staff. Additional sources of data to inform the impact evaluation were a census of program tracking data from the program tracking and reporting system, along with project documentation obtained from the implementation online tool. Program tracking data included customer contact information and descriptions of the measures installed with file storage for submitted applications, and contractor invoices for the work performed. The impact evaluation for this program included the following activities:

- Determination of the number of customers participating in the program by types of measures installed.
- Determination of the gross energy savings and peak demand reduction per project
- Estimation of the net-to-gross ratios to determine the percentage of gross savings directly attributable to the program.
- Documentation of incremental costs for benefit-cost analysis

3.1.1.4.2 Process Evaluation Activities

ADM performed a process evaluation assessing the Home Rebates Program operations and delivery. The program design, operations, and delivery were assessed for the Single Upgrade Program through participant surveys, trade ally surveys, and a facilitated discussion with PSO program staff and implementation staff. Table 3-20 summarizes the data collection activities.

Table 3-20: Single Upgrade - 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 Facilitated Discussion	Assess program strengths, weaknesses, opportunities, and threats
Participant Survey	Assess participant experiences, including satisfaction.
Trade Ally Survey	Assess program support, training, satisfaction, program influence on trade ally practices, and suggestions for improvements.

The process evaluation addressed the following research questions:

- Has the underlying program theory of how the program affects energy saving behaviors changed since the previous program years? If so, how and why?
- How have the program implementation and delivery changed, if at all, since the previous program years? How are these changes related to previous evaluation results and how are they expected to change program impacts going forward?
- Did the program implementation reflect its current design? In what ways did it deviate and how did that affect program success?
- Do program utility and implementation contractor staff effectively coordinate to deliver the program?
- Are the program customer engagement materials effective at advertising the Single Upgrade and Multiple Upgrades components of the program? Could they be improved in any way?
- Are there ways to improve the design or implementation process?
- What is the experience of participants in the Single Upgrades and Multiple Upgrades components of the program?
- Is the program customer engagement content effective? What is working particularly well and what could be improved?
- Is the program reaching all segments of the target market? Is anyone under-represented or left out?

3.1.1.4.3 Sampling Plan

Sampling was conducted to ensure survey responses represent the program population. Table 3-21 summarizes the sample size for each primary data collection activity. The random sample for survey verification was designed to achieve ±10% relative precision or better at the 90% confidence interval.

Table 3-21: Single Upgrade - Sample Sizes for Data Collection Efforts

Data Collection Activity	Achieved Sample Size
Participant Survey	164
Trade Ally Surveys Completed	9
Facilitated Discussion with Program Staff	1

Participant Survey

The sample size for the participant survey was determined by the minimum sample size algorithm with 90% precision and ±10% relative precision. With this assumption, a minimum sample size of 68 participants was needed based on participation levels. This minimum sample size of 68 was exceeded with 164 surveys completed.

3.1.1.4.4 Data Collection

Data collection activities supporting the evaluation included participant surveys, trade ally surveys, a facilitated discussion with PSO program staff and implementation staff, and the collection of all program documentation to complete an engineering analysis.

Participant Survey

ADM conducted a participant survey of PSO customers who participated in the Single Upgrade Program in 2024. 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 a link to the online survey. The survey was emailed in monthly waves to participants from April through November 2024. Participants were offered a monetary incentive if they completed the questionnaire. ADM sent the online survey to a total of 1,156 participants, which resulted in 144 completed surveys.

Trade Ally Survey

ADM conducted a survey of all trade allies who participated in the Single & Multiple Upgrades Program in 2024. All trade allies with contact information were pulled from the tracking data and included in the survey sample list. Any trade ally with a valid email address was emailed a link to the online survey in December 2024. ADM sent the online survey to a total of 77 Trade Allies, which resulted in 9 completed surveys.

Program Staff Facilitated Discussion

ADM conducted a facilitated discussion of the Home Rebates - Single Upgrade and Multiple Upgrades Program with PSO program staff and implementation staff in September 2024. The facilitated discussion involved a group discussion with key personnel discussing past program year recommendations and brainstorming implementation strategies.

3.1.1.4.5 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 the online participant survey and on-site 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 program tracking data were used as inputs to the savings algorithms listed in the Arkansas Technical Reference Manual, Version 8.1 (AR TRM 8.1) and the Oklahoma Deemed Savings Document (OKDSD).

Detailed explanations of the prescriptive algorithms used to determine energy impacts can be found in a supplemental document.

Lifetime Energy Savings

Lifetime energy savings (kWh) 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 3-22 shows the EUL and source for each measure type.

Table 3-22: Single Upgrade – Per Measure Estimated Useful Life (EUL)

Measure Type	EUL (Years)
Central AC	19
Heat Pump	16
Ductless Mini-Split Heat Pump	13
Ground Source Heat Pump	25
Attic Insulation	20
Pool Pump	10
HVAC Tune-Up	10[19]
Wi-Fi Thermostat	11

3.1.1.4.6 Net-to-Gross (NTG) Estimation Methodology

Net impacts of the program were determined through the methodology and calculations of free ridership and spillover as described in a supplemental document. The algorithms are based on self-claimed information gathered during participant survey efforts.

3.1.1.4.7 Verified Gross Savings Results

This section details findings from the impact evaluation of the Single Upgrade program.

Program Activity

In 2024, the Single Upgrade portion of Home Rebates had 2,206 total applications as part of the program. Final energy savings were based on a total of 2,502 energy-savings measures. See Table 3-23 below for a breakdown of total quantities for each energy-saving measure in the program.

[19] Used default EUL of 10 years (refrigerant added) from AR TRM 8.1.

Table 3-23: Single Upgrade – Per Measure Equipment Quantities

Measure	Quantity in Program
Central AC	971
Heat Pump	209
Ground Source Heat Pump	10
Attic Insulation	355
Pool Pump	246
HVAC Tune-Up	643
WiFi Thermostat	68
Total	**2,502**

Single Upgrade Reported and Verified Gross Savings

Table 3-24 presents the gross verified savings by measure, lifetime energy savings (kWh), and realization rates by measure.

Table 3-24: Single Upgrade - Reported and Verified Gross Energy and Peak 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}
Central AC	616,753	604,613	350.80	348.07	9,534,747	98%	99%
Heat Pump	406,199	411,816	70.80	70.48	5,468,916	101%	100%
Ground Source Heat Pump	86,926	75,817	19.44	19.05	1,895,416	87%	98%
Attic Insulation	296,832	303,996	175.86	178.42	5,046,334	102%	101%
Pool Pump	349,235	348,949	80.46	80.39	2,896,277	100%	100%
HVAC Tune-Up	359,401	386,567	184.38	166.86	3,208,506	108%	90%
WiFi Thermostat	49,595	48,843	0.00	0.00	445,937	100%	100%
Total	**2,164,189**	**2,180,601**	**881.73**	**863.26**	**28,496,133**	**101%**	**98%**

The gross impact analysis consisted of verifying measure installation using self-reported data from the participant survey results 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 online participant survey data and then extrapolated to the population. Findings from the participant survey and verification visits determined a 100% ISR for all sampled measures in Single Upgrade for 2024. A description of verified findings for each measure type is included below:

Central Air Conditioner: This measure involves the installation of a new central air conditioning system in a residential home (packaged unit, or split system consisting of an indoor unit with a matching remote condensing unit). 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). The realization rates for central air conditioners were 98% for energy savings and 98% for demand savings. The difference in energy and demand savings is due to rounding.

Heat Pumps:[20] This measure consists of the installation of a new central heat pump system in a residential home (central unit, packaged unit, split system consisting of an indoor unit with one or more matching remote condensing units, or mini-split system). The realization rates for heat pumps were 101% for energy savings and 100% 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 energy savings is due to rounding.

Ground Source Heat Pump: This measure involves the installation of a water-to-air ground source heat pump as a replacement for an existing air source heat pump (ASHP) or other combination of electric heating and air-to-air cooling system. The realization rates for ground source heat pumps were 87% for energy savings and 98% for demand savings. The difference in energy and demand savings is due to the difference between the baseline SEER and COP values used in the reported and verified savings calculations. The verified savings calculations used a baseline SEER value of 11.7 and a baseline COP value of 2.58, while the reported savings calculations used a baseline SEER value of 11.2 and a baseline COP value of 2.26.

Attic Insulation: This measure requires adding ceiling insulation above a conditioned area in a residential home of existing construction to a minimum ceiling insulation value of R-38. The realization rates for attic insulation were 102% for energy savings and 101% for demand savings. The verified savings calculations used deemed values from the AR TRM 8.1 based on whether the insulation was attic or roof deck. The reported savings calculations used deemed values for attic for all projects. The difference in energy and demand savings is due to the reported savings calculations not including extra inches of insulation that provide an R value beyond the R-49 table, as the heat transfer rate diminished with each extra R value past R-49. These extra savings in the verified savings calculations are from homes that had final insulation levels between R-38 and R-49. The

[20] Measure includes air source heat pumps and ductless mini-split heat pumps.

verified savings calculations used the deemed values for R-38, while the reported savings calculations used the interpolated values.

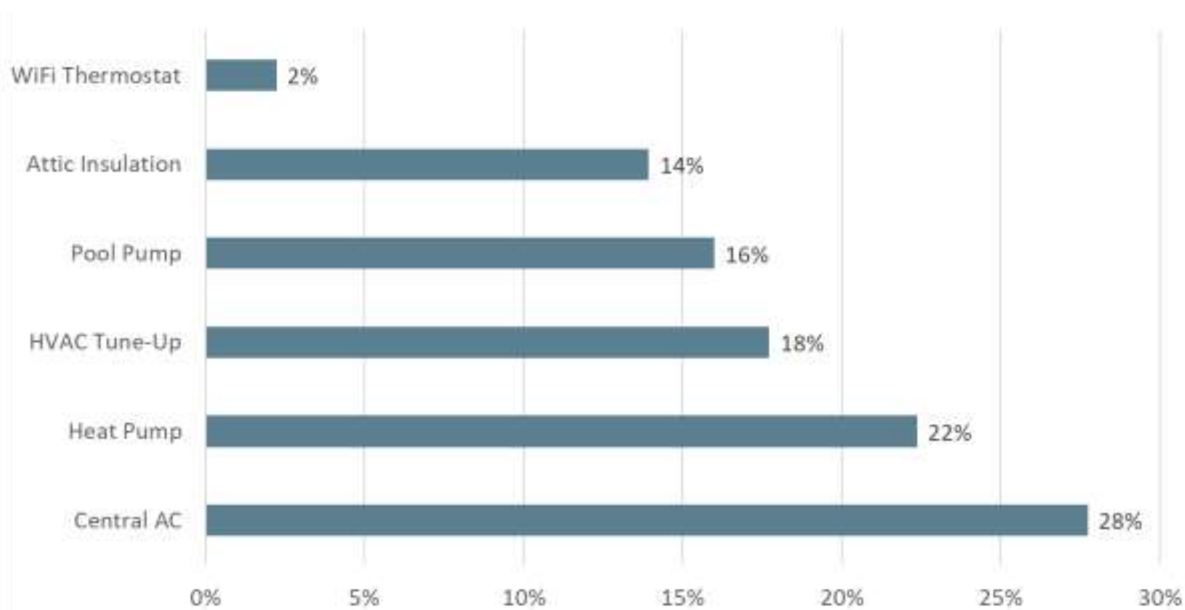
Variable Speed Drive Pool Pumps (Summer Only and Year-Round): This measure involves replacing a single-speed pool pump with a variable speed drive (VSD) pool pump in a residential pool (both summers only and year-round). The realization rates for pool pumps were 100% for energy savings and 100% for demand savings.

HVAC Tune-Ups: This measure applies to central air conditioners and heat pumps. An AC tune-up, in general terms, involves checking, adjusting and resetting the equipment to factory conditions, such that it operates closer to the performance level of a new unit. The realization rates for HVAC tune-ups were 108% for energy savings and 90% for demand savings. 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 8.1 algorithm and was based on a change in efficiency based on pre- and post-measurement of the system. The additional verified savings calculations include a heat pump savings credit for all heat pump tune-up projects, which lowered the baseline HSPF.

Wi-Fi Thermostats: This measure involves the replacement of a manually operated or programmable thermostat with a smart (Wi-Fi) programmable thermostat. The realization rates for Wi-Fi thermostats were 100% for energy savings and 100% for demand savings.

The percent of gross verified energy savings reported by measure for the 2024 Single Upgrade Program are detailed in Figure 3-3 below.

Figure 3-3: Single Upgrades – Percent of Gross Verified Energy Savings per Measure



3.1.1.4.8 Net-to-Gross (NTG) Estimation Results

Survey data from a total of 164 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 measure-level free ridership of each survey participant was then weighted by measure energy savings and averaged to determine the project-level free ridership scores. This score was applied to the other measures where a survey response was not obtained.

Survey respondents were also asked a series of questions to determine if they had installed any additional, non-rebated, energy-efficiency measures as a direct influence of their participation in the program, which is referred to as spillover. Out of 164 survey completes, one respondent provided specific details of additional energy-efficient equipment[21] they purchased in 2024 that was directly influenced by their participation in the program. This response was considered spillover as the participant rated the influence of the program high enough to claim added savings in the NTG estimation. This additional energy-efficient equipment resulted in 0.42% spillover for the Single Upgrade Program in 2024.

The average free ridership score was 16.88%. 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 83.05% for energy savings and demand savings. Based on the impact evaluation results, the total verified net energy savings for the Single Upgrade Program are 1,896,500 kWh, and the total verified net peak demand savings are 716.76 kW. A summary of Single Upgrade impact findings is shown in Table 3-25.

Table 3-25: Single Upgrade - Gross, Net Energy & Demand Savings

Gross Verified Energy (kWh)	Gross Verified Demand (kW)	Net Verified Energy (kWh)	Net Verified Demand (kW)	NTG Ratio
2,180,601	863.26	1,811,407	716.76	83.05%

3.1.1.5 Home Energy Check-Ups

The Public Service Company of Oklahoma (PSO) offers Home Energy Check-ups (HECs) as requested by customers. From the energy audit, PSO recommends ways for

[21] The energy-efficient equipment reported on the participant survey was only included as spillover if it was similar to the measures offered in the Home Rebates Program.

customers to save energy. For example, customers have participated in the Home Rebates program after completing an energy audit. However, completing an audit does not necessarily mean that a customer will take additional actions to save energy. A review of the HECs was conducted to determine whether savings have been realized through energy audit recommendations.

3.1.1.5.1 EM&V Methodology

This section presents the methodology for the evaluation of the HECs.

Data Preparation

To determine annual energy savings (kWh), ADM performed an analysis of the billing data for participants in the program using panel regression modeling. The following data was used in the analysis:

- Raw daily billing data for HEC participants
- Regional temperature obtained from the National Oceanic and Atmospheric Administration (NOAA) for Tulsa International Airport in Tulsa, OK.
- Participant information, including participation in other PSO programs.

After collecting the necessary data, ADM performed the following data cleaning and filtering steps:

- Drop daily measurements below 10 kWh.
- Remove participants without 7 months of post-period data.
- Remove participants who have participated in the Home Rebates program within one year of the HEC inspection date.

After data preparation, 11 accounts remained for the regression model.

Regression Approach

ADM used a mixed effects panel regression model to determine daily average electricity savings in the post-period. Electricity consumption is modeled by the equation in Figure 3-4.

Figure 3-4: Mixed Effects Panel Regression Model

$$AEC_{i,t} = \alpha_i \mathrm{Customer_i} + \beta_1 CDD_{i,t} + \beta_2 HDD_{i,t} + \beta_3 Post_{i,t} \\ + \beta_4 Post_{i,t} * CDD_{i,t} + \beta_5 Post_{i,t} * HDD_{i,t} + E_{i,t}$$

Where the subscript i denotes individual customers and t = 1. $T_{(i)}$ serves as a time index, where $T_{(i)}$ is the number of measurements available for customer i. The model is defined as "mixed effects" because the model decomposes its parameters into fixed-effects (i.e., Heating Degree Days (HDD), Cooling degree days (CDD), Post-Installation period (Post), and interactive terms) and random effects (i.e., the individual customer's baseline period 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.

After an audit, customers may make changes that affect energy consumption. The period between the HEC inspection date and when such change may occur is considered the "commissioning period." The commissioning period is unknown for each sample, so it is treated as a fixed variable at multiple durations. Observations that occur in the commissioning period are not included in the mixed effects panel regression as they contain a mix of pre-treatment and post-treatment data. The post variable is defined as 0 before the inspection date and a 1 for measurements following the commissioning period.

Heating degree day (HDD) and cooling degree day (CDD) were used in the model to control energy demand based on outside temperature. HDD is defined as the 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 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 3-26.

Table 3-26: Description of Variables Used in the Regression Model

Variable	Variable Description
Average Electricity Consumption (kWh)	Average daily use of electricity (kWh)
Customer	A panel of dummy variables that is a 1 for customer or a 0 if not
Cooling Degree Day (CDD)	The difference between actual outside air temperature and 65 degrees
Heating Degree Day (HDD)	The difference between 65 degrees and the actual outside air temperature
Post	Post is a dummy variable that is 1 if the measurement is after the commissioning period and 0 for the periods before the audit
E_t	E_t is the error term

Table 3-27 describes the coefficients that were determined by using the mixed effects panel model.

Table 3-27: Description of the Coefficients Estimated by the Regression Model

Coefficient	Coefficient Description
α_i	is a coefficient that represents the grand mean of the customer-specific intercepts used to control for any customer-specific differences
β_1	is a coefficient that adjusts for the main effect of cooling
β_2	is a coefficient that adjusts for the main effect of heating
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	is a coefficient that adjusts for the interactive effect between the post-period and cooling
β_5	is a coefficient that adjusts for the interactive effect between the post-period and heating

The estimated coefficient for the post-term is used to determine whether HECs yield energy savings. The two interactive effects for heating and cooling with the post-period are included because HECs have an indirect effect on energy savings. During audits, customers are provided with recommendations to reduce consumption, but these may not result in actions that contribute to energy savings. Therefore, temperature in the post-period should be accounted for since it is not known for certain that temperature has a direct effect on energy savings.

3.1.1.5.2 Verified Gross Savings Results

This section reviews the findings from the regression model. Varying commissioning periods were considered as the timeline to implement energy efficiency was unknown. Based on the statistical significance of the billing analysis, a 90-day commissioning period was chosen as the most appropriate. Estimated regression coefficients are displayed below in Table 3-28.

Table 3-28: Estimated Daily Savings (kWh) per Residence

Commissioning Period (Days)	Post Coefficient	T-Statistic	Standard Error†	90% Lower	90% Upper
0	3.36	2.14	1.57	0.78	5.94
30	2.30	1.37	1.68	-0.47	5.07
60	0.90	0.51	1.77	-2.01	3.81
90	-2.00	-1.07	1.88	-5.10	1.09

†This value is the adjusted standard error value obtained from the regression model, multiplied by 1.645 (the statistical z value for the 90% confidence interval).

The Post coefficient for the model with a commissioning period of 90 days was used to calculate average annual residence savings in Table 3-29 as that is most likely representative of the period in which energy savings actions have taken place.

Table 3-29: Estimated HEC Savings per Residence

Daily Savings (kWh)	Annual Savings (kWh)	Percent Savings	Peak Demand Savings (kW)
2.30	731.58	3.97	0.56

The estimated annual savings per customer is approximately 840 kWh annually or about a 4% average daily reduction. The summer peak of PY2024 occurred on August 6, 2024. This peak day was used to determine the peak demand savings for HEC customers. The peak demand reduction was approximately 0.56 kW.

Savings per resident were extrapolated to the 31 residents who received Home Energy Checkups. Extrapolating savings results from the 11 residences in the analysis samples results in the total energy impacts shown in Table 3-30.

Table 3-30: Verified HEC Savings

Annual Savings (kWh)	Peak Demand Savings (kW)
22,679	17.36

3.1.1.6 Home Rebates Impact Evaluation Findings

Program level results for the Home Rebates are listed below with the verified gross energy and demand savings in Table 3-31.

Table 3-31: 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	1,293,670	536.51	1,291,562	533.45	21,360,287
Multiple Upgrades	3,707,683	1,605.83	3,849,082	1,870.77	64,082,160
Single Upgrade	2,164,942	881.73	2,180,601	863.26	28,496,133
Home Energy Check-Ups	6,200	0.00	22,679	17.36	226,790
Total	**7,172,495**	**3,024.09**	**7,343,924**	**3,284.87**	**114,165,370**

Table 3-32 and Table 3-33 summarize the verified net impacts of the complete Home Rebates Program.

Table 3-32: Verified Gross and Net Energy Savings

Program	Free Ridership	Participant Spillover	NTG Ratio	Gross Verified Energy (kWh)	Net Verified Energy (kWh)
New Homes	17.31%	0.00%	82.69%	1,291,562	1,068,014
Multiple Upgrades	9.07%	1.20%	92.12%	3,849,082	3,545,956
Single Upgrades	16.95%	0.42%	83.05%	2,180,601	1,811,407
Home Energy Check-Ups	0.00%	0.00%	100.00%	22,679	22,679
Total				**7,343,924**	**6,448,056**

Table 3-33: Verified Gross and Net Peak Demand Reduction

Program	Free Ridership	Participant Spillover	NTG Ratio	Gross Verified Demand (kW)	Net Verified Demand (kW)
New Homes	18.94%	0.00%	81.06%	533.45	432.43
Multiple Upgrades	9.07%	1.20%	92.35%	1,870.77	1,727.67
Single Upgrades	16.95%	0.42%	83.03%	863.26	716.76
Home Energy Check-Ups	0.00%	0.00%	100.00%	17.36	17.36
Total				**3,284.84**	**2,894.22**

3.1.1.7 Process Evaluation Findings

A process evaluation was performed to assess the program year's operations and delivery. The evaluation of the Home Rebates Program included a review of program materials, a facilitated discussion with program staff, participant surveys, trade ally survey, home buyer survey, and builder survey. A detailed process evaluation memo was provided to PSO after the completion of the program year.

3.1.1.7.1 New Homes

The New Homes process evaluation included a facilitated discussion with program staff, new home buyer surveys, and a home builder survey.

Home Buyer Survey

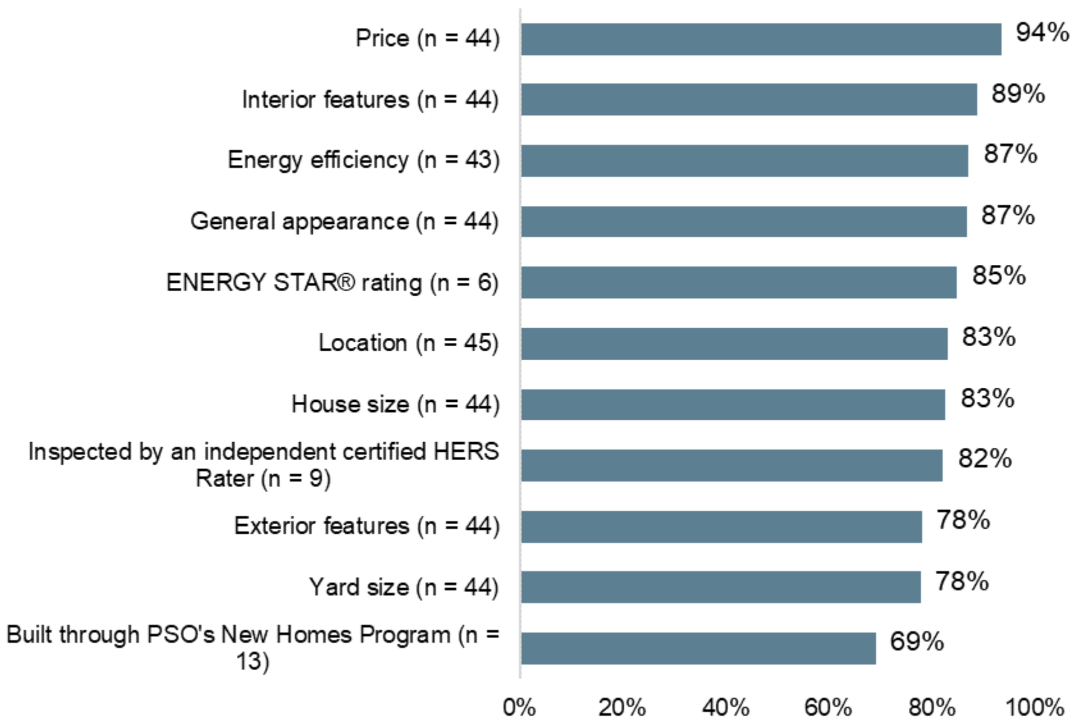
ADM conducted a home buyer survey of PSO customers who purchased an energy efficient home as part of the New Home Program in 2024. Home buyers were emailed to complete an online survey in August 2024 and were entered into a drawing for a digital gift card if they completed the questionnaire. ADM sent the online survey to a total of 274 home buyers, which resulted in 45 surveys completed.

In 2024, survey participants dealt directly with either the home builder (58%) or a real estate agent (16% used the builder's real estate agent, and 24% used a different real estate agent) when buying their home.

Most survey participants (84%) did not know about the PSO New Homes Program before being invited to the survey. Those who knew about the program (n = 4) learned of it from the home builder (75%) or from PSO's website (25%).

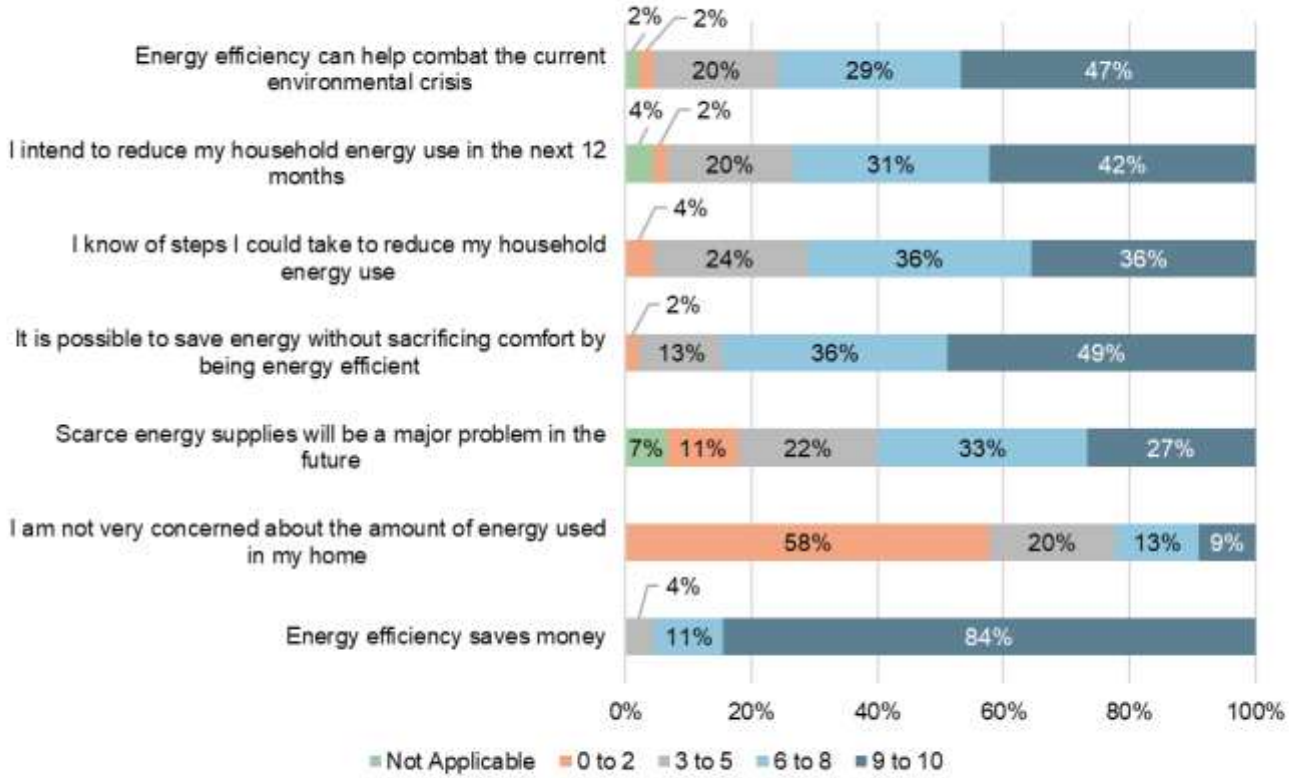
Survey participants rated different factors in their decision to buy their home on a scale of 0 to 10, where 0 meant "Not at all important" and 10 meant "Very important". Home factors' average ratings are shown in Figure 3-5.

Figure 3-5: Importance of Features for Purchasing a Home



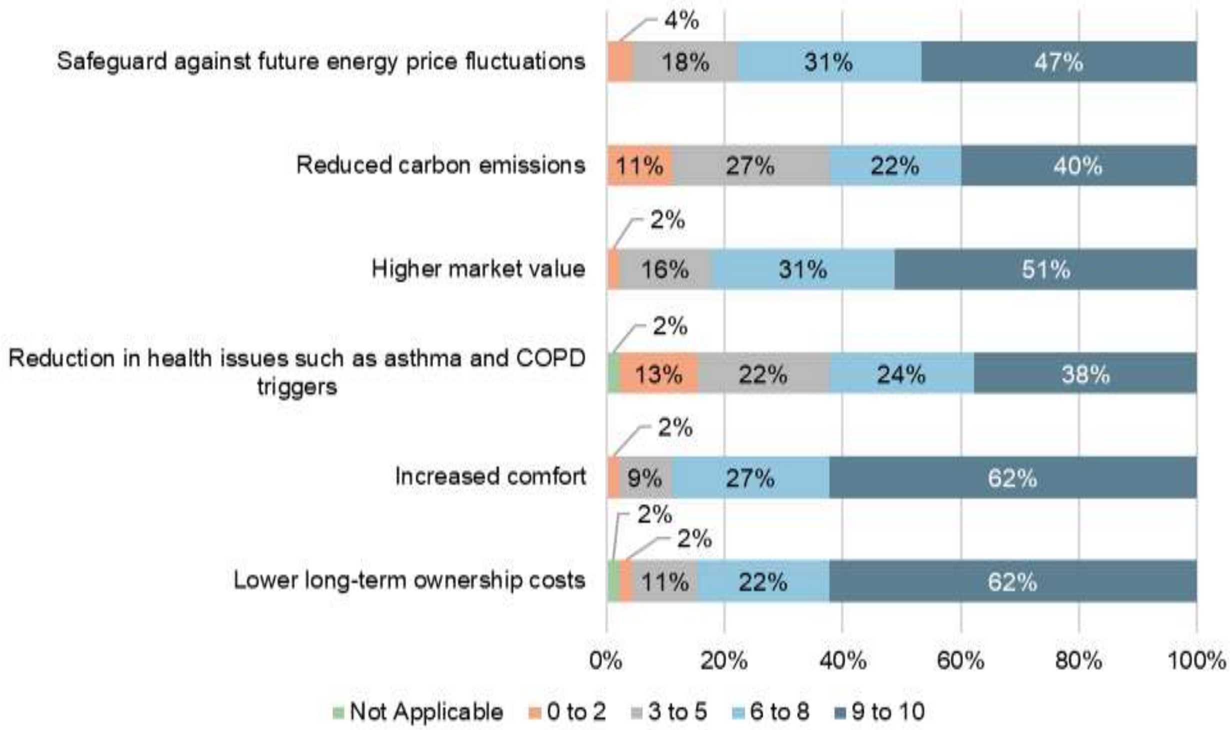
The survey participants provided feedback on how well informed they are about energy efficiency practices and energy-efficient options for their household. On a scale of 1 to 5, with 1 being "Not at all informed" and 5 being "Extremely informed", only a little more than a third of respondents (33%) reported they were informed, providing a rating of 4 or higher. When asked to rate their level of agreement with different statements regarding energy efficiency, survey participants provided responses on a scale of 0 to 10, where 0 is "Strongly disagree" and 10 is "Strongly agree". The results of that question are shown in Figure 3-6.

Figure 3-6: Home Buyer Agreement with Energy Efficiency Statements (n = 45)



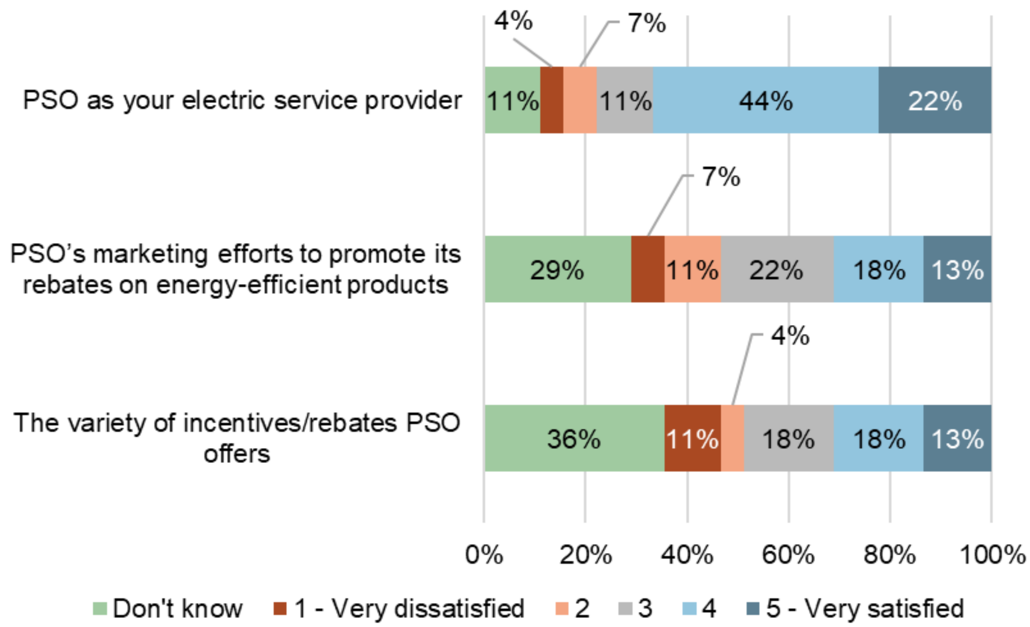
When asked to rate the importance of non-energy benefits when purchasing their new energy-efficient home, survey participants provided responses on a scale of 0 to 10, where 0 is “Not at all important,” and 10 is “Very important.” The results of that question are shown in Figure 3-7.

Figure 3-7: Importance of Non-Energy Benefits for Purchasing a Home (n = 45)



When asked to rate their level of satisfaction with different aspects of PSO, survey participants provided responses on a scale of 1 to 5, where 1 is “Very dissatisfied,” and 5 is “Very satisfied.” The results of that question are shown in Figure 3-8. Most respondents reported being satisfied with PSO overall as their electricity service provider (67%), rating it as a 4 or higher. However, less than a third of respondents reported being satisfied (rated as a 4 or higher) with PSO’s marketing efforts to promote its discounts on energy-efficient products (31%), and the variety of incentives/rebates PSO offers (31%).

Figure 3-8: Home Buyer PSO Satisfaction (n = 45)



Home Builder Survey

Builders that participated in the Home Rebates were contacted via email in January 2025 to complete a survey using an online survey platform (Qualtrics). A total of 21 builders were contacted, which resulted in 5 survey participants. The survey collected data on the builders' organizations, program awareness and involvement, program procedures, customer market and interaction, satisfaction with PSO, and overall satisfaction with the program.

Builders who completed the survey indicated significant experience with the program. Most builders (80%) participated for more than one year. The other 20% of builders did not know how long they participated in the program. Builders primarily learned about the program through a PSO representative (60%) or a contractor (20%). One builder could not recall how they first learned about the program.

When asked about the number of homes their companies built in 2024, homebuilders ranged from 3 to 250. For homes that received a program rebate in 2024, all builders (100%) reported that at least some of the homes they built were custom-built.

Builders differed on the trends of the percentage of homes they built in 2024 that qualified for PSO program incentives. Most builders reported that the percentage of homes stayed about the same (60%), while the remaining builders reported an increase in the percentage of homes (40%).

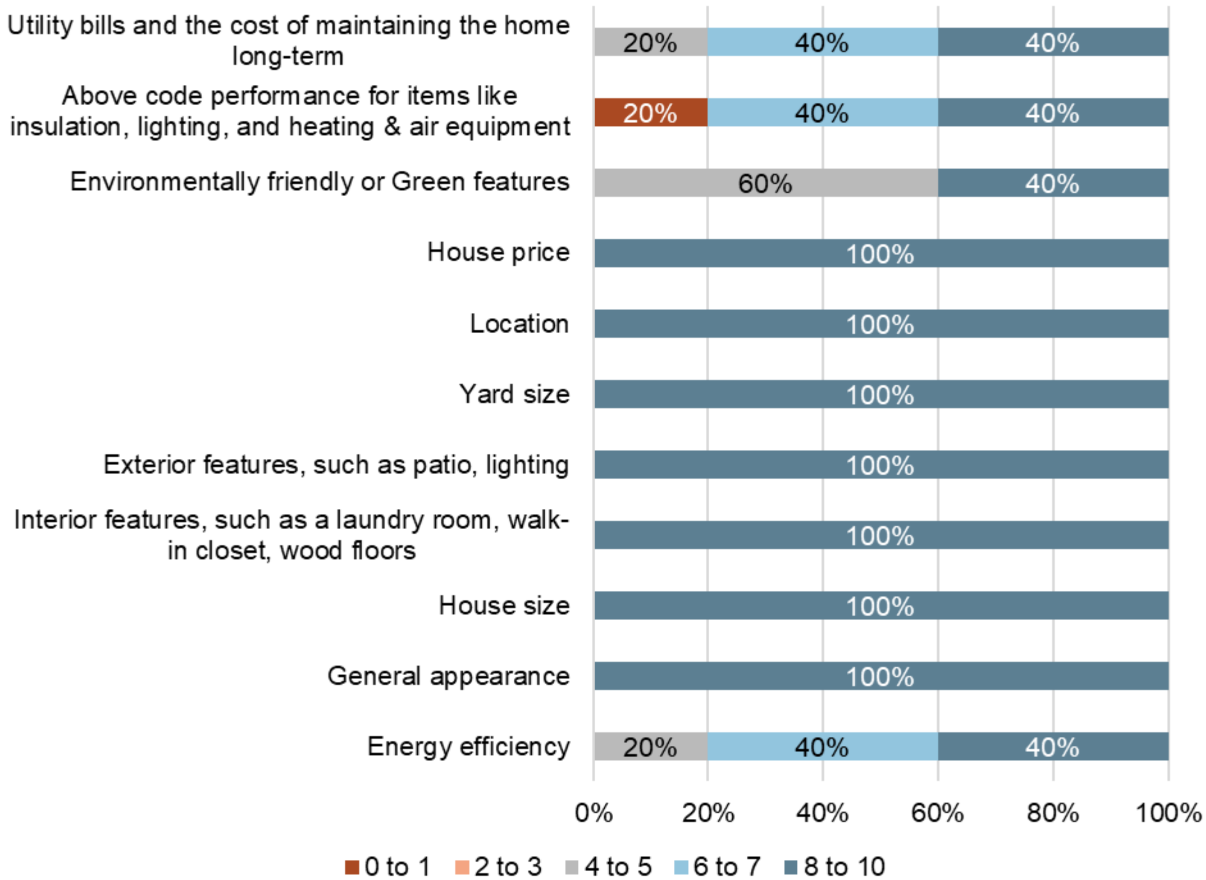
Most homebuilders are satisfied with program outreach (80%), while one builder was neither satisfied nor dissatisfied. The main communication channels to keep builders informed about the program are email, phone calls, and in-person. Some builders (40%) reported attending events in 2024 where a program representative provided information about the New Homes Program, and all those respondents felt that the information provided at the event was useful. Almost all the builders (80%) reported that PSO is a trustworthy source of information regarding energy-efficient building techniques/practices[22] while one reported that they weren't sure.

Most builders (80%) reported that none of their customers knew about PSO's New Homes Program before they began working with them to build or purchase a new home. Most builders (60%) indicated they actively encouraged home buyers not looking for energy-efficient homes to buy a home built to PSO's energy efficiency standards. Builders that encouraged their customers to build a home to PSO's energy efficiency standards reported convincing all their customers (100%) to do so. Builders also noted that word-of-mouth (33%) and media marketing (67%) work best when marketing to customers. The biggest challenge for marketing energy-efficient homes, as reported by builders, is the price of the homes (100%). One builder noted that showing customers their return on investment encouraged them to participate in the program.

Builders reported that the most important aspect home buyers consider when purchasing a home is the price, followed closely by the interior features. See Figure 3-9 for all home aspects as rated by builders.[23]

[22] Rated PSO's trustworthiness a 4 or 5 on a scale from 1 (not at all trustworthy) to 5 (very trustworthy).
[23] Using a scale of zero to ten, where zero is "Not at all important to customers" and ten is "Extremely important to customers".

Figure 3-9: Builder Perspective on Importance of Home Aspects to Buyers (n = 5)

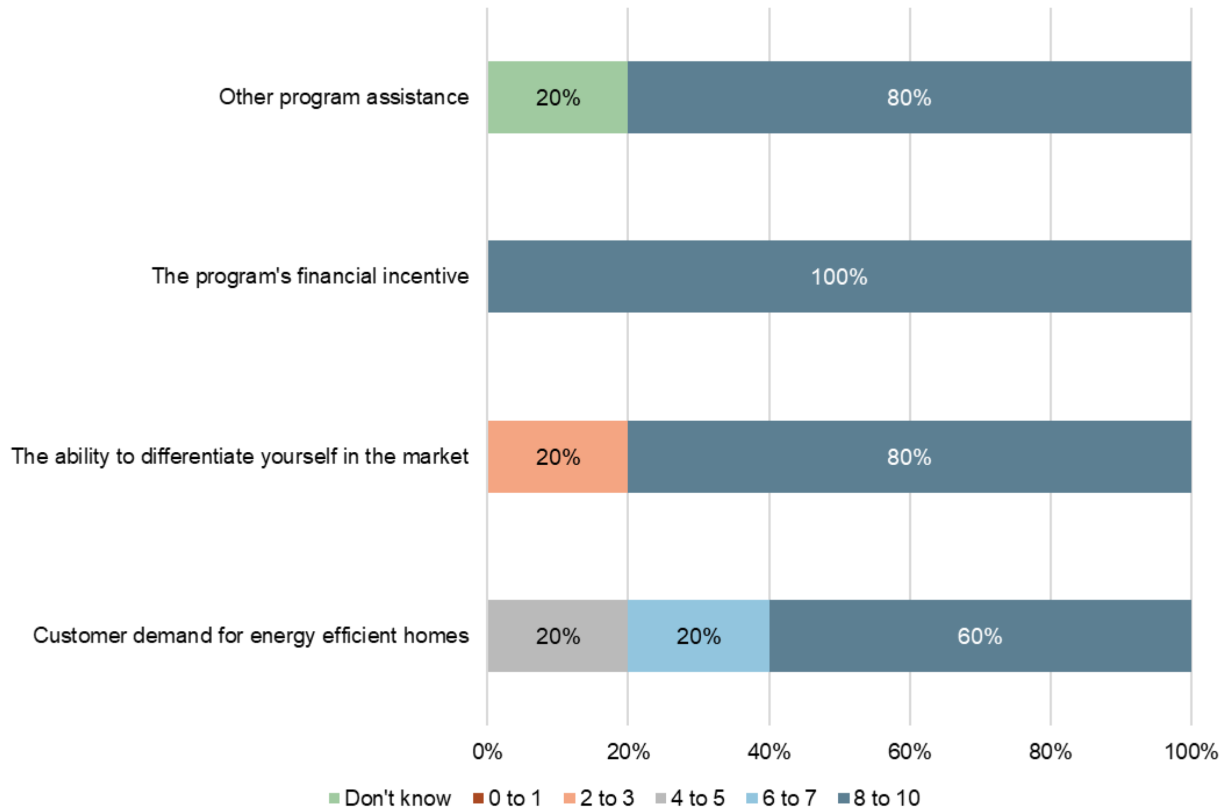


Builders reported that program-qualifying homes, on average, cost more than homes that are otherwise comparable but not built to program standards (80%). Builders also reported that about 26% to 50% of potential home buyers in the current market would choose not to pay the additional price for a program-qualifying home.

Builders were asked to rate the importance of different factors in their decision to build homes to program standards in 2024.[24] The most important factor for builders participating in the program is the program's financial incentive. See Figure 3-11 for all factors as rated by builders.

[24] Using a scale of zero to ten, where zero is "Not at all important" and ten is "Very important".

Figure 3-10: Importance of Factors in Decision to Build Energy-Efficient Homes (n = 5)

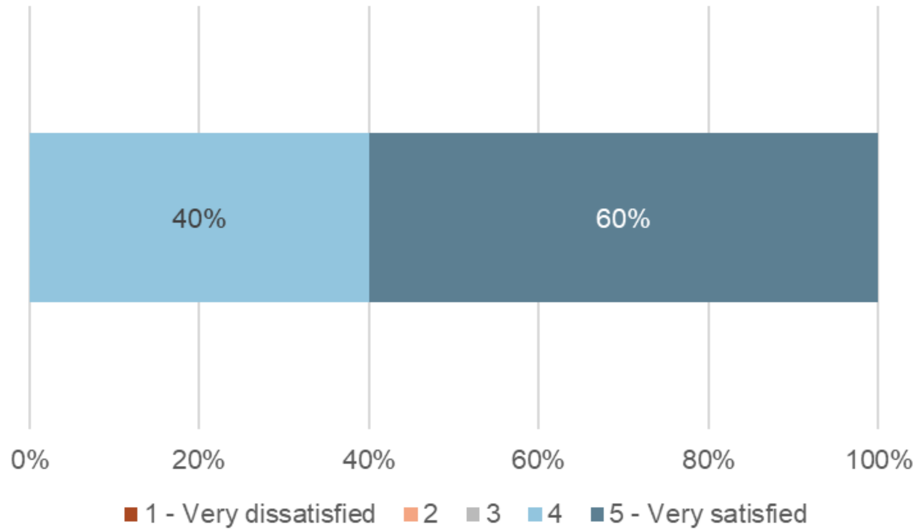


Most builders (60%) reported that their specifications or building practices in general changed since working with the program, even for homes that do not meet PSO program standards. Some of the construction elements that proved to be difficult for the builders were the requirement for house infiltration (20%) and the requirement for duct infiltration (20%). None of the builders reported installing heat pump water heaters in their qualifying new home builds.

Builders reported having positive interactions with program staff (100%)[25]. Most builders (80%) described the processes for paperwork and record-keeping required by the program as easy[26]. For the program incentives, builders were most concerned with the amount being too low (80%) and the potential to not receive rebates for some of their projects (20%). Builders indicated that they were satisfied with the program (100%)[27]. Builder satisfaction with the program overall is shown in Figure 3-11.

[25] Rated their interactions as a 4 or 5 on a scale from 1 (not at all positive) to 5 (very positive).
[26] Rated the ease a 4 or 5 on a scale from 1 (very difficult process) to 5 (very easy process).
[27] Rated satisfaction a 4 or 5 on a scale from 1 (very dissatisfied) to 5 (very satisfied).

Figure 3-11: Builder Satisfaction with the New Homes Program Overall (n = 5)



The following summarizes key findings of the process evaluation of the New Homes component:

- **Limited Program Awareness Among Home Buyers:** The New Homes Program remains largely unknown to home buyers until they engage with a builder or real estate agent. Survey results indicate that 84% of home buyers were unaware of the program before purchasing their home. Additionally, most builders noted that fewer than half of their customers knew about the program before engaging with them. This suggests a need for increased direct outreach to potential buyers.
- **Builders Find Value in Energy-Efficient Construction but Face Market Challenges:** Builders participating in the program see the benefits of constructing energy-efficient homes, with 60% reporting that their building practices have improved even for non-qualifying homes. However, the higher cost of program-compliant homes remains a challenge, as 80% of builders indicated that price is the most important factor for buyers, and 26-50% of potential buyers are unwilling to pay the additional cost for energy-efficient homes.
- **Marketing Efforts Have Expanded but May Not Fully Address Buyer Needs:** The program's marketing initiatives, including bill inserts, Parade of Homes magazine ads, and the St. Jude home sponsorship, have increased outreach. However, survey results show that only 31% of home buyers are satisfied with PSO's marketing efforts, and many buyers do not fully understand the benefits of energy-efficient homes. This indicates a gap in communication that could be addressed.

3.1.1.7.2 Single and Multiple Upgrades

The process evaluation included a facilitated discussion with program staff, a participant survey, and a trade ally survey.

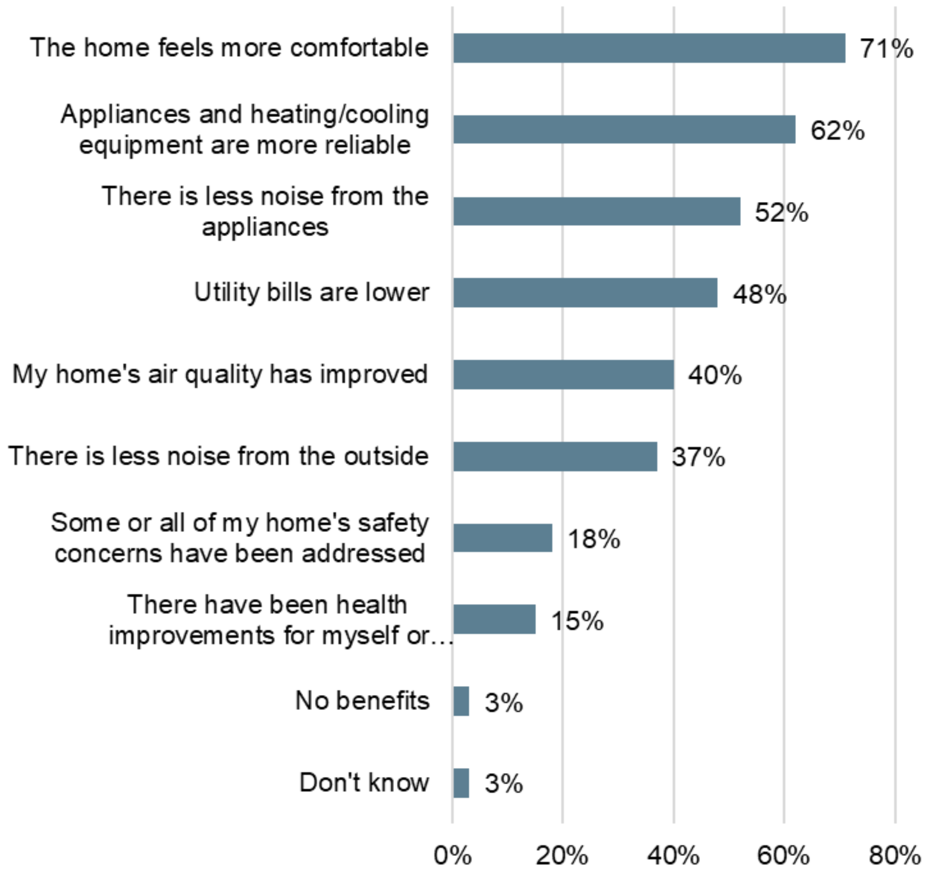
Multiple Upgrades Participant Survey

ADM conducted a monthly participant survey via email from April through November 2024 using an online survey platform (Qualtrics) and offered a monetary incentive if they completed the questionnaire. ADM sent the online survey to a total of 611 participants, which resulted in 119 surveys completed. The survey assessed program awareness, experience with the program, satisfaction with PSO and the program, home characteristics, and demographics.

A customer must utilize a program-certified contractor (trade ally) to participate in the Home Rebates Program. Eighteen percent of participants first contacted their trade ally because they were interested in energy efficiency, while 82% had a specific issue or concern they wanted to address. Issues mentioned included fixing or replacing broken equipment (75%), increasing home comfort (11%), health or safety concerns (4%), fixing or replacing older, inefficient equipment (8%), and attempting to reduce bills (1%).

Participants provided feedback about their experience with the program and the efficiency improvements they made. Respondents reported improved home comfort (71%), higher reliability of heating and cooling appliances (62%), and reduced noise from appliances (52%) as the most perceived benefits from their energy saving upgrades. For all other responses, refer to Figure 3-12.

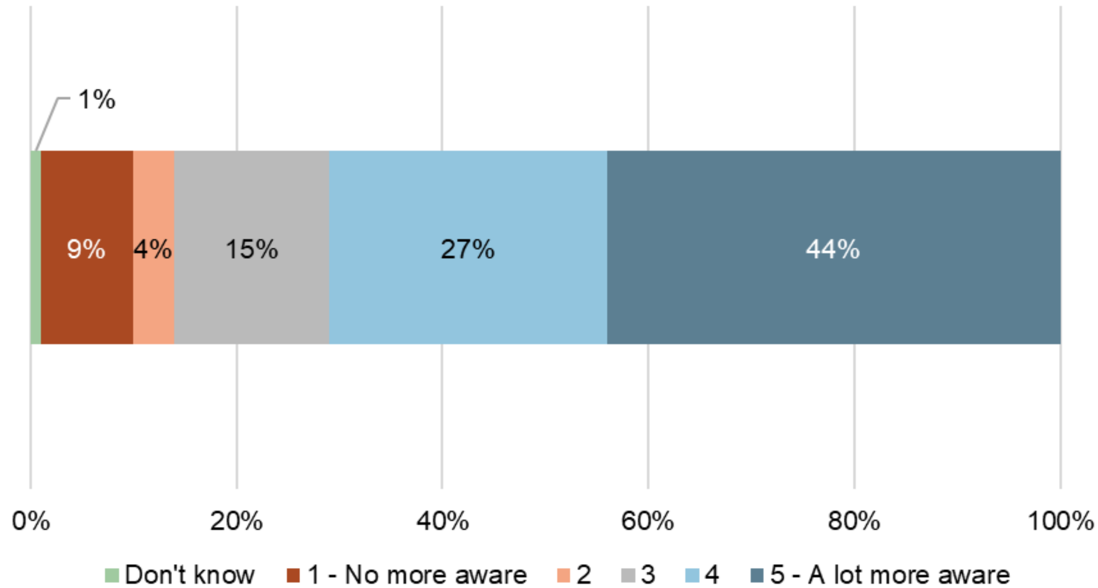
Figure 3-12: Benefits of Energy Saving Upgrade Improvements (n = 119)



Note: Percentages exceed 100% because participants could select more than one response for multi-select questions.

ADM asked respondents if having the improvements made them more aware of the advantages of energy efficiency, and most respondents reported increased awareness (see Figure 3-13).

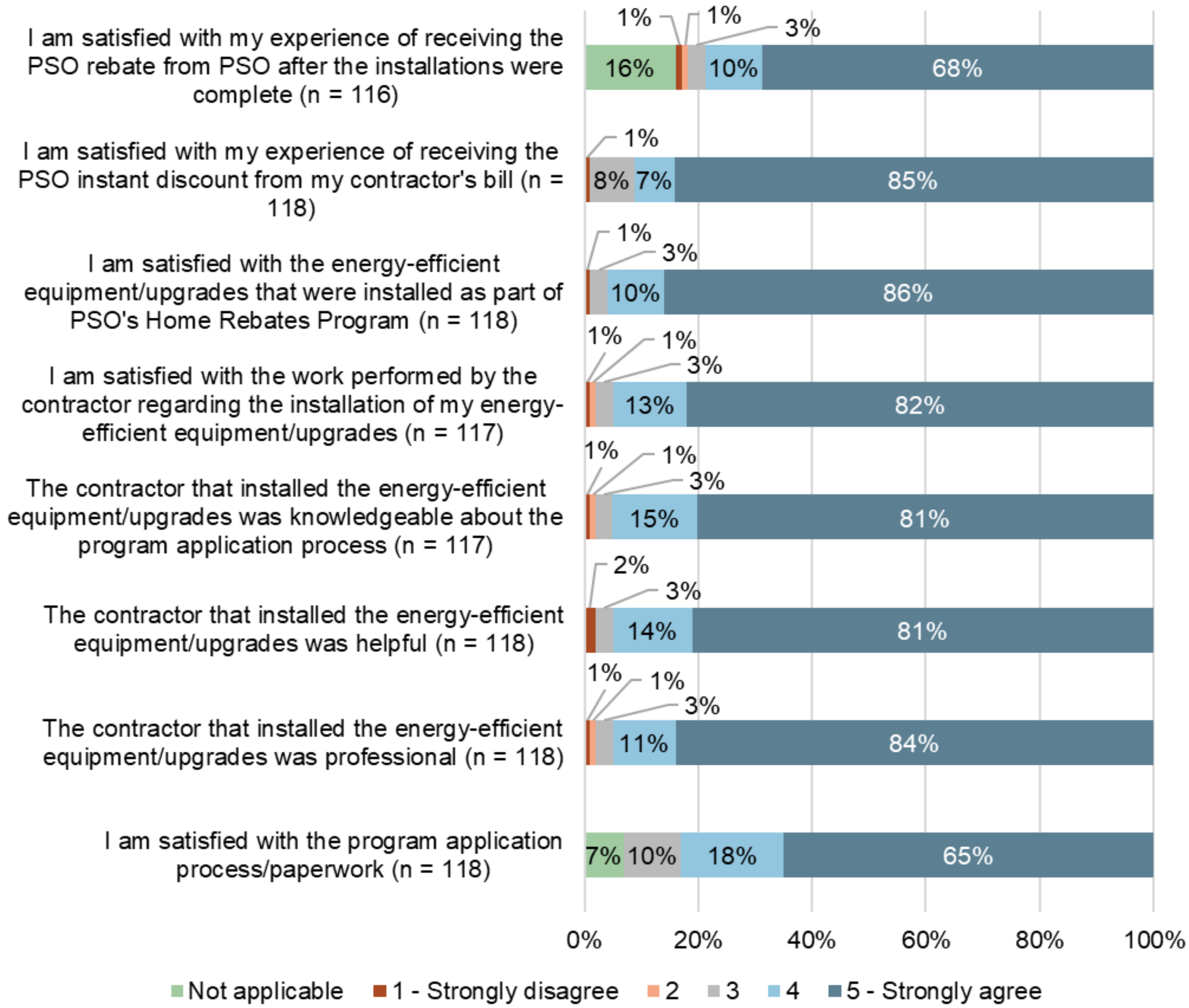
Figure 3-13: Awareness of Energy Efficiency After Upgrade (n = 119)



Participants provided feedback about their satisfaction with program staff, the contractor who installed the upgrades, and the Multiple Upgrades Program overall. Ninety-three percent of respondents indicated satisfaction with their overall experience.[28] None of the participants indicated dissatisfaction with the overall Multiple Upgrades Program.[29] Most respondents were satisfied with their contractor, while three respondents expressed dissatisfaction with the installation process and quality of work. Figure 3-14 displays respondents' level of agreement with various statements about their program experience.

[28] Rated their satisfaction a 4 or 5 on a scale from 1 (very dissatisfied) to 5 (very satisfied).
[29] Rated their satisfaction a 1 or 2 on a scale from 1 (very dissatisfied) to 5 (very satisfied).

Figure 3-14: Multiple Upgrades Program Satisfaction



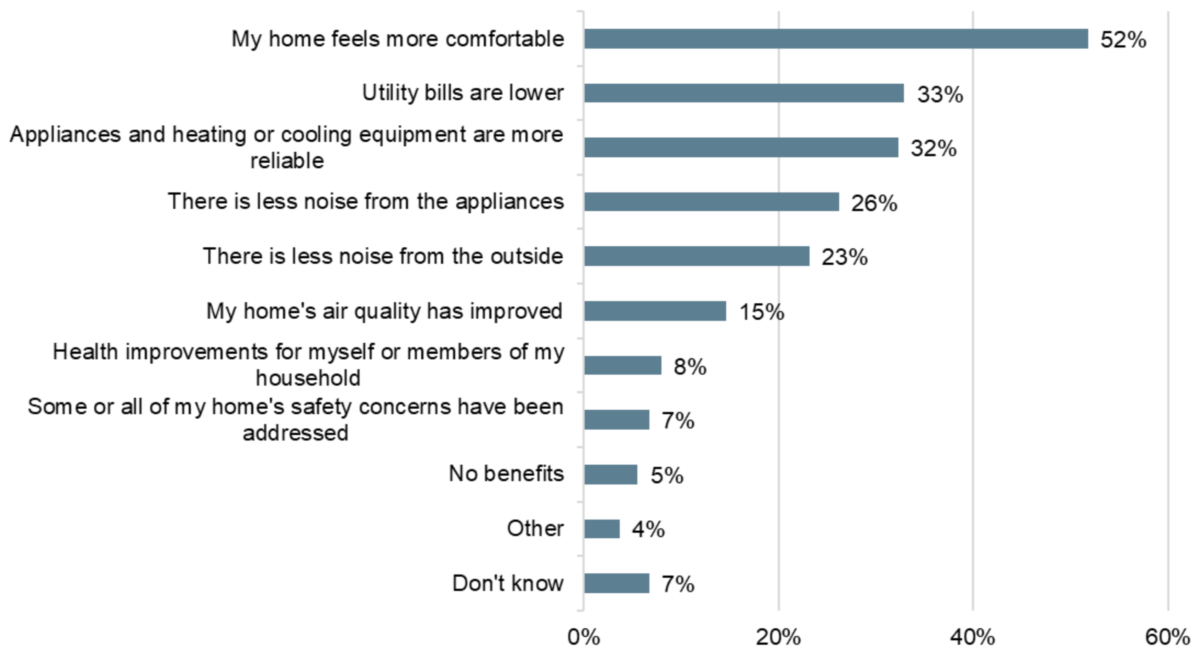
Single Upgrades Participant Survey

Participants were contacted from April through November 2024 to complete a survey using an online survey platform (Qualtrics) and offered a monetary incentive if they completed the survey. ADM emailed the survey to a total of 1,156 participants, which resulted in 164 completed surveys. The survey assessed program awareness, experience with the program, satisfaction with PSO and the program, home characteristics, and demographics.

A customer must utilize a program-certified contractor (trade ally) to participate in the Home Rebates Program. Twenty-nine percent of participants first contacted their trade ally because they were generally interested in energy efficiency, while 66% had a specific issue or concern they wanted to address. The other six percent of respondents could not recall why they first contacted their contractor. Issues mentioned included fixing or replacing broken equipment (60%), increasing home comfort (22%), and fixing or replacing older, inefficient equipment (8%). Other respondents said that they had health or safety concerns (3%), needed maintenance performed on their equipment (5%), or were looking for insulation information (3%).

Participants provided feedback about their experience with the program and their efficiency improvements. Respondents reported improved home comfort (52%), lower utility bills (33%), and higher reliability of heating and cooling appliances (32%) as the most perceived benefits from their energy saving upgrades. For all other responses, refer to Figure 3-15.

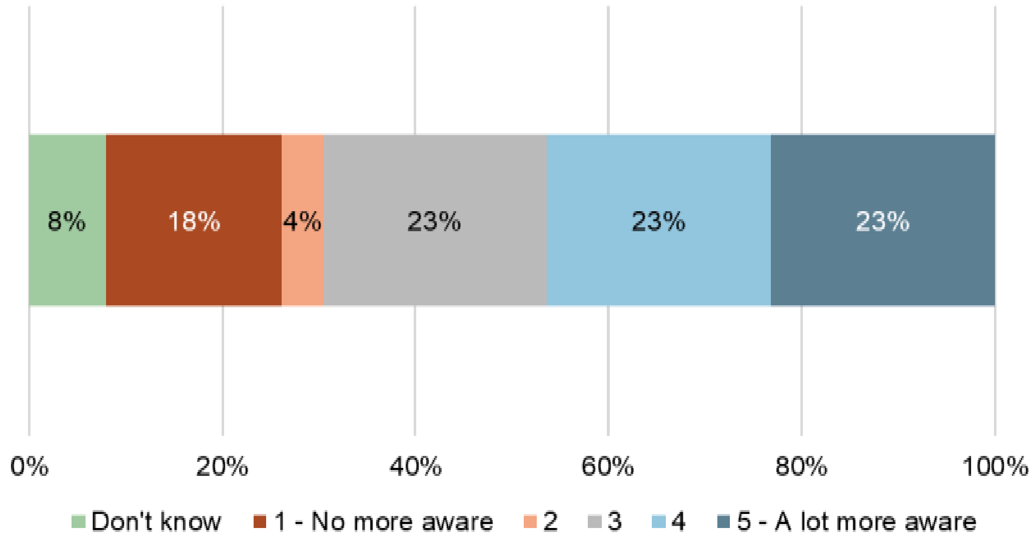
Figure 3-15: Benefits of Energy Saving Upgrade Improvements



Note: Percentages exceed 100% because participants could select more than one response for multi-select questions.

ADM asked respondents if the improvements made them more aware of the advantages of energy efficiency, and almost half of respondents reported increased awareness (see Figure 3-16).

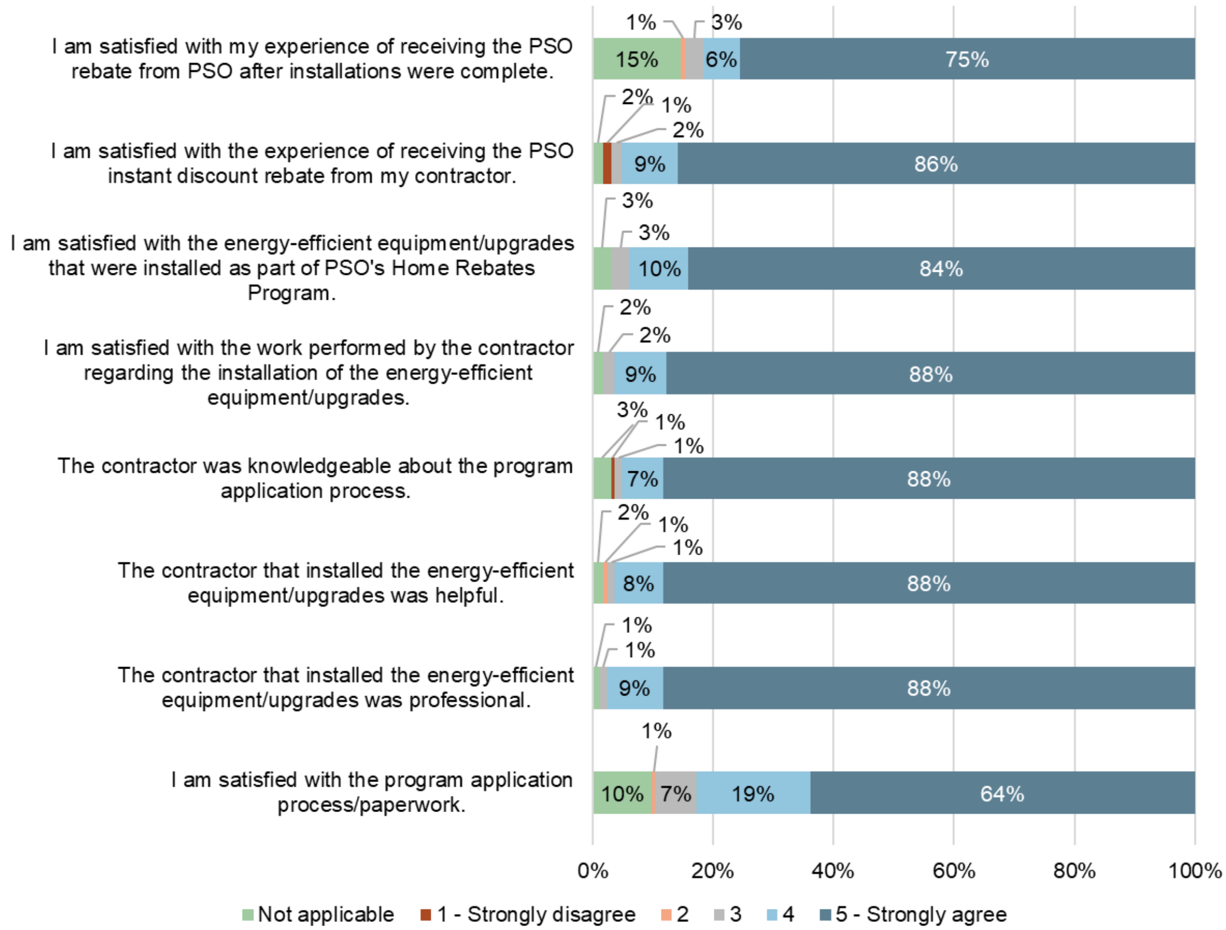
Figure 3-16: Awareness of Energy Efficiency After Upgrade (n = 164)



Single Upgrade Program Satisfaction

Participants provided feedback about their satisfaction with program staff, the contractor who installed the upgrades, and the Single Upgrade Program overall. Most respondents agreed they were satisfied with the application process and the quality of their contractor's work. Figure 3-17 shows respondents' level of agreement with various statements about their program experience.

Figure 3-17: Single Upgrade Program Satisfaction (n = 163)

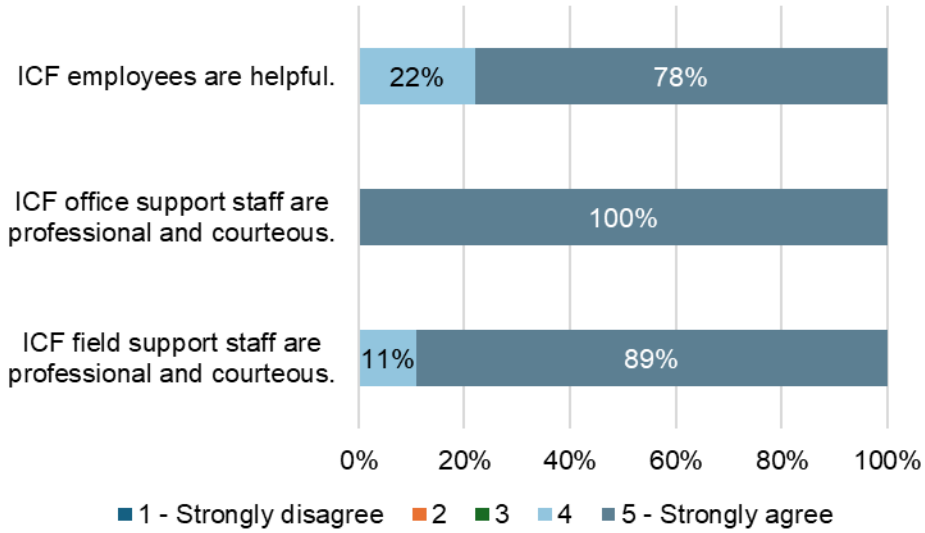


Single and Multiple Upgrades Trade Ally Survey

ADM conducted a survey of trade allies who participated in the Single & Multiple Upgrade Program in 2024. This section summarizes program feedback received from a sample (77 responses) of Home Rebates trade allies. Trade allies were asked to rate their level of agreement with statements regarding their satisfaction with program staff[30] as outlined in Figure 3-18.

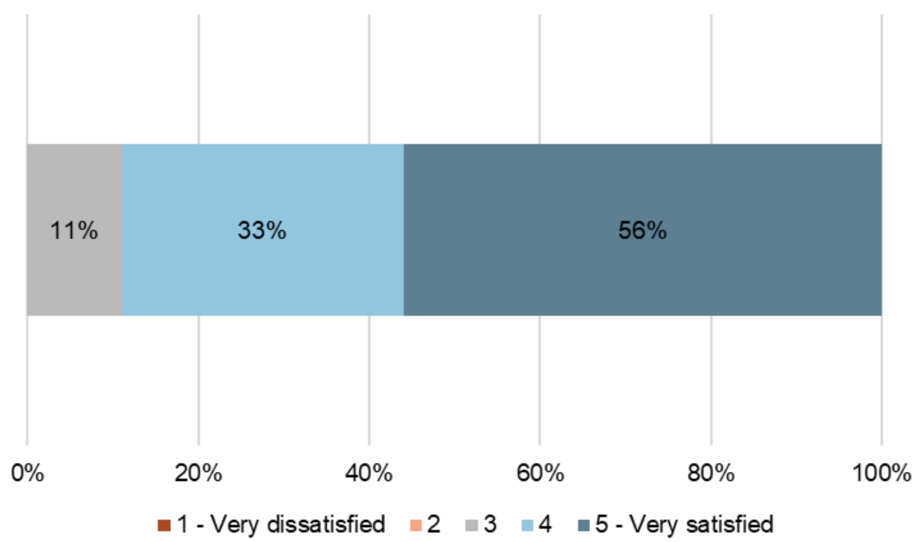
[30] Rated their agreement a 4 or 5 on a scale from 1 (strongly disagree) to 5 (strongly agree).

Figure 3-18: Trade Ally Satisfaction with Program Staff



Eighty-nine percent of trade allies expected the number of Home Rebates Program projects they complete in the next 12 months to increase. Some of the reasons for this expected increase is due to more awareness of the program and a better perceived economic outlook. Overall, most trade allies (89%) were satisfied with PSO's Home Rebate Program[31] (see Figure 3-19). One Trade Ally reported being neither satisfied nor dissatisfied with the program due to the rebate offerings not changing in relation to price increases.

Figure 3-19: Trade Allies' Overall Satisfaction with the Program



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

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

- **High Satisfaction and Awareness from Participants:** The Multiple Upgrades Program has achieved high satisfaction levels among participants, with 93% reporting a positive experience. The program's success is largely attributed to its contractor network, as 79% of participants learned about the rebates through contractors. However, delays in rebate processing and occasional contractor miscommunications indicate areas for operational improvement.
- **Operational Stability with Incremental Improvements:** While the program remained operationally stable from PY2023 to PY2024, incremental changes—such as adding WiFi thermostats—enhanced energy savings. However, evolving ENERGY STAR EER standards pose a challenge, potentially limiting rebate-eligible HVAC units.
- **Challenges in Rebate Processing and Contractor Performance:** Although most participants had a positive experience, a few reported issues with processing delays and contractor inefficiencies. Some participants faced extended waiting periods due to incomplete paperwork submissions by contractors, leading to frustration. Improved contractor education on rebate submission procedures could help mitigate these issues.

The following summarizes the key findings of the process evaluation of the Single Upgrade component:

- **Limited Uptake of Heat Pump Water Heaters:** Despite the introduction of the heat pump water heater measure in PY2023 and a targeted educational campaign, there have been no confirmed projects under the Single Upgrade Program. This suggests that additional barriers, such as contractor awareness, customer understanding, or financial constraints, may be limiting participation. Further research is needed to identify and address the specific factors preventing adoption.
- **Contractor Influence and Education Needs:** Contractors are the primary source of program awareness (77% of participants learned about the rebates from them), highlighting their critical role in program success. However, customer feedback suggests some contractors lack clarity on rebate processes. Improving contractor education and communication about rebates could enhance customer experience and increase participation.
- **High Satisfaction with the Program but Some Areas for Improvement:** Overall, 95% of respondents were satisfied with the Single Upgrade Program, and many reported benefits such as improved home comfort and lower utility bills. However, concerns about rebate amounts, unclear rebate explanations, and the usability of installed equipment indicate areas where program processes and contractor training could be refined to improve customer satisfaction further.

3.1.1.8 Conclusions and Recommendations

The following recommendations are offered for continued improvement of the New Homes component:

- **Enhance Consumer-Focused Marketing and Outreach:** Given that most home buyers are unaware of the program, PSO could expand its marketing beyond builders and real estate agents. This could include targeted digital campaigns, educational webinars, and community events that directly inform potential buyers about the program's benefits. Increasing transparency on energy cost savings through case studies or interactive tools may also improve engagement.
- **Improve Communication of Energy Efficiency Benefits to Home Buyers:** Since many buyers prioritize cost over efficiency, the program could provide builders and real estate agents with better tools to explain long-term savings. Developing clear, concise brochures, interactive calculators, or home certification labels that quantify savings over time could help convince buyers of the value of energy-efficient homes. Encouraging builders to highlight HERS ratings and offering simple cost-benefit breakdowns may also improve program adoption.

The following recommendations are offered for continued improvement of the Multiple Upgrades component:

- **Enhance Contractor Training and Support:** Given that contractors play a crucial role in participant engagement, additional training could be provided to ensure they fully understand rebate submission processes and energy efficiency benefits. This training should emphasize compliance with new ENERGY STAR standards, proper installation of energy-efficient equipment, and streamlined communication with customers to reduce delays.
- **Improve Rebate Processing Efficiency:** To address delays in rebate distribution, the program could investigate the use of digital tracking tools that allow both contractors and participants to monitor rebate status in real time.

The following recommendations are offered for continued improvement of the Single Upgrade component:

- **Enhance Contractor Training and Engagement:** Since contractors play a significant role in program participation, the program could invest in comprehensive training sessions to ensure they fully understand rebate structures, program requirements, and how to effectively communicate these to customers. This could include webinars, in-person training, and easy-to-access digital resources to address common contractor questions.
- **Increase Customer Awareness and Education on Heat Pump Water Heaters:** Given the lack of adoption of heat pump water heaters, a more targeted outreach campaign, potentially including customer testimonials, case studies, and contractor engagement (additional trainings with tours of sites to observe system operation), could help drive interest and participation.
- **Streamline the Rebate Process and Improve Transparency:** Some customers expressed frustration with rebate amounts and unclear timelines for receiving rebates. It appears there is confusion as to how equipment is incentivized. Making sure the incentive is clearly displayed on all invoices could improve participant satisfaction. A rebate status tracking system could also improve transparency and customer confidence.

3.1.2 Energy Saving Products Program

This chapter presents the findings from the impact and process evaluation of the 2024 Energy Saving Products Program (ESP).

3.1.2.1 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 with financial incentives for purchasing products that meet high efficiency standards.

The ESP program consisted of retail price discounts, an online limited time marketplace, downstream measure rebates, and energy efficiency measures distributed at food banks and local pantries. The retail offering included price discounts for qualifying room air purifiers, advanced power strips, bathroom ventilation fans, spray foam, door sweeps and seals, room air conditioners, and air filters. The online Limited Time Offer (LTO) program included discounts for online purchases of smart thermostats, level 2 electric vehicle chargers, and heat pump water heaters. In addition, the program included the distribution of free LEDs in partnership with food banks and local food pantries within the PSO service territory.

The program offered downstream rebates from PSO for qualifying heat pump water heaters, clothes dryers, clothes washers, Wi-Fi Thermostats, and level 2 electric vehicle chargers. This downstream portion of the program accounted for approximately 3% of the reported energy savings realized through the program.

The number of participants in the ESP lighting component of the program is unknown, however a total of 19,032 packages of LEDs and 76,128 individual bulbs were distributed through the partnership with local food pantries. The total number of all other verified upstream measures purchased through the ESP program was 139,621, while the total number of verified measures rebated through the downstream portion of the program was 1,786. Overall, the ESP program supported the purchase of 218,024 energy efficient measures during 2024.

Table 3-34 provides a summary of program metrics for the 2024 program year.

Table 3-34: Performance Metrics – Energy Saving Products Program

Metric	2024
Number of Known Participants[32]	1,132
Budgeted Expenditures	$1,168,837
Actual Expenditures	$687,314
Energy Impacts (kWh)	
Projected Energy Savings	5,594,173
Reported Energy Savings	19,675,981
Gross Verified Energy Savings	17,494,549
Net Verified Energy Savings	12,742,774
Peak Demand Impacts (kW)	
Projected Peak Demand Savings	846.58
Reported Peak Demand Savings	4,092.10
Gross Verified Peak Demand Savings	2,935.83
Net Verified Peak Demand Savings	1,770.82
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	3.57
Utility Cost Test Ratio	6.81

3.1.2.2 Impact Evaluation Activities

This section presents the evaluation activities conducted for the Energy Saving Products program. Evaluation methodologies can be found in a supplemental document.

3.1.2.2.1 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. Tracking data included the following information for each combination of retailer, model number, and discount level for upstream lighting:

- Package sales per week (program sales only)
- Number of bulbs per package
- Rated wattage
- Rated lumens

[32] The actual total number of customers that purchased an energy savings product is unknown. Instead, this table reports the count of unique customers that received rebates for qualifying downstream measures.

- 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 Limited Time Offer survey, two surveys of downstream rebate participants, and interviews with program staff members. The Limited Time Offer survey was administered in two waves, one in the summer of 2024 (July) and a second during the fall of 2024 (October). The final sample size for each primary data collection activity is presented in Table 3-35 below.

Table 3-35: ESP Data Collection Activities

Data Collection Activities		N
General Population Survey (LTO)		116
Downstream Rebate Participant Survey	Appliance Survey	254
	Electric Vehicle Level 2 Charger Survey	34

3.1.2.2.2 Verified Gross Savings Methodology

Energy impacts for the program were calculated using prescriptive methods from the Arkansas TRM v8.1, the Texas TRM v8.0, and the Oklahoma Deemed Savings Document (OKDSD). Inputs to savings algorithms as well as in-service rates were determined through self-claimed survey responses. Evaluation methodologies can be found in a supplemental document.

3.1.2.2.3 Net-to-Gross (NTG) Estimation Methodology

Free ridership was determined for each program delivery mechanism. The spillover was determined by the LTO delivery method. For downstream and upstream, spillover was indeterminant based on primary data collection through participant surveys. Participant survey responses were used to determine free ridership for downstream measures, upstream measures, and LTO offerings. A NTG of 100% was applied to measures distributed through Foodbanks. Detailed explanations of the NTG methodologies can be found in a supplemental document.

3.1.2.3 Process Evaluation Activities

ADM evaluators completed a process evaluation to assess the Energy Saving Products (ESP) Program. The evaluators assessed program design, operations, and delivery through a facilitated discussion and participant surveys. Recommendations for refining and improving the program for next year are located at the end of the memo.

The evaluation addressed the following research questions to better understand the program's effectiveness and efficiency:

- How effective were the marketing efforts for the program? Which marketing methods were most effective? How aware of the program are PSO customers?
- How well did PSO staff, implementation staff, and participating customers/retailers work together?
- Did the channel's implementation reflect its design? Are there underlying assumptions about channel implementation and design that are being made about how the program will unfold? Are there ways to improve the design or implementation process?
- How do participants hear about the program? What portion of participants hear about the discounts before entering a participating retail location?
- Were the program participants satisfied with their experience? What are the perceived benefits associated with the program?
- How satisfied are customers with the variety of incentives? Are customers satisfied with the quality of measures available through the ESP program (including downstream, upstream, and online limited time offering LTO)?
- Is the program adequately serving different types of PSO customers (e.g., by homeownership, income level, and geography)?
- Were there any significant changes or new obstacles during the program year? Were there any outside or external obstacles that influenced the program?
- Looking forward, what are key barriers and drivers to program success within PSO's market?

A summary of process evaluation activities is shown in Table 3-36.

Table 3-36:ESP Process Evaluation Data Collection Activities Summary

Data Collection Activity	Process Evaluation Research Objectives
Program Materials Review	Examine reports and program materials for clarity and alignment with program objectives.
Staff Interviews	Evaluate the viewpoints of program staff concerning program operations, their strengths, weaknesses, obstacles to success, and areas for enhancement.
Participant Survey	Assess participants' reasons for participating and experience with the program, including satisfaction.
General Population Survey	Evaluate customer purchasing and decision-making processes while estimating the net-to-gross ratio and gauging customer satisfaction with recent program-promoted measure purchases.

3.1.2.4 Verified Gross Savings Results

This section reports findings from the impact evaluation of the ESP program.

Lighting Gross Energy Savings and Peak Demand Impact

The tracking data provided for evaluation identified a total of 19,032 packages of LEDs were distributed free-of-charge through local food banks Table 3-37 shows the reported quantities and impacts of measures distributed free-of-charge through the ESP program during 2024.

Table 3-37: ESP Reported Measure Quantities and Impacts – Lighting Only

Distribution Type	Measure Type	Package Quantity	Bulb Quantity	Reported kWh	Reported kW
Food Bank	A19 LED - 8.5W or 9W	19,032	76,128	609,024	129.23

Verification

Verified energy and demand impacts were calculated based on OKDSD, using an adjusted value for hours of use (960.61 hours) and survey derived ISR's. ADM found that for all light bulbs, reported impacts were calculated in accordance with the deemed savings algorithms. The tracking data reported the efficient wattage as 6, while the model verification found that the bulbs distributed through the food bank were 9 watts. The actual wattage was used in the calculation of energy and demand impacts.

In-Service Rate Adjustments

ISR for the foodbank offering was set at 100% due to the difficulties in collecting participant information.

Verified Gross Savings Estimates

Table 3-38 compares reported and verified impact estimates for this program component following verification. The ISR applied to food bank light bulbs was 100%, the differences seen between the reported and verified savings may be due to the hours of use used.

Table 3-38: ESP Program Impact Findings –Gross Verified Lighting Savings

Distribution Type	Measure Type	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW
Food bank	A19 LED - 8.5W or 9W	76,128	609,024	780,290	129.23	104.68

Air Filter Gross Energy Savings and Peak Demand Impacts

ADM's review of program tracking data identified that a total of 20,031 qualifying air filters were sold at participating retail stores during the 2024 program year.

Verification

To verify the types, quantities, and savings associated with distributed measures, ADM performed a census review of the program tracking data for air filters sold through the program. This review found that there were no discrepancies between reported and verified parameters.

Verified Gross Savings Estimates

Verified gross savings includes the application of an ISR. An ISR was sourced from ADM's 2021 and 2023 general population surveys (71%). Table 3-39 compares reported and verified impact estimates for air filters rebated through the program in 2024.

Table 3-39: ESP Program Impact Findings – Air Filters

Distribution	Measure	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW
Retail Discounts	Air filters	20,031	1,040,908	739,045	3,636.08	2,581.62

Advanced Power Strip Gross Energy Savings and Peak Demand Impact

ADM's review of program tracking data identified that a total of 7,360 qualifying advanced power strips (APS) were sold at participating retail stores during the 2024 program year.

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 retailers and provided through the LTO program. This review found that all measures were assigned the correct savings in the program tracking data.

Verified Gross Savings Estimates

Table 3-40 compares reported and verified impact estimates for APS discounted through the program in 2024. ADM found no discrepancies between the reported and verified savings calculations. An ISR was sourced from the 2023 LTO survey (90%).

Table 3-40: ESP Program Impact Findings – Advanced Power Strips

Distribution	Measure	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW
Retail Discounts	APS	7,360	616,032	554,429	69.92	62.93

Bathroom Ventilating Fan Gross Energy Savings and Peak Demand Impact

ADM's review of program tracking data identified that a total of 385 qualifying bathroom ventilation fans (BVF) were sold at participating retail stores during the 2024 program year.

Verification

To verify the types, quantities, and savings associated with distributed measures, ADM performed a census review of the program tracking data for BVF's sold through the program. This review found no discrepancies between reported and verified measure parameters.

Verified Gross Savings Estimates

Table 3-41 compares reported and verified impact estimates for BVFs rebated through the program in 2024. An ISR was sourced from the 2021 and 2023 general population surveys (81%).

Table 3-41: ESP Program Impact Findings – Bathroom Ventilating Fans

Distribution	Measure	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW
Retail Discounts	BVF	385	9,427	7,636	1.17	0.95

Clothes Dryer Gross Energy Savings and Peak Demand Impacts

ADM's review of program tracking data identified that a total of 293 clothes dryers (CD) were rebated during the 2023 program year.

Verification

To verify the types, quantities, and savings associated with distributed measures, ADM performed a census review of the program tracking data for clothes dryers sold through the program. ADM was unable to verify 2 clothes dryers in the program tracking data using the ENERGYSTAR® ID's. One of the clothes dryer's ENERGY STAR® ID was identified as clothes washers and the other was not ENERGY STAR certified, as a result, no verified energy savings were attributed to these measures.

Higher verified kWh and kW savings were a result of using model specific Combined Energy Factor (CEF) efficient parameters while the reported CEF efficient was a deemed value of 3.8. The CEF efficient value across all verified clothes dryer models in the 2024 program year ranged from 3.48 to 9.00 with an average of 4.08. Five ENERGY STAR ID's were verified to be heat pump clothes dryers with CEF's of 6.0 or greater. In total, 16 heat pump clothes dryers were rebated in the 2024 program year resulting in higher verified kWh and kW savings.

Verified Gross Savings Estimates

Table 3-42 compares reported and verified impact estimates for clothes dryers rebated through the program in 2023. Results from ADM's 2024 downstream survey were used to determine an ISR of 100%.

Table 3-42: ESP Program Impact Findings – Clothes Dryers

Distribution	Measure	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW
Downstream Rebates	CD	291	40,944	51,020	4.20	6.85

Clothes Washer Gross Energy Savings and Peak Demand Impact

ADM's review of program tracking data identified that a total of 483 clothes washers (CWs) were rebated during the 2024 program year.

Verification

To verify the types, quantities, and savings associated with distributed measures, ADM performed a census review of the program tracking data for clothes washers sold through the program. This review found that 13 clothes washers discounted through the program were not eligible to receive energy efficiency savings[33]; as a result, no verified energy savings were attributed to these measures.

Higher verified energy savings were the result of 44 clothes washers having zero reported savings. ADM attributed savings to some clothes washers with existing front load type and efficient top load type. Further details on clothes washer energy savings methodology can be found in a supplemental document.

Verified Gross Savings Estimates

Table 3-43 compares reported and verified impact estimates for clothes washers rebated through the program in 2023. Results from ADM's 2024 downstream survey were used to determine an ISR of 99%.

[33] 13 CW's reported having existing front load type to top load efficiency type with gas dryer fuel and gas water heater fuel.

Table 3-43: ESP Program Impact Findings – Clothes Washers

Distribution	Measure	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW
Downstream Rebates	CWs	470	51,187	53,731	12.15	12.77

Electric Vehicle Charger Gross Energy Savings and Peak Demand Impacts

ADM's review of program tracking data identified that a total of 143 qualifying electric vehicle chargers (EVC) were rebated through the downstream program and 24 through the LTO program in 2024. Of these, 6 EVC were installed to support the charging of 2 electric vehicles. Reported energy savings for these EVC were higher than EVC's supporting only 1 electric Vehicle. The current energy saving methodology does not factor in the number of electric vehicles being supported by an EVC, therefore higher verified energy savings were not applied to these 5 measures. Further details on EVC energy savings methodology can be found in a supplemental document.

Verification

To verify the types, quantities, and savings associated with distributed measures, ADM performed a census review of the program tracking data for EV Chargers rebated through the program. This review found that all EV Chargers were assigned the correct kWh and kW savings.

The MPGe used in the verified savings calculation remained at 36 MPGe for 2024. Higher verified energy savings were a result of reported savings estimates using 32 MPGe.

Verified Gross Savings Estimates

Table 3-44 compares reported and verified impact estimates for EV Chargers rebated through the program in 2024. Combined survey results from 2023 – 2024 were used to determine an ISR of 98%

Table 3-44: ESP Program Impact Findings – Electric Vehicle Chargers

Distribution	Measure	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW
Downstream Rebates	EVC	143	37,441	40,001	0.00	0.00
Limited Time Offer	EVC	24	6,227	6,713	0.00	0.00
Total	**1,725**	**932,535**	**43,668**	**46,715**	**0.00**	**0.00**

Heat Pump Water Heater Gross Energy Savings and Peak Demand Impact

ADM's review of program tracking data identified that a total of 23 heat pump water heaters (HPWHs) were rebated during the 2024 program year.

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 that 13 HPWHs reported parameters did not match the verified parameters, including tank storage volume and ambient temperature. Additionally, 2 HPWHs received zero reported savings. As a result, reported and verified energy savings do not match.

Verified Gross Savings Estimates

Table 3-45 compares reported and verified impact estimates for HPWHs rebated through the program in 2023. Combined survey results from 2023 – 2024 were used to determine an ISR of 100%

Table 3-45: ESP Program Impact Findings – Heat Pump Water Heaters

Distribution	Measure	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW
Downstream Rebates	HPWH	23	69,340	71,146	6.08	6.24

Room Air Conditioner Gross Energy Savings and Peak Demand Impacts

ADM's review of program tracking data identified that a total of 358 qualifying room air conditioners (RAC) were sold at participating retail stores during the 2024 program year.

Verification

To verify the types, quantities, and savings associated with distributed measures, ADM performed a census review of the program tracking data for RAC sold through the program. The reported Equivalent Cooling Full Load Hours (EFLHc) and energy efficiency ratio (EER) did not match the verified parameters. ADM followed guidance from the AR TRM v8.1 to estimate annual energy savings and peak demand reduction.

Verified Gross Savings Estimates

An ISR of 76% was sourced from the 2021 and 2023 general population survey. Table 3-46 compares reported and verified impact estimates for Room Air Conditioners rebated through the program in 2024.

Table 3-46: ESP Program Impact Findings – Room Air Conditioners

Distribution	Measure	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW
Retail Discounts	RAC	358	59,722	30,559	70.51	18.49

Room Air Purifier Gross Energy Savings and Peak Demand Impact

ADM's review of program tracking data identified that a total of 140 room air purifiers (RAP) were sold at participating retail stores during the 2024 program year.

Verification

To verify the types, quantities, and savings associated with distributed measures, ADM performed a census review of the program tracking data for room air purifiers sold through retailers. This review found that all air purifiers were assigned the correct energy savings in the program tracking data.

Verified Gross Savings Estimates

For measures discounted at participating retail stores, an ISR was sourced from the 2021 and 2023 general population survey (86%). Table 3-47 compares reported and verified impact estimates for RAP rebated through the program in 2024.

Table 3-47: ESP Program Impact Findings – Room Air Purifiers

Distribution	Measure	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW
Retail Discounts	RAP	140	159,126	136,848	18.26	15.70

Smart Thermostats Gross Energy Savings and Peak Demand Impact

ADM's review of program tracking data identified that a total of 3,950 Wi-Fi Thermostats were available through the downstream program and provided through the LTO program during the 2024 program year.

Verification

To verify the types, quantities, and savings associated with distributed measures, ADM performed a census review of the program tracking data for Wi-Fi Thermostats sold through in the downstream program and provided through the LTO program. ADM followed the AR TRM v8.1 to estimate annual energy savings.

Higher verified energy savings for measures sold through the LTO program were the result of reported savings not including heating savings. For measures sold through the downstream program, the reported energy savings may have used the actual square footage to calculate savings while the ADM used the TRM deemed square footage of 1,832 sqft. The square footage of the home was not provided in the reported tracking data.

Sufficient survey data was available from both the LTO participant survey and the downstream participant survey to develop independent ISR's. ISR for thermostats sold through the LTO offering was 77% and 98% through the downstream rebate offering.

Verified Gross Savings Estimates

Table 3-48 compares the total reported and verified impact estimates for this program component.

Table 3-48: ESP Program Impact Findings – Smart Thermostats

Distribution	Measure	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW
Downstream Rebates	Wi-Fi Thermostat	844	480,466	524,337	N/A	N/A
LTO	Wi-Fi Thermostat	465	307,007	425,710	N/A	N/A
Total		**1,309**	**787,473**	**950,047**	**N/A**	**N/A**

Weatherization Measure 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 5,936 door seals and sweeps, and 105,411 cans of spray foam were sold at participating retail stores during the 2024 program year.

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. This review found that all the WMs were assigned the correct energy savings.

Verified Gross Savings Estimates

An ISR of 82% for door seals and sweeps and 87% for spray foam was sourced from the 2021 and 2023 general population surveys. Table 3-49 compares reported and verified impact estimates for WMs rebated through the program in 2024.

Table 3-49: ESP Program Impact Findings – Weatherization Measures

Distribution	Measure	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW
Retail Discounts	Door Seals and Sweeps	5,936	229,182	187,929	2.05	1.68
Retail Discounts	Spray Foam	105,411	15,959,948	13,885,155	142,46	123.94
Total		**111,347**	**16,189,130**	**14,073,084**	**144.51**	**125.62**

Summary of Impact Evaluation Findings

Verified gross savings are determined through an engineering review of the measure level savings calculations with an In-Service Rate (ISR) applied. Results for all measures are shown in Table 3-50.

Table 3-50: Verified Gross and ISR Impacts – ESP Program

Distribution Type	Measure Type	Gross Verified kWh	Gross Verified kW	ISR	ISR Gross Verified kWh	ISR Gross Verified kW
Retail Discounts	Advanced Power Strip	616,032	69.92	0.900	554,429	62.93
	Air Filter	1,040,908	3,636.08	0.710	739,045	2,581.62
	Bathroom Ventilation Fans	9,427	1.17	0.810	7,636	0.95
	Door Seals and Sweeps	229,182	2.05	0.820	187,929	1.68
	Room AC	40,209	24.33	0.760	30,559	18.49
	Room Air Purifier	159,126	18.26	0.860	136,848	15.70
	Spray Foam	15,959,948	142.46	0.870	13,885,155	123.94
Retail Discount Subtotals		**18,054,831**	**3,894.26**	**N/A**	**15,541,600**	**2,805.30**
Downstream Rebates	Clothes Dryer	51,020	6.85	1.000	51,020	6.85
	Clothes Washer	54,274	12.90	0.990	53,731	12.77
	EV Charger	40,742	N/A	0.982	40,001	N/A
	HPWH	71,146	6.24	1.000	71,146	6.24
	Wi-Fi Thermostat	535,037	N/A	0.980	524,337	N/A
Downstream Rebate Subtotals		**752,219**	**25.99**	**N/A**	**740,235**	**25.86**
LTO Program	Wi-Fi Thermostat	552,870	N/A	0.770	425,710	N/A
	EV Charger	6,838	N/A	0.982	6,713	N/A
LTO Program Subtotals		**559,708**	**0.00**	**N/A**	**432,423**	**0.00**
Foodbank	A19 LED - 8.5W or 9W	780,290	104.68	1.000	780,290	104.68
Foodbank Subtotals		**780,290**	**104.68**	**N/A**	**780,290**	**104.68**
Program Totals		**20,147,049**	**4,024.92**	**0.896**	**17,494,549**	**2,935.83**

Table 3-51 provides a detailed summary of ADM's impact evaluation findings for all measures included in the ESP program in 2024.

Table 3-51: ESP Summary of Impact Evaluation Findings

Distribution Type	Measure Type	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW	RR kWh	RR kW
Retail Discounts	Advanced Power Strip	7,360	616,032	616,032	69.92	69.92	90%	90%
	Air Filter	20,031	1,040,908	1,040,908	3,636.08	3,636.08	71%	71%
	Bathroom Ventilation Fans	385	9,427	9,427	1.17	1.17	81%	81%
	Door Seals and Sweeps	5,936	229,182	229,182	2.05	2.05	82%	82%
	Room AC	358	59,722	40,209	70.51	24.33	51%	26%
	Room Air Purifier	140	159,126	159,126	18.26	18.26	86%	86%
	Spray Foam	105,411	15,959,948	15,959,948	142.46	142.46	87%	87%
Retail Discount Subtotals		**139,621**	**18,074,345**	**18,054,831**	**3,940.44**	**3,894.26**	**86%**	**71%**
Downstream Rebates	Clothes Dryer	291	40,944	51,020	4.20	6.85	125%	163%
	Clothes Washer	470	51,187	54,274	12.15	12.90	105%	105%
	EV Charger	143	37,441	40,742	N/A	N/A	107%	N/A
	HPWH	23	69,340	71,146	6.08	6.24	103%	103%
	Wi-Fi Thermostat	844	480,466	535,037	N/A	N/A	109%	N/A
Downstream Rebate Subtotals		**1,771**	**679,378**	**752,219**	**22.43**	**25.99**	**109%**	**115%**
LTO Program	Wi-Fi Thermostat	465	307,007	552,870	N/A	N/A	139%	N/A
	EV Charger	24	6,227	6,838	N/A	N/A	108%	N/A
LTO Program Subtotals		**489**	**313,234**	**559,708**	**0.00**	**0.00**	**138%**	**N/A**
Foodbank	A19 LED	76,128	609,024	780,290	129.23	104.68	128%	81%
Foodbank Subtotals		**76,128**	**609,024**	**780,290**	**129.23**	**104.68**	**128%**	**81%**
Program Totals		**218,009**	**19,675,981**	**20,147,049**	**4,092.10**	**4,024.92**	**89%**	**72%**

3.1.2.5 Net-to-Gross Estimation Results

The NTG analysis for the ESP program was conducted using industry standard methodologies described in a supplemental document, accounting for free ridership as well as spillover. NTG ratios for the LTO offering were based on participant survey results, as shown in Table 3-52.

Table 3-52: Survey Responses and Free-Ridership Score: ESP LTO

Measure	Survey Responses	Free Ridership Score	Spillover Score	Net-to-Gross Score
Wi-Fi Thermostat	114	6%	1.5%	96%
Electric Vehicle Chargers[34]	67	47%	1.5%	55%

Note: NTG ratios may be greater than 1.00 due to the addition of spillover ratios.

NTG ratios for in-store markdowns (upstream) were sources from PSO's portfolio planning. Ratios are shown in Table 3-53.

Table 3-53: ESP In-Store Markdown NTG

Measure	Net-to-Gross Score
Advanced Power Strip	64%
Air Filter	58%
Bathroom Ventilation Fans	72%
Door Seals and Sweeps	72%
Room AC	69%
Room Air Purifier	69%
Spray Foam	72%

NTG ratios for downstream rebates were determined through participant survey responses. Survey results from 2022 – 2024 were used to represent NTG ratios for EV chargers and heat pump water heaters. NTG ratios for Wi-Fi thermostats, clothes washers, and clothes dryers only used results from 2024 since there were sufficient survey responses. Results are shown in Table 3-54.

[34] Due to a low response rate for electric vehicle chargers in the LTO offering, combined survey responses from the 2022-2024 downstream survey was used with the addition of the LTO spillover results.

Table 3-54: Survey Responses and Free Ridership Scores: ESP Downstream Measures

Measure	Survey Responses				Evaluation Cycle Average Free Ridership	Net-to-Gross Score for 2024
	2022	2023	2024	Total		
Clothes Dryers			75	75	37%	63%
Clothes Washers			97	97	68%	32%
Electric Vehicle Chargers	12	21	34	67	47%	53%
Heat Pump Water Heater	2	6	4	12	13%	87%
Wi-Fi Thermostat	-	-	78	78	27%	73%

Surveys were not feasible for the foodbank light bulb offering. As these bulbs are provided directly to income eligible customers a NTG ratio of 100% was assigned.

3.1.2.5.1 Final Net-to-Gross Ratio

The measure level net-to-gross ratios are calculated as 1 - estimated free ridership + spillover[35]. Net to gross is applied to verified gross savings to determine verified net savings. The final net-to-gross ratios and associated net savings for each measure in the ESP program are shown in Table 3-55. Program level net verified savings results in an overall realization rate of 86% for annual energy savings.

Table 3-55: Verified ISR Gross and Net Impacts – ESP Program

Distribution Type	Measure Type	ISR Gross Verified kWh	ISR Gross Verified kW	NTG	Net kWh	Net kW
Retail Discounts	Advanced Power Strip	554,429	62.93	0.640	354,834	40.27
	Air Filter	739,045	2,581.62	0.580	428,646	1,497.34
	Bathroom Ventilation Fans	7,636	0.95	0.720	5,498	0.68
	Door Seals and Sweeps	187,929	1.68	0.720	135,309	1.21
	Room AC	30,559	18.49	0.690	21,085	12.76
	Room Air Purifier	136,848	15.70	0.690	94,425	10.83
	Spray Foam	13,885,155	123.94	0.720	9,997,311	89.24
Retail Discount Subtotals		**15,541,600**	**2,805.30**	**0.680**	**11,037,109**	**1,652.33**
Downstream Rebates	Clothes Dryer	51,020	6.85	0.630	32,143	4.32
	Clothes Washer	53,731	12.77	0.320	17,194	4.09

35 Spillover was calculated for LTO measures.

Distribution Type	Measure Type	ISR Gross Verified kWh	ISR Gross Verified kW	NTG	Net kWh	Net kW
	Electric Vehicle Chargers	40,001	N/A	0.534	21,344	N/A
	Heat Pump Water Heater	71,146	6.24	0.868	61,759	5.42
	Wi-Fi Thermostat	524,337	N/A	0.730	382,766	N/A
Downstream Rebate Subtotals		**740,235**	**25.86**	**0.616**	**515,205**	**13.82**
LTO Program	Wi-Fi Thermostat	425,710	N/A	0.955	406,489	N/A
	Electric Vehicle Chargers	6,713	N/A	0.548	3,682	N/A
LTO Program Subtotals		**432,423**	**0.00**	**0.752**	**410,170**	**N/A**
Foodbank	A19 LED	780,290	104.68	1.000	780,290	104.68
Foodbank Subtotals		**780,290**	**104.68**	**N/A**	**780,290**	**104.68**
Program Totals		**17,494,549**	**2,935.83**	**0.728**	**12,742,774**	**1,770.82**

3.1.2.6 Lifetime Savings

Lifetime energy savings for all measures in the ESP program are shown in Table 3-56.

Table 3-56: Total Lifetime Energy Savings – ESP Program

Measure Type	Net Total Lifetime Savings (kWh)
Spray Foam	99,973,114
A19 LED	15,605,796
Smart Thermostats	8,681,797
Advanced Power Strips	3,548,344
Door Seals and Sweeps	2,029,632
Room Air Purifiers	849,826
Heat Pump Water Heaters	617,588
Clothes Dryers	417,853
Electric Vehicle Chargers	213,437
Clothes Washers	240,716
Room Air Conditioners	221,396
Air Filters	72,870
Bathroom Ventilation Fans	65,976
Total	**132,538,347**

3.1.2.7 Process Evaluation Findings

A process evaluation was completed to assess the Energy Saving Products (ESP) Program which included a review of program documentation, a facilitated discussion with program staff, participant surveys, and a general population survey. A detailed process evaluation memo was delivered to PSO in December of 2024.

3.1.2.7.1 Program Operations Findings

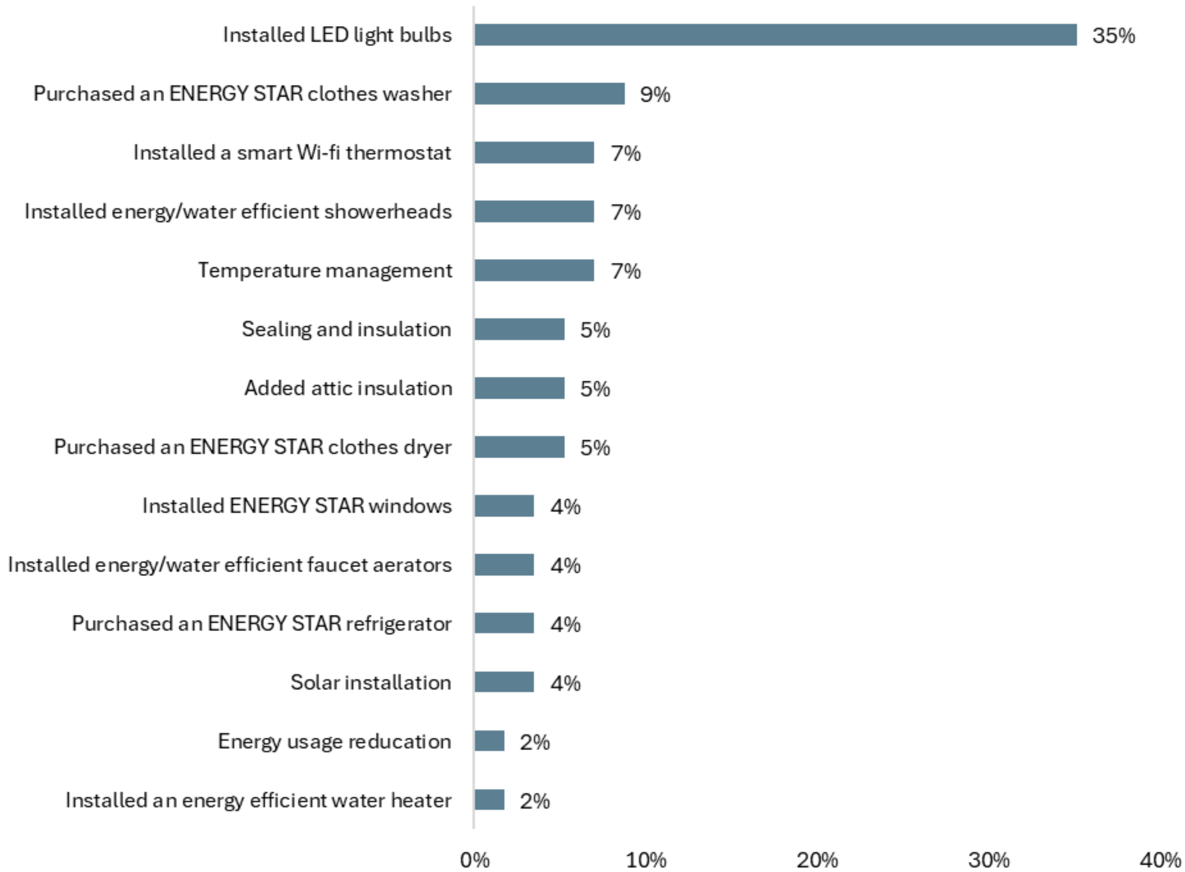
In 2024, one modification to the program was the inclusion of heat pump water heaters as part of the Limited-Time Offer (LTO) measure mix. This change followed the discontinuation of lighting measures in June 2023, alongside the elimination of air purifiers. The current portfolio of measures for the ESP program now comprises Wi-Fi thermostats, EV chargers, clothes dryers and washers, and heat pump water heaters.

3.1.2.7.2 LTO Participant Findings

ADM administered an online survey to customers who purchased measures that PSO promoted through their email campaigns of the LTO website. A total of 116 responses were collected, all of whom purchased a Wi-Fi smart thermostat. The following highlights findings affecting all the LTO measures component of the program.

- The primary reason participants purchased their smart thermostat through the LTO was the reduced price (instant discount), cited by 78% of respondents. Convenience was a factor for 7%, while 12% mentioned confidence in product quality.
- Most survey respondents (62%) stated they installed all or some of their programmable Wi-Fi thermostats. Over half of customers (56%) indicated their new thermostats replaced a standard thermostat that allows users to set on/off temperatures.
- Most respondents (77%) reported receiving a notification regarding enrollment in the Power Hours Program after installing their Wi-Fi thermostat, while 14% did not receive such a notification, and 9% were uncertain. Of those 53 survey respondents who recalled the notification, 87% chose to enroll in the program for 2024, with only 9% opting not to participate and 4% unsure of their enrollment status. Among those five respondents who did not enroll, three indicated that they required more information before signing up, one cited a lack of interest, and another mentioned other reasons, such as a busy schedule preventing them from taking the time to enroll.
- Since purchasing an energy efficient product through the LTO, participants reported various energy-saving actions. The most common action was installing LED light bulbs (35%). Other frequently taken measures included purchasing ENERGY STAR clothes washers (9%), energy efficient showerheads, and managing temperature settings (each at 7%). Additional actions included sealing and insulation, adding attic insulation, and purchasing ENERGY STAR clothes dryers. Some participants also installed ENERGY STAR windows, faucet aerators, and energy efficient water heaters, purchased ENERGY STAR refrigerators, installed solar panels, or focused on reducing overall energy usage. Figure 3-20 provides a summary of all the different energy saving actions survey respondents have conducted.

Figure 3-20: ESP LTO Energy Saving Actions



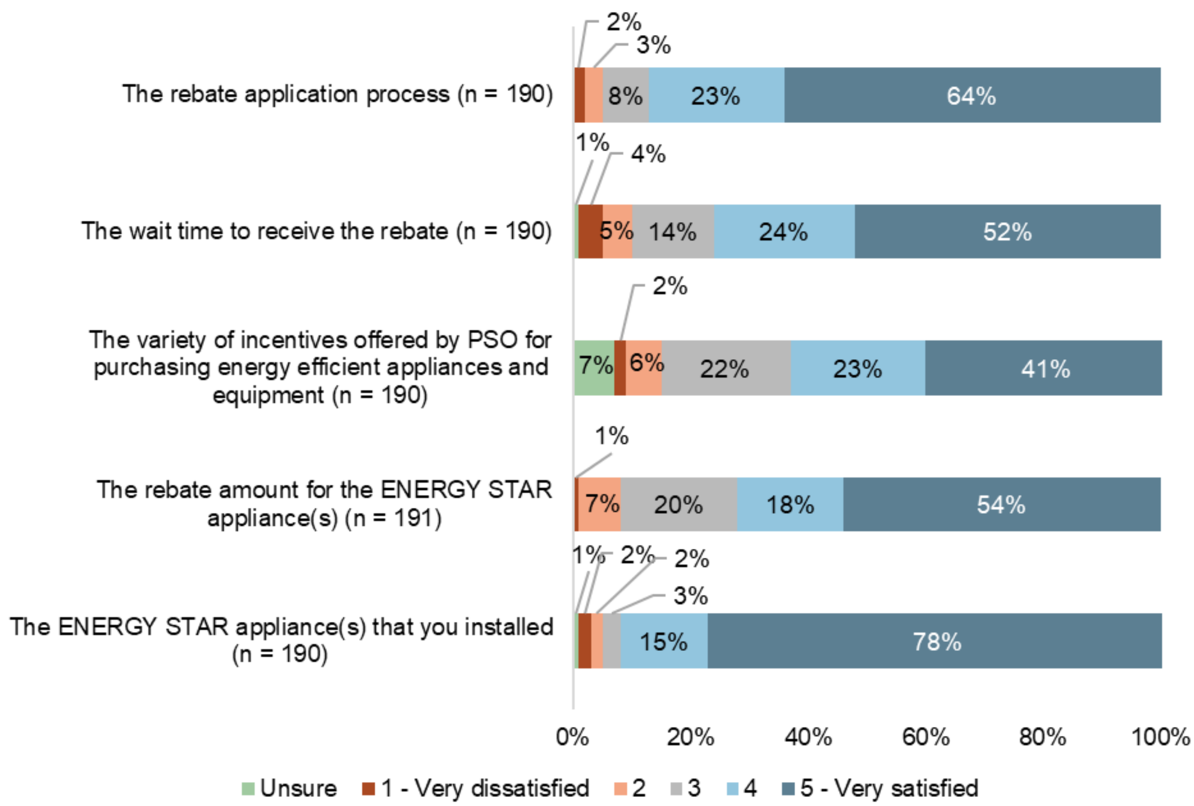
3.1.2.7.3 Downstream Offerings Findings

The downstream participant survey was launched to 2,972 participants with 191 surveys completed. The following highlights findings affecting all the downstream measures component of the program.

- Among the customers who completed the survey, some (34%) bought up to three different measures. The measures eligible for a program rebate in 2024 were programmable Wi-Fi thermostats, clothes washers, clothes dryers, and heat pump water heaters.
- Over a third of survey respondents (38%) first learned about the PSO rebate before they made the purchase, while a similar amount (37%) learned of the rebate at the time of the purchase. A quarter of respondents learned about the program after they made the purchase.
- Downstream participants were satisfied with the equipment and the program overall. Overall, the program participants were satisfied with the ENERGY STAR appliances they installed, the application process, the rebate wait time, the rebate

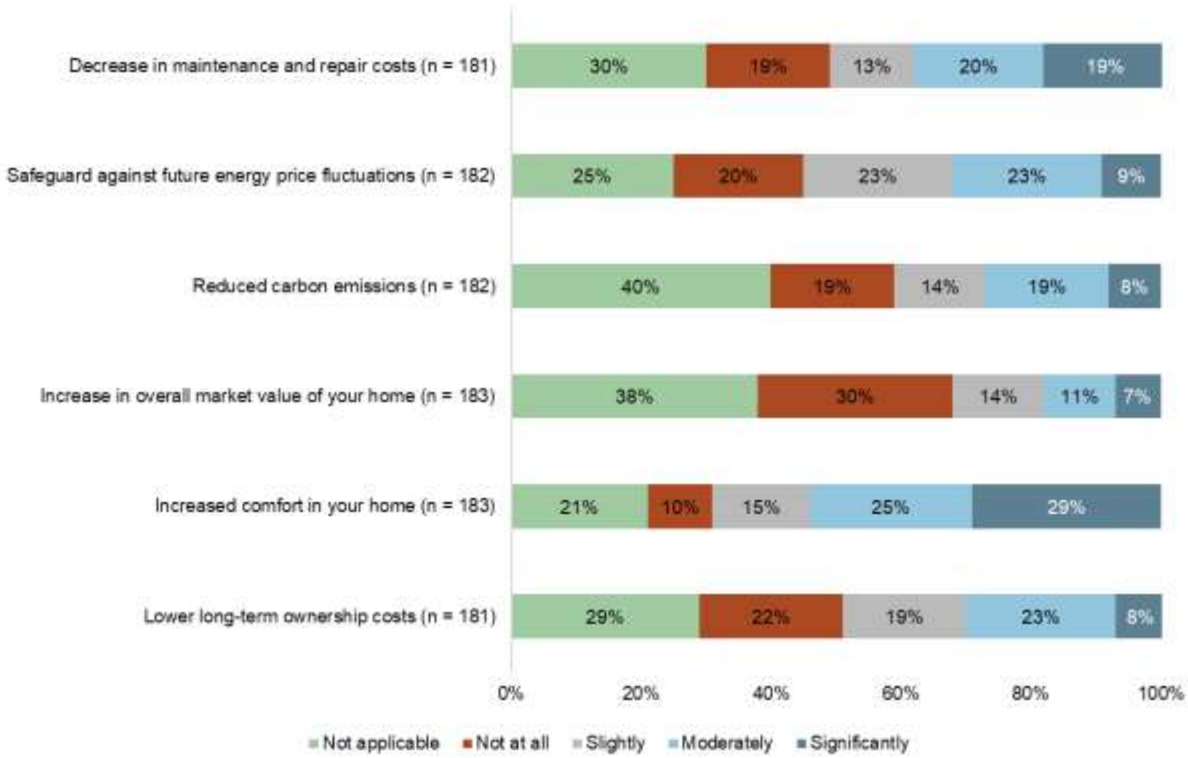
amount, and the variety of measures incentivized. Among the downstream participants, the overall Net Promoter Score (NPS) was 66%. When broken down by measure, the NPS was at its highest for customers who bought a heat pump water heater, with a score of 100%. Conversely, it was the lowest for those who purchased an ENERGY STAR clothes washer, with an NPS score of 65%. Participant satisfaction is shown in Figure 3-21.

Figure 3-21: ESP Downstream Channel Participant Satisfaction



- Respondents provided their feedback on the non-energy benefits of their purchased measure(s) on their homes. Ratings were given on a scale from 1 (not at all) to 4 (significantly) for various aspects (shown in Figure 3-22). The highest impact ratings were found for a decrease in maintenance and repair costs (39%) and increased home comfort (55%), rating 3 or above out of 4. Reduced carbon emissions (27%) and an increase in overall market value of the home (18%) had the lowest impact scores with a rating of 3 or above out of 4. Wi-Fi thermostats had the highest impact scores across all non-energy benefits.

Figure 3-22: ESP Downstream Non-Energy Benefits



Note: percentages exceed 100% due to rounding.

3.1.2.7.4 Level II EV Charger Offering Findings

A survey was administered to 131 program participants with 34 completing the survey. The following highlights findings from the process evaluation of the EV Level 2 Chargers component of the program.

- The most important factor for respondents was charging their car quicker, being rated as highly important. Saving money on energy bills and the incentive available from PSO also ranked highly, though with slightly more varied responses. Environmental concerns and energy efficiency compared to friends or neighbors were rated as less important by a portion of respondents. However, interest in protecting the environment and achieving energy efficiency was important for some participants.
- Most respondents (68%) installed a charger to support their new electric vehicle, while 15% replaced an existing Level 1 or Level 2 charger. Three percent of respondents added a second charger to their home. Most respondents (56%) found information through the PSO PowerForward website. Other sources include word-of-mouth from friends or relatives (12%) and internet searches (9%). The remaining respondents discovered the rebate through various channels, including

the PSO emails, program representatives, electric vehicle salespersons, and manufacturers.

- Half of the respondents (50%) use the charger at least once a day. Additionally, 29% plug in not every day but a few times a week, while 18% report using it once a week or less often. Importantly, no participants indicated that the charger is not installed, and 3% were unsure about their usage frequency.
- Twenty-nine percent stated they use Wi-Fi enabled software or apps at least once a day, another 26% responded with less than once a week, and 26% stated they used it a few times a week, compared to 15% who never used the software.
- EV charger rebates led to various non-energy benefits for participants. The highest-rated impact was the reduction in carbon emissions, followed by a decrease in maintenance and repair costs. Respondents also reported moderate improvements in safeguarding against future energy price fluctuations and lower long-term ownership costs.

3.1.2.8 Conclusions and Recommendations

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

- In 2024, the number of clothes dryers, clothes washers, room air conditioners, and room air purifiers decreased from 2023. To keep the ESP program diverse and not reliant on a few measures, ADM recommends investing in these established measures through marketing and promotional strategies.
- The number of heat pump clothes dryers included in the ESP program has increased in recent years. Heat pump specific methodologies can more accurately estimate kWh savings for these measures. ADM recommends separating heat pump clothes dryers into a new measure to improve the clothes dryer realization rate.
- PSO could leverage customer data to enhance promotional efforts for heat pump water heaters and EV chargers. A focus on connecting the benefits of energy efficiency measures with customer-specific needs in future campaigns could provide additional value.
- PSO could develop materials to address common barriers, such as installation compatibility and product guidance, to encourage broader adoption of energy-efficient technologies. Additionally, promote Time-Of-Day pricing benefits and encourage off-peak charging behaviors through targeted educational campaigns for EV chargers. Further, educate customers about the significance of non-energy benefits, such as reduced emissions and home value increases, to refine program offerings and marketing narratives.

- PSO could address participant feedback regarding communication gaps by providing regular updates throughout the rebate process to improve transparency and customer satisfaction. Also, build on the high satisfaction rates by collecting testimonials to present program successes.
- PSO could simplify the enrollment process for thermostat promotions and Power Hours by eliminating the need for coupon codes to reduce barriers to participation.

3.1.3 Education Program

This chapter presents findings from the impact and process evaluation of the 2024 PSO Education program, also known as the Energy Saver Kits Program.

3.1.3.1 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 in the PSO service territory. The program provides students with the opportunity to learn about energy efficiency through hands-on classroom activities and gives each student a kit with energy efficient products to reduce their home energy use. Table 3-57 summarizes the overall performance of the program in Program Year 2024.

Table 3-57: Performance Metrics – Education Program

Metric	2024
Number of Customers	16,385
Budgeted Expenditures	$952,635
Actual Expenditures	$833,399
Energy Impacts (kWh)	
Projected Energy Savings	2,877,369
Reported Energy Savings	3,469,688
Gross Verified Energy-savings	3,355,104
Net Verified Energy-savings	3,355,104
Peak Demand Impacts (kW)	
Projected Peak Demand Savings	445.06
Reported Peak Demand Savings	521.04
Gross Verified Peak Demand Savings	519.26
Net Verified Peak Demand Savings	519.26
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	2.08
Utility Cost Test Ratio	1.89

The Education program consists of four components. (1) Education materials provided to teachers, (2) kits with energy saving measures for students to install at home, (3) An educational take-home workbook for students providing hands-on learning such as exercises assessing energy usage habits, and (4) the PSO Education Program webpage which includes videos, games, and activities in class and at home.[36]

Educational materials were developed by the implementer to create a curriculum with a flexible timeframe designed to support the Oklahoma Academic State Standards for 5th graders. The curriculum was designed to be easily integrated into the teacher's curriculum at no cost to the school district, teachers, or students. The ready-made curriculum includes documentation explicitly outlining the Oklahoma Academic Standards supported through the program in language arts, mathematics, and science.

To enhance visual learning, classes receive a colorful poster depicting various energy sources, a brief PSO history, and a character from the curriculum. The program also incorporates quizzes and surveys for students to evaluate knowledge acquisition and encourage family engagement and understanding of the curriculum. A detailed teacher survey assesses the program, and its results are used to verify effectiveness, clarity of materials, and satisfaction with the materials.

Each student is then provided with an Energy Saver Kit containing 4 LED lightbulbs, an LED nightlight, a smart power strip, a furnace whistle, and a digital thermometer (used to adjust refrigerator and water heater temperature settings). Students are given instructions on how to install the measures in the kit in their homes. The measures provide energy savings to participating families and reinforce concepts taught through the curriculum.

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, the Energy Information Administration (EIA) Kids, NASA Climate Kids, GetWise and Smithsonian Kids. Parents can access installation instruction for kit contents and other energy-saving tips.

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.

Surveys and quizzes are given to all teachers and students. Over the past four years, at least 80% of teachers reported high student engagement with the lessons. Also, over 91% of teachers in this period found the curriculum to be current, relevant, and a beneficial learning tool, attesting to its effectiveness. The student survey involves a pre- and post-lesson knowledge test. The average quiz score increased by more than 25% after teachers utilized the provided curriculum.

[36] https://www.pso-education.com/

3.1.3.2 Evaluation Activities

This section presents the evaluation activities conducted for the PSO Education Program. Detailed methodologies are provided in a supplemental document.

3.1.3.2.1 Data Collection

Data sources for the evaluation of the program include:

- Program Tracking Data
- Implementation Invoices
- Student Survey Results
- Student Quiz Results
- Teacher Survey Results
- Staff Facilitated Discussion

The program tracking data and implementation invoices are used for the calculation of verified energy savings through confirmation of kit quantities and components. These documents are reviewed for completeness and consistency.

Two quizzes and two surveys are completed by students as part of the implementation strategy of 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, including measure installation and behavioral changes. Impact calculations use survey responses to inform the savings analysis.

Program surveys do 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).

A survey of teachers was conducted to collect information on teacher's perceptions of the program, past participation, how teachers used the curriculum, and their perception of PSO and the Education program.

A facilitated discussion was conducted with program staff to gain insight into the program execution. Interviews were completed in September 2024 with key personnel responsible for the program, discussing past program year recommendations and implementation strategies for future changes. Table 3-58 summarizes the data collection activities and purpose.

Table 3-58: Education Data Collection and Sample Size Effort by Survey

Data Collection Activity	Data Use	Achieved Sample Size
Program Tracking Data	Impact/Process	16,385
PSO Student Survey	Impact/Process	1,124
ADM Teacher Survey	Process	121
Implementation Staff Interviews	Process	1

3.1.3.2.2 Gross Impact Methodologies

To calculate annual energy-savings (kWh) and peak demand impacts (kW), the following evaluation activities were conducted:

- **Reviewed a census of program tracking data**: the tracking data for a census of kits were reviewed. The review looked for data completeness, data entry errors, duplicates, and outlier savings values. Review of program tracking data was conducted periodically during the program year.
- **Reviewed program invoices**: a review of program invoices was conducted to verify shipment of kits reported in program tracking data and reconcile program costs.
- **Calculated gross verified savings**: gross savings were verified using engineering algorithms from industry standard references. The sources for deemed savings algorithms are the 2021 Pennsylvania Technical Reference Manual (PA TRM), Arkansas Technical Reference Manual v8.2 (AR TRM), and Illinois Technical Reference Manual V11 (IL TRM). The Residential Energy Consumption Survey (RECS) was also used to estimate power consumption and energy sources for some measures.
- **Determined measure installation for gross savings adjustments**: the ISR for FilterTone® alarms, LED night lights, advanced power strips, water heater temperature setback, and refrigerator temperature increase was calculated using data collected from a sample of program participants in the student surveys.

Detailed descriptions of energy savings methodologies for each measure can be found in a supplemental document. The survey questions and the evaluation inputs for which they were used, are shown in Table 3-59.

Table 3-59: Student Survey Questions and Uses

Survey Question	Question Use
Did you or someone else install the Advanced Power Strip in your home? (Yes, I did; Yes, my family and I did; Yes, someone else did; No, it isn’t installed)	Advanced Power Strip ISR
If you answered "yes" to question 2, where did you install your Advanced Power Strip?	Advanced Power Strip Savings
Did you or someone else install the FilterTone Alarm in your home? (Yes, I did; Yes, my family and I did; Yes, someone else did; No, it isn’t installed)	Furnace Whistle ISR
Did your family install the LED Night Light?	LED Night Light ISR
Did your family lower your water heater settings?	Water Heater Temperature Setback ISR
Did your family raise the temperature on your refrigerator?	Refrigerator Temperature Increase ISR

3.1.3.2.3 Net-to-Gross Estimation

The Education Program has a net-to-gross (NTG) ratio 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. As students are presented with a series of surveys and quizzes, it is not desirable to add an additional line of questioning.

3.1.3.2.4 Lifetime Savings

Lifetime annual energy savings were calculated by multiplying the verified 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 3-60 shows the EUL and source for each measure type. Lifetime savings for ENERGY STAR® 9W LEDs uses the ISR calculated from the survey for the first year and a rate of 100% for the rest of the EUL. This assumes that unused LEDs from the kit will eventually be installed.

Table 3-60: Education Per-Measure Estimated Useful Life (EUL)

Kit Contents	EUL	Source
Advanced Power Strip	10	AR TRM
FilterTone® Alarm	14	PA TRM
LED Night Light	8	PA TRM
Water Heater Temperature Setback	2	IL TRM
Refrigerator Temperature Increase	1	-

3.1.3.2.5 Process Evaluation

The process evaluation was designed to assess program design, operations, and delivery through discussion with program staff as well as through student and teacher surveys. The evaluation addressed the following research questions to better understand the program's effectiveness and efficiency.

- Were any changes made to the program in the specific program year? If so, why were these changes made and did they accomplish their intended objectives?
- Did implementation of the program reflect its current design? In what ways did it deviate and how did that affect program success?
- Is there effective coordination between program utility and implementation contractor staff to ensure the seamless delivery of the program?
- Were there any notable successes, challenges, or other program developments?
- What quality control processes, if any, have been implemented to guarantee the reliable delivery of kits?
- Is the program progressing towards achieving its kit distribution goals, and if not, what are the obstacles hindering the fulfillment of these objectives?
- Does the program serve all areas of the PSO service territory and all segments of PSO's residential customer population?
- What actions, if any, do participants report taking to save energy and what factors may affect that?
- What is the feedback from teachers regarding the program, educational materials, and kits? To what extent do teachers integrate educational materials into their curriculum, and what subjects or topics would they cover if they did not have access to these materials?
- Are there ways to improve the design or implementation process?

3.1.3.3 Verified Gross Savings Results

Using the methodology described in this chapter, the impact evaluation determines verified annual energy savings (kWh), lifetime energy savings, and peak demand reductions (kW).

3.1.3.3.1 Program Tracking Data

The final program tracking data was reviewed at the end of the year and verified to not contain any issues such as duplicate entries or missing data.

3.1.3.3.2 Measure In-Service Rates (ISR)

Gross energy impacts were adjusted for ISR to determine verified energy impacts based on student survey results. In total, 1,124 student surveys were completed. Table 3-61 displays the in-service rates by measure.

Table 3-61: Education School Kit In-Service Rates

Measure	Number of Measures	ISR
7-Plug Advanced Power Strip	16,385	60%
LED Night Light	16,385	62%
FilterTone® Furnace Filter Alarm	16,385	34%
Water Heater Temperature Setback	16,385	22%
Refrigerator Temperature Increase	16,385	22%

3.1.3.3.3 Advanced Power Strip

The student survey was used to determine the proportion of distributed power strips that were installed, and the proportion of installed advanced power strips controlling home offices, home entertainment systems, or other devices. The verified average energy savings and demand reductions were 110 kWh and 0.01 kW per power strip, resulting in a realization rate for advanced power strips of 105% for both energy and demand savings. The increased realization rate is attributed to an increase in installed measures compared to the previous year.[37]

3.1.3.3.4 LED Night Light

Reported energy savings were found to accurately represent verified energy savings with a minor change in ISR for the LED night lights. The resulting kWh realization rate is 100%, and there are no demand reduction savings.

[37] Previous year results are used for reported savings.

3.1.3.3.5 FilterTone® Alarm

The FilterTone Alarm showed greater savings due to an increase in installation rate. Both the energy and demand savings realization rates are 104%.

3.1.3.3.6 ENERGY STAR® LED

Screw-in bulbs were included in the kits, but due to the federal baseline change in 2022, energy impacts were not considered.

3.1.3.3.7 Water Heater Temperature Setback

A deemed savings value from the Illinois TRM was adjusted by student survey results for the water heater fuel source and ISR to determine verified savings. The ISR did not change significantly from the previous year, resulting in energy and demand savings realization rates of 101%.

3.1.3.3.8 Refrigerator Temperature Setting

The AR TRM was used to determine a deemed savings value based on a weighted average of pre-existing refrigerator temperature assumptions. The efficient condition refrigerator temperature is assumed to be at the curriculum proposed value of 38°F. Savings were adjusted based on the student survey results for ISR, which increased from the previous year. The resulting energy and demand savings realization rate are both 116%.

3.1.3.3.9 Verified Kit Energy Savings

Verified annual energy savings and peak demand reduction are based on unit-level gross energy impacts adjusted for ISR for each energy efficiency measure. Table 3-62 details the education kit contents and savings impacts per measure.

Table 3-62: Summary of Kit Contents and Verified Energy Savings and Demand Reduction– Education Program

Kit Contents	Verified kWh Savings Per Kit	Verified kW Reduction Per Kit
7-Plug Advanced Power Strip	110.02	0.0126
LED Night Light	16.31	0
FilterTone® Furnace Filter Alarm	62.99	0.0171
9-watt LED[38]	0	0
Water Heater Temperature Setback	9.66	0.0011
Refrigerator Temperature Increase	5.78	0.0008
Total	**204.77**	**0.0317**

Table 3-63 and Table 3-64 show a comparison of the verified gross annual energy-savings (kWh) and peak demand reduction (kW) of the 2024 Education Program, by measure to the reported savings estimates.

[38] If savings were counted for PY2024, energy savings per kit would have been 17.53 kWh and demand savings would have been 0.0017 kW.

Table 3-63: Gross Energy-Savings (kWh) Summary by Measure for 2024

Measure	Reported Energy (kWh) Savings	Verified Energy (kWh) Savings	Realization Rate (kWh)	Verified Lifetime Energy Savings (kWh)
7-Plug Advanced Power Strip	1,714,168	1,802,601	105.2%	18,026,010
LED Night Light	268,509	267,318	99.6%	2,138,542
FilterTone® Furnace Filter Alarm	990,307	1,032,077	104.2%	14,449,078
9-watt LED[39]	257,807	0	0%	0
Water Heater Setback	157,156	158,361	100.8%	316,721
Refrigerator Temperature Increase	81,741	94,747	115.9%	94,747
Total	**3,469,688**	**3,355,104**	**96.7%**	**35,025,098**

Table 3-64: Gross Demand Reductions (kW) Summary by Measure for 2024

Measure	Reported Demand (kW) Reduction	Verified Demand (kW) Reduction	Realization Rate (kW)
7-Plug Advanced Power Strip	196.86	207.20	105.2%
LED Night Light	0	0	-
FilterTone® Furnace Filter Alarm	268.66	280.22	104.2%
9-watt LED[40]	25.72	0	0%
Water Heater Setback	17.90	18.05	100.8%
Refrigerator Temperature Increase	11.90	13.80	115.9%
Total	**521.04**	**519.26**	**99.6%**

Reported savings are based on the verified program savings from 2023, meaning differences between the reported and verified program savings are due to differences in installation locations for the advanced power strip, changes in ISRs, and no longer counting savings for LEDs.

3.1.3.4 Process Evaluation Findings

ADM's process evaluation activities included student and teacher surveys as well as a structured conversation with key personnel responsible for the program. ADM provided a detailed process evaluation memo to PSO after the completion of the 2024 program year.

[39] LED verified energy savings would have been 287,235 kWh with a realization rate of 111%. The lifetime energy savings would have been 11,628,010 kWh.
[40] LED verified demand savings would have been 28.55 kW with a realization rate of 111%.

3.1.3.4.1 Program Activity

16,385 kits were sent to 430 fifth-grade teachers in 2024, compared to 12,463 kits and 342 teachers in 2023.

3.1.3.4.2 Facilitated Discussion Findings

The program has embraced more interactive and data-driven approaches to enhance participation. A key component of this shift has been engaging with teachers through webinars, in-person events, and feedback collection at various conferences. This has led to the creation of interactive materials such as games, Google Slides, and Kahoot activities. According to program staff, these resources are aligned with state educational standards, ensuring they are engaging and academically relevant. Program staff will continue to address the demand for digital content and accessible materials for a diverse audience.

3.1.3.4.3 Teacher Survey

ADM conducted an online survey among participating teachers to evaluate their experience with the curriculum, assess its implementation in their classrooms, and measure overall satisfaction. ADM evaluators sent emails to 395 teachers, and 121 of them completed the survey.

In addition to teachers using their Energy Saver Kit in the classroom for lessons or demonstrations, most teachers installed some or all the items in their homes. The LEDs and the advanced power strips were the most installed items by teachers.

Figure 3-23: Utilization of Energy Efficiency Kit Items by Educators

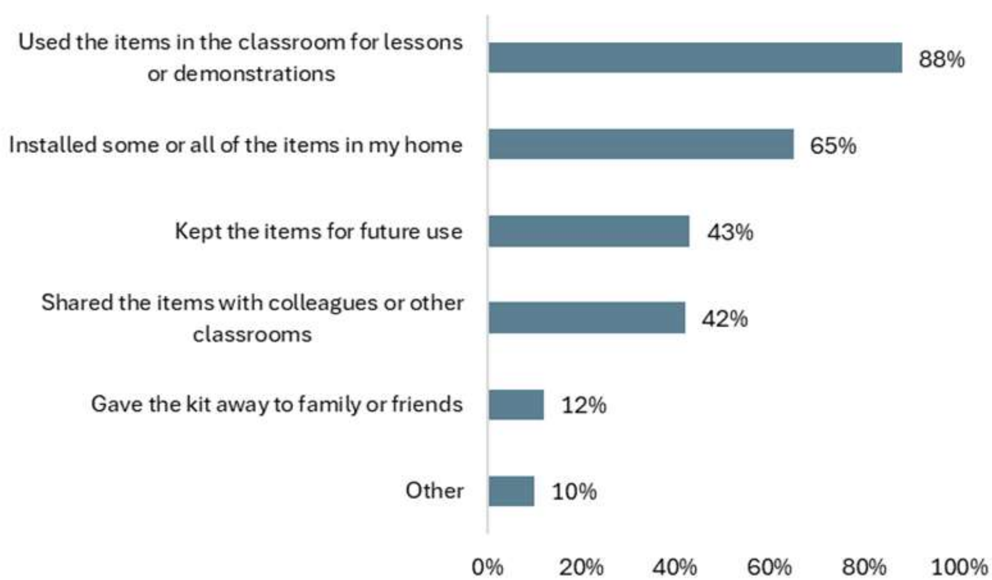
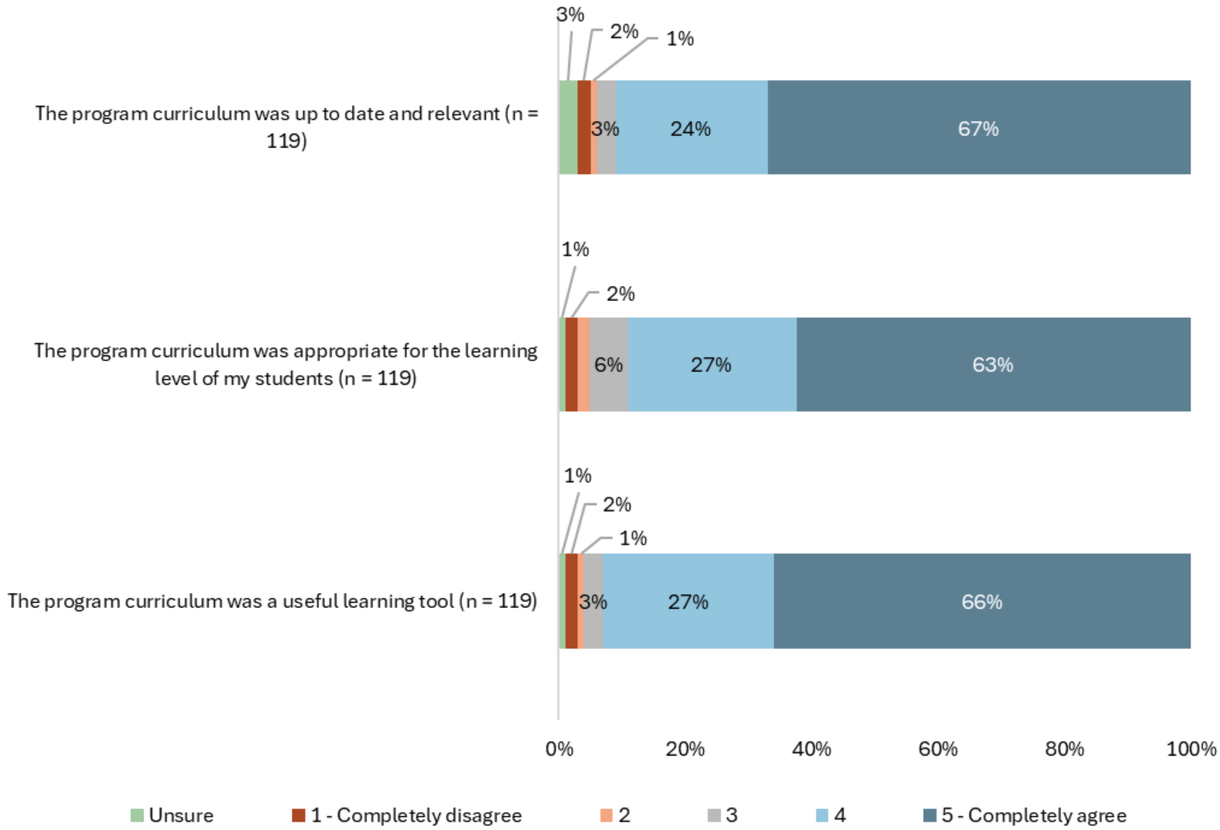
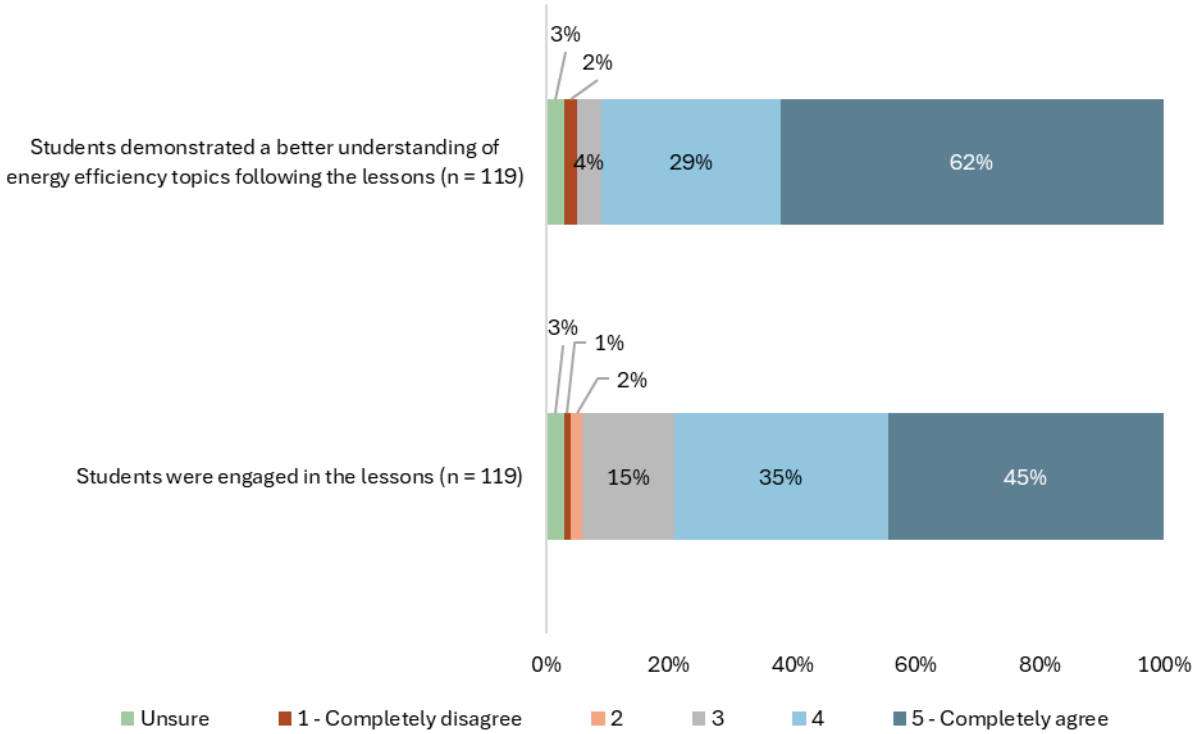


Figure 3-24: Teacher Perceptions of the Program Curriculum



Teachers agreed that students were engaged with lessons and demonstrated a better understanding of energy efficiency topics following the lessons (Figure 3-25). Without the PSO Energy Saver Kit curriculum, many educators noted that their energy efficiency lessons would have lacked hands-on materials, real-world applications, and detailed content provided by the program. Teachers would have relied more on textbooks, digital resources, or materials from platforms like Teacher Pay Teachers. Lessons would have been less interactive, with fewer opportunities for students to connect the material to their daily lives or practice energy-saving techniques at home.

Figure 3-25: Perception of Student Experience



3.1.3.4.4 Student Results

Evaluators compared students pre- and post-test scores. Of the completed tests analyzed, the pre-test scores averaged 58%, while the post-test averaged 83%. The difference between pre- and post-test scores was 25 percentage points and was statistically significant (Table 3-65). The change in pre/post-quiz scores indicates an improvement in overall test scores.

Table 3-65: Analysis of Test Scores – Education Program

Measurements	Pre-Survey (n = 1,119)	Post-Survey (n = 1,116)	P-value
Test Score Mean	58%	83%	<0.0001

3.1.3.5 Conclusions and Recommendations

The following are conclusions from the evaluation of the Education program.

- Overall participation and installation rates are greater than last year. The number of kits delivered also increased by 34%.
- The program's strength lies in its significant impact on teachers and students, providing valuable resources integral to student curriculum. Students demonstrated a 25% increase in knowledge of the energy efficiency content and

93% of teachers found the content to be useful training material towards their required curriculum.

- Teachers praised the Energy Saver Kit program curriculum for its relevance, suitability, and effectiveness as a teaching tool. Educators emphasized the program's essential role in providing depth, engagement, and hands-on experiences, enhancing their energy courses compared to traditional methods.

The following recommendations are offered for continued improvement of the Education Program.

- Continue enhancing digital materials and teacher training to keep students and teachers engaged with the curriculum. Continue to organize targeted training for teachers to integrate refined content into lesson plans. This ensures the program stays current and effective.

3.1.4 Multifamily and Manufactured Homes Program

This chapter presents findings from the impact and process evaluation of the Multifamily and Manufactured Homes 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.

3.1.4.1 Program Overview

The Multifamily Program is in its fifth year in the Public Service Company of Oklahoma (PSO) portfolio during program year 2024. Table 3-66 illustrates performance metrics for the Multifamily and Manufactured Homes Program.

To be eligible for the Program, the property must be composed of three or more dwelling units within the service territory or a manufactured home with electric heat. Energy efficiency equipment is eligible within dwelling units, in common areas, and in office spaces. Measures for manufactured homes include direct installation measures (low-flow showerheads, and faucet aerators) as well as duct sealing and air sealing.

Table 3-66: Performance Metrics - Multifamily Program

Metric	2024
Number of Customers	1316[41]
Budgeted Expenditures	$1,500,417
Actual Expenditures	$1,576,535
Energy Impacts (kWh)	
Projected Energy Savings	1,714,957
Reported Energy Savings	3,517,923
Gross Verified Energy Savings	3,556,148
Net Verified Energy Savings	3,438,995
Peak Demand Impacts (kW)	
Projected Peak Demand Savings	411.68
Reported Peak Demand Savings	1,136.72
Gross Verified Peak Demand Savings	1,135.38
Net Verified Peak Demand Savings	1,096.08
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	3.27
Utility Cost Test Ratio	2.15

The Program provides comprehensive energy efficient measures for qualifying Multifamily properties and Manufactured Homes in the PSO service territory. The program offers direct installation measures (ENERGY STAR® LEDs, faucet aerators, and low-flow showerheads) at no cost to the participating property . Tenant dwellings that receive direct installation 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 program offers commercial energy efficiency measures in addition to the residential measures. The commercial measures include LED lamps and fixtures, air infiltration, ceiling insulation, duct sealing, HVAC system replacements, AC tune-ups, water heaters, ENERGY STAR windows, ENERGY STAR pool pumps, ENERGY STAR washing machines, ENERGY STAR dryers, ENERGY STAR refrigerators, ENERGY STAR ventilation fans, vending machine controls, and ice machines.

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

[41] Represents unique addresses, including individual dwellings

- 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.
- Provide energy efficiency offerings to underserved manufactured home settings.

The 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 Program pays rebates for custom projects (e.g., chillers) that do not fall into prescriptive measure categories by annual energy savings and peak demand impact basis. Table 3-67 summarizes Program activity by the percentage of reported savings by measure type.

Table 3-67: Percentage of Reported Savings by Measure Type – Multifamily and Manufactured Homes Program

Measure Type	Percent of Program
HVAC	78.88%
Building Envelope	20.45%
Lighting	0.37%
Water Heating	0.09%
Appliances	0.21%

AC tune-ups, air sealing, duct sealing, and low-flow showerheads were all offered for manufactured homes. A breakout of measure implemented for manufactured homes and multifamily homes is shown in Table 3-68.

Table 3-68: Installed Measures for Multifamily and Manufactured Homes

Measure	Manu. Home Measure Count	Multifamily Measure Count	Manu. Home Reported kWh	Multifamily Reported kWh
Duct Sealing	51	748	232,882	1,830,005
AC Tune-Up	25	1687	8,506	564,358
Air Sealing	4	196	44,321	364,951
Attic Insulation	N/A	70	N/A	213,809
Window	N/A	4	N/A	96,376
Duct Replacement	N/A	6	N/A	78,927
Heat Pump	N/A	17	N/A	57,524
Lighting	N/A	2	N/A	13,168
ENERGY STAR Refrigerator	N/A	3	N/A	4,832
Low Flow Shower Head	5	N/A	3,088	N/A
Air Conditioner	N/A	10	N/A	2,650
Pool Pump	N/A	1	N/A	2,494
ENERGY STAR Ventilation Fan	N/A	2	N/A	32
Total	**85**	**2,746**	**288,797**	**3,229,126**

3.1.4.2 Evaluation Activities

This section presents the evaluation activities conducted for the program. Detailed methodologies can be found in a supplemental document.

Data Collection

Data collection activities for the evaluation consisted of a review of program materials, on-site verification visits, a facilitated discussion with program staff, service provider interviews, and interviews with participating owners/managers.

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. Information on equipment was also acquired from industry references such as the Air Conditioning, Heating, and Refrigeration Institute (AHRI) and the Design Lighting Consortium (DLC).

One on-site inspection was performed to confirm measure installation and gather information to better inform the program analysis. There was no monitoring equipment deployed during site visits, instead site visits were used to gather baseline conditions and efficient equipment conditions such as quantities, specifications, locations, and operating conditions. The property owner/manager surveys provided self-reported data for the net-to-gross (NTG) analysis as well as process evaluation input. Table 3-69 shows the achieved sample sizes for the different types of data collection activities utilized for this study.

Table 3-69: Multifamily and Manufactured Homes Sample Sizes for Data Collection Efforts

Evaluation Activity	Achieved Sample Size
On-Site Visit	1
Property Owner/Manager Survey	8
Facilitated Discussion with Program Staff	1
In-depth Interviews with Service Providers	4
Engineering Desk Review	Census

3.1.4.2.1 Energy Impacts Methodology

A census review of program tracking data was performed to determine gross energy savings program results. The following steps were used to evaluate the Program's gross energy savings and peak demand reduction:

- Program tracking data was reviewed throughout the year to determine the scope of the Program and to ensure there were no data issues such as duplicate entries or missing data.
- A detailed engineering desk review was conducted for each project completed in the Multifamily program. The desk review process includes a thorough examination of all project documents, 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.
- Verified gross savings impacts were calculated. The sources for deemed savings algorithms are the 2013 Oklahoma Deemed Savings Document, Arkansas Technical Reference Manual v.8 (AR TRM), and Mid-Atlantic Technical Reference Manual v.8 (Mid-Atlantic TRM).
- Data collected through site visits and surveys was used 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.

Table 3-70 below illustrates the references used to calculate annual energy savings, peak demand reductions, and lifetime energy savings for the various measures included in the Multifamily Program.

Table 3-70: Multifamily References for Energy Savings Calculations

Measure	Methodology References
Air Conditioner	Arkansas TRM v.8.1, Section 2.1.6
Air Conditioner Tune-Up	Arkansas TRM v.8.1, Section 2.1.5
Air Infiltration	Arkansas TRM v.8.1, Section 2.2.9
Ceiling Insulation	Arkansas TRM v.8.1, Section 2.2.2
Duct Sealing	2013 OKDSD, Section 5
Duct Replacement	Arkansas TRM v.8.1, Section 3.1.11
Faucet Aerators	Arkansas TRM v.8.1, Section 2.3.4
Heat Pumps	2013 OKDSD, Section 12/Arkansas TRM v.8.1, Section 3.1.18
Pool Pumps	Arkansas TRM v.8.1, Section 2.4.5
Low-Flow Showerheads	Arkansas TRM v.8.1, Section 2.3.5
ENERGY STAR Refrigerator	Arkansas TRM v.8.1, Section 2.4.3
ENERGY STAR Windows	2013 OKDSD, Section 6
Lighting Efficiency	Arkansas TRM v.8.1, Section 2.5.1.4
	Arkansas TRM v.8.1, Section 2.5.1.3
	Arkansas TRM v.8.1, Section 3.6.2
	Arkansas TRM v.8.1, Section 3.6.3
ENERGY STAR Dryer	Mid-Atlantic TRM v8.0
ENERGY STAR Washing Machine	Arkansas TRM v8.1 2.4.1
ENERGY STAR Ventilation Fan	Arkansas TRM v8.1 2.1.13
Water Heater	Arkansas TRM v8.1 2.3.1

3.1.4.2.2 Net-to-Gross Estimation (NTG) Methodology

Net-to-Gross estimation (NTG) was used to determine what portion of gross savings achieved by PSO customers is the direct result of program influence. A survey was administered to owners/managers of Multifamily properties to assess free ridership and spillover for the calculation of NTG. The survey responses were reviewed to assess the likelihood that participants were free riders. The free ridership methodologies used for determining what portion of a customer's savings are attributable to the program varied by whether measures were direct installation or non-direct install. Details on the methodology can be found in a supplemental document.

3.1.4.2.3 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 v8.0. If a measure is not listed in the AR TRM, then a different industry standard reference, such as another technical reference manual, is considered.

3.1.4.2.4 Process Evaluation Methodology

The process evaluation is designed to answer the following research questions:

- How well did PSO staff, service providers, implementation contractors, and property managers/owners 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 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?
- What are PSO staff and implementation staff perspectives on the program? What are the reactions to program design choices that have been implemented?
- What are the key indicators of program success? Is the program achieving success? Do various stakeholders perceive the program to be successful?
- Were there any significant obstacles during the 2024 program year?
- Looking forward, what are the key barriers and drivers to program success within PSO's market?

To address these questions, the process evaluation activities included a survey of decision makers and interviews with service providers and program staff review of PY2023 recommendations and discussion of 2024 updates to gain insight into program design and implementation. Table 3-71 details the data collection activities performed for this program's evaluation.

Table 3-71: Multifamily Process Evaluation Data Collection Activities Summary

Data Collection Activity	Process Evaluation Research Objectives
PY2024 Recommendation Review	Gathered and synthesized data regarding the implementation of ADM's PY2023 recommendations as well as program updates for PY2024.
Review Program Materials	Review program design or implementation materials, customer engagement 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.
Decision-maker 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.
Service Provider Interviews	Assessment of program changes, barriers to participation, satisfaction with program procedures and how it compares to other programs in the region; and assessment of program customer engagement materials, training, and communications with program staff.

3.1.4.3 Impact Evaluation Findings

Impact evaluation findings determine net annual energy savings (kWh) and peak demand reduction (kW). 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 visit verification.

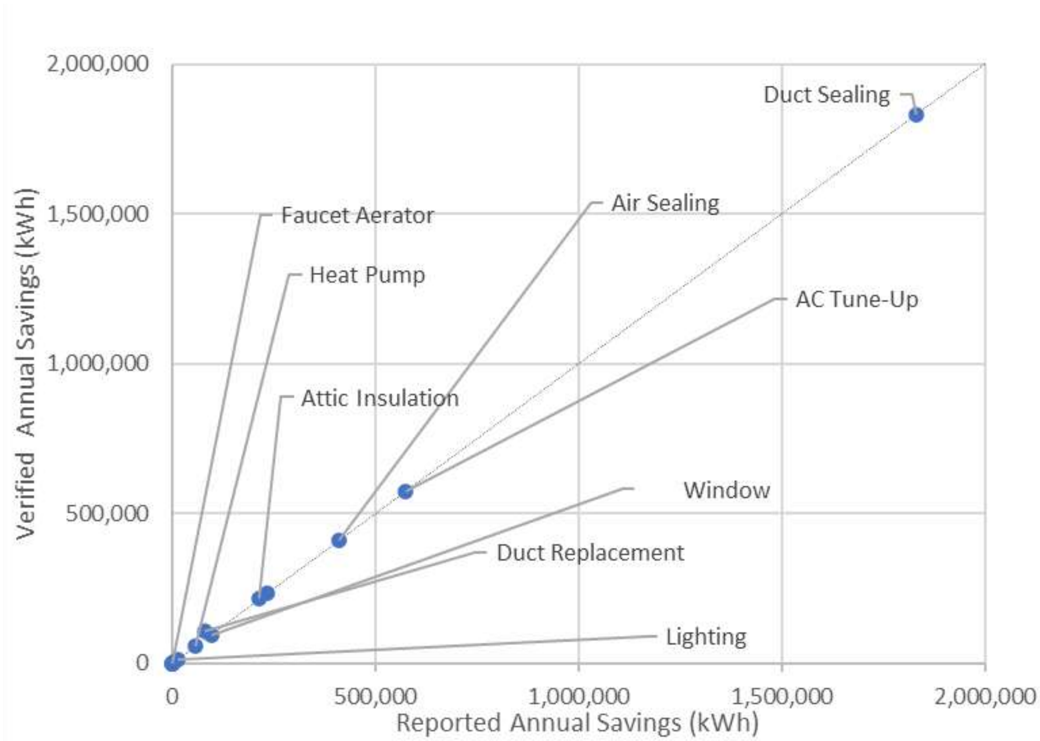
3.1.4.3.1 On-Site Verification

Field work was performed to verify baseline and efficient equipment installation, quantities, and efficiencies. The test-in/test-out values for blower door testing were confirmed during the site visits with implementation staff. A single site visit ride-along was performed during this program year evaluation. The purpose of said visit was to review the staff performing an AC tune-up. During the site visit, ADM staff observed the contractor cleaning the condenser of an AC unit and taking amperage, volt, and refrigerant pressure measurements for prior to and after performing the tune-up.

3.1.4.3.2 Verified Gross Savings

The program in 2024 consisted of 14 measure types spanning both direct install measures and non-direct install measures. A graphical representation of the relative contribution of measures to the Program's reported savings. A graphical representation of the relative contribution of measures to the Program's reported savings are shown in Figure 3-26. The solid line in the figure indicates a theoretical 100% realization rate. As shown in the figure, duct sealing, AC tune-ups, and air sealing are the measures with the largest impact on the program. Duct sealing contributes 52% of program savings, followed by AC tune-up with 16%. The top contributing measures are labeled while measures with minimal impact are not labeled. Those not labeled include air conditioners, ENERGY STAR® refrigerators, low flow shower heads, pool pumps, and ENERGY STAR® ventilation fans.

Figure 3-26: Multifamily and Manufactured Homes Reported vs. Verified Measure Level Energy Savings



The program level realization rate for gross annual energy savings is 101% with measure level variation from 100% to 137%. Figure 3-27 below illustrates the factors causing savings discrepancy and the frequency in which they occurred, while Figure 3-28 illustrates the change in savings affected due to these different factors.

Figure 3-27 Multifamily and Manufactured Homes Factors Affecting Realization Rates, Measures Affected

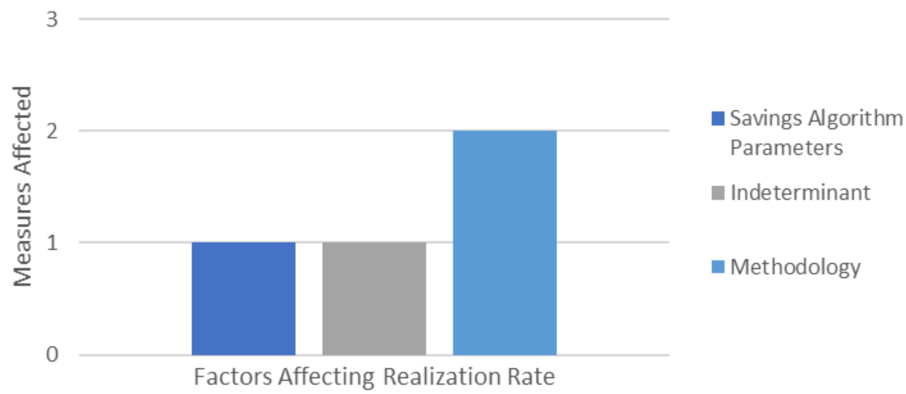
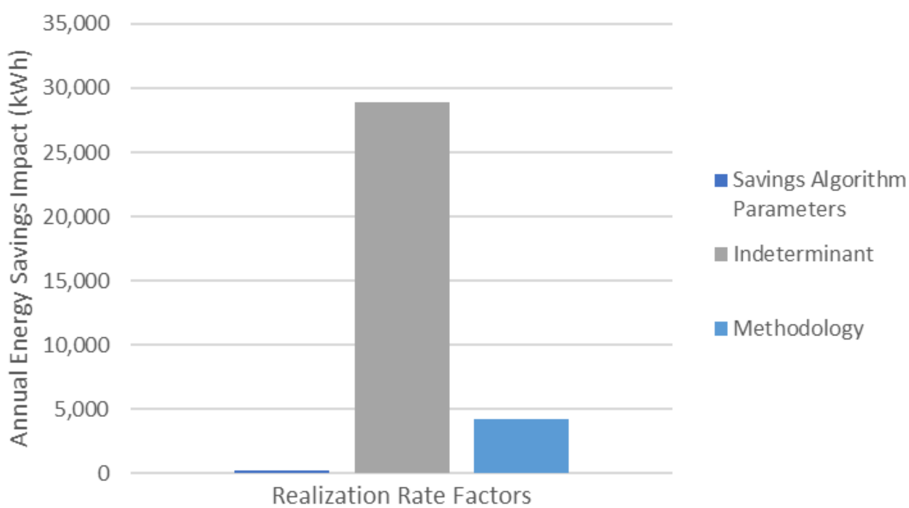


Figure 3-28 Multifamily and Manufactured Homes Factors Affecting Realization Rates, Savings



There were no discrepancies found in energy savings calculations for most of the energy efficiency measures in the program. Measures with any sort of savings discrepancy are detailed below.

Savings Algorithm Parameters

For the measures where "Savings Algorithm Parameters" was the reason for the savings discrepancy, the methodology to calculate savings was determined to be correct, but there was found to be an issue with the savings inputs used to determine savings. Typically, the input difference could be anything from interactive effects, hours of use, or from spec sheets reflecting different efficiencies than what was reported. The only measures where "Input" affected realization rates was for lighting, the difference being a single watt for baseline wattage for both line items between the claimed and verified savings calculations and a difference in the interactive effects utilized in the claimed savings calculations.

Indeterminant

For the measures where "Indeterminant" was the reason for the savings discrepancy, the exact reason for the savings discrepancy could not be determined. The measure where this was chosen was for duct replacement. This was the first instance of the duct replacement measure having reported savings for the program. An initial review of tracking data, project document, and a discussion with PSO and ICF was used to determine that the "duct sealing" methodology was most fitting for use in savings calculations. Claimed savings for all line items could not be recreated using the provided tracking data, an "indeterminant" savings factor was assigned to this measure.

Methodology

For the measure where "Methodology" was chosen as the reason for the savings discrepancy, it was determined that there was a difference in the methodology used for the reported and verified savings calculations. This was the reason for discrepancy for attic insulation and pool pumps. Both the reported and verified savings calculations for attic insulation and pool pumps utilized the AR TRM for determining savings, however, the claimed savings utilized a deemed value and verified savings were determined using an optional, more precise method.

A more detailed explanation for the savings discrepancies of the installed measures is included in the following section.

3.1.4.3.3 Measure Level Verified Savings

Table 3-72 details gross annual energy savings for each measure present in the program. Findings for the measure types that deviated from reported estimates are explained below.

Table 3-72: Verified Gross Annual Energy Savings by Measure – Multifamily and Manufactured Homes Program

Equipment	Reported kWh	Verified kWh	kWh RR
Duct Sealing	1,830,005	1,833,009	100%
AC Tune-Up	572,864	575,130	100%
Air Sealing	409,272	409,272	100%
Mobile Home Duct Sealing	232,882	232,888	100%
Attic Insulation	213,809	217,301	102%
Window	96,376	96,376	100%
Duct Replacement	78,927	107,794	137%
Heat Pump	57,524	57,524	100%
Lighting	13,168	13,417	102%
ENERGY STAR Refrigerator	4,832	4,832	100%
Low Flow Shower Head	3,088	3,088	100%
Air Conditioner	2,650	2,650	100%
Pool Pump	2,494	2,835	114%
ENERGY STAR Ventilation Fan	32	32	100%
Total	**3,517,923**	**3,556,148**	**101%**

Approximately 93% of program savings were attributed to multifamily facilities and 7% to manufactured homes, a similar ratio compared to 92% and 8% from the previous program year. Reported and verified savings by building type is shown in Table 3-73.

Table 3-73: Multifamily and Manufactured Homes Reported and Verified Gross Savings by Building Type

Building Type	Reported kWh	Reported kW	Verified kWh	Verified kW
Multifamily Building	3,229,126	1,076.80	3,311,665	1,078.79
Manufactured Home	288,797	59.92	244,482	56.38
Program Total	**3,517,923**	**1,136.72**	**3,556,148**	**1,135.12**

Pool Pump

The annual energy savings and demand reduction realization rate for pool pumps are 114% and 146%, respectively. There was a single line item for this measure with savings that made up less than 1% of program savings. Savings were determined using the methodology defined in the AR TRM, the factor causing the savings discrepancy was found to be the use of a deemed savings value from the AR TRM.

Retrofit Lighting

The annual energy savings and demand reduction realization rates for retrofit lighting measures are 102% and 100%, respectively. The primary factor driving the realization rate is a difference in baseline wattage and application of interactive effects. This measure only had two line items for this year's evaluation, both line items listed a baseline wattage of 52, and in recreating the claimed savings it was found that a baseline wattage of 51 was used instead. Additionally, an interactive effect of 1.00 for both energy saving and demand reduction were applied in the claimed savings calculations for interior-located fixtures. The verified savings calculations utilized an interactive effect of 1.02 and 1.20 based on the listed HVAC type for the installed space.

Attic Insulation

The annual energy savings and demand reduction realization rates for attic insulation are 102% and 100%, respectively. Both the reported and verified calculations utilized the AR TRM for determining savings. The TRM offers default savings values per square foot. of installation along with an option to interpolate the savings value using the as-found R-value for more accurate savings calculations. The reported calculations used the default values associated with an efficient R-value of 38 in savings calculations, whereas the verified calculations determined savings per square foot of installation by interpolating the reported R-value. The difference in the interpolated savings vs. the default is the reason for the discrepancy.

Duct Replacement

The annual energy savings and demand reduction realization rates for this measure are 137% and 113%, respectively. This was the first instance of this measure contributing savings to the program. Based upon review of the tracking data and the available project documentation, "duct sealing" was chosen as the TRM methodology used to determine savings. An attempt was made to recreate claimed savings using other duct-related measures but was unsuccessful.

3.1.4.3.4 Peak Demand Reduction (kW)

The overall realization rates for the peak demand reduction are 98%. Factors affecting the realization rate were discussed for the listed measures in the previous section. The biggest factor that affected the demand reduction realization rate was an indeterminant factor affecting the duct replacement measure. The next largest factor was from ENERGY STAR refrigerators where the magnitude of demand reduction was 10% of the claimed savings. This issue was present in last year's program analysis. Demand reduction by measure is shown in Table 3-74.

Table 3-74: Verified Gross Peak Demand Reduction by Measure – Multifamily and Manufactured Homes Program

Equipment	Total Reported kW	Total Verified kW	kW RR
Duct Sealing	520.67	521.24	100%
AC Tune-Up	349.42	349.42	100%
Attic Insulation	81.35	81.25	100%
Mobile Home Duct Sealing	50.88	50.89	100%
Air Sealing	45.19	45.19	100%
Window	32.37	32.37	100%
Duct Replacement	25.50	28.85	113%
Lighting	13.84	13.84	100%
Heat Pump	8.66	8.66	100%
ENERGY STAR Refrigerator	6.72	0.67	10%
Pool Pump	1.34	1.96	146%
Air Conditioner	0.45	0.45	100%
Low Flow Shower Head	0.32	0.32	100%
ENERGY STAR Ventilation Fan	0.01	0.01	88%
Total	**1,136.72**	**1,135.12**	**100%**

3.1.4.3.5 Net-To-Gross Estimation Findings

ADM estimated an overall NTG score of 0.97 for the Multifamily and Manufactured Homes Program in 2024. NTG was determined independently for non-direct installation measures (referred to as major measures) and direct installation measures.

- For the “major measure” segment of the program, ADM found a weighted NTG score of 0.97. Three of the four decision-makers said they did not have prior plans to install the measures. One of these decision makers specifically stated that their organization would not have had the financial ability to make the improvements without the program. Another stated that they were unable to make upgrades to another one of their properties because incentives were not enough to offset the cost of those improvements. One of the four decision makers indicated that they had plans to make the improvements before hearing about the program and would have made the improvements within the same year without the program.
- Findings from the 2024 decisionmaker surveys led to the assignment of a NTG score of 0.75 for “direct install” water-saving measures (low-flow showerheads and faucet aerators). ADM utilized its 2022 survey results to assign a NTG score of 1.0 for screw-in LEDs as insufficient information was gathered in 2023 to calculate a

score. ADM spoke to two decisionmakers about the low-flow showerheads they received through the program. Both indicated that their organization had purchased low-flow showerheads in the past and had plans to purchase and install more within one year, before they had heard about the program. They stated that they would have installed the same number of low-flow showerheads, though only a portion of them would have been installed within the same year. None of the respondents to ADM's 2024 decision-maker survey provided decision-making information related to LED screw-in lamps.

The NTG ratios are calculated as 1-free-ridership plus spillover. Results are shown in Table 3-75 for annual energy savings and Table 3-76 for peak demand reduction.

Table 3-75: Multifamily and Manufactured Homes Net Energy Savings

Program	Expected kWh Savings	Verified Gross kWh Savings	Free Ridership (kWh)	Verified Net kWh Savings	Net to Gross Ratio
Multifamily	3,517,923	3,556,148	117,153	3,438,995	96.71%
Total	**3,517,923**	**3,556,148**	**117,153**	**3,438,995**	**96.71%**

Table 3-76: Multifamily and Manufactured Homes Net Peak Demand Savings

Program	Expected Peak kW Reductions	Verified Gross kW Reductions	Free Ridership (kW)	Verified Net kW Reductions	Net to Gross Ratio
Multifamily	1,136.72	1,135.12	39.04	1,096.08	96.56%
Total	**1,136.72**	**1,135.12**	**39.04**	**1,096.08**	**96.56%**

3.1.4.3.6 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 3-77.

Table 3-77: Multifamily and Manufactured Homes Measure EUL's and Lifetime Energy Savings

Equipment	EUL	Gross Lifetime Savings (kWh)	Net Lifetime Savings (kWh)
Duct Sealing	18	32,994,162	31,913,438
AC Tune-Up	10	5,751,300	5,562,916
Air Sealing	11	4,501,992	4,354,529
Attic Insulation	20	4,346,020	4,203,666
Mobile Home Duct Sealing	18	4,191,984	4,054,676
Duct Replacement	18	1,940,288	1,876,734
Window	20	1,927,520	1,864,384
Heat Pump	16	920,384	890,237
Lighting	9	120,751	116,796
ENERGY STAR Refrigerator	17	82,144	79,453
Air Conditioner	19	50,350	48,701
Low Flow Shower Head	10	30,880	23,160
Pool Pump	10	28,350	27,421
ENERGY STAR Ventilation Fan	19	605	585
Total		**56,886,730**	**55,016,696**

3.1.4.4 Process Evaluation Findings

Process evaluation activities included a survey for property owners/managers, service provider interviews, and a facilitated discussion with program staff. A detailed process evaluation memo was provided to PSO after the completion of the 2024 program year.

3.1.4.4.1 Service Provider Perspectives

ADM interviewed four service providers who participated in the PSO Multifamily and Manufactured Homes Program in September and November 2024 to investigate their experiences with the program's design and implementation. There were five service providers listed in the program tracking data in September 2024. The service providers interviewed represented over 99% of program savings at the time of survey administration. The following presents findings from the interviews.

- The service providers are satisfied with the range of program offerings and timeliness of rebate payment design and implementation. All four contacts were satisfied with the measures offered through the program and the timeliness of rebate payment.
- Direct outreach from participating contractors to multifamily properties is driving participation. Three service providers indicated in-person outreach made directly to multifamily properties was the primary way they recruited participants. Service providers noted that outreach was enhanced by additional program support in 2024.
- Rebate levels were generally rated as sufficient, however an opportunity to adjust the rebate amount for attic insulation was noted. The two weatherization multifamily service providers voiced appreciation for increases made to the duct and air sealing rebate levels but noted that the rebate level for attic insulation had not increased. Both stated that the current incentive levels for attic insulation did not cover the cost of materials or labor for most potential attic insulation projects.
- The manufactured homes service provider noted that the program requirements had been updated to allow manufactured homes with gas heating to participate. In 2023 the manufactured home service provider noted the electric space heating eligibility requirement as a primary barrier to manufactured home program recruitment success. The manufactured home service provider estimated that about 70% of manufactured homes in PSO territory have gas-fired space heating and had been ineligible to participate in the program.
- The multifamily service providers observed strong demand for the program. Two service providers indicated that their participation in the program was limited by their company's level of staffing and/or demand for repair and install work. The other two indicated limited program funding was the main factor that limited their participation.

3.1.4.4.2 Decision-maker Survey

In September and October 2024, ADM conducted a telephone survey of decision-makers at properties that participated in the PSO Multifamily and Manufactured Homes Program. ADM completed surveys with eight decision-makers.

- Decision-makers' responses suggested the program was an influential or important factor for most of the improvements. Five of the eight decision-makers said they would not have had the financial ability to complete the PSO-sponsored improvements without the program. Six decision-makers said that the PSO rebate helped their project receive approval; one said that they would have done the project regardless of their participation in the program.

- Survey findings suggest a portion of AC tune ups done through the program would have been completed, even without program incentives or support. Two decision-makers said that though the program was very important in their decision to have AC tune-ups done, they would have done them without the PSO program. Another contact indicated the program was moderately important in their decision to have AC tune-ups, though they would have likely still done maintenance or check-ups for some of their AC units.
- The decision-makers representing properties that had weatherization measures completed were satisfied with the program overall. All five decision-makers that received duct sealing, air sealing, and/or attic insulation through the program were satisfied with the quality of the work completed, performance or quality of improvements, wait time, program overall and their interactions with PSO staff
- There is an opportunity to improve the AC tune-up participants' experience. Two of the four AC tune-up participants voiced dissatisfaction with their experience. One stated that the service provider "did not do anything" and they were not at all satisfied with the quality of work completed through the program.

3.1.4.5 Conclusions and Recommendations

The following conclusions were developed from the evaluation findings.

- Decision-maker satisfaction varies depending on their service provider or the measures implemented. High satisfaction was recorded from the five decision-makers that received weatherization measures. Satisfaction with AC tune-ups was mixed, with two out of four decision-makers that received AC tune-ups expressing dissatisfaction.
- Service providers generally express satisfaction with the program's design and implementation. However, they also noted an opportunity to adjust the rebate amount for attic insulation, which they noted as insufficient to cover costs. Both HVAC service providers were generally satisfied, though one expressed a desire for additional support and program tool updates, particularly in areas of training, IT support, and rebate processing.
- Participation is limited by available funding and service provider staffing. Two service providers indicated that their participation was limited by their company's level of staffing, while the two others cited limited program funding as the main constraining factor. This finding suggests there may be untapped potential for program expansion if these constraints can be addressed.
- The program is enabling improvements at multi-family properties that might not have occurred otherwise.

The following recommendations were developed for the Multifamily Program.

- Enhance service provider support and training for new service providers. Existing service providers have a strong understanding of participation requirements, however new service providers may benefit from additional support. One participating AC tune-up service provider called for improvements to the timeliness of IT support as well as more comprehensive onboarding training. They suggested training could aid in program participation and help avoid issues with applications and rebate payments.
- Work with AC tune-up service providers to streamline the administrative process. One of the AC tune-up service providers requested that the application tool's functionality be adjusted to easily allow retention of information about projects (e.g., PDF downloads). They also requested simpler, more consistent payment processes and observed that they had received hundreds of individual checks for some projects while others had been paid with single checks.
- Ensure all decision-makers receive a sufficient summary of work completed. Decision-maker survey findings indicate a written report of AC tune-up work completed with suggestions for additional work would improve the decision-makers' experience and help clarify the benefits of participation.

3.1.5 Behavioral Modification Program

This chapter presents findings from the impact and process evaluation of the 2024 Behavioral Modification program.

3.1.5.1 Program Overview

The Behavioral Modification Program provides customers with individualized energy reports to generate greater awareness of energy use and educate customers in ways they can reduce energy consumption. The energy report recommends energy saving behaviors and provides customers with a comparison of energy use at similar homes in their area, and across multiple years. It is expected the regular tips and reminders will encourage customers to adopt energy saving behaviors that will lead to more efficient energy use in their homes. In addition, participants are also encouraged to go to an online portal where they can input information about their home to receive specific tips addressing their home energy use.

In developing the program, a pool of potential participants was identified that had emails associated with their accounts. Participants were randomized into treatment and control groups and the equivalency of their pre-program-year data was verified. Opower has been the implementer for this program since 2022.

Five separate cohorts of PSO customers have received reports through the program. The first group of participants (Wave 1) began receiving reports on October 25, 2017. A second wave (Wave 2) commenced on May 22, 2018. Both Wave 1 and Wave 2 participants initially only received emailed reports. Mailed paper reports were delivered to a subset of customers starting in 2019.

Wave 3 of the program was added on March 20, 2019, via paper reports, and email reports when email contact information is available. A fourth wave (Wave 4) was added for 2020, and this group began receiving paper and emailed reports on March 1, 2020.

Wave 5 customers were added on a rolling basis beginning January 1, 2022. Paper energy reports were mailed to treatment participants every odd-numbered month. Additionally, monthly emailed energy reports were sent to participants in each wave where email addresses were available.

Table 3-78 shows the performance metrics achieved by the program.

Table 3-78: Performance Metrics – Behavioral Modification Program

Metric	2024
Number of Customers	266,237
Budgeted Expenditures	$1,181,250
Actual Expenditures	$922,914
Energy Impacts (kWh)	
Projected Energy Savings	26,816,300
Reported Energy Savings	23,236,754
Gross Verified Energy Savings	28,186,622
Net Verified Energy Savings	28,186,622
Peak Demand Impacts (kW)	
Projected Peak Demand Savings	4,221.62
Reported Peak Demand Savings	3,658.10
Gross Verified Peak Demand Savings	5,492.50
Net Verified Peak Demand Savings	5,492.50
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	1.74
Utility Cost Test Ratio	1.74

PSO's Behavioral program serviced 266,237 households during the 2024 program year. Table 3-79 shows the annual energy savings (kWh) per wave for 2024.

Table 3-79: Behavioral 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
1	55,093	0.46	167.2	8,877,150	8,877,150
2	22,040	0.39	142.0	3,129,680	3,129,680
3	29,301	0.34	124.8	3,656,765	3,656,765
4	25,576	0.38	138.1	3,532,046	3,532,046
5	136,227	0.18	66.0	8,990,982	8,990,982
Total	**266,237**	**0.29***	**105.9***	**28,186,622**	**28,186,622**

**Reflects an average value weighted by the count of treatment group participants.*

3.1.5.2 Evaluation Activities

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 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.

3.1.5.2.1 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 and program year 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, including the associated account number and whether the participant was still a part of the program.
- 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 cross-program participation.
- Treatment and control surveys to determine differences in LED purchasing patterns, energy savings actions, and customer satisfaction.
- In-depth interviews with program staff to support the process evaluation.

Additionally, a survey was conducted to participants and non-participants to gain insights into energy efficiency behaviors and the effectiveness of the home energy reports.

3.1.5.2.2 Survey Sampling Plan

To ensure proper extrapolation of survey results to program participants, ADM surveys a statistically representative sample of both participants and non-participants. A minimum sample size of 68 participants per wave is desired to represent results with ±10% precision at the 90% confidence interval.

3.1.5.2.3 Survey Objective

The objective of the program survey is to assess participants' overall satisfaction with the program, perceptions of the reports, actions taken to reduce energy consumption, and compare treatment and control group behaviors, household characteristics, and energy efficiency purchases.

The survey was administered online using an emailed link to a randomly selected group of 19,876 participants and controls. Reminder emails were sent as needed to increase the number of responses. Of those, 823 completed the survey for a response rate of 4.1%. The number of surveys completed by wave is shown in Table 3-80.

Table 3-80: Behavioral Summary of Completed Surveys

Wave	Control	Treatment
1	79	87
2	73	74
3	74	83
4	102	94
5	92	65
Total	**420**	**403**

3.1.5.2.4 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.

- Verified participants were sent energy reports during 2024.
- Calendarized the billing data provided by PSO.
- Cleaned the data by removing duplicate bills and string characters in the monthly consumption column.
- Removed billing months with negative consumption on their monthly bill.
- Removed billing readings with consumption less than 10 kWh or greater than 10,000 kWh.
- Removed billing months with reported lengths of fewer than 9 days or more than 60 days. It is assumed that these values are in error.
- Removed customers without sufficient pre-program and post-program billing data. Pre-Program data was defined as January 1, 2016 – December 31, 2016, for Wave 1, and the 400 days preceding the start date for Waves 2-5.
- Removed data for November 1, 2024 – December 31, 2024. During this period, most customers did not receive reports.[42]

[42] An issue with PSO system-wide AMI data led to errors in report generation for November and December resulting in reports not delivered.

3.1.5.2.5 Cross Participation and Uplift

Cross participation occurs when a participant in the Behavioral program also participates in any of 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, as well as upstream measures from the Energy Saving Products lighting program. Although one of the goals of the Behavioral program is to educate participants on other PSO programs, these programs are all evaluated independently and must be considered to avoid double counting of savings.

A two-sample t-test was used to determine if there was a statistically significant difference between the rate of cross-participation among those who received reports (participants), and those who did not (controls). For programs and waves where there was a statistically significant difference in the rate of cross participation (p-value < 0.1), ADM removed all cross participants from both the treatment and control groups to avoid double-counting savings from other programs.

Because the participants in the upstream lighting program are unknown, ADM asked participants and controls about the number of bulbs that they purchased during the year. ADM evaluated if there was a statistically significant difference between the number of bulbs purchased by participants and controls using a two-sample t-test.

3.1.5.2.6 Methodology for Regression Approach

ADM utilized a mixed effects panel regression model specified in a supplemental document to determine daily average electricity savings for treatment group members.

3.1.5.2.7 Calculation of Annual Energy Savings

The average daily energy savings for the post-period treatment group is defined as a coefficient in the regression model. Note that the daily savings are calculated only using data from January through October since most customers did not receive HER reports at the end of the year. To determine per participant annualized savings, the average daily energy savings value is multiplied by 365. The verified annual energy savings for the program is determined by multiplying the annualized energy savings by the number of participants in the treatment group who had existing accounts in 2024.

3.1.5.2.8 Calculation of Coincident Peak Demand Reduction

The peak demand reduction was determined by applying the program annual energy savings to a normalized residential 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 one 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 on non-holiday weekdays between 2 PM and 6 PM in the months of June through September.

3.1.5.2.9 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 groups. 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.

3.1.5.2.10 Lifetime Savings

The Behavioral program is considered to have an effective useful life (EUL) of 1 year. This is consistent with behavioral practices and the recommended value from the energy efficiency portfolio plan, as all participants are evaluated each year. Therefore, the lifetime savings total is equivalent to the annual verified energy savings.

3.1.5.2.11 Process Evaluation

The evaluation addressed the following research questions to better understand the program's effectiveness and efficiency:

- Has the underlying theory of how the program affects energy-saving behaviors changed since the previous program years? If so, how, and why?
- Did the program implementation reflect its current design? In what ways did it deviate and how did that affect program success? Are there ways to improve the design or implementation process?
- What information is presented in the HERs? Is the information presented clearly or are there opportunities for improvement? Could altering the order in which the information is presented affect energy efficiency?
- Were the reports delivered according to the planned schedule and frequency, by enrolled participants, and by program design?
- Do program utility and implementation contractor staff effectively coordinate to deliver the program?
- What is the utilization rate of additional engagement tools (e.g., customer portals)?
- What share of report recipients read the reports? Do recipients find the reports to be clear and useful? Do report recipients believe what the reports say? Why did participants decide not to read the reports?

- Were the program participants satisfied with the reports and the frequency of receiving them?
- What actions, if any, do participants report taking to save energy?
- How much does the program affect energy-saving actions and purchases?

Table 3-81 below summarizes the data collection activities and corresponding process evaluation research objectives used to complete the process evaluation.

Table 3-81: Process Evaluation Data Collection Activities Summary – Behavioral Program

Data Collection Activity	Process Evaluation Research Objectives
Program Materials Review	Review reports and support materials for clarity and consistency with program objectives.
Recommendation Review	Assess implementation of recommendations provided by ADM to determine the feasibility, usefulness, and any implementation of the recommendations.
Facilitated Discussion with Program Staff	Assess program staff perspectives regarding program operations, strengths, or barriers to success.
Treatment Group Survey (Email)	Assess participant perceptions of the reports, including satisfaction, and actions taken to reduce energy.
Control Group Survey (Email)	Assess the marginal difference in energy savings actions/purchases taken by those that do not receive HERs reports.

3.1.5.3 Impact Evaluation Findings

The following section reports the findings of annual energy savings and peak demand reduction.

3.1.5.3.1 Data Review

ADM calculated the average daily pre-treatment consumption for both the treatment and control group participants with current 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 3-82. Propensity score matching was used to test pre-treatment energy consumption consistency between the control and treatment group. Waves 2 and 5 have different pre-treatment energy consumption, indicating potential bias.

Table 3-82: Pre-Treatment Average Daily Consumption – Behavioral Program

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	
1	11,985	42.64	52,365	42.56	0.27
2	7,303	48.71	22,007	49.04	0.01*
3	14,314	35.09	28,754	35.13	0.46
4	7,345	40.27	25,448	40.39	0.22
5	28,444	35.19	130,301	35.08	0.03*

* *Control matching was performed on this wave. Without control matching, the t test p-value was <0.001.*

3.1.5.3.2 Cross Participation

ADM assessed whether members of the treatment and control groups participated in PSO's other residential energy-efficiency programs at the same rate by comparing participation in treatment and control groups using a two-sample t-test. ADM determined a statistically significant difference in the rate at which Wave1, Wave 2, and Wave 5 treatment and control group customers participated in the Home Rebates Single Upgrade program. Participants in Wave 3 and Wave 5 who were also in the Power Hours Program were significantly different. These members of the treatment and control groups were eliminated from the model to avoid double counting savings from the program. No other statistically significant differences were found between participation rates among treatment and control groups for any wave.

Table 3-83 shows the results of the t-tests for each program and wave. The p-values showing evidence of a statistically significant difference are bolded.

Table 3-83: Behavioral Cross Participation with other PSO Residential Programs

ESP Program					
Behavioral Program Wave	Control Group		Treatment Group		t-test
	n	%	n	%	p-value
1	61	0.51%	279	0.53%	0.796
2	37	0.40%	107	0.49%	0.936
3	40	0.27%	61	0.21%	0.215
4	14	0.19%	79	0.31%	0.115
5	96	0.29%	396	0.29%	0.375

Home Weatherization Program					
Behavioral Program Wave	Control Group		Treatment Group		t-test
	n	%	n	%	p-value
1	58	0.48%	298	0.57%	0.285
2	40	0.43%	93	0.42%	0.216
3	53	0.36%	129	0.44%	0.263
4	36	0.49%	116	0.45%	0.779
5	94	0.29%	509	0.38%	0.156

Home Rebates, Multiple Upgrades Program					
Behavioral Program Wave	Control Group		Treatment Group		t-test
	n	%	n	%	p-value
1	53	0.44%	201	0.38%	0.404
2	17	0.18%	48	0.22%	0.951
3	43	0.29%	88	0.30%	0.981
4	24	0.32%	55	0.22%	0.117
5	43	0.13%	171	0.13%	0.450

Home Rebates, Single Upgrades Program					
Behavioral Program Wave	Control Group		Treatment Group		t-test
	n	%	n	%	p-value
1	89	0.74%	316	0.60%	**0.095**
2	37	0.40%	130	0.59%	0.437
3	54	0.37%	155	0.53%	**0.026**
4	49	0.66%	119	0.47%	**0.044**
5	78	0.24%	393	0.29%	0.491

Multifamily and Manufactured Homes Program					
Behavioral Program Wave	Control Group		Treatment Group		t-test
	n	%	n	%	p-value
5	23	0.07%	104	0.08%	1.000

Power Hours Program					
Behavioral Program Wave	Control Group		Treatment Group		t-test
	n	%	n	%	p-value
1	561	4.65%	2525	4.79%	0.524
2	284	3.06%	923	4.19%	0.224
3	301	2.06%	533	1.82%	**0.092**
4	224	3.03%	808	3.16%	0.610
5	833	2.54%	3989	2.97%	0.273

3.1.5.3.3 Data Cleaning

Table 3-84 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 rationale 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.

Table 3-84:Number of Accounts After Each Data Cleaning Step – Behavioral Program

Cleaning Step	Wave 1		Wave 2		Wave 3		Wave 4		Wave 5	
	Control Group	Treat Group*	Control Group	Treat Group	Control Group	Treat Group	Control Group	Treat Group	Control Group	Treat Group
Original participant list	23,999	104,999	17,830	41,689	25,000	50,000	13,000	45,000	49,957	203,854
Participants not listed in billing data	12,701	55,408	9,734	23,077	15,424	30,828	7,883	27,217	38,297	156,670
Participants not active PSO customers in the program year	12,181	53,093	9,297	22,040	14,626	29,301	7,395	25,576	33,298	136,227
Filter to participants with actual billing readings	12,181	53,093	9,297	22,040	14,626	29,301	7,395	25,574	33,298	136,225
Removed outliers	12,171	53,061	9,286	22,013	14,617	29,285	7,392	25,561	32,966	134,867
Accounts before Control Matching and Cross Participant Removal	12,072	52,665	9,282	22,007	14,614	29,281	7,391	25,560	32,802	134,284
Number of accounts in final model:	11,985	52,365	7,303	22,007	14,314	28,754	7,345	25,448	28,444	130,301

** "Treatment Group"*

3.1.5.3.4 Verified Energy Savings (kWh)

Table 3-85 provides the results of the mixed-effects panel regression model. A negative coefficient indicates daily savings attributable to the program.

Table 3-85: Behavioral Results of Mixed Effect Panel Regression Modeling

Wave	Post × Treat Coefficient	Standard Error	T-Statistic	P-Value	R-Squared
1	-0.46	0.06	-7.30	<0.001	0.69
2	-0.39	0.10	-3.82	<0.001	0.72
3	-0.34	0.05	-6.64	<0.001	0.59
4	-0.38	0.09	-4.21	<0.001	0.67
5	-0.18	0.03	-5.37	<0.001	0.72

3.1.5.3.5 Total Verified Annual Energy Savings (kWh)

Annual energy savings per customer were determined by multiplying the daily energy savings value by 365 days. 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. The annual energy savings by wave are reported in Table 3-86.

Table 3-86: Behavioral Program 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
1	53,093	0.46	167.2	8,877,150	8,877,150
2	22,040	0.39	142.0	3,129,680	3,129,680
3	29,301	0.34	124.8	3,656,765	3,656,765
4	25,576	0.38	138.1	3,532,046	3,532,046
5	136,227	0.18	66.0	8,990,982	8,990,982
Total	**266,237**	**0.29***	**105.9***	**28,186,622**	**28,186,622**

Reflects an average value weighted by the count of treatment group participants.

The average daily savings in 2024 are comparable to the average savings from 2023. The average daily savings for each wave from 2020 through 2023 are shown in Table 3-87.

Table 3-87: Behavioral Program Average Daily Savings, by Wave, from 2020-2024

Wave	Daily kWh Savings per Customer, PY2021	Daily kWh Savings per Customer, PY2022	Daily kWh Savings per Customer, PY2023	Daily kWh Savings per Customer, 2024	2023 to 2024 Change
1	0.31	0.32	0.44	0.46	+0.02
2	0.42	0.56	0.43	0.39	-0.05
3	0.20	0.25	0.30	0.34	+0.04
4	0.23	0.26	0.26	0.38	+0.12
5	-	0.12	0.16	0.18	+0.03
Weighted Average	**0.29**	**0.25**	**0.27**	**0.29**	**+0.02**

3.1.5.3.6 Coincident Peak Demand Reduction (kW)

The peak demand reduction results by wave are reported in Table 3-88.

Table 3-88: Behavioral Program Coincident Peak Demand Reduction, by Wave

Wave	Number of Treatment Customers	Verified Net kW Peak Reduction
1	53,093	1,729.82
2	22,040	609.86
3	29,301	712.56
4	25,576	688.26
5	136,227	1,752.00
Total	**266,237**	**5,492.50**

Verified and reported annual energy savings (kWh) as well as peak demand reduction (kW) are shown in Table 3-89.

Table 3-89: Behavioral 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
23,236,754	3,658.10	28,186,622	5,492.50	121%	150%

3.1.5.3.7 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.

3.1.5.4 Process Evaluation Findings

This section presents findings from the participant and non-participant surveys. The survey yielded 823 participant and control survey responses. ADM provided a process evaluation memo to PSO in December of 2024 with detailed findings. The following summarizes the key findings from the process evaluation of the Program.

3.1.5.4.1 Program Operations Perspective

According to program staff, the overarching goal of the Behavioral Program is to support PSO's efforts in educating customers on how they can modify their behaviors to save energy in their homes and which energy-efficient investments they can make (e.g., purchasing energy-efficient items or completing an energy-efficient upgrade). Through the Behavioral Program, PSO staff strive to motivate customers to choose more energy-efficient products over standard ones and to incorporate no or low-cost actions to save energy in their households through personalized tips and recommendations. The more customers adopt energy efficiency practices, the more they impact market transformation within the PSO service territory.

3.1.5.4.2 Behavioral Survey Findings

Satisfaction with the information provided on home energy use, number of emails received regarding energy usage, frequency of receiving a HER, and the method of receiving a HER are shown in Table 3-90. From 2020 to 2024, there has been a decrease in satisfaction (selecting a 4 or 5 on a 5-point scale) with the information provided on home energy use, frequency of receiving HERs, and the methods of receiving HERs.

Table 3-90: Behavioral Program Year Comparison of Satisfaction with HERs Aspects

Satisfaction	2020	2021	2022	2023	2024
Information Provided on Home's Energy Use					
1 – Very dissatisfied	1%	3%	5%	4%	2%
2	1%	3%	6%	4%	6%
3	14%	13%	13%	19%	19%
4	22%	28%	24%	22%	26%
5 – Very satisfied	60%	52%	50%	46%	44%
Don't know	2%	1%	2%	5%	3%
Number of Emails Received on Home's Energy Use					
1 – Very dissatisfied	1%	1%	3%	3%	1%
2	4%	3%	5%	4%	5%
3	19%	17%	14%	18%	22%
4	23%	26%	22%	22%	24%
5 – Very satisfied	48%	47%	48%	42%	38%
Don't know	5%	7%	8%	12%	10%
Frequency of Receiving HER					
1 – Very dissatisfied	1%	1%	3%	4%	1%
2	4%	5%	5%	3%	4%
3	9%	14%	14%	16%	19%
4	26%	22%	18%	20%	22%
5 – Very satisfied	56%	56%	53%	50%	48%
Don't know	4%	2%	6%	8%	7%
Method of Receiving HER					
1 – Very dissatisfied	1%	2%	3%	3%	2%
2	2%	2%	2%	3%	5%
3	8%	11%	15%	15%	17%
4	26%	24%	15%	20%	20%
5 – Very satisfied	63%	59%	60%	55%	52%
Don't know	0%	2%	4%	5%	4%
Note: percentages may exceed or be less than 100% due to rounding errors.					

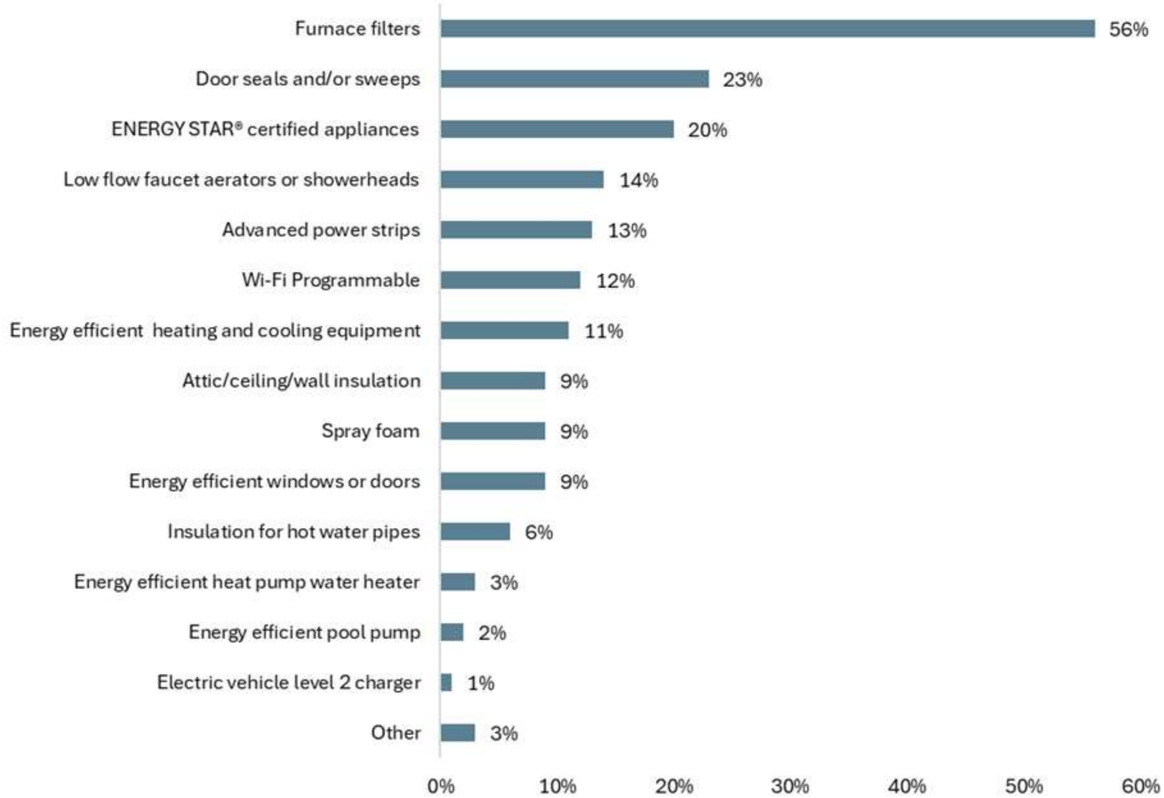
Coincidentally, participants found value in the home energy report information (see Table 3-91).

Table 3-91: Rated Value of HER Information

Rating	Comparison to Similar Homes (n = 370)	Comparison to Last Year (n = 286)	Energy Use Benchmark (n = 367)	Energy Saving Tips and Recommendations (n = 366)
5 - Very valuable	41%	45%	44%	30%
4	22%	25%	26%	27%
3	16%	19%	16%	23%
2	8%	4%	7%	8%
1 - Not at all valuable	9%	4%	4%	7%
Not applicable	1%	0%	1%	2%
Don’t know	3%	3%	2%	3%

Fifty-nine percent of respondents reported that they adopted new energy saving behaviors in their homes in 2024. Among those who adopted new behaviors, 67% indicated the information they learned from their HERs was an important factor of their decision. Homeowners reported adopting new energy saving behaviors at a slightly higher rate than renters (65% versus 59%, respectively). Many HERs participants made one or more energy efficient purchases in 2024. Furnace filters, door seals/sweeps , ENERGY STAR® certified appliances, and low flow faucet aerators were the most common purchases in 2024 (see Figure 3-29).

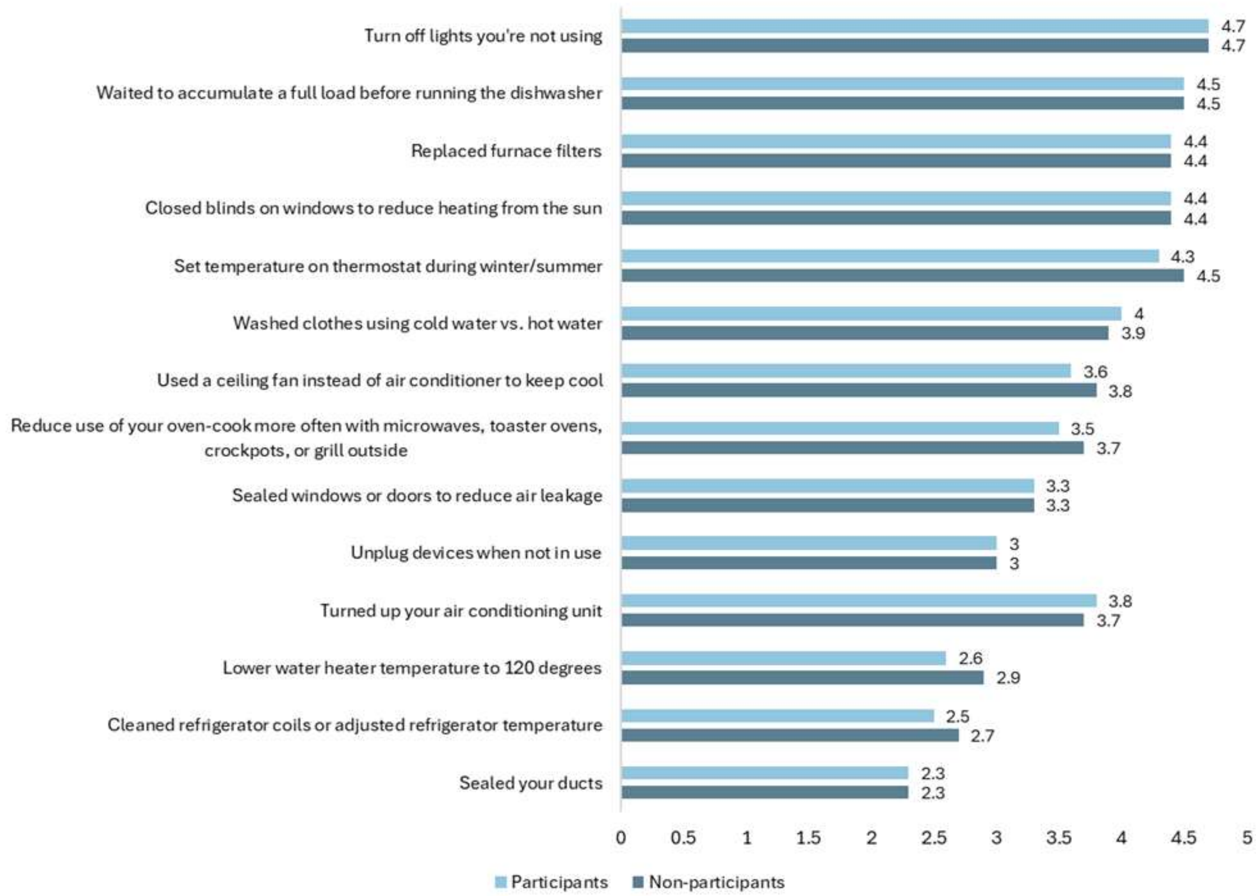
Figure 3-29: Energy Efficient Purchases in 2024 Among Participants



The amount of participant interactions with available online tools can be used as an indicator of interest in performing energy efficiency actions. Of the survey respondents, 8% recalled logging onto the Energy Management Tool web portal, greater than 6% in 2023. Among those who accessed the portal, a large majority (90%) stated they viewed information about their home's energy use.

Participants and non-participants were compared on self-claimed energy-saving actions taken (e.g., turning off lights, changing thermostat settings, changing dish and clothes washing practices) and the number of energy efficient items installed. A scale from 1 to 5 was used, where 1 was "never considered doing this" and 5 was "doing this all the time" to compare customers who receive a HER and those who do not. Figure 3-30 summarizes the average score of all energy saving actions among participants and non-participants. The higher the score, the more likely the respondent was to take that action more frequently. Non-participants and participants had similar average scores for most actions.

Figure 3-30: Average Scores among Participants and Non-Participants for Energy Saving Actions



3.1.5.5 Discussion of Findings

Waves 1, 3, and 5 showed similar savings as in previous years. The daily savings for Wave 2 decreased by 0.05 kWh, while Wave 4 increased by 0.12 kWh. However, the overall average savings is about the same as last year's.

The control and treatment groups in Wave 2 and Wave 5 had statistically different energy consumption in the pre-treatment period, even after control matching. Wave 2 showed this behavior last year, but the difference is new for Wave 5. The difference for Wave 5 is mainly due to the difference of control and treatment consumption during the Summer 2023 season. The statistically different consumption suggests that there is some bias in the estimated savings because the daily pre-period difference is the same magnitude as the daily savings.

In 2019-2021, the previous implementor excluded multifamily homes as part of their data cleaning process. Because Opower did not implement a similar data cleaning step, Wave 5 was the only wave to have multifamily cross-participants and had a higher proportion of both multifamily residents and renters compared to the other waves (Pearson's Chi-squared test, $p < 0.1$). In 2024, Wave 5 continued to have the lowest daily savings and a larger proportion of renters. Because previous waves are mostly homeowners in single-family homes, splitting Wave 5 by home type may yield results like the other waves.

3.1.5.6 Conclusions and Recommendations

This section presents conclusions and recommendations based on evaluation of the 2024 program year.

3.1.5.6.1 Conclusions

The following conclusions were developed from the evaluation findings:

- Final verified PSO Behavioral Program energy savings and demand reduction were above-reported energy savings.
- Significantly more treatment group participants reported adopting energy-saving behaviors in 2024 compared to the control group.
- Wave 1 had the highest average daily energy savings per customer (0.46 kWh). Wave 5 had the lowest average daily energy savings per customer (0.15 kWh), The lower savings for Wave 5 compared to other waves could be attributed to its lower percentage of homeowners.
- Over 70% of respondents are satisfied with the information presented in the HERs, frequency, and method of receiving HERs.
- Only 8% of respondents are using the Energy Management tool, which is an increase from last year, with a plurality of those who had not logged into the tool stating that they were not aware that it existed.

3.1.5.6.2 Recommendations

The following recommendations are offered for improvement of the Behavioral Program.

- Consider continuing to distribute and expand the distribution of vHERs. The introduction of vHERs over the summer had mixed feedback. Most respondents did not recall receiving it, and among those who did, only 28% found the information to be moderately to very helpful. ADM recommends continuing utilizing and potentially expanding the use of the vHER format in future deployments if feasible.
- Incorporate behavioral insights to encourage participants to utilize energy saving practices. Consider implementing behavioral science techniques into the HERs, such as social proof (e.g., "Neighbors like you have adopted these practices and saved 15% on their bills."). Social influence and framing can promote HERs

recipients to act by presenting them with comparisons and showing how others are taking action, thus motivating behavioral change.

- Wave 5 will need to be monitored for the pre-period average daily consumption. Because the control and treatment groups had significantly different pre-period consumptions, the estimated savings is also affected.
- Break out customer information by single-family and multifamily. The Wave 5 survey showed significantly more residents in multifamily buildings compared to other waves. An exploratory analysis could demonstrate if this difference is affecting the savings coefficient for this wave.

3.2 Business Rebates Program

This chapter presents findings from the impact and process evaluation of the 2024 Business Rebates program year. The Business Rebates Program includes incentives for Custom and Prescriptive measures, Small Business Energy Solutions measures, Midstream Lighting measures, and Midstream Heating, Ventilation, and Air Conditioning (HVAC) measures.

3.2.1 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, Retail Sales, and Custom and Prescriptive (C&P). The program offers incentives for many commercial and industrial measures including lighting, plug load & controls, building envelope, appliance & equipment, HVAC, agricultural, strategic energy management, custom measures, and refrigeration.

To participate in the Small Business Energy Solutions (SBES) subprogram, businesses must use 320,000 kWh or less annually and use a PSO-approved service provider. Current energy efficiency offerings in this subprogram include lighting and refrigeration measures.

The Midstream subprogram 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 through distribution channels. The program is focused on lighting and HVAC distributors.

The Retail Sales subprogram provides discounts to commercial lighting equipment at retail stores to encourage shelving practices that promote the purchase of energy efficient 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[43], customers have additional options to receive incentives through custom applications. Custom applications include a channel for Oil & Gas and Agriculture projects as well as Strategic Energy Management (SEM).

[43] https://powerforwardwithpso.com/rebates/#rebatebusiness

3.2.2 Evaluation Summary

The Business Rebates Program exceeded annual energy savings goals within budget for the 2024 program year. Table 3-92 summarizes projected, reported, and verified demand impacts as well as other program performance metrics. Detailed Business Rebate program results by subprogram and measure are presented in this chapter.

Table 3-92: Performance Metrics – Business Rebates Program

Metric	2024
Number of Participants	1,020
Budgeted Expenditures	$11,959,747
Actual Expenditures	$11,476,201
Energy Impacts (kWh)	
Projected Energy Savings	38,608,825
Reported Energy Savings	41,059,626
Gross Verified Energy Savings	42,011,972
Net Verified Energy Savings	36,208,309
Peak Demand Impacts (kW)	
Projected Peak Demand Savings	7,978.92
Reported Peak Demand Savings	7,267.15
Gross Verified Peak Demand Savings	7,428.85
Net Verified Peak Demand Savings	5,883.66
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	1.46
Utility Cost Test Ratio	1.81

The evaluation included both process and impact components. Evaluation activities included surveying, in-depth interviews, program tracking data review, field verification visits, gross energy savings analysis, and net energy savings analysis. Table 3-93 summarizes the achieved sample sizes for the various data collection activities for the Business Rebates Program evaluation.

Table 3-93: Sample Sizes for Data Collection Efforts

Data Collection Activity	Achieved Sample Size		
	Custom/Prescriptive	SBES	Midstream/Retail Sales
On-Site M&V Visits & Engineering Analysis	47	21	0
Engineering Desk Reviews Only (including billing regression analysis and provided system trend data)	1	-	Census
Customer Decision-Maker Surveys/Interviews	50	53	23
Program Staff Facilitated Discussions	-	1	1
Trade Ally Surveys	16	4	0
Midstream Distributor Interviews	N/A	N/A	6

3.2.3 Small Business Energy Solutions (SBES)

SBES seeks to generate energy savings for small commercial and industrial customers by promoting high-efficiency electric end-use lighting and refrigeration products. It seeks to combine provision of financial inducements with access to technical expertise to maximize program penetration across the range of potential small business customers. SBES 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 installation rebates are available to customers that qualify. To qualify for businesses must use 320,000 kWh or less annually and use a PSO approved service provider. Customers may request an exemption of these requirements.

3.2.3.1 Impact Evaluation Overview

The impact evaluation of SBES consisted of gross and net annual energy savings and peak demand reduction determination. Gross energy savings were determined through measurement and verification practices with on-site data collection. Net-to-gross was determined through survey efforts of participants and trade allies to calculate values of free ridership and spillover.

PSO provided rebates for a total of 279 SBES projects. The number of rebated projects decreased from 314 in 2023 to 279 in 2024. The reported energy savings decreased from 8,757 MWh (2023) to 6,158 MWh (2024). As with previous years, program energy savings were driven by lighting projects.

Table 3-94 provides projected and verified energy and demand impacts, as well as other program performance metrics for SBES projects.

Table 3-94: Performance Metrics – Small Business Energy Solutions

Metric	2024
Number of Projects	279
Energy Impacts (kWh)	
Reported Energy Savings	6,158,072
Gross Verified Energy Savings	6,439,159
Net Verified Energy Savings	6,399,429
Peak Demand Impacts (kW)	
Reported Peak Demand Savings	1,708.43
Gross Verified Peak Demand Savings	1,539.42
Net Verified Peak Demand Savings	1,529.53
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	1.53
Utility Cost Test Ratio	1.26

3.2.3.2 Process Evaluation Overview

The process evaluation consisted of participant surveys, trade ally surveys, and facilitated discussions with program staff. The objective of the participant survey was to assess sources of program awareness, factors that influenced project decision-making, experience with the participation process, and program satisfaction. A total of 53 customer decision-makers responded to the participant survey and 4 SBES trade allies were interviewed by ADM. A detailed process evaluation memo was provided to PSO in December 2024.

Table 3-95 summarizes program activity by service provider. Four lighting service providers represented most of the energy savings. National Resource Management (NRM) represented 1% of energy savings with refrigeration equipment.

Table 3-95: SBES Summary by Service Provider

Service Provider	Sum of Reported Energy Savings (kWh)	Percentage of Program kWh
Bridgepoint Electric	1,832,986	30%
Entegrity Partners	1,351,631	22%
First Light Systems	2,428,952	39%
Luminous of OK	467,920	8%
National Resource Management	76,583	1%
Total	**6,158,072**	**100%**

3.2.3.2.1 Project Activity by Location

Table 3-96 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 3-96: SBES District Share of Reported Annual Energy Savings

Region	Sum of Reported Total Energy Savings (kWh)	Percentage of Projects kWh
Eastern District	1,304,676	21%
Tulsa District	3,912,892	64%
Tulsa Northern District	442,327	7%
Western District	498,177	8%
Total	**6,158,072**	**100%**

3.2.3.3 Evaluation Activities

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

3.2.3.3.1 Data Collection

Data for the analysis was collected through review of program materials, on-site inspections, surveys with participating customers, and interviews with service providers and program staff. A sample was developed for on-site collection based on tracking data obtained via the tracking and reporting database.

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 desk reviews. Additional project materials including invoices, equipment cut sheets, pre- and post-inspection reports, and estimated savings calculators assist in preparing for visits and during analysis. On-site visits were used to collect data for gross impact calculations, to verify measure installation, and to determine measure operating parameters. Facility staff members were interviewed to determine the operating hours of the installed systems and provide any additional operational characteristics relevant to calculating energy savings.

In addition to the on-site data collection effort, customer surveys provided self-report data for the net-to-gross analysis and process evaluation. The customer survey was administered to a census of participants who had completed projects at the time of surveying. A total of 53 customer decision-makers who completed SBES incentive projects completed the survey. 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.

Table 3-97 shows the achieved sample sizes for the different types of data collection employed for this study.

Table 3-97: Sample Sizes for Data Collection Efforts – SBES

Data Collection Activity	Achieved Sample Size
On-Site M&V Visits & Engineering Analysis	21
Customer Decision-Maker Survey	53
Program Staff Facilitated Discussion	1
Trade Ally interviews	4

3.2.3.3.2 Impact Evaluation Sampling Plan

A stratified sampling approach based on the amount of estimated annual energy savings and type of measure installed in each project was used to select a statistically significant sample. Sample sizes were designed to meet ±10% precision at the 90% confidence level for annual energy savings. Table 3-98 below shows the sample design that was used for SBES projects. The 21 projects sampled for measurement and verification account for approximately 22% of reported program annual energy savings.

Table 3-98: 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	433,793	0-7,999	103	2
Lighting 2	939,051	8,000-17,999	75	2
Lighting 3	1,684,136	18,000-44,999	60	4
Lighting 4	1,821,185	45,000-109,999	27	6
Lighting 5	938,346	110,000-154,999	7	4
Lighting 6	264,979	155,000+	1	1
Refrigeration	76,583	0-40,000	6	2
Total	**6,158,072**		**279**	**21**

3.2.3.3.3 Gross Savings Analysis Methodology

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

- Program Data Review: The program tracking database was reviewed to determine the scope of the program, check for data completeness, identify data entry errors, outlier values, and ensure there were no duplicate project entries.
- Sampling Plan: Samples of projects for was drawn from the population established in the tracking system review for process evaluation and impact evaluation.
- Impact Evaluation Sample Tasks: A detailed desk review was conducted for each project sampled for on-site verification and data collection. The desk review process included a thorough examination of all project materials including invoices, equipment cut sheets, pre- and post-inspection reports, and estimated savings calculators. This review process informed ADM's on-site 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, on-site verification visits for data collection were scheduled for sampled projects. The on-site visits were used to collect data for savings calculations, to verify measure installation, and to determine measure operating parameters.
- The data collected during the on-site verification visits was used to revise reported savings calculations, as necessary. For example, if the reported savings calculations relied on certain operating hours that were determined inaccurate based on the facilities' actual schedule, changes were made to reflect actual operating conditions more accurately.

- Process Evaluation Sample Tasks: Participants and trade allies were surveyed to provide program feedback, and information on program influence for the calculation of net-to-gross ratios. A process evaluation memo was delivered with detailed findings.
- Impact Evaluation Analysis: After determining the verified 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 verified annual 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 annual energy savings.

3.2.3.3.4 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 is described in a supplemental document.

3.2.3.3.5 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 Arkansas TRM v8.1. If a measure is not listed in the AR TRM, then a different industry standard reference, such as another technical reference manual, is considered.

3.2.3.3.6 Process Evaluation Methodology

The strategy and design for the process evaluation for SBES mirrored the Custom and Prescriptive program. For a description, see the Custom and Prescriptive Evaluation Methodology section.

3.2.3.4 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 Measurement and Verification 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.

3.2.3.4.1 Verified Gross Annual Energy Savings

The verified gross annual energy savings for SBES projects are summarized by sampling stratum in Table 3-99. Projects saw an overall realization rate of 105%. Ninety-nine percent of verified annual energy savings for the SBES Program resulted from lighting projects.

Table 3-99: Reported and Verified Gross Annual Energy Savings by Sampling Stratum – SBES

Stratum	Reported kWh Savings	Verified Gross kWh Savings	Gross kWh Realization Rate
Lighting 1	433,793	501,452	116%
Lighting 2	939,051	934,137	99%
Lighting 3	1,684,136	1,890,964	112%
Lighting 4	1,821,185	1,663,450	91%
Lighting 5	938,346	1,124,715	120%
Lighting 6	264,979	246,123	93%
Refrigeration	76,583	78,318	102%
Total	**6,158,072**	**6,439,159**	**105%**

The achieved sample resulted in reported gross annual energy savings estimates with ±9.52% relative precision at the 90% confidence interval and verified gross annual energy savings at ±9.83% for kWh.[44] Realization rates varied from project to project and stratum to stratum.

[44]That is, we are 90% confident that the true verified gross savings are between 5,806,205 and 7,072,112 kWh based on the uncertainty introduced by sampling.

Differences from reported to verified energy savings stem from annual hours of operation and baseline wattage assumptions. In cases where baseline wattage was not able to be determined during verification visits, ADM used default baseline wattages as presented in the Arkansas TRM v8.1 (AR TRM). Annual hours of use for verified calculations were determined either through on-site verification interviews or referenced the AR TRM. There were no differences between reported fixture quantities and verified fixtures.

For Small Business lighting projects, linear tubes are the highest percentage of equipment type retrofitted through the program as can be seen from Table 3-100 at around 65% of the lighting program.

Table 3-100: SBES Percentage of Lighting by Type

Lighting Type	Percent of Program Lighting kWh
LED Linear Tubes	64.83%
LED Fixture	23.83%
LED Exterior Lights	7.85%
LED Exit Sign	1.93%
Occupancy Sensor	1.24%
LED Case Lights	0.22%
Abandoned Fluorescent	0.10%
Total	**100%**

For the 6 Small Business non-lighting projects, evaporator/ compressor controls accounted for the highest percentage of reported annual energy savings (kWh). Equipment type retrofitted through the program can be seen in Table 3-101.

Table 3-101: SBES Percentage of Non-Lighting by Measure Type

Measure Type	Percent of Program Non-Lighting kWh
Evaporative/Compressor Controls	72%
Cooler Door Heater Controls	13%
EC Motors	10%
Novelty Setback Controls	5%
Total kWh for Non-Lighting	**100%**

3.2.3.4.2 Gross Coincident Peak Demand Reduction (kW)

The verified gross peak demand reduction is summarized by sampling stratum in Table 3-102. Overall, the verified gross peak demand reduction is equal to 90% of the reported reduction for SBES projects.

Table 3-102: SBES Reported and Verified Gross kW Reduction by Sampling Stratum

Stratum	Reported Peak kW Reduction	Verified Gross Peak kW Reduction	Verified Gross kW Realization Rate
Lighting 1	170.60	156.80	92%
Lighting 2	286.98	272.28	95%
Lighting 3	460.57	381.71	83%
Lighting 4	499.06	386.04	77%
Lighting 5	251.38	311.92	124%
Lighting 6	31.76	22.36	70%
Refrigeration	8.08	8.32	103%
Total	**1,708.43**	**1,539.42**	**90%**

The achieved sample design resulted in reported gross peak demand reduction estimates with ±19.05% relative precision at the 90% confidence interval and verified at ±18.85%.[45] Much of the difference between reported and verified demand reduction, as in past program years, is explained by either 1) operating hours aligning with the peak period, or 2) use of stipulated coincidence factors (CF) that did not align well with actual equipment schedules. For lighting projects, the ADM verified lighting calculators generate an hourly savings curve (8,760 hours) to determine the average peak demand reduction value across the peak demand period for each lighting schedule within a project.

3.2.3.4.3 Net-to-Gross Estimation

The data used to assign free ridership scores was collected through a survey of SBES customer decision-makers for projects rebated. Free ridership was estimated using the methodology described in a supplemental document, consistent with the Custom and Prescriptive Program. NTG Results are based on 51 participant survey respondents, each representing a unique project. The percentage of free ridership found for each project was applied to each project's verified annual energy savings. The overall results were then extrapolated to the remaining projects in the program. Table 3-103 shows percentages of total gross verified savings associated with different combinations of free ridership indicator variable values for the SBES incentive component.

[45] That is, we are 90% confident that the verified gross peak demand reduction is between 1,249.20 and 1,829.64 kW based on the uncertainty introduced by sampling.

Table 3-103: 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 SBES 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	1%	100%
Y	Y	N	Y	0%	100%
Y	Y	Y	N	0%	67%
N	Y	N	Y	0%	67%
N	Y	N	N	0%	33%
N	Y	Y	N	0%	0%
N	Y	Y	Y	0%	33%
N	N	N	Y	0%	33%
N	N	N	N	42%	0%
N	N	Y	N	5%	0%
N	N	Y	Y	1%	0%
Project would have been deferred by one year or more in the absence of the program				2%	0%
Total				**100%**	**0.62%**

Overall, the estimated percentage of program free ridership was 0.62%. Project specific free ridership was determined on a measure level basis. Table 3-104 displays free-ridership and spillover for SBES projects.

Table 3-104: Free-Ridership and Spillover for SBES Projects

Savings	Free Ridership	Spillover
Annual Energy Savings (kWh)	39,730	0
Peak Reduction (kW)	9.88	0

The NTG for the program is calculated as 1 – free-ridership + participant spillover. This results in an NTG of 99.4% for annual energy savings and 99.4% for peak demand reductions. The SBES gross and net verified energy savings and peak demand reduction are summarized in Table 3-105.

Table 3-105: Summary of SBES Verified Gross and Net Impacts

Program	Verified Gross kWh Savings	Verified Net kWh Savings	Net-to-Gross Ratio	Verified Gross kW Reduction	Verified Net kW Reduction
SBES	6,439,159	6,399,429	99.4% - kWh 99.4% - kW	1,539.42	1,529.53

3.2.3.4.4 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 3-106.

Table 3-106: SBES EUL's and Lifetime Energy Savings

Stratum	EUL	Gross Program Lifetime Energy Savings (kWh)	Net Program Lifetime Energy Savings (kWh)
Lighting 1	14.78	7,413,843	7,368,099
Lighting 2	14.82	14,217,899	14,130,174
Lighting 3	13.87	26,224,352	26,062,547
Lighting 4	14.04	23,362,787	23,218,639
Lighting 5	14.91	16,766,585	16,663,135
Lighting 6	11.36	2,795,903	2,778,652
Refrigeration	11.69	915,449	909,801
Total	**13.91**	**91,696,817**	**91,131,048**

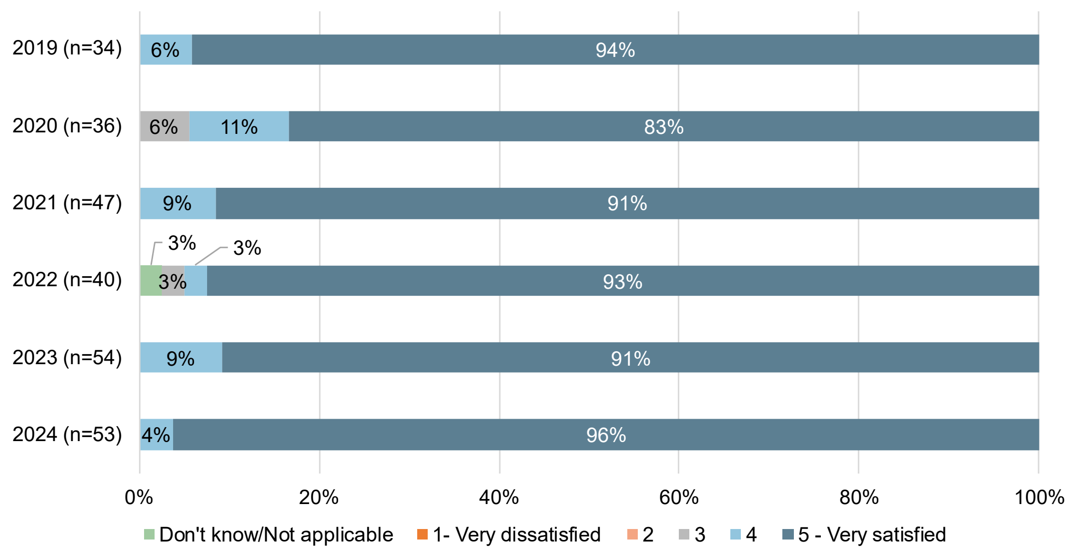
3.2.3.5 Process Evaluation Findings

The process evaluation consisted of a participant survey, trade ally interviews, and program staff discussions. ADM provided a process evaluation memo to PSO presenting detailed findings from all activities of the process evaluation.

3.2.3.5.1 SBES Participant Survey

ADM conducted a mixed-mode survey (email/phone) of Small Business Energy Solutions participants in May, August, and November 2024. ADM sent an email survey invitation and one reminder to all potential respondents with valid email addresses. To collect additional responses, ADM contacted customers with up to three phone calls. Fourteen customers completed the survey through an email invitation link and 39 completed the survey over the phone. Overall satisfaction was high and consistent with past program years (see Figure 3-31 for SBES customer satisfaction from 2019-2024).

Figure 3-31: Overall SBES Respondent Satisfaction 2019-2024



Sixty-six percent of survey respondents said that they recommended the program to someone else. All of those who had not yet recommended the program said they would be likely to recommend it to a friend or colleague. Ninety-two percent of respondents said they were satisfied with PSO as their electric utility.

3.2.3.5.2 SBES Trade Ally Survey

In November and December 2024 ADM solicited and received feedback from four participating SBES trade allies. Three respondents represented trade allies that assist PSO customers with lighting projects and the other represented a trade ally that provides refrigeration improvements. These are the key takeaways from the interviews:

- SBES trade allies are satisfied overall. All four of the trade allies said they were satisfied with the steps required to participate in the offering, the range of equipment that qualifies, the amount of time it takes to receive the rebate, and SBES overall. Furthermore, trade ally comments indicate satisfaction with the application tool and participation process.
- Increased incentives and raising the eligibility criteria were cited as ways to increase program participation. Two trade allies suggested that increasing the program incentive to account for a higher portion of project costs would entice additional customers to participate. Additionally, one suggested raising the energy savings limit for small businesses to 350,000 or 400,000 kWh from 320,000 kWh or less annually to increase participation.

3.2.3.6 SBES Conclusions and Recommendations

This section presents conclusions and recommendations for the SBES Program based on the 2024 process and impact evaluation findings.

Conclusions

- SBES program participants and trade allies are satisfied overall. All SBES survey respondents were satisfied with their experience and 87% either would not change anything about the program or did not know what they would change to improve the program. All four of the interviewed trade allies said they were satisfied with the steps required to participate in the offering, the range of equipment that qualifies, the amount of time it takes to receive the rebate, and SBES overall. Furthermore, trade ally comments indicate satisfaction with the application tool and participation process.
- Trade ally comments indicated increased interest in specific project types or trends in 2024. Specifically, one lighting trade ally noted that manufacturing customers have shown increased interest in LED lighting controls. The refrigeration trade ally noted that online monitoring has become more popular with companies that have larger refrigeration setups. The other two lighting trade allies did not notice any overall increase or notable interest in any services or products from small businesses. Moreover, one of these allies pointed out that small business owners generally only consider energy saving projects or potential for savings upon receiving project proposals.

Recommendations

- Track market trends and emerging technologies to consider expanding measures offered and promoted through the program. Trade ally feedback suggests there is increased interest in measures beyond LED lighting retrofits, such as LED lighting controls and online monitoring for refrigeration. Continuing the search for relevant contractors to support program expansion is recommended.
- To build on the success of the Small Business Energy Solutions program, consider developing focused marketing tailored to specific business types. This might include a marketing campaign catered toward restaurants and kitchens or small offices. These targeted programs can address the unique energy efficiency needs of each sector by offering specialized messaging, training, and support. PSO may be able to drive greater energy savings and ensure more holistic improvement projects are undertaken if specific offerings are made focusing on the specific needs of these markets.

3.2.4 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 Commercial and Industrial (C&I) facilities by businesses that would not have done so in absence of the program.

3.2.4.1 Impact Evaluation Overview

Custom projects accounted for approximately 31% of Custom and Prescriptive reported savings (up from 9% in 2023) and constituted the largest share of savings in 2024. Lighting system retrofit projects continued to be an important source of program savings with approximately 28% of reported annual energy savings (kWh). A breakdown of measure type (aggregated by category based on the provided measure type) by the percentage of program savings is shown in Table 3-107.

Table 3-107: Measure Type as Percentage of Reported Annual Energy Savings

Aggregated Measure List	Percent of Program
Custom	31.3%
Retrofit Lighting	27.6%
Agriculture	19.2%
Multiple	6.2%
New Construction Lighting	5.7%
Oil & Gas	5.1%
SEM	4.1%
Refrigeration & Kitchen Equipment	<1%
Business Appliances	<1%
HVAC VFD	<1%
Total	**100%**

Overall, the number of rebated projects decreased from 419 in 2023 to 382 in 2024, however, the magnitude of reported annual energy savings increased by approximately 20%. Compared to 2023, Custom projects saw a substantial increase of 311% in reported savings. This was driven by some large custom manufacturing projects completed in 2024. Table 3-108 provides a summary of Custom and Prescriptive project savings in the program.

Table 3-108: Performance Metrics – Custom & Prescriptive

Metric	2024
Number of Projects	408
Energy Impacts (kWh)	
Reported Energy Savings	31,990,622
Gross Verified Energy Savings	32,681,763
Net Verified Energy Savings	27,266,650
Peak Demand Impacts (kW)	
Reported Peak Demand Savings	4,933.82
Gross Verified Peak Demand Savings	5,354.70
Net Verified Peak Demand Savings	3,882.36
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	1.39
Utility Cost Test Ratio	2.14

3.2.4.2 Process Evaluation Overview

The process evaluation consisted of participant surveys, trade ally surveys, and a discussion of PY2023 program recommendations with program staff. The objective of the participant survey was to assess sources of program awareness, factors that influenced project decision-making, experience with the participation process, and program satisfaction. A total of 47 customer decision-makers responded to the participant survey and 16 Prescriptive and Custom trade allies were interviewed. A detailed process evaluation memo was provided to PSO in December 2024.

Table 3-109 summarizes the share of reported 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 and Western Districts saw a slight increase (+2%) in annual energy savings.

Table 3-109: District Share of Reported kWh Savings

Region	Sum of Reported Energy Savings (kWh)	Percentage of Program kWh	Reported Rebate Dollars Paid	Percent of Reported Rebate Dollars Paid
Eastern District	4,894,579	15%	$541,291	15%
Tulsa District	19,558,158	61%	$2,190,373	60%
Tulsa Northern District	3,134,152	10%	$371,745	10%
Western District	4,403,733	14%	$549,227	15%
Total	**31,990,622**	**100%**	**$3,652,636**	**100%**

3.2.4.3 Evaluation Activities

This section provides a brief overview of the data collection activities, impact evaluation methodologies, and process evaluation activities that were employed in the evaluation of the program. Detailed energy savings methodologies are provided in a supplemental document.

3.2.4.3.1 Data Collection

Data for analysis is collected through a review of program materials, on-site inspections, end-use metering, provided site trend data (such as energy management system data), advanced meter infrastructure (AMI) data, and interviews with participating customers and service providers. Based on program tracking data provided by PSO through the online reporting tool, a random sample is developed for the evaluation sample to statistically represent the population with verified energy impacts.

Site-specific verifications are performed for projects selected in the random sample. Site verification visits are used for the 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. A subset of sampled projects (grow lighting) was monitored to obtain accurate operational profiles. Data is collected through building automation systems, equipment control systems, or facility tracking systems.

All available project documentation is acquired for sampled projects. Project documentation includes reported energy savings analysis, invoices, specification sheets, trend data, and pre-and-post implementation inspection reports. Advanced Meter Infrastructure (AMI) data provided daily through a secure transfer for data visualization and consumption analysis is used. When observations and information are not available during on-site verification, project documents may be relied on to support verified energy savings. Projects evaluated in which only partial information was collected from the site contact are to be considered desk reviews.

In addition to the on-site collection, customer surveys provide self-reported data for the Net-To-Gross (NTG) analysis and process evaluation. 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 sixteen program contractors. Table 3-110 shows the achieved sample sizes for the different types of data collection utilized for this evaluation.

Table 3-110: Sample Sizes for Data Collection Efforts

Data Collection Activity	Achieved Sample Size
On-site M&V Verification	47
Customer Decision-Maker Surveys	50
Engineering Desk Review	1
On-site M&V Verification W/Monitoring	1
Trade Ally Surveys	16

3.2.4.3.2 Impact Evaluation Sampling Plan

A stratified random sample based on the amount of annual energy savings and the type of measure installed in each project was created. Ratio estimation is used to determine precision (better than ±10% based on annual energy savings) at a 90% confidence interval across all Custom and Prescriptive strata. Sample strata are bound by measure type and magnitude of annual energy savings such that realization rates (the ratio of verified to reported savings) for projects sampled in each stratum are only extrapolated to other projects within that stratum. Verification of sample precision, using each stratum's contribution to variance, is then performed on the verified extrapolated annual energy savings (kWh) for the program. Table 3-111 shows the sample design that was used for custom and prescriptive projects. The 51 projects that were sampled for evaluation verification account for approximately 50% of reported program annual kWh savings.

Table 3-111: Sample Design for Prescriptive and Custom

Stratum Name	Reported kWh Savings	Strata Boundaries (kWh)	Population of Projects	Design Sample Size
Agriculture 1	267,461	31,284 – 138,009	4	2
Agriculture 2	1,900,675	232,913 – 585,754	5	3
Agriculture 3	3,985,120	611,768 – 2,091,783	3	2
Custom & Other 1	129,671	396 – 11,105	27	2
Custom & Other 2	1,860,176	14,592 – 118,321	37	3
Custom & Other 3	4,875,710	120,560 – 579,189	18	6

Stratum Name	Reported kWh Savings	Strata Boundaries (kWh)	Population of Projects	Design Sample Size
Custom & Other 4	8,102,804	760,771 – 2,819,252	5	5
New Const. Light 1	901,435	1,297 – 73,570	30	4
New Const. Light 2	908,825	115,166 – 513,809	4	2
Prescriptive 1	76,236	61 – 7,250	32	3
Prescriptive 2	143,254	8,399 – 44,800	8	3
Retrofit Lighting 1	921,619	324 – 19,513	113	2
Retrofit Lighting 2	3,031,421	20,078 – 96,371	67	6
Retrofit Lighting 3	4,886,215	105,410 – 339,690	29	8
Total	**31,990,622**		**382**	**51**

3.2.4.3.3 Gross Savings Analysis Methodology

The verification 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, missing data, or data entry errors. 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 On-site verification and data collection. The desk review process includes a thorough examination of all project materials including invoices, equipment cut sheets, pre- and post-inspection reports, and estimated savings calculators. This review process informs on-site fieldwork by identifying potential uncertainties, missing data, and sites where monitoring equipment is needed to verify key inputs to the reported savings calculations.
- After reviewing project materials, On-site verification/data collection interviews are scheduled for sampled projects. If sufficient information and data were provided that represented verification, then a desk review may be considered to reduce participant fatigue. The interviews are used to collect data for savings calculations, verify measure installation, and determine measure operating parameters.
- The data collected during the On-site verification visits are used to revise savings calculations, as necessary. For example, if the reported savings calculations relied on operating hours for a given measure that was found to be inaccurate

based on the On-site verification and data collection, changes are made to reflect actual operating conditions more accurately.

- After determining the verified 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 verified annual energy (kWh) savings with a given amount of sampling precision and confidence.

3.2.4.3.4 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 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 was spillover effects associated with non-rebated purchases by program participants.[46] The Custom and Prescriptive and SBES Programs utilized the same NTG methodology. The methodology is described in a supplemental document.

3.2.4.3.5 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 Arkansas TRM v8.1. 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.

3.2.4.3.6 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 well do PSO staff, distributors, and trade allies work together? Are there rebate processing, data tracking, and/or communication efficiencies that can be gained?

[46] 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.

- 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, trade allies, and 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 their reactions to the program design choices that have been implemented?
- What types of buildings/facilities participated in the program? Could certain facility types be targeted more effectively?
- Were there any significant obstacles to program implementation?
- What changes, if any, were made to the program design or implementation procedures?
- What customer barriers do trade allies see to participation? How can these be mitigated?
- Are trade allies satisfied with the program? Are trade allies aware of any barriers to participation?
- Looking forward, what are the key barriers and drivers to program success within PSO's market?

To address these questions, the process evaluation activities included a review of tracking data, surveys to program participants, and trade allies interviews. Table 3-112 provides a summary of data collection activities for the process evaluation.

Table 3-112: Process Evaluation Data Collection Activities

Data Collection Activity	Process Evaluation Research Objectives
Review Tracking Data	Reviewed program design and implementation materials, marketing materials, program procedure manuals, program websites, and other program documentation as it became available. This included application forms, savings calculation spreadsheets, databases, and tracking systems to verify relevant information needed for the evaluation being collected.
Recommendation Review	ADM investigated the status of its PY2023 evaluation recommendations through its program staff, participating market actors, and customer outreach.
Participant Surveys (Prescriptive, Custom, SBES)	Source of program awareness, factors that influenced project decision-making, experience with the application process, energy consultant, and program satisfaction.

Data Collection Activity	Process Evaluation Research Objectives
Trade Ally Interviews (Prescriptive, Custom, SBES)	Assessment of program changes, barriers to participation, satisfaction with program procedures and how it compares to other programs in the region; and assessment of program marketing materials, training, and communications with program staff.

3.2.4.4 Impact Evaluation Findings

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

3.2.4.4.1 Verified Gross Annual Energy Savings

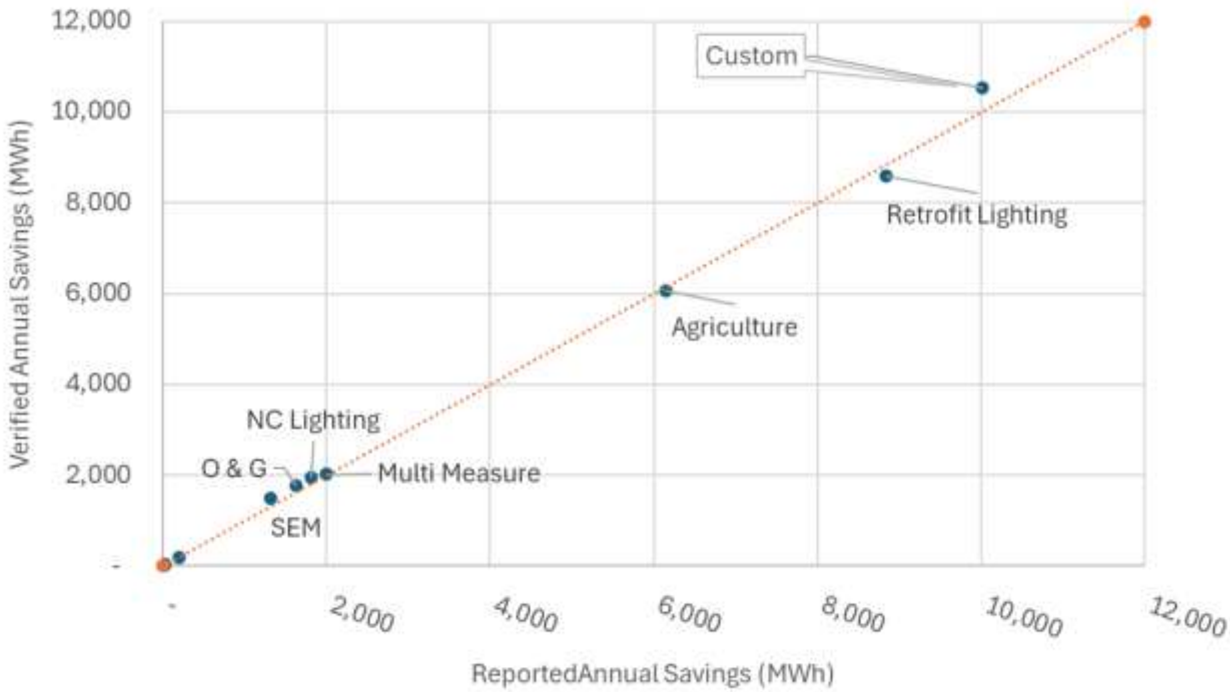
The verified gross annual energy savings for Prescriptive and Custom projects are summarized, by sampling stratum, in Table 3-113.

Table 3-113: Reported and Verified Gross kWh Savings by Sampling Stratum – Prescriptive and Custom

Stratum	Reported kWh Savings	Verified Gross kWh Savings	Gross kWh Realization Rate
Agriculture 1	267,461	267,461	100%
Agriculture 2	1,900,675	1,846,880	97%
Agriculture 3	3,985,121	3,962,759	99%
Custom & Other 1	118,565	120,348	102%
Custom & Other 2	1,545,376	1,553,861	101%
Custom & Other 3	4,622,427	5,367,711	116%
Custom & Other 4	8,681,992	8,793,538	101%
New Const. Light 1	827,865	882,682	107%
New Const. Light 2	982,395	1,060,827	108%
Prescriptive 1	76,236	76,248	100%
Prescriptive 2	143,254	153,306	107%
Retrofit Lighting 1	1,097,560	1,063,729	97%
Retrofit Lighting 2	2,962,313	2,622,897	89%
Retrofit Lighting 3	4,779,382	4,909,516	103%
Total	**31,990,622**	**32,681,763**	**102%**

The achieved sample design results in reported gross annual energy savings estimates with ±9.9% relative precision at the 90% confidence interval, and ±9.6% in verified gross annual energy savings.[47] Variability was found within individual projects, with realization rates ranging from 51% to 150%. Figure 3-32 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, Custom has the largest impact based on the magnitude and is at an 106% realization rate. Agriculture represented the second largest impact based on magnitude. Agriculture measures commonly included horticultural lighting and humidifiers.

Figure 3-32: Custom and Prescriptive 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: retrofit lighting (RL 1-4), and new construction lighting (NCL 1-2). Due to the difference in energy savings methodologies, new construction lighting is extrapolated separately from retrofit lighting. Project level realization rates ranged from 51% to 137%.

[47] That is, we are 90% confident that the true verified gross savings are between 28,823,550 and 35,157,694 kWh based on the uncertainty introduced by sampling.

Retrofit Lighting Projects

Project level realization rates ranged from 51% to 123% with an overall realization rate near 100%. Differences between reported and verified energy savings can be explained by differences in reported and verified hours of use (HOU), and a difference in HVAC interactive effects. Verified savings used lighting schedules from detailed interviews with facility staff. Lighting settings from Energy Management Systems (EMS), timers, and photocells were used, where appropriate, based on on-site verification. When an accurate HOU was not available deemed values from the Arkansas TRM v8.1 were used. The overall retrofit lighting realization rate was 97%.

The driver of evaluation risk for retrofit lighting projects was operating hours and interactive effects. On-site verifications indicated different operating hours from what was claimed in reported savings. Table 3-114 below shows the frequency of realization rate factors for retrofit lighting sampled projects.

Table 3-114: Frequency of Realization Rate Factors, Retrofit Lighting

Sample Size	Impact of Factor	Differing HOU	Differing IEFe	Differing CF	Other
16	Positive	2	7	10	-
	Negative	9	1	2	-

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 is stipulated by space type. Project realization rates ranged from 97% to 137%. The variation in realization rates was due to some variation in the hours of use, interactive effects, and other factors. The overall realization rate was 107% and was driven by the largest new construction site in the sample. The reported savings utilized a 8 hours per day (2912 annually) for the outdoor lighting, the verified savings used dusk to dawn hours (3996 annually) verified on site. Table 3-115 below shows the frequency of realization rate factors for new construction lighting sampled projects.

Table 3-115: Frequency of Realization Rate Factors, NC Lighting

Sample Size	Impact of Factor	Differing HOU	Differing IEFe	Differing CF	Other
6	Positive	2	4	3	-
	Negative	2	-	-	-

Custom & Other Projects

The variance in realization rates for custom and other equipment projects varies by measure and savings algorithm implemented. Custom analyses were performed for measures such as chillers, BAS/EMS controls, RCx, and steel mill tempering. These measure types were grouped in the sample due to the nature of the measure, multiple measures at the same site, and the annual energy savings (kWh). Some larger projects underwent pre-reviews to help mitigate evaluation risk. Additionally, AMI data was utilized on two custom projects that incorporated HVAC controls and process improvements.

All sampled projects fell within a realization rate of 74% to 135%. Projects representing a higher level of risk included:

- Two multi-measure projects that included new construction lighting and kitchen equipment. These sites had energy savings realization rates ranging from 93% to 135%. The discrepancy in energy savings is mostly attributed to a difference in hours of use found on the site. The verified savings calculations rely on interviews with the staff on-site and their description of the lighting operation. Additionally, one of the sites' discrepancies was a result of differences in the deemed dimming factor. The reported savings utilized a stepped dimming factor while the verified savings utilized a continuous dimming factor verified on-site.
- An HVAC controls project which included an ionization system, were installed on the inlet of supply fans for (10) RTUs and (74) Condensing Units. The energy savings realization rate for this custom project was 74%. The primary reason for the discrepancy is a difference in the analytical approach used to determine savings. The verified savings used a billing regression with 24 months of billing data and CDD/HDD data. Verified savings used a billing regression because prior to this project there was HVAC equipment replacement and there were other measures implemented such as schedule controls (Ecobee thermostats replacing manual units in each room), these measures all have interactions with each other. The reported savings applied a 15% savings factor based on literature research. ADM reviewed the provided documentation on bipolar ionization, and found a lack of evidence of the claimed 15% savings.
- A new construction lighting project in which the discrepancy in energy savings is mostly attributed to a difference in hours of use found on the site as well as HVAC interactive effects. The verified savings calculations rely on interviews with the staff on-site and their description of the lighting operation. This resulted in the verified hours (7280 annually of use being greater than the values (6188 annually) used by the reported savings.

Overall, custom projects represented a realization rate of 106%.

Agriculture

Differences between reported and verified energy savings can be explained by differences in reported and verified hours of use (HOU). Verified savings used lighting schedules from detailed on-site interviews with facility staff as well as monitoring hours of use when applicable. Some larger projects underwent pre-reviews to help mitigate evaluation risk. Monitoring was conducted on one agriculture project, an indoor grow lighting site.

All sampled projects fell within a realization rate of 94% to 100% with the majority near 100%, largely due to the pre review process that identifies concerns early on. Projects representing a higher level of risk included:

- An indoor agricultural grow lighting project that was visited to verify hours of use and dimming schedules. This site had an energy savings realization rate of 94%. The evaluator relied on schedules confirmed with site contacts during field verification which differed from what the reported utilized. This site also installed new dehumidifiers, and the discrepancy can also be attributed to differing baseline assumptions. Reported savings uses a weighted average of the new efficient dehumidifiers along with old dehumidifiers that were not replaced or removed.

Overall, agriculture projects represented a realization rate of 99%.

Measure-Level Results

The realization rate by measure type for the program is presented in Table 3-116.

Table 3-116: C&P Annual Energy Savings Realization Rate by Project Type

Project Type	Realization Rate	Percent of Custom and Prescriptive
Custom	106%	31%
Retrofit Lighting	97%	28%
Agriculture	99%	19%
Multiple	94%	6%
New Construction Lighting	107%	6%
Oil & Gas	109%	5%
SEM	114%	4%
Refrigeration & Kitchen Equipment	103%	1%
HVAC VFD	102%	<1%
Business Appliances	119%	<1%
Total	**102%**	**100%**

3.2.4.4.2 Gross Coincident Peak Demand Reduction (kW)

The verified gross coincident peak demand reduction (kW) is summarized by the sampling stratum in Table 3-117. The peak demand reduction realization rate for prescriptive and custom projects is 109%.

Table 3-117: Reported and Verified Gross Peak Demand Reduction by Sampling Stratum

Stratum	Reported Peak kW Reduction	Verified Gross Peak kW Reduction	Verified Gross kW Realization Rate
Agriculture 1	44.47	77.82	175%
Agriculture 2	531.46	628.48	118%
Agriculture 3	623.00	612.31	98%
Custom & Other 1	27.12	31.24	115%
Custom & Other 2	229.63	217.50	95%
Custom & Other 3	789.15	847.92	107%
Custom & Other 4	719.51	743.71	103%
New Const. Light 1	194.20	207.01	107%
New Const. Light 2	51.68	52.91	102%
Prescriptive 1	8.09	8.40	104%
Prescriptive 2	19.80	19.62	99%
Retrofit Lighting 1	208.20	223.75	107%
Retrofit Lighting 2	611.59	695.62	114%
Retrofit Lighting 3	875.92	988.41	113%
Total	**4,933.82**	**5,354.70**	**109%**

The achieved sample design resulted in reported gross peak demand reduction estimates with ±17.2% relative precision at the 90% confidence interval and 14.5% for verified peak demand reduction.[48] Peak demand reduction was variable from project to project, resulting in a high precision value. Differences between reported and verified demand reduction may be attributed to:

- Instances where the reported did not calculate demand reduction, but the verified found demand reduction savings present. This was the main driver for the greater than 100% realization rate.
- Use of stipulated coincidence factors (CF) that did not align well with actual equipment schedules.

[48] That is, we are 90% confident that the verified gross peak demand reduction is between 4,621 and 6,187 kW based on the uncertainty introduced by sampling.

- Instances where the reported did not apply demand interactive effects (IEFd) for sites that were found to have air conditioning.

For lighting projects, the verified 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 verified calculators used the deemed coincidence factors provided in the AR TRM v8.1.

3.2.4.4.3 Net-to-Gross Estimation

The data used to assign free ridership scores were collected through a survey of customer decision-makers for 2024 Custom and Prescriptive projects. The calculation of NTG was determined based on the free ridership criteria (four areas of questions) and spillover described in a supplemental document.

Table 3-118 shows percentages of total gross verified annual energy savings associated with different combinations of free ridership indicator variable values for the custom and prescriptive incentive component. Results are based on 47 Custom and Prescriptive survey respondents, each representing a unique project. 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.

Table 3-118: Estimated Annual Energy Savings Free Ridership for Custom and Prescriptive

Had Plans and Intentions to Install Measure Without C&I Program? (Definition 1)	Had Plans and Intentions to Install Measure Without C&I Program? (Definition 2)	C&I Program had Influence on Decision to Install Measure?	Had Previous Experience with Measure?	Percentage of Total Gross kWh Savings	kWh Free Ridership Score
Y	Y	Y	Y	0%	100%
Y	Y	N	N	11%	100%
Y	Y	N	Y	1%	100%
Y	Y	Y	N	5%	67%
N	Y	N	Y	0%	67%
N	Y	N	N	0%	33%
N	Y	Y	N	1%	0%
N	Y	Y	Y	0%	33%
N	N	N	Y	3%	33%
N	N	N	N	11%	0%
N	N	Y	N	63%	0%
N	N	Y	Y	0%	0%
The project would have been deferred by one year or more in the absence of a program				0%	0%
Total				**100%**	**17%**

Overall, the estimated percentage of program free ridership was 17%. Project specific free ridership was determined on a measure level basis. One C&P survey respondent indicated that they had installed additional un-incented energy-efficient equipment. However, this respondent indicated that their program experience was unimportant, and they would have been likely to install this equipment regardless of their participation in the PSO Business Rebates program.

The NTG for the program is calculated as 1 – free-ridership + participant spillover. This results in an NTG of 83% for annual energy savings and 73% for peak demand reductions. Table 3-119 shows the amount of savings and peak demand reduction impacted by free ridership and spillover.

Table 3-119: 2024 Free-Ridership and Spillover for Custom and Prescriptive

Savings	Free Ridership	Spillover
Annual Energy Savings (kWh)	981,818	0
Peak Reduction (kW)	183.58	0

The gross and net verified annual energy savings and peak demand reduction for Custom and Prescriptive projects are summarized in Table 3-120.

Table 3-120: Summary of Verified Gross and Net Impacts

Program	Verified Gross kWh Savings	Verified Net kWh Savings	Net-to-Gross Ratio	Verified Gross kW Reduction	Verified Net kW Reduction
Custom and Prescriptive	32,681,763	27,266,650	83% - kWh 73% - kW	5,354.70	3,882.36

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 strata level lifetime savings. Sample level EUL's by strata as well as total population lifetime energy savings are shown in Table 3-121.

Table 3-121: C&P EUL's and Lifetime Energy Savings

Stratum	EUL	Gross Program Lifetime Energy Savings (kWh)	Net Program Lifetime Energy Savings (kWh)
Agriculture 1	20.04	5,361,157	4,472,855
Agriculture 2	12.30	22,717,656	18,953,517
Agriculture 3	9.47	37,530,386	31,311,893
Custom & Other 1	10.00	1,203,480	1,004,073
Custom & Other 2	14.96	23,251,507	19,398,913
Custom & Other 3	13.09	70,268,125	58,625,244
Custom & Other 4	9.04	79,493,615	66,322,142
New Const. Light 1	11.85	10,457,082	8,724,425
New Const. Light 2	14.35	15,218,196	12,696,660
Prescriptive 1	4.47	340,489	284,072
Prescriptive 2	9.15	1,403,213	1,170,712
Retrofit Lighting 1	10.73	11,417,427	9,525,648
Retrofit Lighting 2	13.08	34,319,016	28,632,622
Retrofit Lighting 3	12.76	62,634,885	52,256,772
Total	**11.49**	**375,616,233**	**313,379,549**

3.2.4.5 Process Evaluation Findings

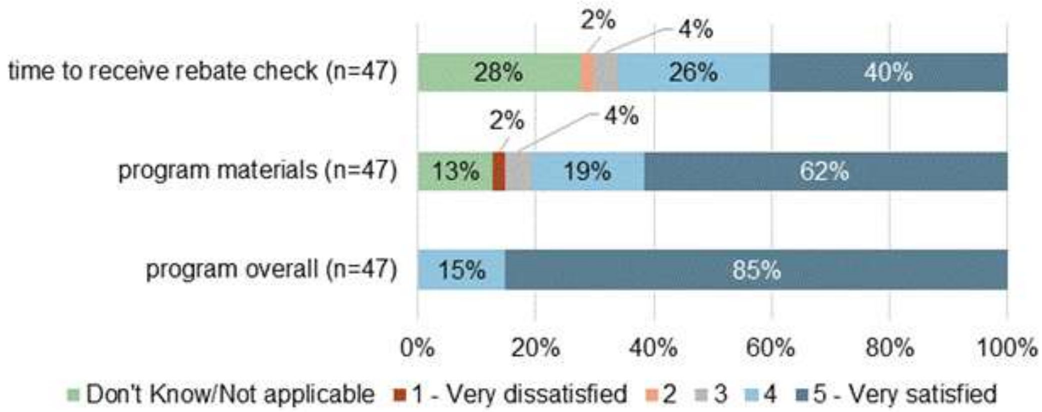
The process evaluation consisted of a participant survey and a trade ally survey as well as a recommendation review with program staff. ADM provided a detailed process evaluation memo to PSO after the completion of the 2024 program year.

3.2.4.5.1 Custom and Prescriptive Customer Survey

ADM conducted a mixed-mode survey (email/phone) of Custom and Prescriptive participants in May, August, and November 2024. Before the survey launch, ADM reviewed tracking data and removed businesses that had contractors' email addresses listed in the "Premise Email" field. About 9% of Project Numbers were assigned Premise Emails that were affiliated with contractors.

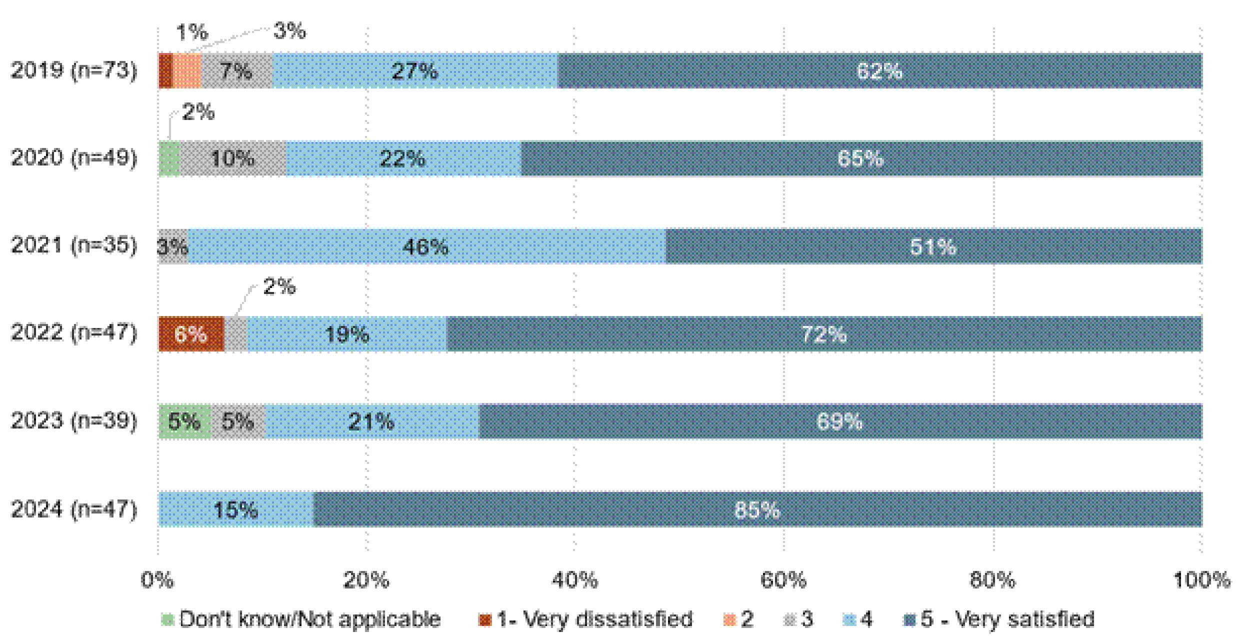
ADM sent an email survey invitation and one reminder to all potential respondents with valid email addresses. To collect additional responses, ADM contacted customers with up to two phone calls. Nine customers completed the survey through an email invitation link and 39 completed the survey over the phone. A total of 47 participants completed the survey. Most respondents were satisfied with their overall experience as well as the program materials and the time it took to receive their rebate payment (Figure 3-33).

Figure 3-33: Prescriptive and Custom Survey Respondent Satisfaction



Overall satisfaction was high and consistent with past years (see Figure 2-8 for overall satisfaction from 2019-2024). Nine percent of respondents provided additional comments about their satisfaction. These customers noted dissatisfaction with the application requirements or tools (4 percent), incentive amount (2 percent), and time to receive the rebate (2 percent). Sixty percent of respondents said they had recommended the program. All those who had not recommended it said they would be very likely to recommend it (n=17).

Figure 2-8: Overall Respondent Satisfaction 2019-2024



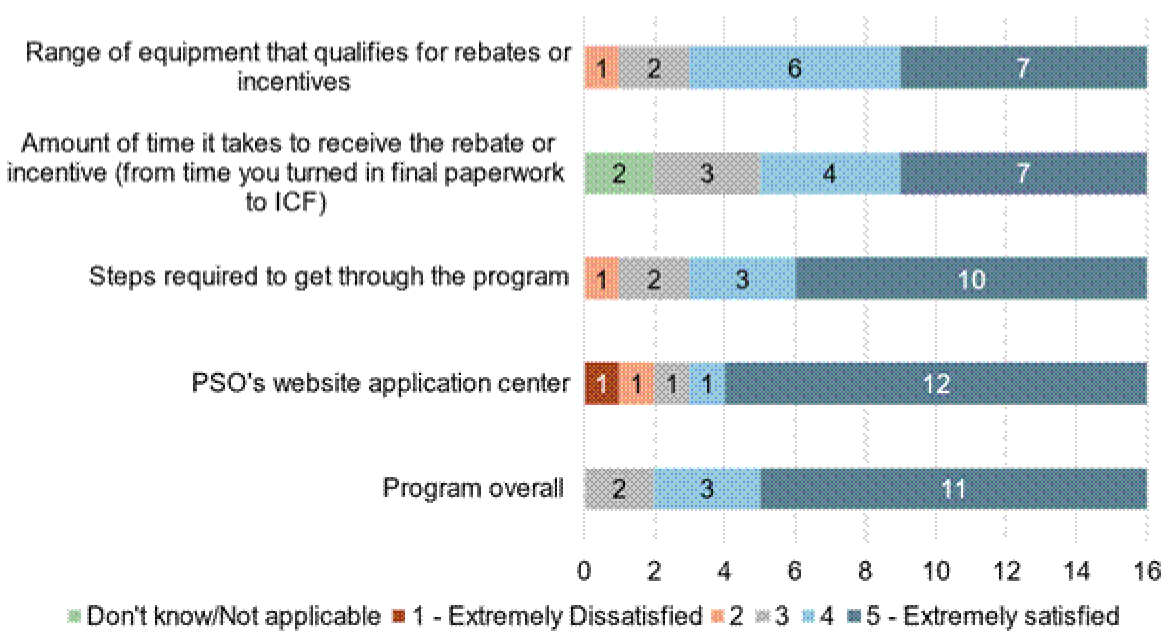
3.2.4.5.2 Prescriptive and Custom Trade Ally Interviews

In November and December 2024, ADM collected interview responses from sixteen C&P rebate trade allies. Trade allies were contacted up to three times each, via phone and email, depending on contact information available in tracking data. The following are key takeaways from the Prescriptive and Custom trade ally interviews:

- Current incentive levels are generally perceived as effective at motivating customers to purchase high-efficiency equipment instead of standard-efficiency equipment. Eleven trade allies rated the incentive levels as effective.[49] However nine indicated that some or all their customers would still be installing high efficiency equipment regardless of the incentives. These trade allies mentioned that a portion of their customers were purchasing high efficiency lighting, refrigeration, kitchen, HVAC, and dehumidifier equipment without incentives, though incentives were important and may be essential for certain equipment or project types or customers.
- Trade allies are generally satisfied with the PSO Business Rebates Program design, however eleven trade allies made suggestions to adjust the range of qualifying prescriptive measures, incentive levels, or incentive payment structure.
- ICF and PSO staff generally provide strong communications and sufficient trade ally support. Thirteen of the respondents had some sort of interaction with ICF staff in 2024, and all of them agreed that the staff provided timely responses and were professional, courteous, knowledgeable about energy efficient equipment, and able to explain participation rules and customer eligibility.
- Program design may inhibit participation for HVAC and other non-lighting measures. Three trade allies noted that their clients were interested in or had installed high efficiency HVAC or other non-lighting measures but had not applied for rebates or sought out incentives through PSO. Regarding HVAC measures, they noted that the Midstream offering was challenging for third-party representatives to access. National chains may struggle to purchase equipment through the Midstream offering as it requires working with regional distributors and these accounts have many locations.
- Trade allies are generally satisfied with their Custom and Prescriptive Program experience. Figure 2-10 displays trade ally satisfaction.

[49] Ten trade allies rated the effectiveness of motivating customers to buy high efficiency equipment instead of standard efficiency equipment a 4 or 5 on a scale from 1 (not at all effective) to 5 (very effective). Five rated their effectiveness a 3.

Figure 2-10: Trade Ally Satisfaction



3.2.4.6 Custom and Prescriptive Conclusions and Recommendations

This section presents conclusions and recommendations for the Custom and Prescriptive subprogram based on the 2024 evaluation.

Conclusions

- Verified gross savings were found to be higher than reported savings resulting in a realization rate of 102%. The net savings resulted in a 17% reduction from reported annual energy savings.
  - Most of the program's annual energy savings (>75%) were from lighting, custom, and agricultural projects.
- The Business Rebates program design may inhibit participation for HVAC and other non-lighting measures. Three prescriptive and custom trade allies noted that their clients were interested in or had installed high efficiency HVAC or other non-lighting measures but had not applied for rebates or sought out incentives through PSO. They noted that the Midstream offering was challenging for third-party representatives to access. National chains may struggle to purchase equipment through the Midstream offering as it requires working with regional distributors and these accounts have many locations.
- PSO and ICF excel in communication with trade allies and customers. All trade allies who interacted with ICF staff reported receiving timely, knowledgeable responses, while all trade allies who engaged with PSO staff noted their strong program knowledge and professionalism. These robust communication channels

drive program success through satisfied trade allies who actively promote the program, with all surveyed trade allies informing customers about offerings during sales visits and including incentives in project proposals. Customer satisfaction was high in 2024, consistent with past years. Beyond satisfaction, the program benefits from word-of-mouth recommendations, with 51% of participants recommending it and 88% likely to do so.

Recommendations

- Consider additional assistance for trade allies that assist national accounts or chain stores for HVAC and non-lighting measures. The Midstream and Prescriptive structures may inhibit these account types from participating in the program in some cases as they may prefer centralized purchasing rather than regional coordination. Providing additional training or catered one-on-one coaching for rebate processing contractors could help to enable greater program participation as national accounts may have issues coordinating with multiple regional distributors to purchase through the Midstream program or submitting multiple Custom applications. Having a more catered approach to enable chain stores and national accounts to more easily access rebates for high efficiency equipment would increase non-lighting measure participation while maintaining program quality standards.
- Promote awareness and engagement with the Custom offering. Trade allies and Midstream distributor's suggestions to potentially expand the Midstream and Prescriptive offerings suggest an opportunity to increase engagement with the Custom offering.
- Consider implementing a pre-screening questionnaire for large replacement and new construction projects. Findings from past evaluations indicate there may be variation from year to year in free ridership estimation. A pre-screening survey administered by the Evaluator could help identify projects that have significant free ridership risk.
- Ensure participating trade allies understand participation requirements for non-lighting measures. Though window film rebate eligibility is not restricted in any way to the direction of the windows, a window film trade ally suggested the program expand to offer incentives for south facing windows. This might indicate an opportunity to improve communication from account managers or program staff to or with trade allies.

3.2.5 Commercial Midstream

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.

3.2.5.1 Impact Evaluation Overview

The goal of the impact evaluation is to determine net savings impacts of annual energy savings (kWh), coincident peak demand reduction (kW), and lifetime energy savings. Net savings are achieved through verification of gross savings estimates which are adjusted for program influence to determine net savings impacts.

PSO's midstream program provided rebates for a total of 196 projects. 174 projects consisted of lighting measures and 22 projects consisted of HVAC equipment. Table 3-122 provides projected, reported, and verified energy and demand impacts, as well as other program performance metrics for midstream projects.

Table 3-122: Performance Metrics – Midstream Lighting and HVAC

Metric	2024
Number of Projects	196
Energy Impacts (kWh)	
Reported Energy Savings	2,531,404
Gross Verified Energy Savings	2,551,071
Net Verified Energy Savings	2,257,394
Peak Demand Impacts (kW)	
Reported Peak Demand Savings	519.54
Gross Verified Peak Demand Savings	466.42
Net Verified Peak Demand Savings	412.79
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	1.96
Utility Cost Test Ratio	1.61

3.2.5.2 Process Evaluation Overview

The process evaluation consisted of a review of PY2023 recommendations with program staff, distributors interviews, and surveys of end use customers. The objective of the customer survey was to assess the source of program awareness, factors that influenced project decision-making, experience with the application process or energy consultant, program satisfaction, and inform the calculation of a Net-to-Gross ratio.

3.2.5.3 Evaluation Activities

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

3.2.5.3.1 Data Collection

Data for the analysis was collected through provided program and project documentation, program staff facilitated discussion, distributor and service provider interviews, and end-use customer surveys. These materials were supplemented with information from manufacturers as well as the Air Conditioning, Heating and Refrigeration Institute (AHRI).

3.2.5.3.2 Gross Savings Analysis 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). A census review of all midstream projects and line items was performed. Verified savings from the Midstream Lighting program channel are determined through a review of the implementation database, end-use customer surveys, and distributor interviews. For lighting measures, engineering analysis was conducted to determine the 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 both the lighting and HVAC analysis the methodologies from the Arkansas TRM v.8.1 and the Mid-Atlantic v.10 were employed.

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 census of all fixtures/lamps sold through the program. The verified lumen output of the sold lamps will then be compared to the reported 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. This data will be used to categorize the facility type where the fixtures/lamps were installed. The facilities will be categorized according to the definitions provided in the AR TRM. The deemed Hours of Use (HOU) and Coincident Factors (CF) provided in the TRM for each facility will be used in the verified 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.

3.2.5.3.3 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. The PSO Midstream Program's net-to-gross ratio (NTGR) were investigated separately for Lighting and Non-Lighting (HVAC).

Midstream Lighting NTG

The PSO Midstream lighting net-to-gross ratio (NTGR) was investigated through a survey of end-use customers as well as through distributor interviews. Only end user scores were used to assign a NTG score. Self-reported responses were used from end-use customers who purchased efficient lighting from the Midstream offering during the current program year to estimate lighting discount free ridership.

The survey aimed to elicit information from which to estimate the portion of the high efficiency lighting that the customer would have purchased in the counterfactual scenario where the efficient lighting was not discounted. Survey respondents were asked a series of questions to elicit feedback regarding influences on their purchasing decisions. Each respondent was assigned a free ridership score based on a consistent free ridership scoring algorithm. The scoring algorithm used is based on the methodology in the AR TRM and described in a supplemental document.

Spillover was not assessed for the Midstream Lighting program. The final respondent net-to-gross score is calculated as 1 minus free ridership.

Midstream Non-Lighting NTG

Free ridership was calculated using only data collected through the end-user survey. Scores were only developed from end-use customers who responded affirmatively to the question "Were you aware that you received a discount on that equipment?"

The methodology for end-user Midstream Non-Lighting free ridership is the same as Custom and Prescriptive and described in a supplemental document.

3.2.5.3.4 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. If a measure is not listed in the AR TRM, then a different industry standard reference, such as another technical reference manual, is considered.

3.2.5.3.5 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 was this program marketed? How effective were the marketing efforts?
- 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?
- What do distributors like about the Midstream model? Why? What would they like to change about the program? Why?
- What are PSO staff and implementation staff perspectives on the program? What are the reactions to program design choices that have been implemented?
- 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 2024 program year?
- Looking forward, what are the key barriers and drivers to program success within PSO's market?

To address these questions, the process evaluation activities included a review of program materials and tracking data, incentive comparison, recommendation review with program staff, distributor and service provider interviews, and end-use customer surveys. Table 3-123 provides a summary of data collection activities for the process evaluation.

Table 3-123: Commercial Midstream Process Evaluation Data Collection Activities Summary

Data Collection Activity	Process Evaluation Research Objectives
Review Program Materials and Tracking Data	Review customer engagement materials, program procedure manuals, program websites, and other program documentation as it becomes available. Review program tracking data to investigate distribution of incentives by year, region, and distributor.
HVAC Offering Comparison & Review of Incentive Structures	ADM compared four other utilities' publicly available incentive overview documents to PSO's 2023 incentive offerings for Midstream HVAC.
Recommendation Review	ADM investigated the status of its PY2023 evaluation recommendations through its program staff, participating market actors, and customer outreach.
Distributor Interviews (HVAC & Lighting)	Investigate benefits of program participation, satisfaction with program training, feedback on the program provided customer engagement support and program direct customer engagement 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.
Service Provider Interviews (HVAC)	Investigate benefits of program participation, satisfaction with program training, feedback on the program provided customer engagement support and program direct customer engagement 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 (HVAC & Lighting)	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.

3.2.5.4 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) to determine program level net energy impacts.

3.2.5.4.1 Midstream Lighting Gross Impacts

The Midstream lighting program included 13,586 items sold. A summary of the program level savings is shown in Table 3-124.

Table 3-124: Summary of Midstream Lighting Savings

Reported kWh Savings	Verified kWh Savings	Gross kWh Realization Rate	Reported kW Savings	Verified kW Savings	Gross kW Realization Rate
1,689,410	1,697,233	100%	372.87	323.11	87%

A summary of savings by facility type can be seen in Figure 3-34. Office and Warehouse: Non-refrigerated are the first and second largest facility types contributing to program savings with 845,767 kWh, making up 50% of overall savings. The "Education: College and Vocational" space type is the third largest contributing space type with savings of 246,352 kWh, 14.5% of overall savings.

Figure 3-34: Commercial Midstream Reported kWh Savings by Facility Type

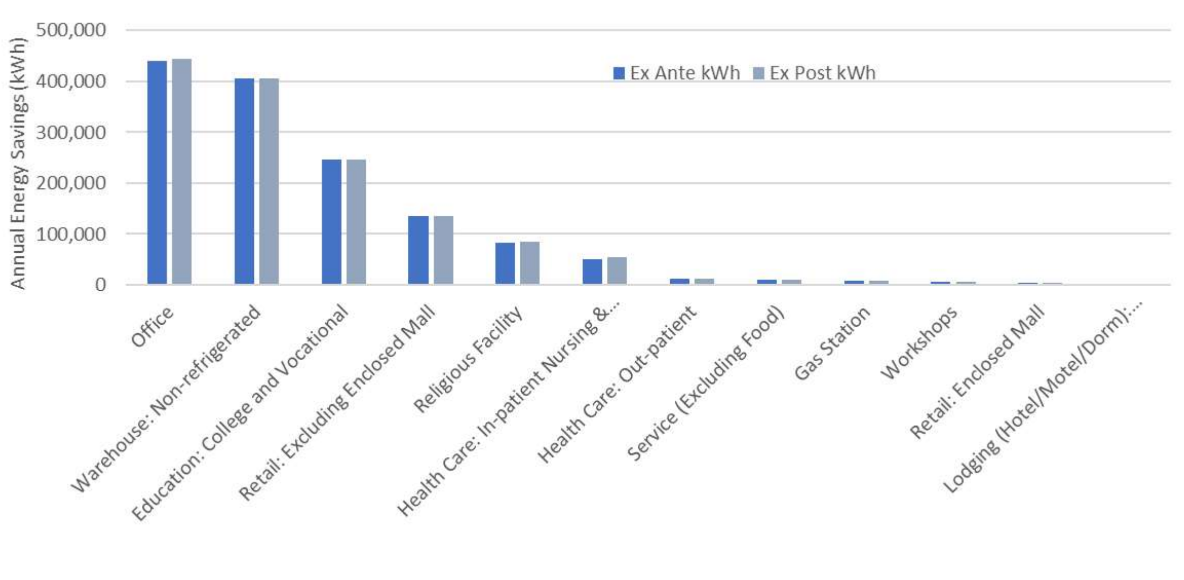
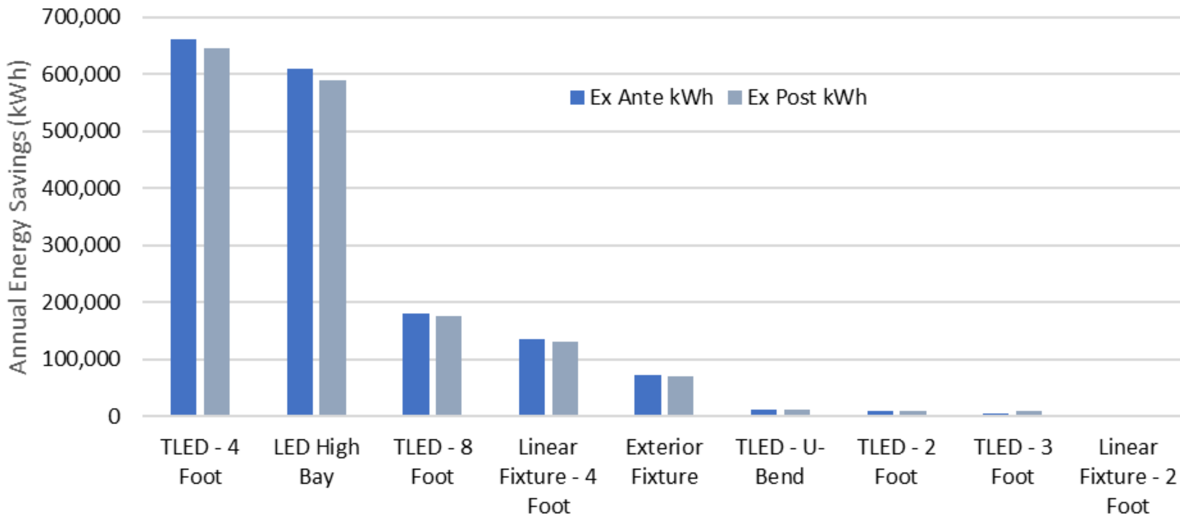


Figure 3-35 illustrates the relationship between reported and verified savings for lighting measures.

Figure 3-35: Commercial Midstream kWh Savings per Lamp Type



Line-item energy savings discrepancies can be attributed to a difference in the baseline and efficient wattages utilized in savings calculations. The verified efficient wattages were determined by reviewing the specification sheets of the installed equipment, where 13% of line items had a difference in the efficient wattage when comparing the reported and verified data, the range of difference goes from -0.4W to 3W. 9% of line items had a difference in the baseline wattage when comparing the reported and verified data, with a range of -10.2W to 0.5W. These differences had no effect on a program-level scale as the energy savings realization rate was 100%.

The discrepancy affecting the demand reduction savings is a difference in the waste heat factor for demand (otherwise known as interactive effect for demand savings), as the claimed savings calculations utilize a value of 1.20, which is in line with the values used in the AR TRM. The verified savings calculations used a value of 1.00, taken from the Mid-Atlantic TRM's "Midstream Lighting – Commercial" section, specified for use when the HVAC type of the installed space is unknown. As the HVAC type is not information available in the tracking data, this was chosen to be applied for verified savings calculations.

Midstream Lighting ISR

In-Service Rate questions have been included in the end-use survey for the past four years. Low survey participation has resulted in the use of industry standard references in place of survey results. The combined survey results over the past four years have resulted in 131 responses resulting in an ISR of 93.76% for all lighting and 94.84% for tube lighting (n=84). In 2024, questions about the lifetime install rate of the measures were added to the survey. However these questions were not included in the previous years and data from the 2024 end user survey was determined to be insufficient to generate a lifetime ISR. Instead, an ISR of 100% was utilized, based on the Mid-Atlantic TRM's guidance for midstream lighting ISRs.

3.2.5.4.2 Midstream Lighting NTG

A mixed-mode survey was administered to customers that purchased lighting through the PSO Midstream Lighting program. ADM invited 45 customers to take the survey and 18 replied (response rate of 40%). ADM sent an email invitation to all customers included in the tracking data through mid-October 2024. Eighteen percent, or 8 contacts, had invalid email addresses in the tracking data. Subsequently, ADM's in-house survey team made up to three follow-up phone calls to 42 customers. Four survey responses were collected via email invitation, and 14 were collected via follow-up phone calls.

Self-reported responses from customers who had purchased efficient lamps and fixtures over the past four program years were used to estimate a NTG score of 85.29% for Midstream Lighting.[50] The NTG score is below 100% as some respondents stated that the discount, sales messaging, and marketing materials had no influence on their purchases. Some participants also stated that they would have purchased the same equipment regardless of the program. See Table 3-125 and Table 3-126 for a summary of net savings impacts for the Midstream lighting program.

Table 3-125: Summary of Net kWh Savings - Midstream Lighting

Gross Reported Savings kWh	Gross Verified Savings kWh	Gross Realization Rate	Gross Lifetime Savings kWh	kWh NTG Ratio	Net Verified Savings kWh	Net Lifetime Savings kWh
1,689,410	1,697,233	100%	22,752,256	85.29%	1,447,502	19,404,484

Table 3-126: Summary of Net kW Savings – Midstream Lighting

Reported kW Savings	Gross Verified Savings kW	Gross Realization Rate	kW NTG Ratio	Net Verified Savings kW
372.87	323.11	87%	86.33%	278.96

3.2.5.4.3 Midstream Non-Lighting Gross Impacts

The Midstream Non-Lighting subprogram involved the installation of 314 units through 22 projects consisting of unitary and split system air conditioners, air source heat pumps, water source heat pumps, and variable refrigerant flow heat pumps. A summary of the program level savings is shown in Table 3-127.

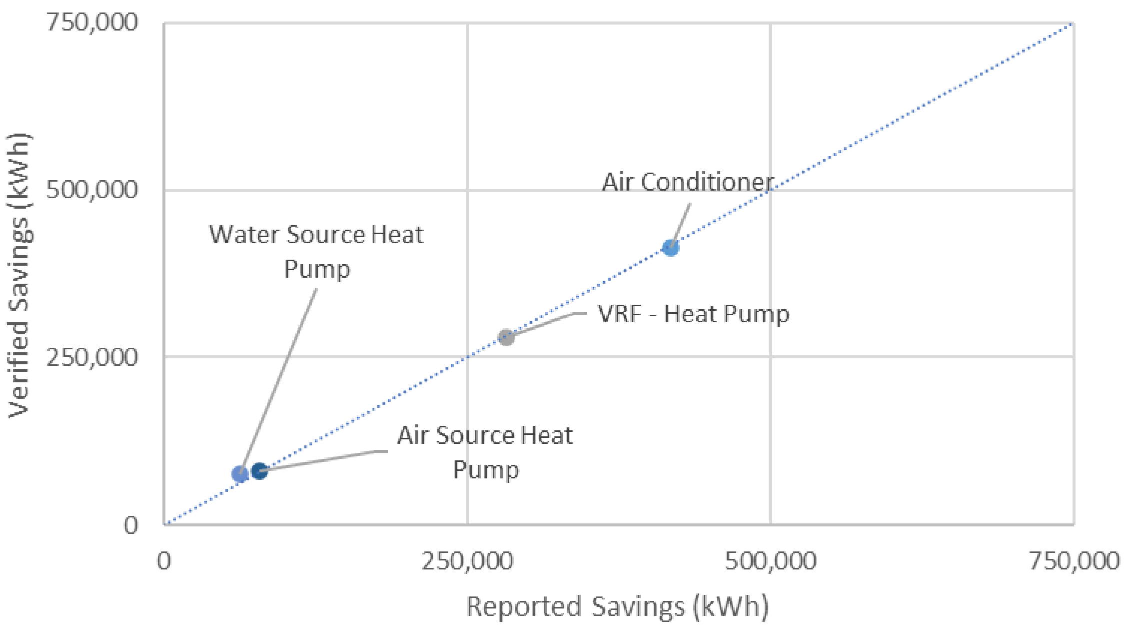
[50] Responses received in 2023 alone did not yield a statistically significant sample size.

Table 3-127: Summary of Midstream Non-Lighting Savings

Reported kWh Savings	Gross Verified kWh Savings	Gross kWh Realization Rate	Reported kW Savings	Gross Verified kW Savings	Gross kW Realization Rate
841,994	853,838	101%	146.67	143.31	98%

A summary of savings by equipment type is shown in Figure 3-36. The figure plots the reported annual energy savings versus the verified annual energy savings for the installed equipment types. The "Air Conditioner" equipment type was the largest contributing equipment type.

Figure 3-36: Commercial Midstream Non-Lighting Reported Savings vs Gross Verified Savings (kWh) by Equipment Type



The primary factor affecting the gross verified savings realization rate of 101% are the "Water Source Heat Pump" measures. It was determined through a recreation of the claimed savings that the baseline efficiencies for the heating mode used in the claimed energy savings calculations were that of units with capacities between 65,000 btu/h and 135,00 btu/h, while all installed units had capacities less than 65,00 btu/h. Additionally, it appeared that the EER was used to calculate cooling savings, which is typically calculated using the SEER value. In TRMs such as the PA TRM, EER is recommended for use in calculating cooling savings only for equipment with capacities greater than 65,000 btu/h. This contributed to a 1.65% increase in the program-level energy savings realization rate.

The other savings discrepancies in the analysis were due to differences in AHRI-rated efficiencies of the installed equipment, as opposed to the nameplate efficiencies utilized in the reported calculations. In most of these cases, the only value changed in the verified savings analysis were the heating and cooling capacities. The utilization of AHRI-rated efficiencies resulted in a net negative effect of -0.24% on the program-level energy savings realization rate.

3.2.5.4.4 Midstream Non-Lighting NTG

In September, October, and November 2024, ADM attempted to reach the seven end use customers that had purchased HVAC equipment through the PSO Midstream offering. ADM attempted to reach all customers included in the tracking data through October 2024. We interviewed five customers after contacting all seven customers up to seven times (five phone calls, two emails). Four interviewees confirmed that they were able to provide details on their organization's high efficiency equipment purchase decision-making process.

For Midstream HVAC, ADM will use a 4-year weighted average end-use decisionmaker score of 94.85%. The primary reason for assigning a 4-year weighted average is the limited number of interviewees with verified, informed end-use HVAC decisionmakers in 2024. Four of the five Midstream Non-Lighting end use survey respondents provided decision-making information. One was scored as a partial free rider as they confirmed having plans to purchase high efficiency equipment without the program, and indicated they would have gone ahead with the high efficiency equipment purchase regardless of the incentive. Three Midstream HVAC end user survey respondents indicated that the discount had impacted their decision-making process and said they did not have plans to purchase the high efficiency equipment before learning about the PSO Midstream offering. None of these three interviewees would have gone ahead with the high efficiency equipment installations if they had not received a discount. Based on these results, ADM determined that the assignment of a free ridership score using 2024 end use customer interview results alone was imprudent. A 4-year weighted average score for Midstream HVAC was calculated using end use decisionmaker interviews from 2021, 2022, 2023, and 2024 to assign a NTG score of 94.85% for 2024.

Table 3-128 and Table 3-129 for details the summary of net savings impacts for the Midstream Non-Lighting Program.

Table 3-128: Summary of Net Annual Energy Savings - Midstream Non-Lighting

Program Year	Reported Savings kWh	Gross Verified Savings kWh	Gross Realization Rate	Gross Lifetime Savings kWh	kWh NTG Ratio	Net Verified Savings kWh	Net Lifetime Savings kWh
2024	841,994	853,838	101%	10,610,947	94.85%	809,892	10,064,814

Table 3-129: Summary of Net Peak Demand Reduction – Midstream Non-Lighting

Program Year	Reported kW Savings	Gross Verified Savings kW	Gross Realization Rate	kW NTG Ratio	Net Verified Savings kW
2024	146.67	143.31	98%	93.38%	133.83

3.2.5.4.5 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 3-130. Average EUL by measure classification is provided for reference.

Table 3-130: Midstream EUL's and Lifetime Energy Savings

Measure Classification	Average EUL	Gross Program Lifetime Energy Savings (kWh)	Net Program Lifetime Energy Savings (kWh)
Lighting	13.47	22,752,256	19,404,484
Non-Lighting	12.43	10,610,947	10,064,814
Total	**N/A**	**33,363,203**	**29,469,298**

3.2.5.5 Process Evaluation Findings

The process evaluation consisted of a participant survey, distributor and service provider interviews, and program staff recommendation review. A detailed process evaluation memo was provided to PSO after the completion of the 2024 program year.

3.2.5.5.1 Lighting End User Survey

ADM administered a mixed-mode (web/phone) survey from September to November 2024 to customers who purchased lighting through the PSO Midstream offering. The survey gathered information regarding awareness of the offering, decision-making, satisfaction, and the participation process.

ADM invited 45 customers to take the survey and 18 replied (response rate of 40%). ADM sent an email invitation to all customers included in the tracking data through mid-October 2024. Eighteen percent, or 8 contacts, had invalid email addresses in the tracking data. Subsequently, ADM's in-house survey team made up to three follow-up phone calls to 42 customers. Four survey responses were collected via email invitation, and 14 were collected via follow-up phone calls. Customers who responded to the survey confirmed purchasing LED linear lamps, interior LED fixtures, and exterior LED fixtures.

Findings from the end-user survey included:

- Midstream lighting end-use customers represent a variety of business types and typically rely on their organization's staff to install the lighting. Fifty-six percent of respondents noted that their organization had installed discounted lighting, while the remaining 44% said that they had hired another company to install them. Table 3-131 displays the facility types where discounted lights were installed. None of the survey-takers noted installing any of the discounted products outside of PSO territory. Other facility types included two auto repair facilities and a self-storage space.

Table 3-131: Commercial Midstream Types of Spaces Lights were Installed

Type of Work	Percent of Respondents
Religious worship	28%
Warehouse or distribution center	22%
Office	17%
Retail	11%
Industrial/Manufacturing	11%
School K-12 or other education building	6%
Other	17%

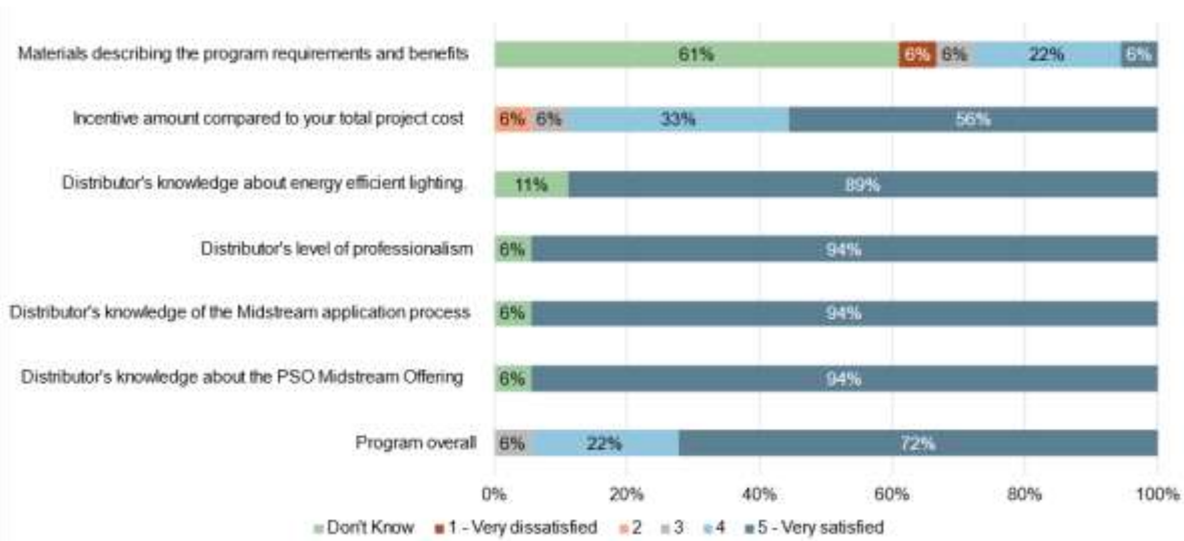
- Lighting distributor staff plays a significant role in awareness of PSO's Midstream offering and customer understanding of lighting products. Sixty-seven percent of respondents said that they learned about the discounted lighting from a distributor employee. Other respondents mentioned learning about the offering from previous experience with it (22%), their electrician (6%), or from another retailer (6%).
- Survey findings indicate that both the Midstream discounts and lighting distributor recommendations were important factors in customers' decision-making process, though over half of respondents had purchased energy-efficient lighting in the past without a discount. respondents with the greatest savings indicated the Midstream offering was an important factor in their decision-making process.
- Most Midstream-incented lamps are installed. Most of the survey respondents said that all the discounted lamps they purchased had been installed, though some respondents mentioned they had not had an opportunity to install all the lamps yet. Table 3-132 displays the percent of the program discounted lamps respondents reported having installed currently. The sample size was not statistically significant to use as a gross savings adjustment.

Table 3-132: Commercial Midstream Lighting In-Service Rates

Product Type	Percent Installed Now	Percent Installed in 6 Months	Sample Size (n)
LED Linear Lamp(s)	97%	100%	17
LED Interior Fixture(s)	100%	100%	2
LED Exterior Fixture(s)	100%	100%	1
LED High/Low Bay(s)	100%	100%	1
BR Type Lamp(s)	100%	100%	1

- Midstream lighting customers were satisfied with the Midstream offering and purchase experience. Most respondents were very satisfied with their lighting distributor, materials describing the offering, the incentive amount compared to the total project cost, as well as the Midstream offering overall (see Figure 3-37).

Figure 3-37: Midstream Lighting Customer Satisfaction



- Survey findings suggest customers are generally satisfied with the range of discounted equipment; a portion requested discounts for a wider range of lighting. Responses indicated an opportunity to increase awareness about fixture discount offerings. One-third of respondents wrote in comments suggesting additional lamp or fixture types that should be incentivized by PSO or made other comments about the range of eligible equipment. These respondents mentioned outdoor security lighting, exterior fixtures, parking lot lighting, troffers, as well as screw-in lamps and 4-Pin LEDs. One said they were interested in higher rebates for exterior fixtures.

3.2.5.5.2 Lighting Distributor Interviews

In September 2024, ADM interviewed both participating Midstream lighting distributors. These interviews addressed distributors' reasons for participating, the training they received, the types of customers they serve and how they reach them, their program experience, and the impact of Midstream participation on their sales and promotion practices. ADM also sought to investigate distributors' perspectives regarding the Midstream Program design and implementation and any perceived opportunities for improvement.

- One lighting distributor was satisfied with the participation process, the other was dissatisfied and voiced frustration with the processing tools and lack of support from program staff.
- LED fixture incentives motivated one distributor to reengage with the program. This lighting distributor stated that their participation in 2024 was primarily driven by the inclusion of fixture incentives in the program.
- Distributor responses suggested that a substantial portion - possibly 50% or more - of Midstream lighting sales would have occurred regardless of PSO's discount offerings. One distributor estimated they would have sold about half of the LED linear lamps and fixtures without the Midstream offering; the other said they would have sold all the lamps and fixtures but said the purchases would have been made later in the same year or delayed further depending on customers' budgets.
- An online fixture verification tool was requested. One distributor requested the ability to verify fixture model eligibility online.

3.2.5.5.3 Non-Lighting End User Survey

In September, October, and November 2024, ADM attempted to reach the seven end use customers that had purchased HVAC equipment through the PSO Midstream offering. ADM attempted to reach all customers included in the tracking data through October 2024. We interviewed five customers after contacting all seven customers up to seven times (five phone calls, two emails). Findings are as follows.

- The Midstream incentive acted as an influential factor in pushing three of the five interviewees to choose high efficiency equipment.
- Interview findings suggest the high-efficiency equipment replaced either old non-functional equipment or equipment that was nearing the end of its life
- The interviewees were satisfied with their experience. All five interviewees were satisfied with PSO as their electric utility as well as the Midstream HVAC offering overall. They were also satisfied with their service provider/distributor's knowledge of energy efficient equipment and the application process, and level of

professionalism. None of the interviewees provided any recommendations to improve the Midstream HVAC offering.

3.2.5.5.4 HVAC Distributor Interviews

In September, October, and November 2024, ADM interviewed four HVAC distributor contacts who participated in the PSO Midstream offering. Findings are as follows.

- HVAC distributor contacts are satisfied overall though findings from the interviews suggest opportunities to increase program support. All distributor contacts were satisfied with the program overall. Further, three of the five HVAC distributor contacts were satisfied with the level of support they received through the program. One contact noted that changes to application requirements for certain equipment types had made the process cumbersome and frustrating. Two distributor representatives were interested in more proactive engagement with and support from program staff.
- HVAC distributor processing fees may vary. Two distributor representatives estimated that their companies held back 10% of the Midstream incentive though one noted the percentage held back was calculated on a case by case basis. The consultant stated that their company held back 20% of the Midstream incentive. The other distributor representative said that their company did not have a set percentage held back and the amount passed onto the customer or contractor varied from project to project. They noted that they did not hold any rebate back for one job, whereas on another they held back $25 of the rebate that was $325/ton.
- An opportunity to improve the program's eligibility verification tool and better enable distributors to verify eligibility was identified. Two distributor representatives voiced interest in assistance with verification of customer eligibility. One distributor representative stated that their business sells equipment in 12 states and requested a coverage map or list to assist with determining customer eligibility for the PSO Midstream offering.
- Interview findings indicate incentive amounts may be an inadequate lever to motivate customers to purchase high efficiency equipment. Two distributor representatives said that none of the incentive levels were sufficient to induce customers to choose high efficiency equipment over standard equipment. One elaborated and noted that the incentives are less impactful depending on the equipment tier and its efficiency level, product line, and overall cost.

3.2.5.6 Commercial Midstream Conclusions and Recommendations

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

Conclusions

- Lighting distributors had mixed satisfied with the participation process and support from program staff.
- HVAC distributor representatives are satisfied overall though findings from the interviews suggest opportunities to increase program support.
- Continued and/or increased lighting distributor engagement hinges on staff engagement, program support, and the administrative burden of participation.
- HVAC distributor interview findings from 2024 and service provider interview findings from 2023 suggest distributors and rebate processing companies take differing rebate processing fees.
- Findings from the service provider and distributor interviews indicated opportunities to increase the promotion of the program. The HVAC service provider and one of the three interviewed HVAC distributors estimated that almost none of their customers were aware of the Midstream HVAC offering before they informed them of it. Two distributors specifically noted that they do not have marketing materials for the program.
- An opportunity to improve the Midstream HVAC offering's verification tool and better enable distributors to verify eligibility was identified. Two distributor representatives voiced interest in assistance with verification of customer eligibility.

Recommendations

- Ensure reliability and functionality of the lighting distributor portal/rebate processing website.
- Ensure interested HVAC and lighting distributors receive timely communication and sufficient program support.
- Explore ways to improve customer eligibility verification process.
- Investigate rebate fees recouped by HVAC distributors. Understanding the distribution of rebates between distributors, service providers, and end use customers is crucial to ensuring the fidelity of the program and its alignment with its design and intentions of influencing distributor and service provider recommendations, distributor stocking practices, and customer decision-making.
- Utilize 4-year weighted average NTG scores for the next program cycle if there are no significant program changes. During the next program cycle, develop NTG scores based on the duration of the program cycle to use in the following program cycle.

3.2.6 Retail Sales

The retail sales portion of the Business Rebates Program, started in 2024, 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 retailers to promote the sale of higher efficiency equipment. In 2024, the program offered discounts on energy efficient lighting with commercial SKU's.

This section presents the evaluation methodologies, findings, and conclusions on the savings impacts from retail sales.

3.2.6.1 Impact Evaluation Overview

Energy savings and peak demand reduction for lighting products with commercial SKU's used the algorithm presented in measure 3.6.3 of the AR TRM v8.0 representing retrofit lighting. Energy savings assumptions align with the Midstream Lighting evaluation. Gross verified savings were determined using the values and assumptions listed in Table 3-133.

Table 3-133: Commercial Lighting Point-of-Sale Assumptions

Variable	Value	Source
Baseline Wattage	Lookup	MidAtlantic TRM V10 based on fixture type and lumens
Installed Wattage	Lookup	Application
Annual Hours	Lookup	Weighted average of 2024 C&I Midstream Program based on fixture type (Tube fixtures, High Bay fixtures, Exterior fixtures)
Interactive Effects	1.00	MidAtlantic TRM v10
ISR	0.984/1.00	First year savings ISR is based on weighted average of 2023 C&I Midstream Program (Survey data). Lifetime savings will use a value of 1.00
Coincidence Factor	0.5864	Weighted average of 2023 C&I Midstream Program based on AR TRM v8.0

Net energy savings and net peak demand reductions will be calculated using results from the commercial midstream program. Net savings represent the portion of gross energy savings that can be attributed to program influence. A net-to-gross ratio (NTG) is used to adjust gross energy savings. Table 3-134 provides projected, reported, and verified energy and demand impacts, as well as other program performance metrics for retail sales.

Table 3-134: Performance Metrics – Retail Sales

Metric	2024
Number of Projects	137
Energy Impacts (kWh)	
Reported Energy Savings	379,529
Gross Verified Energy Savings	333,979
Net Verified Energy Savings	284,837
Peak Demand Impacts (kW)	
Reported Peak Demand Savings	104.33
Gross Verified Peak Demand Savings	68.31
Net Verified Peak Demand Savings	58.98
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	2.82
Utility Cost Test Ratio	2.37

3.2.6.2 Evaluation Activities

Evaluation activities included data collection, gross savings impact analysis, net savings impact analysis and the development of conclusions and recommendations for the program.

3.2.6.2.1 Data Collection

Provided sales data included information on purchased lighting equipment and quantities. Customer information was not available to determine installed conditions such as hours of operation.

3.2.6.2.2 Gross Savings Analysis

Energy impacts were calculated as annual energy savings, peak demand reduction, and lifetime energy savings. As-found conditions were assumed to be similar to the Midstream Lighting Program, so those operating hours and in-service rates were applied.

Sales included lighting categories of LED Downlights and LED Tubes. A summary of gross savings impacts is shown in Table 3-135.

Table 3-135: Commercial Lighting Point-of-Sale Gross Savings

Category	Quantity	Reported Savings (kWh)	Verified Savings (kWh)	Reported Peak Reduction (kW)	Verified Peak Reduction (kW)
LED Downlight	7,677	144,694	141,955	35.31	29.04
LED Tube	4,060	234,835	192,024	69.02	39.28
Total	**11,737**	**379,529**	**333,979**	**104.33**	**68.31**

Evaluated energy impacts resulted in an annual energy savings realization rate of 88% and a peak demand reduction realization rate of 65%. Realization rates were negatively impacted by baseline wattage assumptions, in-service rates, and coincidence factors. Realization rates were positively impacted by annual operating hours.

3.2.6.2.3 Net-to-Gross Estimation (NTG)

Free ridership and spillover were not able to be calculated for retail sales due to insufficient customer and retailer information. Net-to-Gross scores from Commercial Midstream Lighting was applied to Retail sales, with results shown in Table 3-136.

Table 3-136: Commercial Lighting Point-of-Sale Net Savings

Category	Verified Gross	NTG	Verified Net
Annual Energy Savings (kWh)	333,979	85.29%	284,837
Peak Demand Reduction (kW)	68.31	86.33%	58.98

3.2.6.2.4 Lifetime Energy Savings

Manufacturer data provided estimated lifetime hours of operation, informing the calculation of lifetime energy savings by applying the anticipated annual hours of operation from the Commercial Midstream Program. The weighted average lifetime was calculated as 16.25 years.

3.2.6.3 Retail Sales Conclusions and Recommendations

The following conclusions were determined from the evaluation of the Retail Sales Program:

- This new avenue of business rebates provides PSO customers with greater access to energy-efficient lighting through point-of-sale discounts. The program started in 2024 with lighting discounts.

- Savings impact assumptions varied between reported savings and verified savings for baseline wattages, in-service rates, and coincidence factors. Resulting realization rates are 88% for annual energy savings and 65% for peak demand reduction.

Recommendations

- Consistency between reported and verified savings assumptions will minimize realization rate risk. Evaluation should work with implementation in 2025 to gain consistency.
- As the program expands, future evaluation activity should include data collection for the calculation of net-to-gross.

3.3 Home Weatherization Program

This chapter presents evaluation findings from the impact and process evaluation of the Home Weatherization's 2024 program year.

3.3.1 Program Overview

PSO's Home Weatherization Program objective is to generate energy savings and peak demand reduction for income-qualified residential customers through the direct installation of weatherization measures in eligible dwellings. The weatherization program provides no-cost energy efficiency improvements to PSO customers living in homes that are less than 2,200 square feet, built before 2010, with household incomes of $55,000 or less. 2024 performance metrics are summarized in Table 3-137.

Table 3-137: Performance Metrics – Weatherization

Metric	2024
Number of Customers	1,971
Budgeted Expenditures	$3,447,546
Actual Expenditures	$3,457,760
Energy Impacts (kWh)	
Projected Energy Savings	2,670,356
Reported Energy Savings	5,017,447
Gross Verified Energy Savings	5,008,807
Net Verified Energy Savings	5,008,807
Peak Demand Impacts (kW)	
Projected Peak Demand Savings	982.61
Reported Peak Demand Savings	2,726.67
Gross Verified Peak Demand Savings	2,723.26
Net Verified Peak Demand Savings	2,723.26
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	3.40
Utility Cost Test Ratio	2.02

In 2024, PSO partnered with Titan ES and Revitalize T-Town (RTT) to deliver weatherization efficiency improvements:

- 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.

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 3-138 shows measures installed through the program in 2024. Duct sealing made up the largest share of reported kWh savings and was the most common measure type installed. In conjunction with attic insulation and air sealing, this made up more than 99% 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). In 2024, the program provided mobile home air infiltration, faucet aerators, showerheads, advanced power strips, and LEDs to a limited number of participants. These measures made up less than one percent of program savings.

Table 3-138: Summary of Weatherization Measures Implemented

Measure	Number of Projects	% Share of Reported kWh Savings
Duct Sealing	1572	52%
Attic Insulation	1388	25%
Air Infiltration	1676	22%
Air Infiltration (Mobile home)	15	0.2%
Water Heater Pipe Insulation	432	0.1%
Showerheads (Mobile home)	9	0.1%
Advanced Power Strips (Mobile home)	10	0.1%
LED lightbulbs (Mobile home)	12	<0.1%
Water Heater Jacket	19	<0.1%
Faucet Aerators (Mobile home)	8	<0.1%

PSO's Home Weatherization Program serviced 1,971 households during the 2024 program year. Participants saved an average of 2,546 kWh. This compares to an average of 2,158 in 2022, and 2,376 kWh in 2023. Titan ES was responsible for the installation of these energy efficiency measures at most of these homes (see Table 3-139).

Table 3-139: Weatherization Homes by Agency

Agency	Number of Homes
Titan ES	1,921
RTT	50
Total	**1,971**

3.3.2 EM&V Activities

This section provides an overview of evaluation methods employed for the verification of energy impacts and reporting on program feedback. Impact evaluation methodologies included a review of program data and materials, data collection activities, and gross and net impact calculation methodologies. Additional impact methodology information can be found in a supplemental document. Process evaluation activities included a participant survey, site visits with the program's contractor and third-party verifier, and a facilitated discussion with staff to gather and synthesize staff perspectives regarding the implementation and status of the program.

3.3.2.1 Data Collection

Several primary and secondary data sources were used for the evaluation. Tracking data was used as the basis for quantifying participation and assessing program impacts. Additional data was collected through surveys and staff interviews Table 3-140 summarizes the data collection activities and evaluation purposes.

Table 3-140: Weatherization Data Collection Efforts

Data Collection Activity	Achieved Size	Evaluation Purpose
Photo verification of make-ready measures (utility/implementor staff)	8	Verified make-ready projects by viewing photo evidence provided by implementor/utility staff
Photo verification of water heater pipe wrap/jacket (survey)	2	Verified water heater pipe wrap/insulation and jackets by viewing photo evidence provided by survey respondents
Customer Surveys	101	Measure verification, In-Service Rate, customer satisfaction
In-Depth Interviews with Program Staff	1	Gather and synthesize staff perspectives regarding the implementation of ADM's PY2023 recommendations and the status of the program, including any actions taken to update the design or implementation of the program.

3.3.2.1.1 Participant Survey Sampling Plan

ADM conducted a mixed mode (phone/email) survey of 2024 Home Weatherization Program participants. The survey sample was designed to be statistically representative of the program population and ensure accurate program insights. The sampling approach was designed to achieve a minimum ±10% precision at a 90% confidence level (90/10). As this is considered a large population, a sample size of 68 is desired.

Both respondent types (phone/email) were offered a $10 incentive (either digital or physical gift card) for completing the survey. Additional survey completes were obtained to increase the chance of survey participation in all areas the program impacted and to increase the chance of receiving feedback regarding all program measures.

3.3.2.1.2 Participant Survey Procedure

The participant 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 were used to develop In-Service Rates (ISRs) that represent the portion of energy efficiency measures that were installed and are operational. Survey questions also sought to evaluate customer satisfaction with individual measures, program stakeholders, and the program overall.

Program participants that receive direct installation measures including faucet aerators, low flow showerheads, or water heater pipe insulation or jackets were asked if they were willing to send an email with photographic evidence of measure installation to further verify the installation of program measures.

3.3.2.2 Verified Gross Savings Methodologies

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

- Verifying measure installation: Calculation of installation rates (ISR) by measure for a sample of program participants utilizing data from a participant survey.
- Reviewing reported savings estimates for each measure: Review program tracking data and reported savings calculations for all measures to verify the accuracy of reported savings and provide an explanation of any savings discrepancies.
- Verified savings are calculated through an engineering desk review utilizing:
    - Oklahoma Deemed Savings Document (OKDSD)
    - Arkansas Technical Reference Manual v8.1 (AR TRM)

A brief description of each measure's calculation methodology is identified in this section. Detailed measure level algorithms and deemed savings values utilized for the verified annual energy savings (kWh) and peak demand (kW) reduction are explained in greater detail in a supplemental document. Table 3-141 displays the references or sources for savings methodologies for the measures offered through the home weatherization program in 2024.

Table 3-141: Home Weatherization Savings Methodologies

Methodology Source	Measure
AR TRM v8.1	Air Infiltration
	Attic Insulation
	Faucet Aerators
	ENERGY STAR Omni-Directional LEDs
	Advanced Power Strip(s)
Oklahoma Deemed Savings Document (OKDSD)	Duct Sealing
	Pipe Insulation and Water Heater Jackets
Prescriptive-like Savings	Mobile Home Air Infiltration

3.3.2.2.1 Measure Verification

ADM staff relied on documentation and photo evidence of energy efficiency improvements completed by the program's implementation contractor and Third-Party Verification (TPV) contractor during installation and post-installation verification visits.

3.3.3 Impact Evaluation Findings

This section provides information on the impact evaluation findings for 2024.

3.3.3.1 Verified Gross Annual Energy Savings

ADM conducted a mixed-mode (phone/email) survey of customers who participated in the Home Weatherization program. Customers were randomly assigned to phone or email administration groups. A sample from each group was invited to take the survey in April, July, and October. Before reviewing program data for valid contact information, we randomly assigned 1,430 program participants to either a phone (712) or a web group (718). There was a combined response rate of 17% for the phone and email surveys. Survey responses represented 15 counties and 44 zip codes.

3.3.3.1.1 Air Infiltration

A total of 83 customers were asked to confirm air infiltration improvements made through the program. One customer did not recall receiving air infiltration improvements and was removed from ADM's ISR calculation. Another customer indicated that their home had not received air infiltration improvements, however Titan ES staff followed up with this customer and was able to verify this improvement had been completed at their home. Visually identifying caulking and/or air sealing is not always apparent to customers; explanation of the work completed may be needed to ensure knowledge of the improvement. Based on these findings, an ISR of 100% was applied.

The energy savings methodology for this measure is defined in the AR TRM. The required inputs are the results of the blower door test (CFM50 between pre-installation and post-installation) and an energy savings factor dependent on climate zone and HVAC system type. Algorithm inputs were confirmed through a review of program tracking data and survey efforts. These inputs were found to be consistent with reported estimates. The program level realization rates for air infiltration were 100% for kWh savings and kW peak demand reduction.

3.3.3.1.2 Attic Insulation

A total of 74 survey respondents were asked to confirm whether they had attic insulation installed; all of them confirmed having insulation installed through the program. An ISR of 100% was applied for attic insulation.

ADM found proper use of the algorithms in the AR TRM for reported energy savings. The program level realization rate for attic insulation was 100% for kWh savings and kW peak demand reduction.

3.3.3.1.3 Duct Sealing

A total of 78 customers were asked to confirm duct sealing improvements made through the program. Seven respondents did not recall receiving duct sealing. Three stated they did not receive this measure. Titan ES staff followed up with these customers and were able to verify installation of duct sealing at their homes. Based on these results an ISR of 100% was applied.

ADM found proper use of the Oklahoma Deemed Savings Document (OKDSD) for reported savings in conjunction with the duct leakage reduction results to calculate measure savings. ADM calculated the prescriptive savings values for each home and determined the program-level realization rates for duct sealing were 100%.

3.3.3.1.4 Manufactured Home LED Light Bulbs

ADM applied an ISR of 94% to the verified energy-saving calculation for LED lightbulbs installed in manufactured homes. This ISR was determined using responses from ADM's 2020 and 2021 surveys because of limited participation with the measure from 2022-2024. Reported savings calculations were consistent with the methodology specified in AR TRM v8.1. An updated baseline was applied per the AR TRM; this updated baseline and the ISR of 94% led to a less than 100% realization rate. LED savings made up a small portion of total program savings (<0.1%). The program level realization rate for LED lightbulbs was 30% for kWh savings and 31% kW peak demand reduction, respectively.

3.3.3.1.5 Water Heater Jackets and Pipe Insulation

ADM completed 33 verification surveys with customers that had water heater insulation or jackets installed in their homes through the program. Seven respondents stated that they did not know if this improvement had been made and were removed from the analysis. Eight indicated they had not received pipe insulation; four of these were removed from the analysis as Titan ES staff followed up with these customers but were unable to reach them. Three respondents' homes were revisited and the measure was verified as installed. One respondent's home was revisited, and it was verified that the improvement had not been made.

Based on these findings, an ISR of 95% was applied (21 of the 22 verification surveys that were vetted with follow up contact confirmed the improvement was made).

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. The algorithm inputs were found to be properly used in reported savings calculations. The program-level realization rates for water heater jackets and pipe insulation were 95% for kWh savings and peak demand reduction, respectively. The main driver of the less than 100% realization rates for water heater jackets and pipe insulation was the application of the ISR.

3.3.3.1.6 Faucet Aerator(s)

Due to the limited installation of this measure through the program in 2024, ADM utilized survey responses from 2020 and 2021 to calculate the ISR for this measure. An ISR of 80% was applied to the verified energy saving calculation (ISR=12/15).

Combined with the ISR, realization rates of 82% for peak demand reduction and 85% for annual energy savings were determined. The main driver of the less than 100% realization rate for faucet aerator(s) was the application of the ISR. A minor factor that impacted the realization rate was that verified savings calculations relied on ARM TRM v8.1 whereas reported values were determined from AR TRM v7.0. Mixed water temperature assumptions for each weather zone were revised in AR TRM v8.1.

3.3.3.1.0 Advanced Power Strip(s)

Due to the limited installation of this measure through the program in 2024, ADM utilized survey responses from 2020 and 2021 to calculate the ISR. An ISR of 79% was applied to the verified energy saving calculation (ISR=11/14).

The program-level realization rates for advanced power strips were 79% for kWh savings and peak demand reduction, respectively. The main driver of the less than 100% realization rate was the application of the ISR.

3.3.3.1.0 Low Flow Showerhead(s)

Due to the limited installation of this measure through the program in 2024, ADM utilized survey responses from 2020 and 2021 to calculate the ISR for this measure. An ISR of 73% was applied to the verified energy saving calculation (ISR=11/15).

We found a realization rate of 74% for peak demand reduction and kWh savings for this measure. A minor factor that impacted the realization rate was a difference in the methodology used to calculate the calculation of savings for low flow showerheads. The reported kWh savings and kW demand reduction calculations utilized AR TRM v7.0, whereas the verified calculations used AR TRM v8.1. Updates to the values in Table 162 for mixed water temperature in different climate zones as well as the gallons of water saved per year resulted in slightly increased savings. However, the application of the ISR was the main driver of the less than 100% realization rate for low flow showerhead(s).

3.3.3.2 Verified Savings Summary

Prescriptive methodologies were used 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 discrepancies with algorithm inputs. The methodologies were consistent with past evaluation years. Realization rate risk was apparent for direct installation measures in the application of in-service rates to gross savings. Table 3-142 displays the results.

Table 3-142: Home Weatherization In-Service Rates[51]

Measure	Verified/Claimed	Number of Measures	ISR	Other Realization Rate Factors
Attic Insulation	Verified	74	100%	N/A
	Claimed	74		
Duct Sealing	Verified	89	100%	N/A
	Claimed	89		
Infiltration	Verified	27	100%	N/A
	Claimed	27		
WH Pipe Wrap/Insulation	Verified	11	100%	N/A
	Claimed	11		
LED Bulbs	Verified	93	94%	N/A
	Claimed	99		
Faucet Aerators	Verified	12	80%	Savings Algorithm
	Claimed	15		
Low Flow Showerhead(s)	Verified	11	73%	Savings Algorithm
	Claimed	15		
Advanced Power Strip(s)	Verified	11	79%	N/A
	Claimed	14		

As Home Weatherization measures are offered free of charge to income qualified residential customers, the net-to-gross ratio is set at 100%. Verified and reported annual energy savings and peak demand reduction by measure are shown in Table 3-143. As shown, the measures with the largest impact were 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 from 2018 to 2023.

[51] No survey responses were collected in 2024 for LED bulbs, faucet aerators, low flow shoerheads, or advanced power strip(s); claimed and verified values and calculated ISRs for these measures are based on 2020 and 2021 survey responses.

Table 3-143: Home Weatherization Reported and Verified Energy Savings (kWh and Peak kW)

Measure	Reported Energy Savings (kWh)	Reported Peak Demand Savings (kW)	Verified Net Energy Savings (kWh)	Verified Net Peak Demand Savings (kW)	kWh Realization Rate	kW Realization Rate
Duct Sealing	2,602,223	1,158.71	2,598,359	1,156.40	100%	100%
Attic Insulation	1,269,013	1,179.88	1,268,822	1,179.46	100%	100%
Air Infiltration	1,124,295	382.62	1,122,242	382.30	100%	100%
Air Infiltration (Mobile home)	8,979	3.02	8,979	3.02	100%	100%
Water Heater Pipe Insulation	4,708	1.50	4,494	1.43	95%	95%
Water Heater Jacket	1,292	0.10	1,233	0.09	95%	95%
LED (Mobile home)	1,384	0.22	419	0.07	30%	31%
Faucet Aerators (Mobile home)	293	0.03	250	0.03	85%	82%
Advanced Power Strips (Mobile home)	2,522	0.30	1,982	0.24	79%	79%
Low Flow Showerheads (Mobile home)	2,738	0.29	2,028	0.21	74%	74%
Total	**5,017,447**	**2,726.67**	**5,008,807**	**2,723.25**	**100%**	**100%**

3.3.4 Process Evaluation Findings

ADM's process evaluation activities included a participant survey, tracking data review, and a facilitated discussion with program staff to review past recommendations and any changes to the program operations or design. The process evaluation memo ADM provided to PSO in December of 2024 contained more detailed information on the discussion and participant survey.

3.3.4.1 Distribution of Home Weatherization Projects

Figure 3-38 displays the distribution of program projects by county in Oklahoma. Sixty-two percent of Weatherization Program projects were completed in Tulsa County. The three counties with the next largest portion of projects were Comanche (13%), Washington (4%), and Pittsburg (3%).

Figure 3-38: Distribution of Projects by County in Oklahoma (Percent of Total)

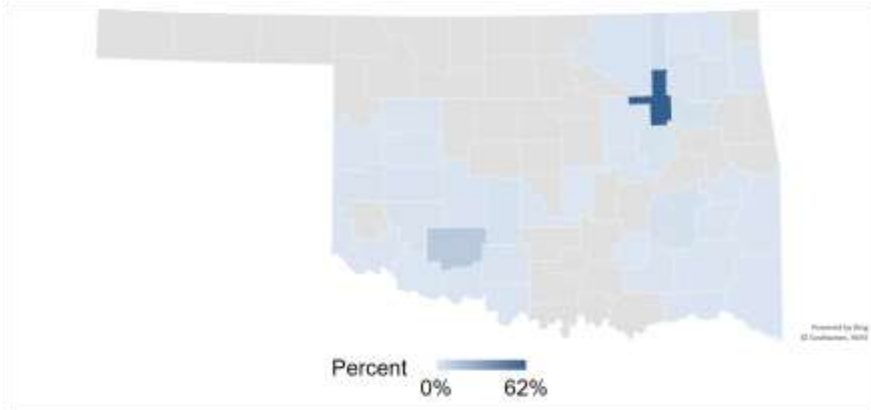
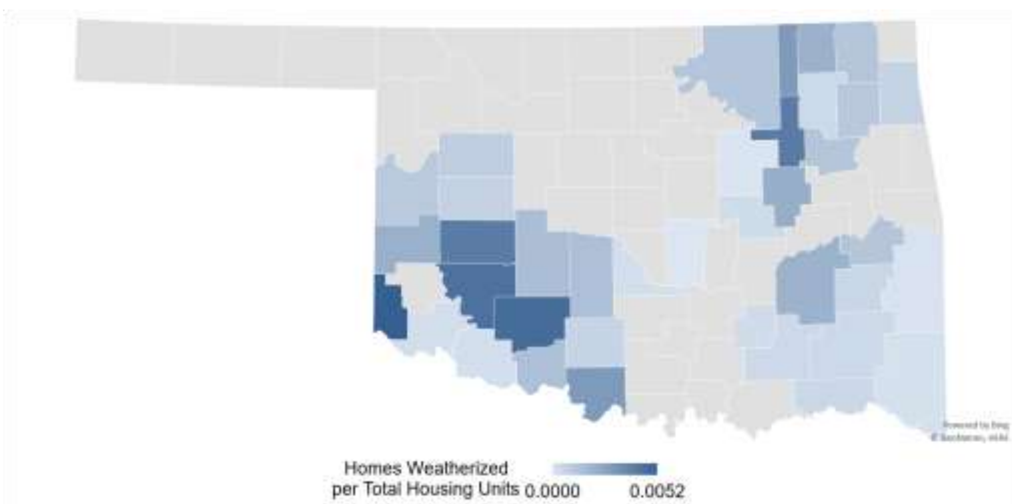


Table 3-144 displays the ten counties that had the most participating homes, per the total number of homes in each county. Figure 3-39 shows the distribution of projects by county, normalized using Census housing estimates for each county. Harmon and Comanche counties had the highest participation when considering the total housing stock in each county. ADM also reviewed the number of homes served by the PSO Home Weatherization Program compared to the total number of homes in each county. We found that Harmon, Comanche, Kiowa, and Tulsa counties had the highest number of participating homes per total housing units in the county.

Figure 3-39: Distribution of Projects by County in Oklahoma (Per Total Housing Units)[52]



[52] US Census estimates for the number of single-family homes in each county in 2022 were used to create a standardized way of comparing participation. PSO may not serve all homes within a county.
Source: Annual Estimates of Housing Units for Counties in Oklahoma: July 1, 2022. US Census Bureau.

Table 3-144: Homes Weatherized by County, 2024
(Top Ten Counties per Total Unit Count)

County	PSO Homes Weatherized	US Census Housing Unit Count	Homes Weatherized per Total Housing Units	Standardized Rank	Percent of Total Homes Weatherized
Harmon	201	1,345	0.0052	1	<1%
Comanche	58	52,708	0.0047	2	13%
Kiowa	741	4,668	0.0045	3	1%
Tulsa	14	297,854	0.0041	4	62%
Washita	35	5,121	0.0041	5	1%
Washington	23	23,765	0.0029	6	4%
Jefferson	28	2,736	0.0029	7	<1%
Okmulgee	13	16,739	0.0022	8	2%
Beckham	6	10,142	0.0021	9	1%
Nowata	5	4,375	0.0021	10	<1%

3.3.4.2 Program Operations Perspective

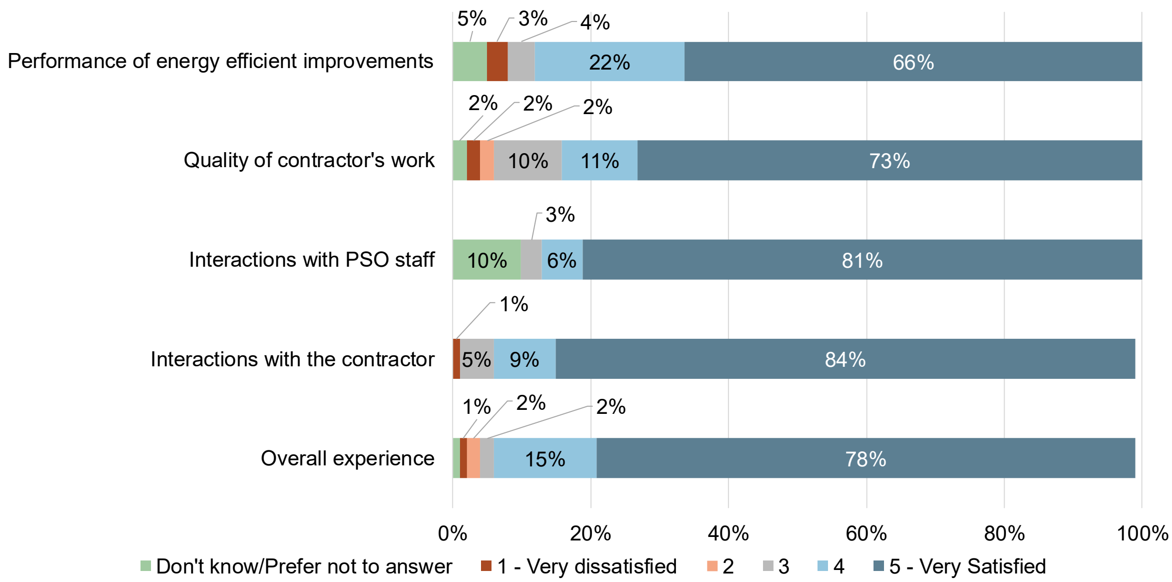
ADM had a facilitated discussion with PSO program staff with the purpose of investigating the status of the program's implementation and design. The program remained consistent in 2024 in energy efficiency measures offered except for additional budget available to implementation staff for "home readiness". This allows for minor home modifications to make homes eligible for energy efficiency improvements. In the past, homes that required modification could not participate in the program.

3.3.4.3 Participant Survey Results

The participant survey was completed by 47 participants through email and 55 participants through phone calls. Most survey respondents stated they were satisfied with the performance of the improvements, the quality of the contractor's work, interactions with the contractor, PSO staff, and the program overall (see Figure 3-40). Ninety-three percent of survey respondents were satisfied with their experience overall.[53] Further, 85% of respondents said they had recommended the program to someone else. Of those who had not recommended the program, 73% said they would be likely to recommend it (n=23).[54]

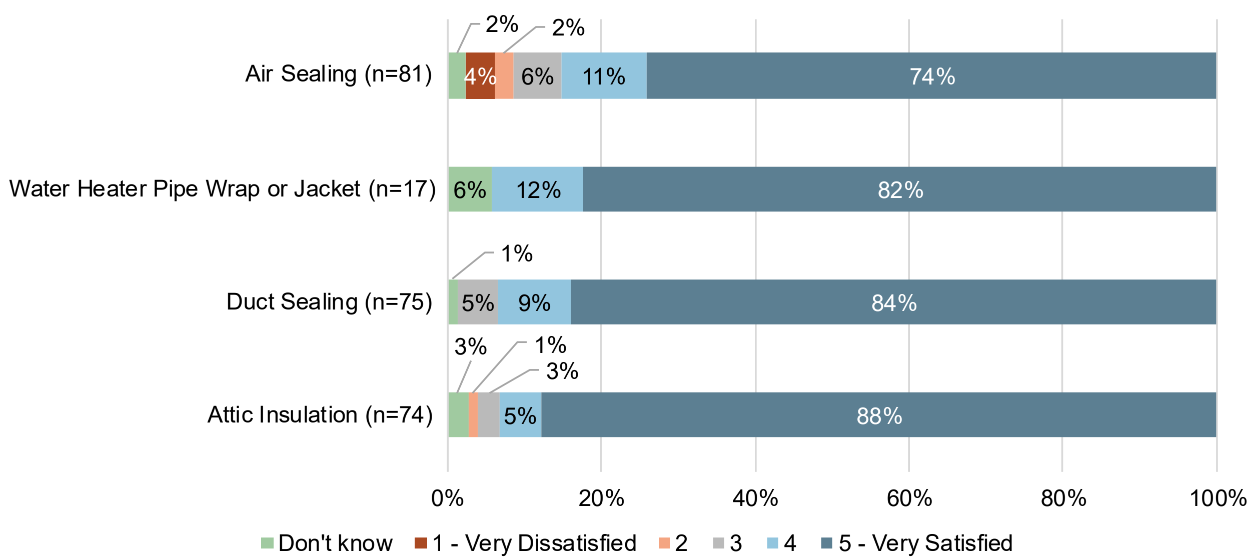
[53] Ninety-three percent of respondents rated their overall satisfaction with the home weatherization service a 4 (15%) or 5 (78%).
[54] Rated their likelihood of recommending the program a 7 or higher on a scale from 0 (not at all likely) to 10 (extremely likely).

Figure 3-40: Home Weatherization Customer Satisfaction



Most survey respondents were satisfied with the measures they received through the program (see Figure 3-41).

Figure 3-41: Satisfaction with Weatherization Measures



3.3.4.4 Conclusions and Recommendations

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

- Participant satisfaction remains high. Most participant survey respondents were satisfied with the program overall, the measures they received, and with PSO as their electric utility.

- PSO has implemented a home readiness measure. This has enabled more homes to participate, resulting in 23 make-ready projects in 2024.
- The program serves a diverse customer base across the PSO territory. Tulsa County had the most projects. Okmulgee and Comanche counties had higher participation rates relative to their total number of homes. Demographic backgrounds of participants vary as well with participants representing various ages, educational backgrounds, and ethnic or racial identities.
- Multiple quality control and feedback mechanisms enable PSO and Titan to ensure high satisfaction and take necessary actions to address customer requests. The program has third-party verification and internal quality control procedures. Additionally, ADM administered its survey three times in 2024. This enabled PSO and Titan to contact customers who made requests for follow-up or provided notes suggesting a need for additional communication or verification of program measures.
- Survey findings suggest limited engagement with energy efficiency and PSO post-program participation. Sixteen percent of customers said they had bought energy-saving equipment and six percent said they had participated in another program offered by PSO since participating in the program.
- Participant survey findings suggest there may be continued opportunities to improve communication. Ten percent noted opportunities to either improve or increase communications from the contractor regarding the improvements completed and the participation process (e.g., size of crew and access needed to the home, additional advice on energy efficiency, and information on work completed).

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

- Expand the home readiness measure to enable more homes to participate. The home readiness measure enabled over 20 homes to participate in 2024; ADM has reviewed and confirmed the cost-effectiveness of this measure.
- Continue to provide customers with summary reports and verbal explanation of improvements completed. Consider adjustments to improve participants' engagement with reports. Findings from the participant survey and contractor follow-up suggest understanding of measures completed through the program could be improved for a portion of participants. Adjustments could be to add additional language to help clarify details included in the summary report and/or to provide digital copies and use more understandable terms to enhance participant's understanding and satisfaction.

3.4 Conservation Voltage Reduction (CVR) Program

This chapter presents findings from the impact evaluation of the 2024 Conservation Voltage Reduction (CVR) program.

3.4.1 Program Overview

PSO's Conservation Voltage Reduction (CVR) program uses a system of devices, controls, software, and communications equipment to lower voltage levels for implemented distribution circuits. PSO implemented the program using Eaton's Yukon Integrated Volt/VAR Control (IVVC) automation software.[55] Voltage levels were controlled independently for each of the three phases for all evaluated circuits.

The 2024 CVR program evaluation consisted of 10 substations and 42 circuits (See Table 3-145). 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 installation 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 3-145: CVR Deployment Timeline

Substation	In Service Date
21st and 89th E Avenue	1/17/2024
Elk City	12/27/2023
Falcon Road	4/4/2024
Mayo Road	4/15/2024
Mingo	1/19/2024
Norge Road	12/18/2023
Northeast Power Station	1/11/2024
Nowata	12/28/2023
Rush Springs	12/12/2023
Southern Hills	12/28/2023

[55] 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

Circuits associated with the 10 substations serve a range of residential, commercial, industrial, municipal, and other/unknown customers. A breakdown of customer counts by sector (from historical data) is shown in Table 3-146.

Table 3-146: CVR Circuit Customer Count

Substation	Customer Count	Residential	Commercial	Industrial	Other/ Unknown	Municipal
21st and 89th E Avenue	8,808	7,418	1,014	48	414	37
Elk City	4,788	3,479	624	171	81	25
Falcon Road	2,450	1,816	281	32	285	43
Mayo Road	11,720	10,851	584	17	113	64
Mingo	5,444	4,627	664	47	68	63
Norge Road	4,988	4,360	373	78	278	43
Northeast Power Station	1,332	1,094	139	14	280	42
Nowata	3,094	2,426	306	74	14	17
Rush Springs	1,271	976	142	22	435	79
Southern Hills	11,749	10,176	1,090	32	2,179	490

Table 3-147 provides reported and verified program performance metrics.

Table 3-147: Performance Metrics - CVR

Metric	2024
Number of Customers	55,644
Budgeted Expenditures	$1,775,539
Actual Expenditures	$1,912,154
Energy Impacts (kWh)	
Projected Gross Energy Savings	34,793,768
Reported Energy Savings	24,703,907
Gross Verified Energy Savings	22,569,621
Net Verified Energy Savings	22,569,621
Peak Demand Impacts (kW)	
Projected Gross Peak Demand Savings	9,222.58
Reported Gross Peak Demand Savings	6,548.12
Gross Verified Peak Demand Savings	4,400.21
Net Verified Peak Demand Savings	4,400.21
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	1.49
Utility Cost Test Ratio	1.33

3.4.2 Evaluation Activities

For the 2024 CVR Program, ADM estimated typical year annual energy savings (kWh) resulting from the implementation and evaluation testing 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.

ADM provided a schedule of events to deactivate CVR for an energy savings baseline. The schedule was balanced in terms of days where CVR was either on or off, such that ADM would be able to maximize operational time but still have enough “off” data to achieve a statistically significant counterfactual baseline for the evaluation methodologies employed in this analysis. Beginning 2022, PSO provided ADM with monthly data showing when each bus was enabled or disabled. In addition, time series 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.

3.4.2.1 Regression Analysis

The on/off regression analysis for CVR is the accepted industry standard for evaluation of voltage control technologies.[56] The regression model configuration used for this analysis is described in Equation 3-1.

Equation 3-1: CVR Regression Model Configuration

$$kWh_t = \beta_o + \beta_1 * Mode_t + \beta_2 * CDD_t + \beta_3 * WeatherVar2_t + \beta_4 * DayType_t + \beta_\theta * Hour_t + e_t$$

Where:

t	= the hourly interval the model is predicting usage for
$Mode_t$	= 1 if CVR is on during time t; 0 otherwise
CDD_t	= cooling degree days at time t
$WeatherVar2_t$	= if modeling the heating season months then it is heating degree days at time t; otherwise, it is cooling degree days at time t-1
$DayType_t$	= if the day was a weekday or a weekend/holiday
$Hour_t$	= An adjustment factor for varying consumption during different hours of the day.

The coefficient 1 gives the estimated hourly savings the occur due to a substation circuit operating in CVR mode. All other coefficients are meant to control for other known variables that impact energy consumption, such as weather, time-of-day, and time-of-week. Separate regressions are run for the cooling season dataset (May through September) and the heating season dataset (October through April). In the event circuit level consumption is not dependent on weather (such as high industrial loads), or day of the week, the regression parameters are adjusted as needed.

3.4.2.2 CVR Factor Calculation

The result of the regression analysis is an estimated hourly savings value that results from CVR being operational on the given circuit during a given season. This value is then extrapolated to a percent reduction value to calculate the "CVR factor." The CVR factor represents the ratio between the percentage change in energy and the associated percentage change in voltage. CVR factor is calculated as the percent change in energy consumption divided by the percent change in voltage. Exceptions to the use of this

[56] 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

framework are detailed in a supplemental document with detailed information on the evaluation methodologies.

3.4.2.3 Voltage Profile Determination

The final estimate of savings for each circuit and phase in the evaluation pool was calculated 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. For more information on the process used for determining the most accurate voltage profile for each circuit are described in a supplemental document.

3.4.2.4 Final Savings Calculation

With CVR factors calculated and baseline voltage profiles determined, final savings can be calculated. Note that this is done separately for each circuit, phase, and season combination. Equation 3-2 shows how average daily percent usage reductions are calculated using the CVR factors estimated in previous steps.

Equation 3-2: Daily Percent Savings Calculation

$$DailySavingsPercent = CVR_{Factor} * \%\Delta Voltage$$

Where:

CVR_{Factor} = %ΔEnergy Consumption / %ΔVoltage

%ΔVoltage = The average percent reduction in voltage when CVR is operational vs. not operational

Daily kWh savings are then calculated by multiplying the average daily percent savings value with the average daily baseline energy consumption value. Final seasonal savings values are then calculated by multiplying the actual daily kWh savings by the number of days in the season. Equation 3-3 shows this calculation.

Equation 3-3: Season Savings Calculation

$$Season\ Savings = (DailySavingsPercent * DailyBaselineEnergyUsage) *sdays$$

Where:

DailySavingsPercent =Average daily percent reduction in energy consumption

DailyBaselineEnegyUsage =Average daily usage when CVR is not operational

Sdays =Number of days in the evaluated season

Note that these are “typical year annual energy savings.” This means that final savings values represent the amount of savings that would have occurred had CVR been operational during every hour of the year.

3.4.2.5 Coincident Peak Demand Reduction (kW) Methodology

The gross verified peak demand reduction (kW) is calculated by multiplying the identified percent energy consumption reduction for each circuit and phase by the total consumption during the system-wide peak consumption hour. In 2024, the system peak consumption time was 4 PM to 5 PM on August 6, 2024.

3.4.2.6 Net-to-Gross Methodology

A net-to-gross ratio of 100% is assumed for this program, as it is impossible for a premise to receive reduced voltage due to CVR in the absence of the program.

3.4.3 Impact Evaluation Results

The evaluation of 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 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.

3.4.3.1 Verified Annual Energy Savings (kWh)

The gross verified annual energy savings (kWh) represents an overall annual percent energy savings of 3.11% relative to the evaluated circuit demand. Table 3-148 and Table 3-149 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 3-148: CVR Cooling Season Verified Energy Savings (kWh)

Substation	Circuit	% Savings	Cooling Season Savings (kWh)	Cooling Season Annual Baseline Consumption (kWh)
21st and 89th E Avenue	Q2	2.81%	395,349	14,087,300
	Q3	2.31%	387,672	16,768,450
	Q4	2.55%	467,157	18,341,277
	Q5	1.26%	112,616	8,922,494
	Q6	1.81%	305,095	16,831,828
	Q7	1.66%	257,237	15,498,660
Elk City	EC11	5.26%	319,128	6,065,115
	EC13	6.26%	1,042,158	16,649,644

Substation	Circuit	% Savings	Cooling Season Savings (kWh)	Cooling Season Annual Baseline Consumption (kWh)
	EC14	3.85%	544,026	11,258,292
	EC16	3.66%	544,026	14,862,747
Falcon Road	FR11	3.58%	279,272	7,790,606
	FR13	2.66%	255,520	9,614,765
	FR15	3.38%	29,742	880,045
	FR19	2.81%	257,381	9,145,259
Mayo Road	ZB1	1.21%	194,207	15,999,630
	ZB3	1.32%	191,767	14,554,194
	ZB5	1.28%	109,460	8,518,789
	ZB7	1.01%	121,301	11,983,863
Mingo	ZK1	2.07%	236,698	11,422,770
	ZK2	2.21%	374,864	16,932,444
	ZK3	4.10%	423,111	10,328,203
	ZK4	3.28%	174,628	5,322,112
	ZK5	2.03%	225,214	11,114,782
	ZK6	4.28%	442,028	10,323,175
Northeast Power Station	86431	2.10%	207,223	9,888,015
	86432	1.26%	73,962	5,876,954
Norge Road	NR11	3.19%	442,577	13,874,689
	NR13	1.26%	221,183	17,601,004
	NR14	1.62%	213,460	13,160,573
	NR16	1.96%	154,567	7,882,616
Nowata	31431	3.60%	134,158	3,724,160
	31432	3.37%	242,707	7,192,349
	31433	3.36%	343,596	10,224,997
Rush Springs	RS11	2.22%	273,733	12,310,726
Southern Hills	T1	1.89%	360,522	19,107,173

Substation	Circuit	% Savings	Cooling Season Savings (kWh)	Cooling Season Annual Baseline Consumption (kWh)
	T2	1.95%	202,205	10,350,142
	T3	1.91%	247,873	12,973,996
	T4	1.98%	250,926	12,662,819
	T5	1.87%	208,277	11,116,906
	T6	2.40%	303,722	12,648,828
	T7	2.37%	493,847	20,841,286
	T8	1.62%	144,345	8,933,839
Total		**2.55%**	**12,574,615**	**493,587,416**

Table 3-149: CVR Heating Season Verified Energy Savings (kWh)

Substation	Circuit	% Savings	Heating Season Savings (kWh)	Heating Season Annual Baseline Consumption (kWh)
21st and 89th E Avenue	Q2	1.62%	195,411	12,040,922
	Q3	1.92%	270,350	14,044,926
	Q4	1.66%	251,276	15,167,170
	Q5	2.37%	190,033	8,023,287
	Q6	2.52%	563,797	22,331,377
	Q7	2.27%	289,690	12,786,438
Elk City	EC11	1.65%	88,856	5,373,429
	EC13	1.95%	245,111	12,564,657
	EC14	1.97%	202,798	10,318,203
	EC16	2.01%	283,479	14,083,127
Falcon Road	FR11	2.57%	200,467	7,794,465
	FR13	2.53%	249,562	9,853,998
	FR15	2.61%	28,092	1,077,533
	FR19	2.52%	199,798	7,925,674
Mayo Road	ZB1	2.14%	278,328	12,977,263
	ZB3	3.04%	352,466	11,608,375

Substation	Circuit	% Savings	Heating Season Savings (kWh)	Heating Season Annual Baseline Consumption (kWh)
	ZB5	3.79%	269,716	7,108,238
	ZB7	1.81%	247,528	13,673,279
Mingo	ZK1	2.12%	241,785	11,422,770
	ZK2	2.23%	377,697	16,932,444
	ZK3	4.16%	429,312	10,328,203
	ZK4	3.31%	175,983	5,322,112
	ZK5	2.06%	228,797	11,114,782
	ZK6	4.31%	444,926	10,323,175
Northeast Power Station	86431	2.12%	209,408	9,888,015
	86432	1.27%	74,645	5,876,954
Norge Road	NR11	2.11%	359,549	17,046,683
	NR13	1.60%	315,085	19,678,486
	NR14	2.13%	263,129	12,354,307
	NR16	2.27%	197,319	8,700,737
Nowata	31431	2.28%	106,430	4,671,983
	31432	1.81%	205,035	11,351,675
	31433	2.56%	264,588	10,330,535
Rush Springs	RS11	2.14%	315,922	14,792,883
Southern Hills	T1	1.29%	184,034	14,317,666
	T2	2.25%	198,515	8,836,970
	T3	1.28%	190,768	14,898,793
	T4	2.80%	266,849	9,514,969
	T5	1.26%	165,199	13,085,094
	T6	2.80%	303,378	10,831,670
	T7	2.92%	553,787	18,980,244
	T8	2.03%	160,592	7,897,610
Total		**2.16%**	**9,995,006**	**463,730,345**

3.4.3.2 Verified Coincident Peak Demand Reduction (kW)

The gross verified coincident peak demand reduction (kW) results per circuit are shown in Table 3-150.

Table 3-150: Verified Peak Demand Reduction

Substation	Circuit	Peak Demand Reduction (kW)
21st and 89th E Avenue	Q2	110.39
	Q3	104.85
	Q4	95.78
	Q5	24.88
	Q6	56.95
	Q7	56.97
Elk City	EC11	275.54
	EC13	279.94
	EC14	253.15
	EC16	201.43
Falcon Road	FR11	191.48
	FR13	77.41
	FR15	169.99
	FR19	16.08
Mayo Road	ZB1	41.12
	ZB3	40.09
	ZB5	44.51
	ZB7	19.88
Mingo	ZK1	76.88
	ZK2	119.22
	ZK3	242.06
	ZK4	148.48
	ZK5	79.96
	ZK6	183.91

Substation	Circuit	Peak Demand Reduction (kW)
Northeast Power Station	86431	90.74
	86432	24.77
Norge Road	NR11	174.54
	NR13	22.71
	NR14	36.70
	NR16	101.70
Nowata	31431	283.03
	31432	83.98
	31433	171.42
Rush Springs	RS11	78.51
Southern Hills	T1	33.70
	T2	34.66
	T3	52.77
	T4	45.80
	T5	25.93
	T6	87.31
	T7	99.80
	T8	41.15
Total		**4,400.21**

3.4.4 Conclusions and Recommendations

The following summarizes the key findings of the evaluation of the CVR Program.

- The overall average reduction in distributed energy due to CVR across the evaluated circuits is 2.36%. Table 3-151 shows a comparison of how overall percent reduction compared to previous years' evaluations.

Table 3-151: CVR On/Off Overall Percent Reduction; Year-to-Year Comparison

Season	2019	2020	2021	2022	2023	2024
Cooling	2.69%	3.16%	2.13%	2.08%	3.51%	2.55%
Heating	2.66%	2.54%	3.29%	2.47%	2.68%	2.16%

- The average CVR factor is 0.58 (0.63 during the cooling season, and 0.56 during the heating season). Table 3-152 shows a comparison of how the average CVR factors compared to previous years' evaluations. CVR factors are known to range from zero to above one if the load is mostly unconverted (in-phase) electrical consumption (such as electric resistance heating and incandescent light bulbs).

Table 3-152: On/Off CVR Factors; Year-to-Year Comparison

Season	2019	2020	2021	2022	2023	2024
Cooling	0.63	0.73	0.71	0.63	1.07	0.63
Heating	0.62	0.54	0.92	0.76	0.91	0.54

Recommendations

The following recommendations are offered for the CVR Program.

- Load reduction can be dependent on various variables, including weather. Ensuring sufficient evaluation test days is critical to identifying load reduction across all variables. ADM recommends continuing the practice of evaluation testing over the course of a year for new CVR installations.
- Continuous tracking of CVR operability is important to ensure proper data collection during evaluation test days as well as optimizing load reduction. ADM recommends the continued active monitoring of substations.
    - Active monitoring supports maximizing CVR days (outside of evaluation test days). More data provides the potential to capture additional weather conditions which may support higher savings.

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.

Table 4-1: Annual Energy Savings – Demand Response Programs

Program	Gross Annual Energy Savings (kWh)					Net Impacts	
	Projected	Reported	Verified	Gross Realization Rate	Verified Lifetime Savings	NTG Ratio	Net Annual Energy Savings (MWh)
Power Hours	0	0	266,797	NA	266,797	100%	266,797
Peak Performers	76,090	0	1,134,454	NA	1,134,454	100%	1,134,454
Demand Response Totals	**76,090**	**0**	**1,401,251**	**NA**	**1,401,251**	**100%**	**1,401,251**

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 (kW)				Net Impacts	
	Projected	Reported	Verified	Gross Realization Rate	NTG Ratio	Net Peak Demand Reduction (MW)
Power Hours	25,246.07	21,353.07	22,744.34	107%	100%	22,744.34
Peak Performers	77,860.80	114,994.49	107,841.23	94%	100%	107,841.23
Demand Response Totals	**103,106.87**	**136,347.56**	**130,585.57**	**96%**	**100%**	**130,585.57**

4.1 Power Hours Program

This chapter presents findings from the 2024 impact and process evaluation of the 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. DLC events reduce energy usage when demand is highest by communicating with registered Wi-Fi-enabled thermostats installed in the homes of participants. Table 4-3 shows the performance metrics achieved by the program. The program resulted in over 267 megawatt-hours (MWh) of energy savings and over 22.7 megawatts (MW) of peak demand reduction.

Table 4-3: Performance Metrics – Power Hours Program

Metric	2024
Number of Customers	13,611[a]
Number of Devices	17,467[a]
Budgeted Expenditures	$2,163,843
Actual Expenditures	$1,588,095
Energy Impacts (kWh)	
Projected Energy Savings	-
Reported Energy Savings	-
Gross Verified Energy Savings	266,797
Net Verified Energy Savings	266,797
Peak Demand Impacts (kW)	
Projected Peak Demand Savings	25,246.07
Reported Peak Demand Savings	21,353.07
Gross Verified Peak Demand Savings	22,744.34
Net Verified Peak Demand Savings	22,744.34
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	3.48
Utility Cost Test Ratio	2.15

[a]Represents participants active from June 24 to August 27, 2024

Peak demand reduction (kW) and annual energy savings (kWh) for each DLC event were calculated for customers in the DLC program. 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 at least one program-eligible Wi-Fi-enabled thermostat installed. During the event season, which spanned from June 1, 2024, to September 30, 2024, there was a total of 17,467 active devices for at least one day. For each event, the available devices ranged from 14,108 to 17,164 with an average of 16,702 devices.

The thermostats allow participants to receive a load curtailment signal performing a temperature offset. The temperature offset changes participants' thermostat setpoint at the beginning of the event period. Setpoints can be increased by up to four degrees. A subset of participants in 2024 received a pre-cooling event where participants' thermostats received a signal to lower the thermostat setpoint by two degrees 60 minutes before the DLC event.

Nine DLC events occurred in PY2024. All events used a temperature offset curtailment strategy, with an offset of three degrees. In six instances, precooling was utilized for a subset of customers to lower the temperature of their homes one hour before the event, enhancing overall comfort during the event.

Participants can override the DLC curtailment if they do not wish to participate in an event or the precooling period. Participants can override (or opt out of) the curtailment or precooling adjustment either by using a mobile application or by manually changing the setpoint on the thermostat.

4.1.2 EM&V Methodologies

The savings impact of the Power Hours program is measured in peak reduction (kW) and annual energy savings (kWh) during DLC events. Savings during peak event periods are the difference between a calculated counterfactual baseline and actual consumption for each residence. Counterfactual baselines are calculated for each residence using a regression analysis based on non-event, non-holiday weekdays with similar weather. 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 by summing the two 15-minute kWh data within the 30-minute period. This provides a better match with weather data, improving 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.

Once the necessary data is processed, the devices that participate in the DLC events are identified. Because customers can manually override the DLC adjustment 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.

A device is considered a non-responsive device (NRD) if it does not respond to the curtailment signal sent by PSO. This information is available for all devices at every 15-minute interval during the DLC events except Google Nest thermostats, which do not release account numbers due to an enhanced security strategy. For Google Nest devices, NRDs are identified using a combination of three tests, each of which is a different method of identifying if a drop in energy usage occurred at the start of a DLC event. A device is considered non-responding for an event day only if all three tests identify the device as non-responding. Nevertheless, it is challenging to pinpoint NRD during the precooling period due to the brief duration of the adjustment (60 minutes) and the relatively minor shift in energy consumption when contrasted with the inherent variability in energy consumption patterns.

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 for every month in which a DLC event was called (in PY2024, this was June through August). Then the k-means clustering algorithm is applied to the daily weather data. This method splits every day into one of the 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 appropriate data has been determined to calculate each event's baseline curve, a linear regression model is calculated using that data (Equation 4-1).

Equation 4-1: 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 as the ratio of the actual and baseline energy consumption two hours before the event, which is then applied to the baseline curve of each event day.

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 precooling period, event period, and the snapback period. The event period is the time from when the event starts to when the event ends. The precooling period spans 60 minutes leading up to the event's start. 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 4-2 shows the formula for calculating demand reduction.

Equation 4-2: 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 hourly energy savings for each event. Program level saving was calculated by taking the sum of all the events in the season. Peak reduction is calculated for each event, representing the mean drop in energy usage that occurred for the average event participant. Program level peak reduction was calculated by taking the average peak reduction across all events.

4.1.2.2 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. 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 DLC events. This program was not expected to generate significant spillover effects; therefore, the evaluators did not assess spillover.

4.1.2.3 Process Evaluation Methodology

A process evaluation was completed to assess the Power Hours program. The program provides PSO residential customers with a way to reduce energy usage during peak demand periods by participating in DLC events. The evaluators assessed program design, operations, and delivery through a logic model facilitated discussion and a participant survey.

The evaluation addressed the following research questions to understand the program's effectiveness and efficiency better:

- What changes, if any, have been made to the program design or implementation procedures?
- Did the program implementation reflect its design? Are there ways to improve the design or implementation process?
- How do PSO customers learn about this program? What factors motivated participants decision to participate? Were there any trends in enrollment?
- How does PSO market this program? Which marketing methods are most effective? Which marketing methods are more effective?
- Were participants satisfied with their experience? What was the level of satisfaction with the incentives, the application process, and other aspects of program participation?
- How and when were participants notified about an event?
- What were the key successes and challenges during each program year?
- Looking forward, what are the key barriers and drivers to program success within PSO's market?

Table 4-4 summarizes the data collection activities and corresponding process evaluation research objectives used to complete the process evaluation.

Table 4-4: Process Evaluation Data Collection Summary

Data Collection Activity	Process Evaluation Research Objectives
Program Materials Review	Review reports and support materials for clarity and consistency with program objectives.
Participant Survey	Assess participant's reasons for participating and experience with the program, including satisfaction.
Logic Model Develop and/or Review	Develop program logic models or review already-developed logic models by program staff.

4.1.3 Impact Evaluation Findings

The methods described in the EM&V Methodologies section were used to determine the energy impacts on customer energy use for the Power Hours program. The goal of the impact evaluation is to verify annual energy savings (kWh) and peak demand reduction (kW). Findings are presented and discussed in this section. In 2024, nine Direct Load Control (DLC) events were called. The schedule of these events is summarized in Table 4-5.

Table 4-5: Summary of Events

Date	Event Start Hour	Event End Hour	Duration (Hours)	Curtailment Strategy
6/24	15	17	2	Temperature Offset
7/15*	14	17	3	Temperature Offset
7/16*	14	17	3	Temperature Offset
7/31	15	17	2	Temperature Offset
8/1	15	17	2	Temperature Offset
8/6	15	17	2	Temperature Offset
8/15	14.5	16.5	2	Temperature Offset
8/26	15	17	2	Temperature Offset
8/27	16	18	2	Temperature Offset

*During 7/15 and 7/16, the event was 14:00-16:00 for non-TOD (Time-Of-Day) customers and 15:00-17:00 for TOD customers.

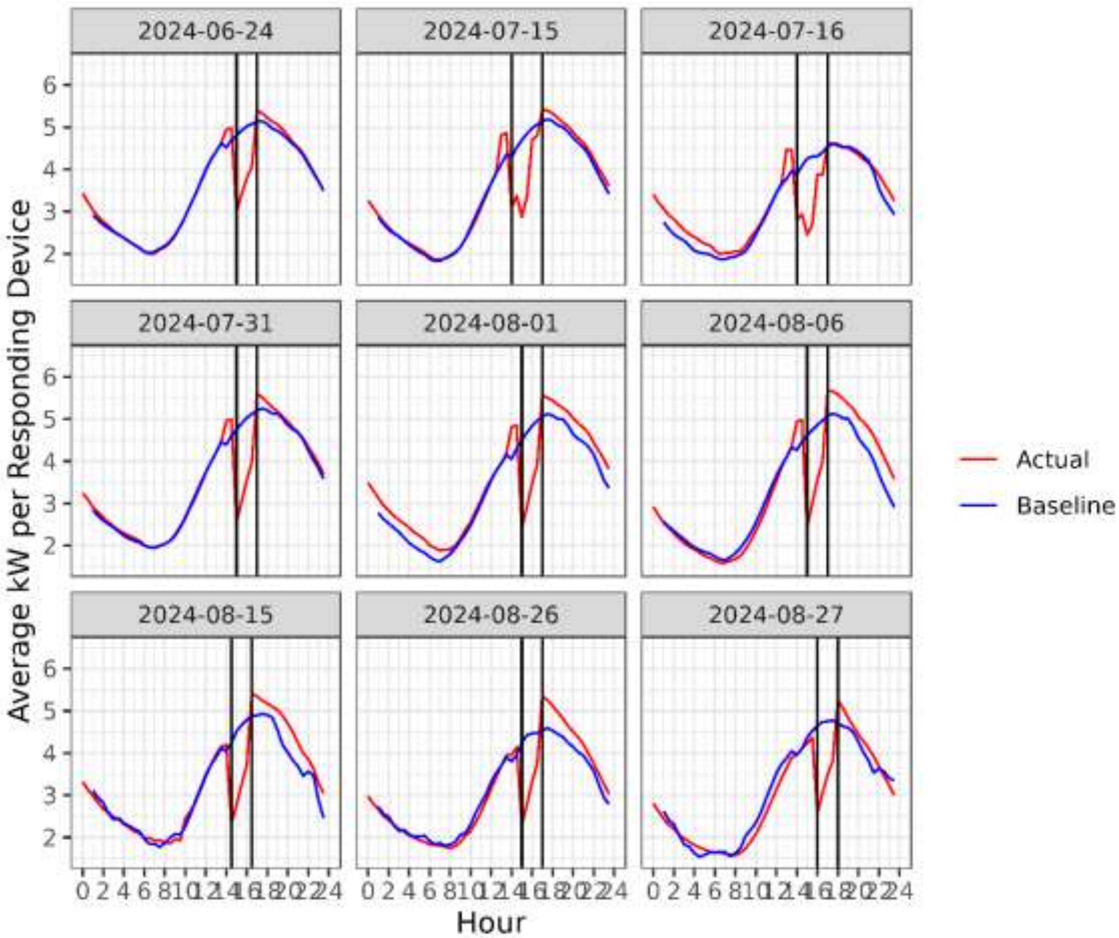
During the event season, which spanned from June 1, 2024, to September 30, 2024, there was a total of 17,467 active devices for at least one day. For each event, the available devices ranged from 14,108 to 17,164 with an average of 16,702 devices. Out of the nine events, six of them had precooling groups. The precooling period for these events was set at 60 minutes. The distribution of devices between the precooling and non-precooling groups is detailed in Table 4-6.

Table 4-6: Summary of Participants

Date	Total Available Devices	Precool Devices
6/24	14,108	6,998
7/15	16,796	9,331
7/16	16,877	9,348
7/31	17,001	9,190
8/1	16,989	9,164
8/6	17,094	9,166
8/15	17,141	NA
8/26	17,164	NA
8/27	17,146	NA

Using the methodology described previously in this chapter, a baseline consumption curve was developed for each event day to represent a typical residence's performance. This was used to estimate what energy usage would have been during the event day had the event not occurred. The baseline consumption curve used for the demand reduction calculations are shown in Figure 4-1. Vertical lines represent the start and end time of the event.

Figure 4-1: Actual vs. Baseline Energy Usage per Responding Device



Non-responsive device (NRD) 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. The average response rates ranged from 83% to 87% with a higher rate for Google Nest (95% to 96%) than other model of devices (78% to 82%).

Table 4-7: Active and Responsive Device Counts per Event

Date	Device Provider	Available Devices	Responsive Devices	Response Rate
6/24	Google Nest	4,362	4,136	95%
	Others	9,746	7,612	78%
	Total	14,108	11,748	83%
7/15	Google Nest	5,983	5,737	96%
	Others	10,813	8,899	82%
	Total	16,796	14,636	87%
7/16	Google Nest	6,048	5,811	96%
	Others	10,829	8,886	82%
	Total	16,877	14,697	87%
7/31	Google Nest	6,101	5,845	96%
	Others	10,900	8,804	81%
	Total	17,001	14,649	86%
8/1	Google Nest	6,094	5,809	95%
	Others	10,895	8,759	80%
	Total	16,989	14,568	86%
8/6	Google Nest	6,148	5,885	96%
	Others	10,946	8,812	81%
	Total	17,094	14,697	86%
8/15	Google Nest	6,175	5,900	96%
	Others	10,966	8,842	81%
	Total	17,141	14,742	86%
8/26	Google Nest	6,171	5,922	96%
	Others	10,993	8,794	80%
	Total	17,164	14,716	86%
8/27	Google Nest	6,156	5,903	96%
	Others	10,990	8,765	80%
	Total	17,146	14,668	86%

Demand reduction was calculated by comparing the hourly consumption predicted by the baseline consumption curve to the actual hourly consumption during the event. Results include demand reduction from the precooling period, event period, and the snapback period.

Demand reduction was calculated in 30-minute increments as shown in Table 4-8. Each column represents the average kW reduction per responding device during the specified time interval. Time intervals during the precooling and snapback periods are identified with grey cells.

Table 4-8: Power Hours Demand Reduction (kW) per 30-Minute Interval (Green shades mark event hours)

Date	13-13.5	13.5-14	14-14.5	14.5-15	15-15.5	15.5-16	16-16.5	16.5-17	17-17.5	17.5-18	18-18.5	18.5-19	19-19.5	19.5-20
6/24			-0.42	-0.29	1.81	1.51	1.23	1.01	-0.27	-0.18	-0.15	-0.17		
7/15	-0.69	-0.51	1.2	1.15	1.82	1.5	0.29	0.26	-0.26	-0.21	-0.18	-0.18		
7/16	-0.69	-0.49	1.08	1.15	1.8	1.62	0.42	0.54	-0.06	-0.02	-0.03	-0.01		
7/31			-0.57	-0.39	2.19	1.85	1.48	1.15	-0.39	-0.27	-0.18	-0.14		
8/1			-0.76	-0.55	2.08	1.76	1.36	1.04	-0.5	-0.38	-0.36	-0.33		
8/6			-0.68	-0.51	2.16	1.75	1.3	0.98	-0.59	-0.53	-0.5	-0.46		
8/15		-0.05	-0.15	1.9	1.75	1.39	1.07	-0.53	-0.45	-0.32	-0.27			
8/26			-0.15	-0.18	1.96	1.64	1.15	0.74	-0.81	-0.66	-0.59	-0.52		
8/27					0.14	0.15	2.07	1.69	1.26	0.96	-0.54	-0.43	-0.23	-0.15

4.1.3.1 Verified Savings

Average energy savings per responding device was calculated for each event, using the demand reduction results above. Total energy savings for each event were 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 the duration of each event.

Table 4-9: Power Hours Energy Savings (kWh) per Event

Date	Responsive Devices	Savings During Event Hours, per Device (kWh)	Savings During Snapback Hours, per Device (kWh)	Savings During Precool Hours, per Device (kWh)	Energy Savings per Device (kWh)	Total Energy Savings (kWh)
6/24	11,748	2.78	-0.39	-0.35	2.04	23,966
7/15*	14,636	3.60	-0.71	-0.64	2.25	32,931
7/16*	14,697	3.73	-0.32	-0.65	2.76	40,564
7/31	14,649	3.33	-0.49	-0.48	2.36	34,572
8/1	14,568	3.13	-0.79	-0.66	1.68	24,474
8/6	14,697	3.09	-1.04	-0.59	1.46	21,458
8/15	14,742	3.06	-0.78	-	2.28	33,612
8/26	14,716	2.74	-1.29	-	1.45	21,338
8/27	14,668	2.99	-0.68	-	2.31	33,883
Total						**266,797**

*The event hours, snapback hours, and precool hours were different for non-TOD (14-16) and TOD (15-17) customers in these two events.

Peak reduction per device was calculated by finding the average difference between the baseline curve and the actual usage curve that occurred during event hours. The peak reduction per event was then calculated by multiplying the peak reduction per device by the number of responsive devices for that event. Table 4-10 shows peak reduction per device and total reduction for the duration of each event.

Table 4-10: Power Hours Program-Level Peak Reduction (kW) per Event

Date	Responsive Devices	Peak Reduction per Device (kW)	Peak Reduction per Event (kW)
6/24	11,748	1.39	16,329.72
7/15*	14,636	1.81	26,491.16
7/16*	14,697	1.86	27,336.42
7/31	14,649	1.67	24,463.83
8/1	14,568	1.56	22,726.08
8/6	14,697	1.55	22,780.35
8/15	14,742	1.53	22,555.26
8/26	14,716	1.37	20,160.92
8/27	14,668	1.49	21,855.32
Average			**22,744.34**

*The event hours, snapback hours, and precool hours were different for non-TOD (14-16) and TOD (15-17) customers in these two events.

Program level peak reduction was calculated by taking the average peak reduction across all events. Max peak reduction was calculated by finding the maximum peak reduction across the nine events. These results are shown in Table 4-11.

Table 4-11: Power Hours Total Peak Reduction

Verified Peak Reduction (kW)	Max Peak Reduction (kW)
22,744.34	27,336.42

Total net energy savings were calculated by adding up the total energy savings of each DLC event. The results are shown in Table 4-12.

Table 4-12: Power Hours Total Net Energy Savings

Source	Total Energy Savings (kWh)
DLC Events	266,797

4.1.3.2 Precooling Findings

The events that occurred on 6/24, 7/15, 7/16, 7/31, 8/1, and 8/6 had precooling groups, as indicated in Table 4-6. All these groups had an hour precooling period before the event began. The energy usage curves for these events (as shown in Figure 4-1) reveal a relatively small peak in energy consumption during the precooling period. Figure 4-2 provides a comparison of consumption patterns between participants who had precooling and those who did not.

Figure 4-2: Pre-Cooling Event Impact

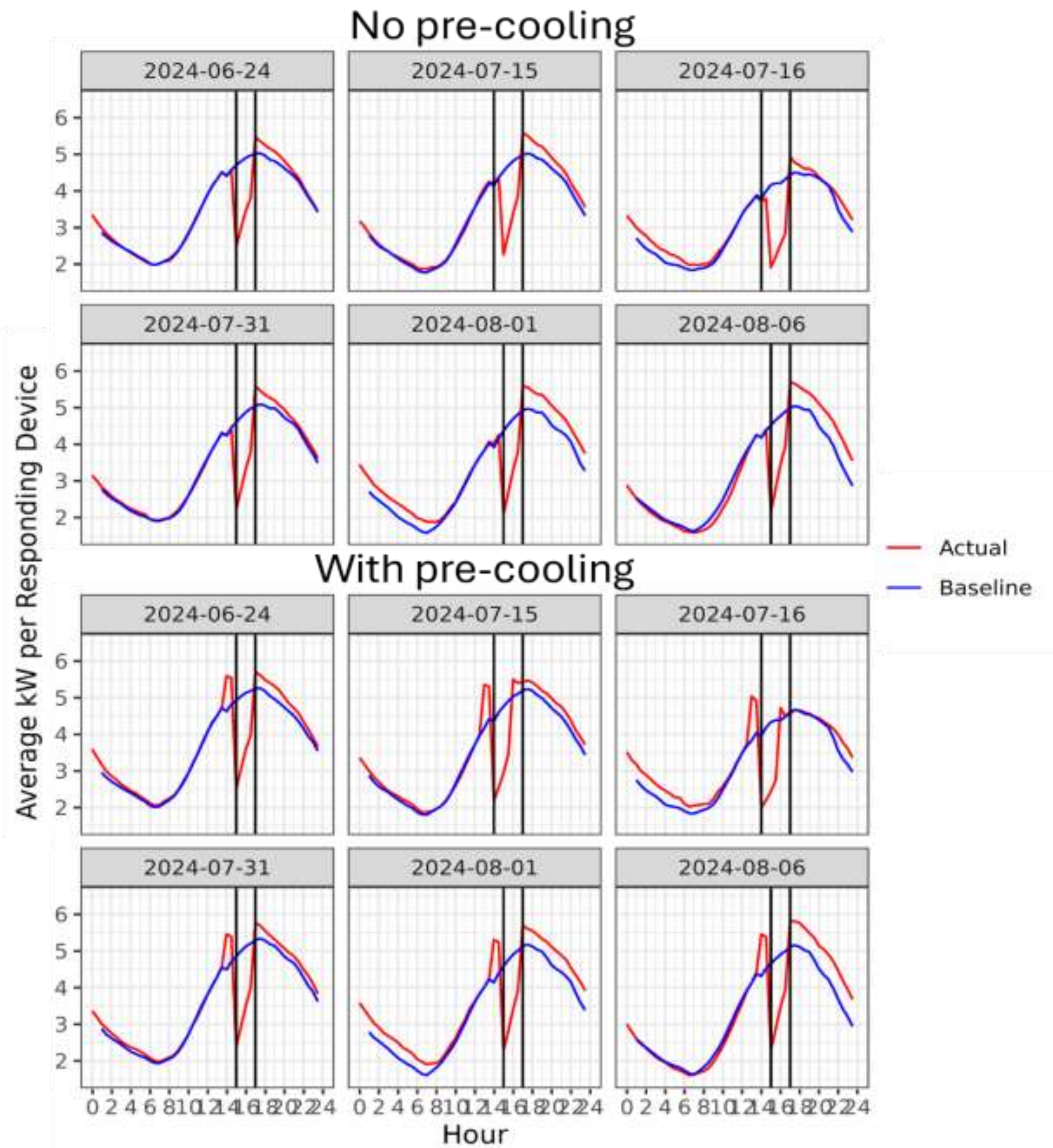


Table 4-13 and Table 4-14, show the demand reduction in 30-minute increments for devices in different precool modes.

Table 4-13: Demand Reduction (kW) per 30-Minute Interval for Devices without Precooling (Green shades mark event hours)

Date	13-13.5	13.5-14	14-14.5	14.5-15	15-15.5	15.5-16	16-16.5	16.5-17	17-17.5	17.5-18	18-18.5	18.5-19	19-19.5	19.5-20
6/24			-0.02	0.02	2.23	1.83	1.45	1.17	-0.46	-0.32	-0.29	-0.3		
7/15	-0.1	-0.04	-0.05	-0.01	2.28	1.87	1.43	1.06	-0.61	-0.49	-0.39	-0.38		
7/16	-0.02	0.03	0.07	0.2	2.25	2.01	1.67	1.48	-0.49	-0.26	-0.22	-0.18		
7/31			0.01	0.04	2.39	1.98	1.56	1.2	-0.54	-0.37	-0.3	-0.29		
8/1			-0.11	-0.1	2.27	1.85	1.38	1.04	-0.68	-0.58	-0.52	-0.5		
8/6			-0.01	-0.02	2.36	1.87	1.32	0.96	-0.7	-0.61	-0.55	-0.53		

Table 4-14: Demand Reduction (kW) per 30-Minute Interval for Devices with Precooling (Green shades mark event hours)

Date	13-13.5	13.5-14	14-14.5	14.5-15	15-15.5	15.5-16	16-16.5	16.5-17	17-17.5	17.5-18	18-18.5	18.5-19	19-19.5	19.5-20
6/24			-0.96	-0.73	2.43	1.99	1.55	1.22	-0.46	-0.36	-0.31	-0.36		
7/15	-1.18	-0.88	2.18	2.05	1.82	1.46	-0.46	-0.29	-0.23	-0.23	-0.23	-0.25		
7/16	-1.21	-0.88	1.97	1.99	1.89	1.65	-0.33	-0.03	0.06	0.01	-0.02	-0.04		
7/31			-0.98	-0.67	2.48	2.07	1.63	1.23	-0.47	-0.36	-0.27	-0.23		
8/1			-1.17	-0.85	2.29	1.94	1.49	1.11	-0.57	-0.43	-0.43	-0.42		
8/6			-1.14	-0.86	2.36	1.91	1.43	1.07	-0.7	-0.65	-0.65	-0.61		

Table 4-15 contrasts the peak and average reduction per device among subgroups with and without precooling during the 6/24, 7/31, 8/1, and 8/6 events. The events 7/15 and 7/16 are excluded due to the different event hours between the subgroups with and without precooling. It indicates that precooling increased the maximum peak reduction per device during all four events, occurring at the onset of each event. The difference was up to 0.2 kW on 6/24. This was because precooling lowers the household temperature and more A/Cs remained off during the first 30-min of events, compared with households without precooling. The average reductions across the event hours were also increased for all the events. The average kW difference ranged from 0.06 to 0.13 kW, smaller than the first 30-min of events. It reflected the fact that the temperature difference between the pre-cooling and non-precooling households became smaller at a later stage of the event.

Table 4-15: Contrast of Demand Reduction (kW) per 30-Minute Interval Devices with Different Pre-cooling Modes for Power Hours

Date	Precool Duration (Min)	Number of Available Devices	Maximum Peak Reduction per Device (kW)[a]	Average Peak Reduction per Device (kW)
6/24	60	6,998	2.43	1.80
	0	7,110	2.23	1.67
7/31	60	9,190	2.48	1.85
	0	7,811	2.39	1.78
8/1	60	9,164	2.29	1.71
	0	7,825	2.27	1.64
8/6	60	9,166	2.36	1.69
	0	7,928	2.36	1.63

[a]The maximum 30-min demand reduction during the events occurred in the first 30-min.

Table 4-16 contrasts the energy savings per device among subgroups with and without precooling (and duration of precooling period) during the 6/24, 7/31, 8/1, and 8/6 events. It indicates that precooling had decreased savings per device during all four events. This is caused by the energy consumption during the precooling periods.

Table 4-16: Contrast of Energy Savings (kWh) for Devices with Different Precool Modes

Date	Precool Duration (Min)	Number of Available Devices	Savings per Device (kWh)			
			Event Hours	Snapback Hours	Precool Hours	Total
6/24	60	6,998	3.60	-0.75	-0.85	2.01
	0	7,110	3.34	-0.69	-	2.66
7/31	60	9,190	3.71	-0.67	-0.83	2.22
	0	7,811	3.57	-0.75	-	2.82
8/1	60	9,164	3.42	-0.93	-1.01	1.48
	0	7,825	3.27	-1.14	-	2.13
8/6	60	9,166	3.39	-1.31	-1.00	1.08
	0	7,928	3.26	-1.20	-	2.06

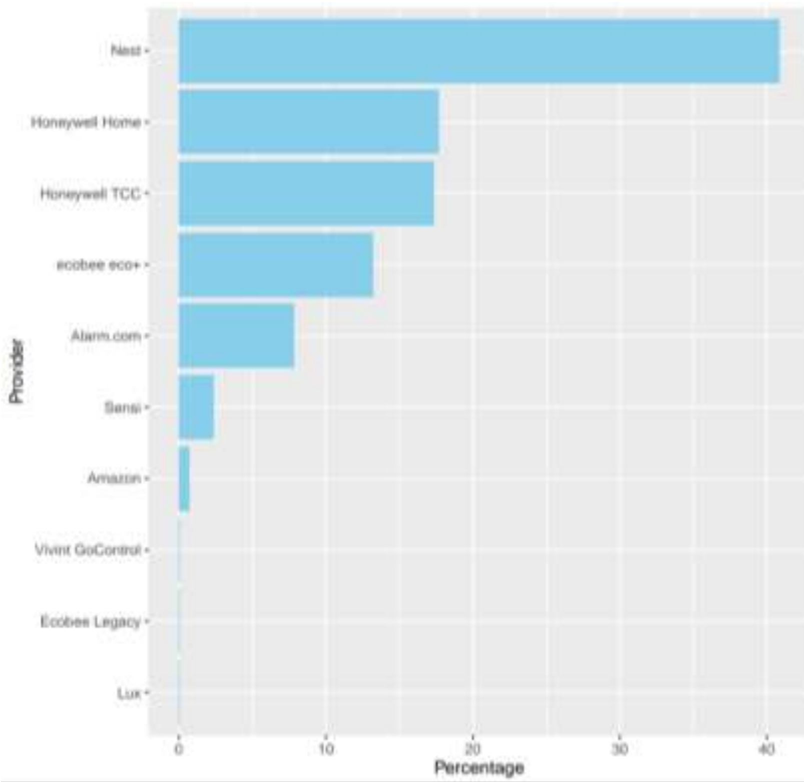
4.1.4 Process Evaluation Findings

ADM's process evaluation activities included a review of program materials, a participant survey, and program staff interviews. A process evaluation memo was delivered to PSO after the completion of the 2024 program year which includes details of the methodologies and findings. This section summarizes findings from the process evaluation.

4.1.4.1 Program Activity

The Power Hours Program had 13,611 participating customers with 17,467 devices in 2024. Nest thermostats accounted for 41% of the thermostats participating in the Power Hours program, followed by Honeywell (35%) and Ecobee (13%). (see Figure 4-3)

Figure 4-3: Thermostats Participating in Power Hours



4.1.4.2 Participant Survey

ADM administered an online survey to collect information about participants' experiences and satisfaction with the Power Hours program for 2024. Evaluators developed the survey to address program awareness, program satisfaction, and demographics (Table 4-17 summarizes the results from the email campaign).

Table 4-17: Summary of Email Campaign

Survey Statistics	Count
Number of participants initially contacted by email	2,614
Number of undelivered emails	63
Completed surveys	357
Response rate	14%

New enrollees provided feedback about the most influential factors in their decision to enroll in the program, with 59% primarily driven to save money on their energy bills, followed by 23% who mentioned that the enrollment incentive played a significant role in their decision (see Table 4-18). Additionally, 14% indicated their enrollment was motivated by a commitment to reducing energy consumption to address climate change and 4% cited the program's recommendation by PSO. Participants cited a range of other reasons for enrolling in Power Hours (e.g., saving electricity, money, and energy). Some highlighted the program's incentives and financial benefits as motivating factors. Additionally, the convenience of automatic temperature adjustments, the potential to help the grid, and a focus on energy conservation were among the other reasons for enrollment.

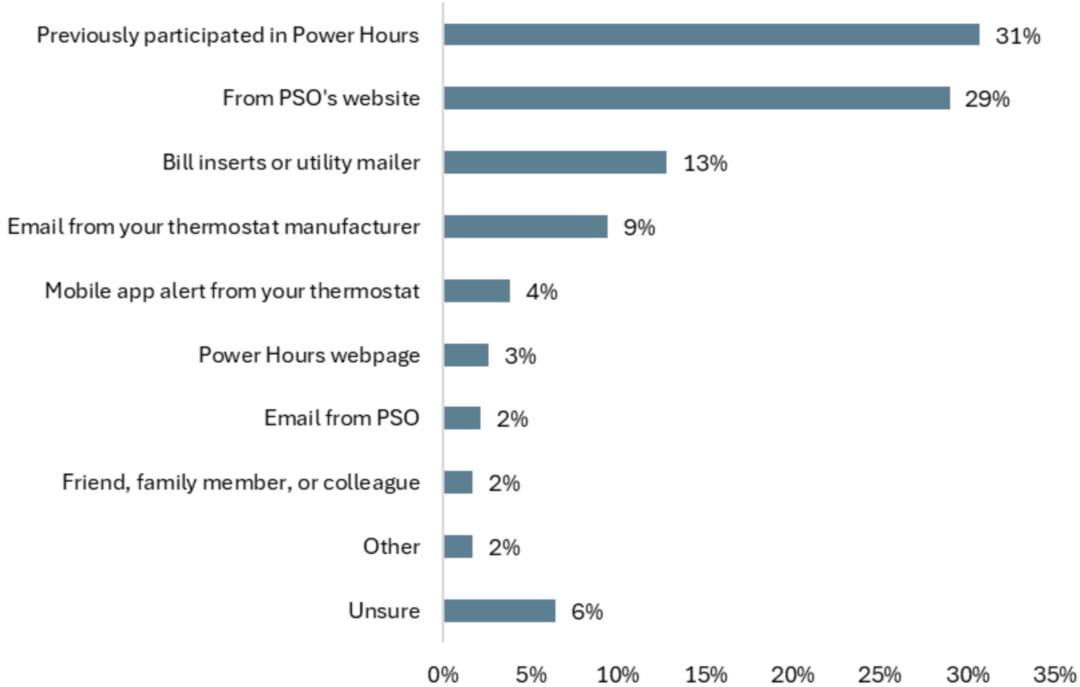
Table 4-18: Reasons to Enroll in the Power Hours Program

Response	Percentage of Respondents (n = 70)
Save money overall on energy bills	59%
The enrollment incentive	23%
Program was recommended by PSO	4%
To reduce energy to address climate change	14%

4.1.4.2.1 Program Awareness & Enrollment

Most respondents learned about Power Hours through previous participation (31%) and PSO’s website (29%).

Figure 4-4: Sources of Program Awareness



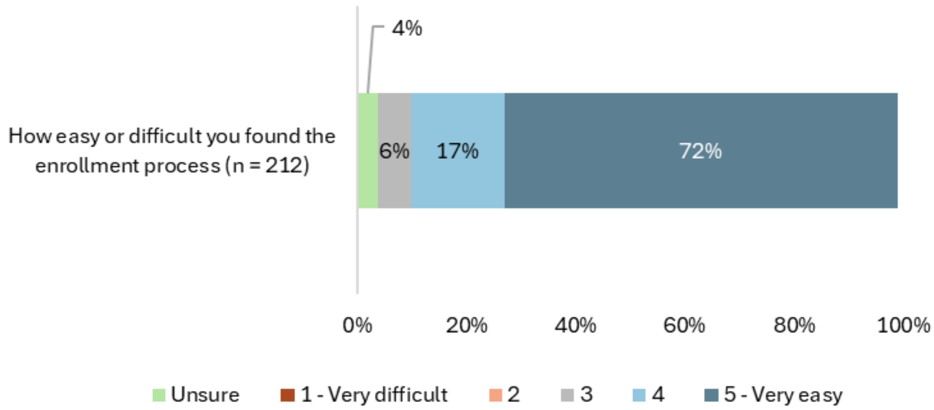
A significant portion of respondents (65%) reported receiving and reading emails from PSO regarding Power Hours, followed by 44% of participants who visited the PSO website. Most new participants indicated they enrolled in the program through PSO's website (66%), while 24% enrolled through their thermostat mobile app (see Table 4-19)

Table 4-19: Enrollment Channels

Response	Percentage of Responses (n = 233)
Online through PSO's website	66%
Thermostat mobile app	24%
Some other way	1%
Unsure	9%

Seventy-two percent of respondents found the enrollment process very easy (see Figure 4-5). Among those who found the process somewhat challenging, issues were noted with unenrolling from the program, which required multiple steps, including phone calls and emails.

Figure 4-5: Customers' Ease of Enrollment and Registering Thermostat



New enrollees provided feedback about the most influential factors in their decision to enroll in the program (see Table 4-20). Additional reasons included contributing to grid stability and supporting efforts to mitigate system strain during high-demand periods. For some, the program aligned with existing habits of energy monitoring.

Table 4-20: Reasons to Enroll in the Power Hours Program

Response	Percentage of Respondents (n = 233)
Save money overall on energy bills	49%
The enrollment incentive	25%
To reduce energy to address climate change	17%
Program was recommended by PSO	9%

4.1.4.2.2 Precooling

The 16 participants who were aware of the pre-cooling found it effective and generally positive. Many felt it worked well or had no noticeable impact, and some appreciated the consistent comfort it provided during peak events. A few respondents indicated no clear change in their experience, while one user expressed concern that pre-cooling might increase electricity use, preferring to have an option to disable it.

4.1.4.2.3 Peak Events

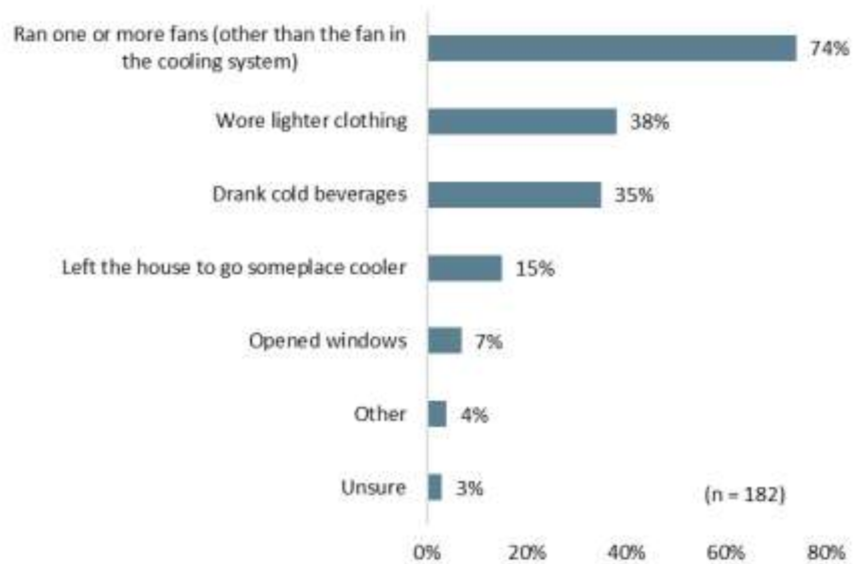
Participants provided feedback on their experiences with peak events (see Table 4-21).

Table 4-21: How Participants First Became Aware of a Peak Event

Response	Percentage of Responses (n = 271)
Saw the notice on the app on phone	28%
Noticed the difference in how the home felt	27%
Saw the notice on thermostat	23%
Was not aware of peak events	16%
Other	2%
Unsure	3%

During peak events, most respondents (62%) found their home to be somewhat less comfortable than usual, while 26% did not observe any change in comfort. Many participants ran fans during events to remain comfortable, followed by wearing lighter clothing, or drinking cold beverages (see Figure 4-6).

*Figure 4-6 Actions Taken During Peak Events to Remain Comfortable**



**Survey respondents who indicated they did nothing or were not home for any events were removed from the figure.*

In response to peak events, 30% of participants indicated that someone in their home overrode the temperature adjustment made by the thermostat, while 58% reported no adjustments, and 12% were unsure. Among those who overrode the settings, the majority (68%) cited discomfort as the main reason for adjusting the thermostat back, while 15% reported that someone else in the home, unaware of the event, made the change.

More than half of the survey respondents (56%) indicated the number of peak events that occurred over the summer was about what was expected (see Table 4-22). Those who anticipated fewer events indicated they expected approximately 11 peak events. About six peak events are what was expected among those who indicated there were more events than they had anticipated.

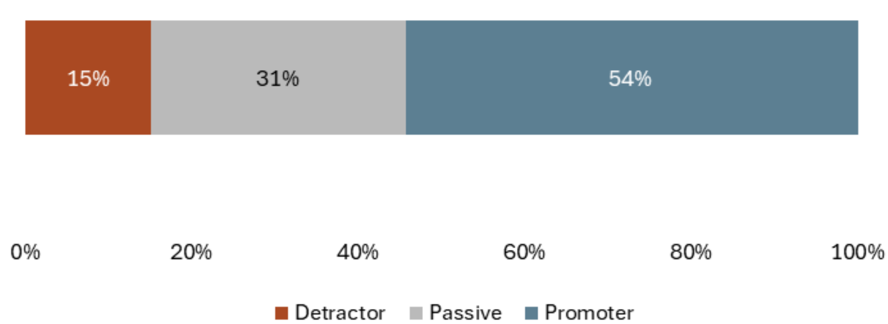
Table 4-22: Expected Number of Peak Events

Response	Percentage of Responses (n = 356)	Average Number of Anticipated Peak Events
More than expected	7%	6
About what was expected	56%	n/a
Fewer than expected	18%	11
Unsure	19%	n/a

4.1.4.2.4 Participant Satisfaction

The overall net promoter score (NPS) for Power Hours was 39%. Most survey respondents (54%) were considered promoters, 31% were passive, and 15% as detractors. (see Figure 4-7)

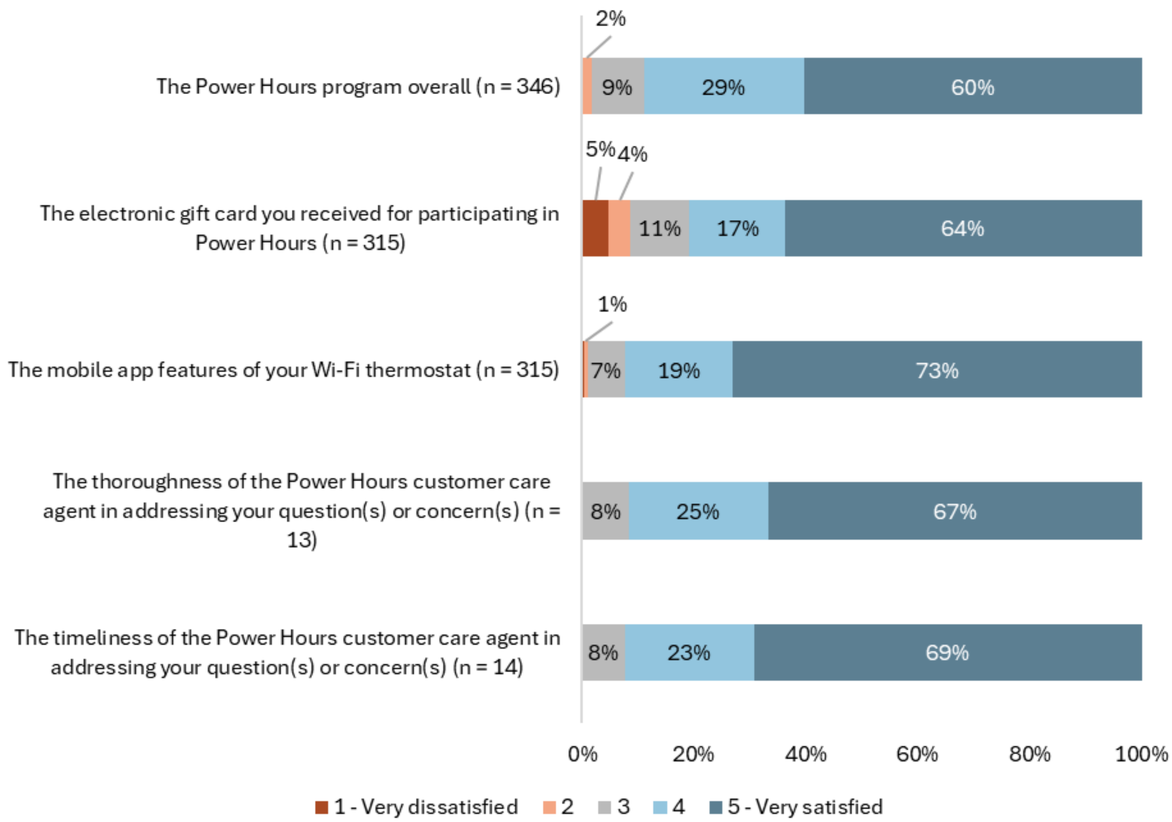
Figure 4-7: Net Promoter Score (n = 357)



Promoters praised the program for its financial savings, environmental benefits, and ease of participation. Some felt it fostered community responsibility by helping prevent grid strain and outages. Passive respondents generally had a neutral or mildly positive view of the program. Some felt it was only beneficial under certain conditions, such as being away during peak hours. Most were willing to recommend it but only discussed it when prompted, as thermostat or energy topics are rarely brought up among friends and family. Many detractors of the program mentioned discomfort, lack of savings, and logistical challenges. Some felt the financial benefits did not justify the inconvenience of adjusting temperatures. Issues with the thermostat app, mistrust of utility motives, and doubts about environmental impact were also noted. Health needs, minimal savings, and rare energy discussions made some hesitant to recommend the program.

Many survey respondents (89%) were very or somewhat satisfied with the program overall (see Figure 4-8).

Figure 4-8: Participant Satisfaction



4.1.5 Conclusions and Recommendations

The following summarizes the key findings from the evaluation of the Power Hours program:

- **Demand Reduction:** Demand reduction is highest at the beginning of the event, dropping to approximately half by the end of the second hour.
  - Device response rate was greater than 80% for all events.
  - Devices receiving pre-cooling saw similar or slightly higher reduction during the first hour of the event and higher reduction in the second hour.
- **Program Design and Implementation:** The program maintained its design in 2024, with enrollment through thermostat apps and OEM partners. Enhancements included automatic mailing of physical gift cards if e-gift cards remained unused after seven days and a switch to Choice Digital for improved satisfaction.
- **Participant Experience**: Most participants found enrollment easy, citing financial savings, incentives, and environmental benefits as motivators, though some faced challenges with unenrollment, login, and Wi-Fi connections. The program achieved

a net promoter score of 39%, with satisfaction driven by savings and ease of use, while detractors mentioned discomfort, low savings, and app issues. Dissatisfaction with electronic gift cards highlighted a preference for physical cards or billing credits.

- **Precooling and Peak Events:** Less than half of respondents were familiar with precooling, though those who noticed its effects found them positive despite concerns about increased energy use. Peak events were identified via app notifications, comfort changes, or thermostat alerts, with participants often running fans or adjusting clothing to stay comfortable. About one-third overrode thermostat settings during social gatherings or hot days.

The following recommendations are offered for continued improvement of the Power Hours program:

- **Motivate event participation:** Not all thermostats responded to events, and some participants overrode the thermostat setback during events. ADM recommends exploring options to provide additional motivation for full participation during events. An additional raffle for each event or a series of events could increase event participation.
- **Simplify Website Information**: ADM recommends exploring ways to update the website to clearly explain incentives and program benefits. One possibility would be to include detailed information about available incentives, the benefits of participating in program events, and managing thermostat settings after events.
- **Enhance Communication Channels**: ADM recommends expanding targeted email campaigns with clear messages about incentives and benefits of participating in the Power Hours program. To expand targeted email campaigns, PSO could utilize customer data to identify key segments, develop personalized content that highlights Power Hours incentives, and optimize messaging to enhance engagement. Continue to collaborate with thermostat manufacturers to communicate about Power Hours during purchase or installation.
- **Inform Participants about Precooling**: ADM advises increasing awareness of the benefits of precooling while addressing concerns about energy consumption. Provide detailed descriptions of how precooling works to ensure comfort and reduce energy costs.

4.2 Peak Performers Program

This chapter presents findings from the impact and process evaluation of the 2024 Peak Performers Program.

4.2.1 Program Overview

The Peak Performers program is a demand response (DR) program that provides incentives to commercial and industrial (C&I) customers that can, on short notice, reduce their electric usage to provide extra capacity during hours of peak demand.

The Peak Performers program is run between June 1 and September 30, which is the height of the cooling season. Participation among businesses is completely voluntary. Businesses who choose to participate are typically given at least two hours of advanced notice via email or text message and are requested to reduce electric consumption over a requested period, known as a “Peak Event.” A Peak Event may be called for a duration of two to four hours on any weekday from 1 p.m. to 7 p.m., excluding holidays. Businesses can opt out of any event and will not be penalized. Program agreements specify that there will be no more than three events during any one calendar week and no more than 16 events in each season. At the end of the season, participants are reimbursed based on verified demand savings at a rate of $32 per average kW reduction. A bonus equivalent to 5% of the total payout will be paid to customers who participate in all Peak Events.

A total of 228 customers and 1,867 premises participated in the program during 2024 with 828 participating in all events. Table 4-23 shows the performance metrics achieved by the program.

Table 4-23: Performance Metrics – Peak Performers

Metric	2024
Number of Customers	228
Number of Premises	1,867
Budgeted Expenditures	$4,294,431
Actual Expenditures	$5,410,697
Energy Impacts (kWh)	
Projected Energy Savings	76,090
Reported Energy Savings	0
Gross Verified Energy Savings	1,134,454
Net Verified Energy Savings	1,134,454
Peak Demand Impacts (kW)	
Projected Peak Demand Savings	77,860.80
Reported Peak Demand Savings	114,994.49
Gross Verified Peak Demand Savings	107,841.23
Net Verified Peak Demand Savings	107,841.23
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	10.50
Utility Cost Test Ratio	2.96

4.2.2 EM&V Activities

The section below presents the impact and process evaluation methodologies to assess the 2024 Peak Performers program. The purpose of the impact evaluation is to determine gross verified peak demand savings (kW) and gross verified annual energy savings (kWh). Savings are verified by developing a counterfactual baseline consumption curve and calculating the difference between the baseline curve and actual consumption throughout the Peak Event. The purpose of the process evaluation is to assess program design, operations, and delivery through a facilitated discussion about the program logic model and participant surveys.

4.2.2.1 Data Retrieval and Review

The impact of peak events is analyzed using program tracking data and interval meter data for all program participants. This data was accessed and delivered to ADM via AEG’s SQL Server Reporting Services (SSRS). Software written in R's statistical programming language was used to process and analyze the data. Various data processing steps are applied to the data before analyzing. These steps include:

- Validating that the files are not corrupt and of a consistent size.
- Extracting and transferring data from these files.
- Identifying any periods of missing interval meter data for any of the program participants.
- Updating PSO with remaining data needs (i.e., if files were missing or corrupted).

After the above steps are performed, the data is ready for analysis.

4.2.2.2 Calculating Baseline Demand Curves

Baseline demand curves are developed for each customer with the data provided. These are used to estimate what the demand would have been during an event day had the event not occurred. In PY2024, ADM employed multiple baseline methodologies and selected the best-fitting models for each premise number.

To choose the most accurate baseline model for each premise, ADM evaluated each model's performance on the 30 weekdays over the program year where demand is highest (07/01/2024, 07/02/2024, 07/03/2024, 07/10/2024, 07/12/2024, 07/15/2024, 07/17/2024, 07/18/2024, 07/19/2024, 07/25/2024, 07/26/2024, 07/29/2024, 07/30/2024, 07/31/2024, 08/02/2024, 08/05/2024, 08/08/2024, 08/12/2024, 08/13/2024, 08/14/2024, 08/15/2024, 08/16/2024, 08/19/2024, 08/20/2024, 08/21/2024, 08/22/2024, 08/23/2024, 08/28/2024, 08/29/2024, 08/30/2024) during typical demand response hours for each premise number. These days were chosen from all non-event, non-holiday[57] weekdays during the months of July to August. ADM also excluded days with apparent non-routine adjustments (08/07/2024, 08/26/2024, and 08/27/2024) after visually checking the hourly energy consumption profiles. These will be referred to throughout the report as "proxy event days". Performance was measured by fitting every type of baseline model to each proxy event day and calculating the residual root mean squared error (RRMSE) scores of each model's predictions.

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 five models for each premise number. The weights were the inverse squares of the model RRMSEs. For example, if the five best-fitting models have RRMSEs of 5%, 11%, 25%, 40%, and 52% respectively, their relative weights will be 78.6%, 16.2%, 3.1%, 1.2%, and 0.7% respectively.

[57] ADM defined a "holiday" as any date that falls on a U.S. federal holiday or observed U.S. federal holiday. See https://www.opm.gov/policy-data-oversight/pay-leave/federal-holidays/#url=Historical-Data for a complete list.

4.2.2.3 Savings Calculations

With baseline demand curves determined for each participant, demand reduction can be calculated by comparing it to the site-specific actual consumption on the day of a Peak Event. Demand reduction represents the average decrease in demand that occurs for an event participant during an hourly period. Demand reductions during peak events are estimated on a premise-by-premise basis. Equation 4-3 shows the formula for calculating demand reduction.

Equation 4-3: Hourly Demand Reduction Calculation

$$kW_t^{reduction} = kW_t^{baseline} - kW_t^{actual}$$

Where:

t	= the hourly 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

Peak demand reduction is calculated by taking the average of every hourly demand reduction that occurred during the event period; the event period being the time from when the event starts to when the event ends. The equation is shown in Equation 4-4. The seasonal peak demand reduction was then calculated as the mean reduction of all the event hours.

Equation 4-4: DR Event Peak Demand Reduction (kW) Calculation

$$kW_{reduced} = \frac{1}{|EventPeriod|} \sum_{t \in EventPeriod} kW_t^{reduction}$$

Where:

t	= an hourly interval
EventPeriod	= all time intervals from event start hour to the event ending hour
$kW_t^{reduction}$	= hourly demand reduction calculated at time t

Hourly demand reduction is also used to calculate the energy savings for a given premise/event. The total DR event energy savings for a premise/event is calculated by summing together the hourly demand reduction that occurred at every hour during a DR event day[58]. The equation is shown in Equation 4-5. The seasonal energy savings was then calculated as the sum of the savings of all the events.

[58] Note that the entire day is used for calculating energy savings because previous years have indicated that some load shifting was occurring during the event day. Therefore, the entire day must be used as the evaluation period to accurately capture energy savings.

Equation 4-5: DR Event Energy Savings (kWh) Calculation

$$kWh_{saved} = \sum_{t \in EventDay} kW_t^{reduction}$$

Where:

t = an hourly interval

EventDay = all hourly time intervals that occur during a DR event day

$kW_t^{reduction}$ = hourly demand reduction calculated at time t

4.2.2.4 Process Evaluation

ADM evaluators completed a process evaluation to assess the Business Demand Response program, also referred to as Peak Performers. During 2024, the evaluators assessed program design, operations, and delivery through a program staff interview and participant surveys.

The evaluation addressed the following research questions to better understand the program’s effectiveness and efficiency.

- What modifications, if any, have been implemented in the program design or procedures compared to previous years?
- Did the execution of the program align with its intended design? Are there opportunities for enhancing the program's design or implementation process?
- How do PSO customers become aware of this program, and what factors influenced their decision to participate? Have there been any discernible patterns in enrollment?
- How does PSO market the program, and which types of participants are targeted (e.g., sectors, business sizes, service territory areas)? What marketing methods have proven most effective?
- To what extent were participants satisfied with their experience, including reimbursement amounts, the enrollment process, and other aspects of program participation?
- Has participating in the program prompted involvement in other PSO initiatives or additional energy efficiency actions not endorsed by the program?
- What types of businesses actively participate in the program?
- How and when did participants receive notifications about program events?

- What were the notable successes and challenges experienced during each program year?
- Looking ahead, what are the primary barriers and drivers influencing program success within PSO's market?

Table 4-24 below summarizes the data collection activities and corresponding process evaluation research objectives used to complete the process evaluation.

Table 4-24: Peak Performers Process Evaluation Data Collection Activities Summary

Data Collection Activity	Process Evaluation Research Objectives
Program Materials Review	Examine reports and support materials to ensure they are clear and align with program goals.
Participant Survey	Evaluate why participants joined and their satisfaction with the program.
Program Staff Interview	assess program staff perspectives on operations, strengths, weaknesses, challenges, and improvement opportunities.

A detailed report on the methodologies and findings of the process evaluation was delivered to PSO in December 2024.

4.2.2.5 Net-to-Gross Methodology

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. 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 DLC events. This program was not expected to generate significant spillover effects; therefore, the evaluators did not assess spillover.

4.2.3 Impact Evaluation Results

The methods described in this section were used to determine the impacts on customer energy use for each participant. Aggregated participant results determine program level impact for the peak demand reduction (kW) and energy savings (kWh). Findings are presented and discussed in this section.

4.2.3.1 Peak Events

In 2024, three Peak Performers Demand Response events were called. The schedule of these events is summarized in Table 4-25.

Table 4-25: Summary of Peak Performers Demand Response Events

Date	Event Start Hour	Event End Hour	Duration (Hours)
07/16/2024	14	17	3
08/01/2024	14	17	3
08/06/2024	14	17	3

A baseline demand curve was developed for each premise for each event day, used to estimate what the demand would have been during the event day had the event not occurred.

ADM chose 30 proxy event days based on which non-event; non-holiday weekdays had the highest overall energy demand within the participant population. Proxy event days are meant to closely represent the conditions of a regular event day. Therefore, an accurate baseline methodology should be able to closely predict actual demand during each of the proxy event days. Figure 4-9 shows the sum of actual demand (all premises) as well as the sum of predicted baseline demand during each proxy event day, for the entire participant population.

Figure 4-9: Actual vs. Baseline Energy Demand -- Proxy Event Days

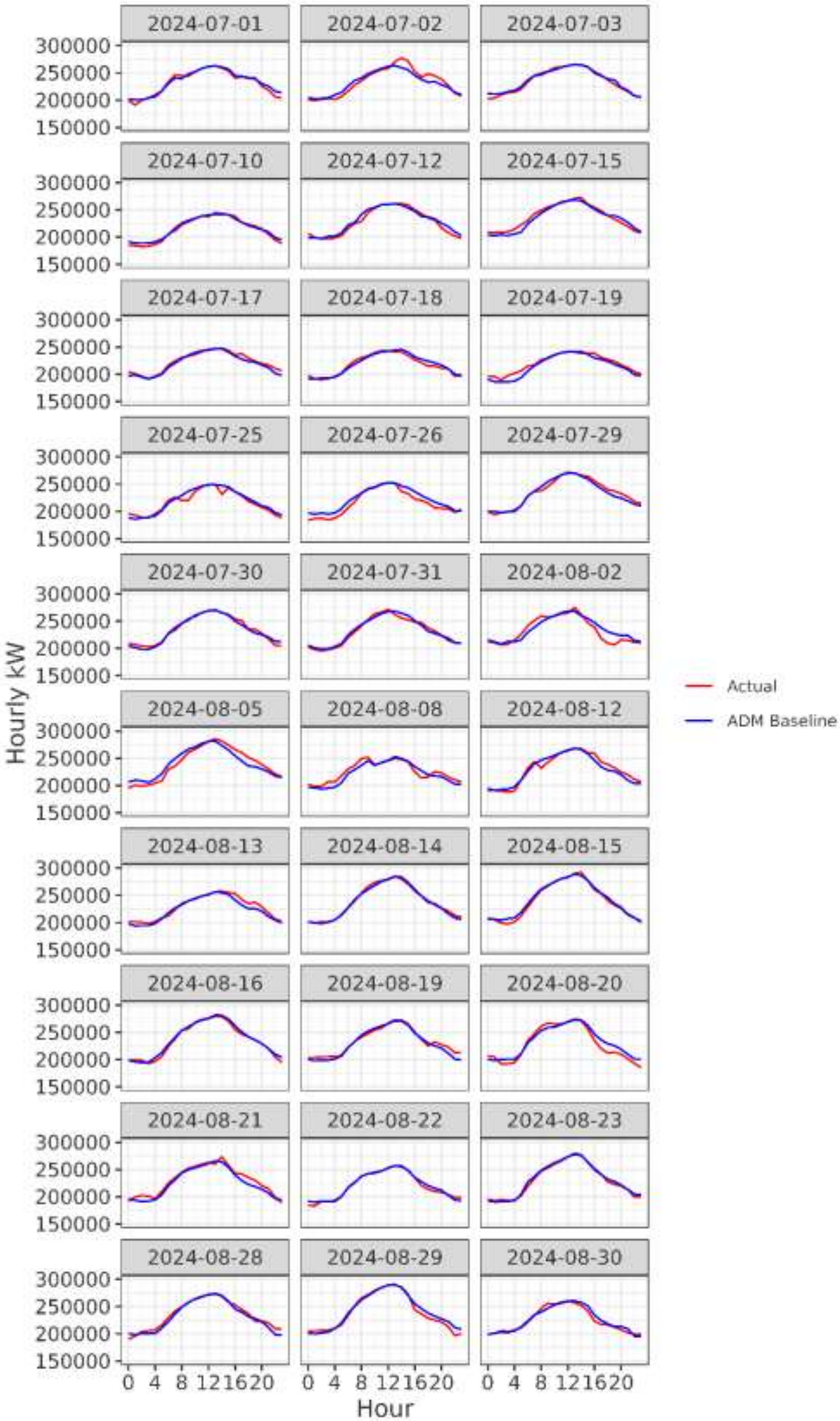
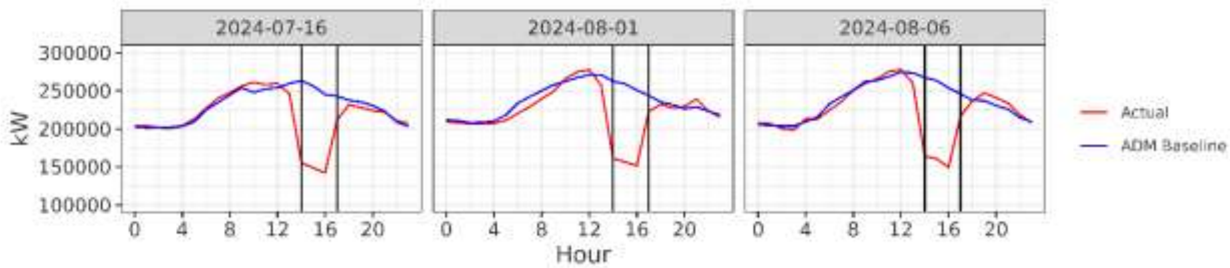


Figure 4-10 shows the sum of actual energy demand as well as the sum of predicted baseline demand during each peak event day, for the entire participant population. The grey area represents the event period.

Figure 4-10: Peak Performers Actual vs. Baseline Energy Demand – Peak Event Days



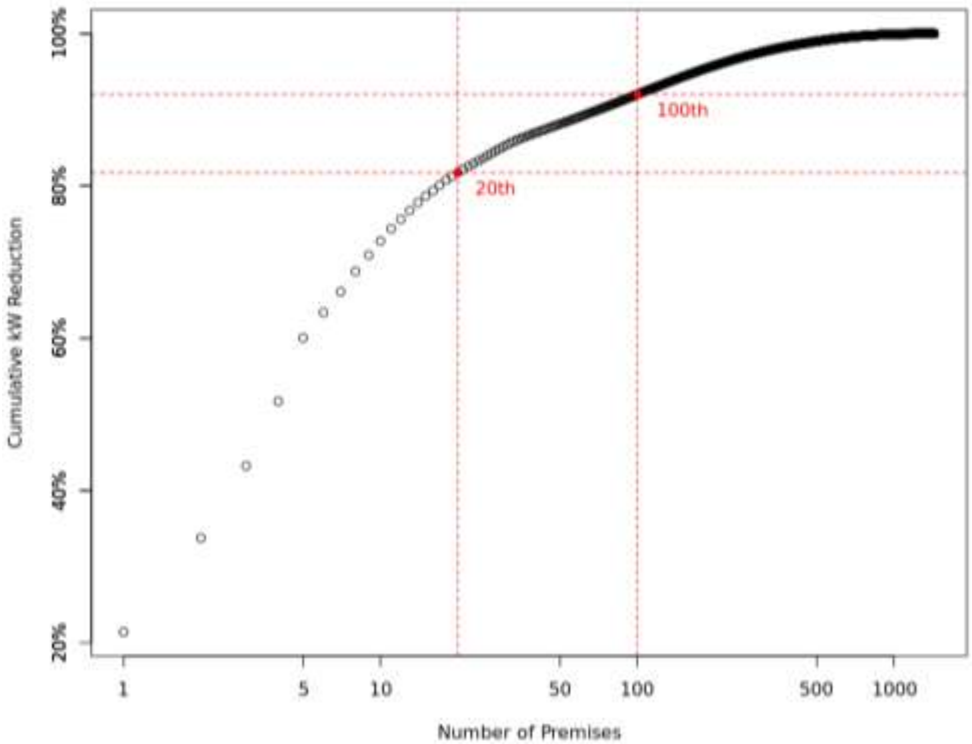
The difference between the modeled baseline and actual demand for each hour of each event was calculated for each premise. Consistent with industry standards for calculating peak demand reduction, such as the Uniform Methods Project (UMP), the peak demand reduction for each event was determined as the average reduction across event hours for each premise. Therefore, the total peak demand reduction per event is the summation of each premises hourly average reduction during the event. The total peak demand reduction for the program is the average reduction across all events. Table 4-26 shows the peak demand reduction for each event as well as how many participants curtailed consumption.

Table 4-26: Program-Level Peak Demand Reduction (kW) per Event

Date	Participants	Non-Participants	Percent kW Reduction (%)	Peak Reduction per Event (kW)
07/16/2024	1,533	184	50.5	108,097.17
08/01/2024	1,146	566	59.2	107,007.63
08/06/2024	1,202	210	57.9	108,418.88
PY2024 Verified Peak Demand Reduction (kW)				**107,841.23**

The program's total kW peak reduction is largely contributed by the top premises. The cumulative fraction of peak reduction is shown in Figure 4-11. The top 20 premises with the highest kW peak reduction contributed to 81% of the program's total peak demand reduction.

Figure 4-11: Cumulative kW Reduction for top sites



Participant incentives are determined based on reported estimates of peak demand reduction. A comparison of reported estimates to verified results is shown in Table 4-27.

Table 4-27: Peak Demand Reduction Results

Reported Peak kW	Verified Peak kW	Peak kW Realization Rate
114,996.14	107,841.23	93.8%

Energy savings were calculated for each event. Total energy savings for each event were calculated by summing the hourly demand reduction values for each premise during every hourly period on a peak event day. Table 4-28 shows the total energy savings for each event and the total across all events.

Table 4-28: Energy Savings (kWh) per Event

Date	Total Energy Savings (kWh)
07/27/2024	360,181
08/02/2024	438,737
08/03/2024	335,536
Verified Energy Savings (kWh)	**1,134,454**

4.2.3.2 Lifetime Energy Savings

Energy impacts 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.

4.2.4 Process Evaluation Findings

This section presents findings from the 2024 program year process evaluation.

4.2.4.1 Participant Survey Results

ADM administered an online survey to program participants between November 2024 and December 2024. The survey was conducted to collect data on how participants learned of the program, satisfaction with the events, and overall program satisfaction. ADM sent the online survey to 212 program contacts. Thirty participants completed the survey. Table 4-29 summarizes the responses to the survey.

Table 4-29: Participant Survey Response

Response Metrics	Number of Participant Contacts
Participants Contacted by Email	212
Email Undelivered	29
Completed Surveys	30
Response Rate	**16.5%**

Survey participants represented various industry sectors. Thirty percent were from the educational institutes, followed by municipalities and public entities at 20%, manufacturing and industrial at 17%, religious organizations at 13%, and retail and commercial at 10%. Other sectors included insurance and technology (7%) and other organizations (3%).

Thirty-seven percent of survey respondents indicated their role was financial or administrative, and an additional 17% were presidents/CEOs. Other roles included managers, energy managers/specialists, and facility managers (see Figure 4-12).

Figure 4-12: Respondent's Job Title (n = 30)

Most respondents (87%) indicated their role involves communicating with others in the organization when a peak event is happening. A significant portion (83%) serves as the organization's point of contact for the Peak Performers program. Additionally, 53% reported signing the organization up for the program, and an equal percentage manage energy use during a peak event. See Table 4-30 for more details.

Table 4-30: Survey Respondent's Role in Peak Performers

Response	Percentage per Response (n = 30)
Communicated to others that the peak events were happening	87%
Primary point of contact for Peak Performers	83%
Signed up for program on behalf of organization	53%
Managed energy use during peak events	53%

4.2.4.1.1 Event Participation

The Peak Performers program outlines that up to 16 events can be conducted within a program year, with three events taking place in 2024. Ninety-seven percent of survey respondents accurately recalled the number of events their organization participated in. Most respondents (77%) indicated they did not opt out of any events, whereas 3% opted out of one event (20% could not recall whether they had opted out of any events). The sole participant who opted out of an event cited the absence of the individual responsible for managing energy use on the event day as the reason.

Sixty percent of respondents found the number of peak events aligned with their expectations. Meanwhile, 37% experienced fewer peak events than anticipated, and none reported more peak events than expected. Additionally, 3% expressed uncertainty regarding their expectations about the peak events in 2024 (see Table 4-31).

Table 4-31: Expected Number of Events per Year

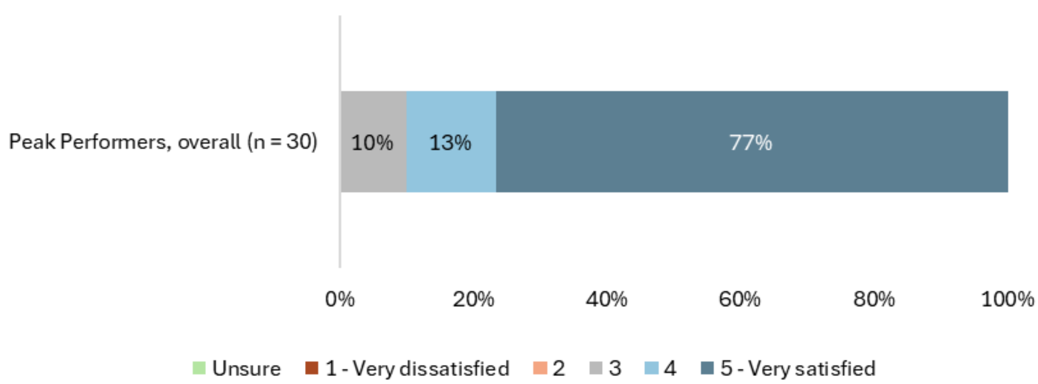
Response	Percentage per Response (n = 30)
Less than expected	37%
About what was expected	60%
More than expected	0%
Unsure	3%

Thirty percent of surveyed organizations preferred participating in 5 to 7 events per year, followed by 2 to 4 events (23%). Additionally, 27% were open to participating in as many events as needed, while a few preferred fewer events or were uncertain.

4.2.4.1.2 Participant Satisfaction

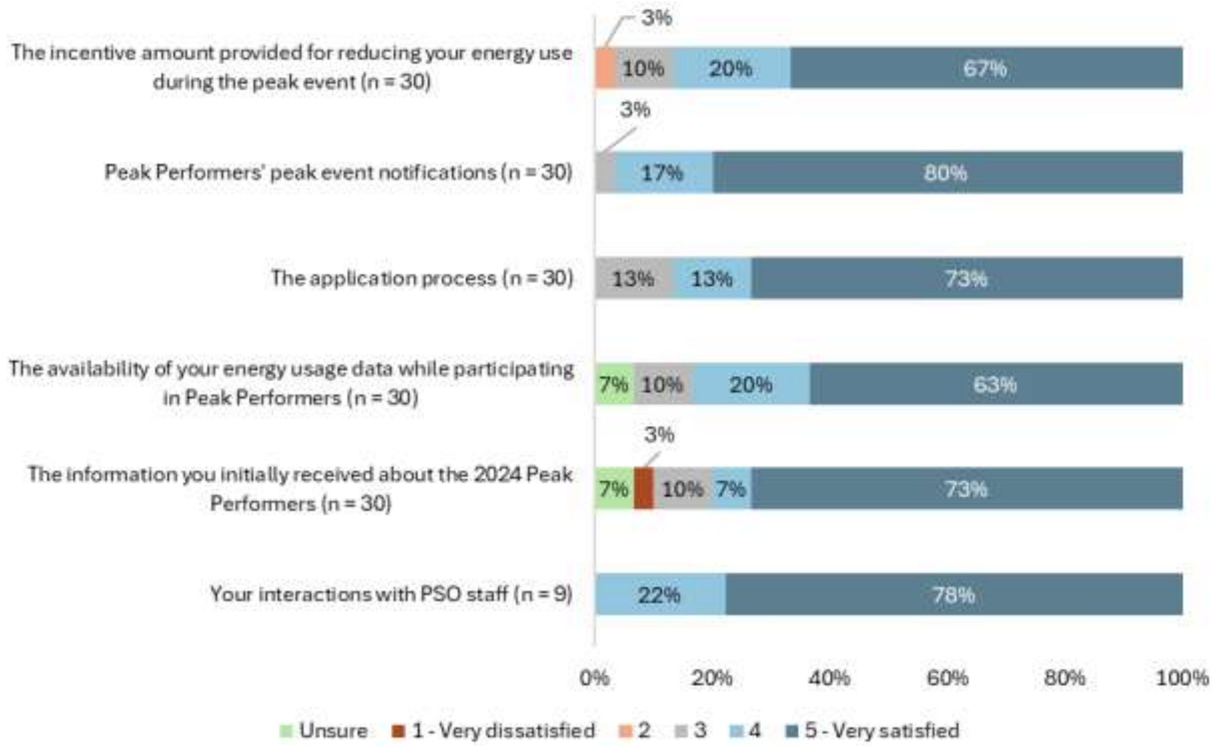
As illustrated in Figure 4-13, 90% of participants are somewhat or very satisfied with the program overall. Ninety-three percent of participants indicated they were very likely to participate in Peak Performers again in 2025. One respondent provided feedback as to why their organization may not participate in 2025. The organization may not participate depending on how the program aligns with their needs and the return on investment, with a preference for more incentives to install solar on their building for long-term benefits.

Figure 4-13: Overall Satisfaction with Peak Performers



Participant survey findings indicate a strong overall satisfaction with the program, with most respondents rating their experiences positively. Specifically, 73% were very satisfied with the initial information received about the program. Similarly, satisfaction with the availability of energy usage data, the application process, and peak event notifications was high, with 63% to 80% rating these aspects as very satisfactory. The incentive amount for reducing energy use and the program overall also received positive feedback, with 67% and 77% of respondents, respectively, expressing strong satisfaction. See Figure 4-14 for more details.

Figure 4-14: Participant Satisfaction



Respondents expressed satisfaction with various aspects of the program, including effective notifications, ample time to prepare for events, and the overall ease of participation. They appreciated the communication about peak events, the opportunity to earn money back, and the program's positive impact on energy savings. Many also highlighted the program's cooperative nature, the flexibility of event scheduling, and the ease of renewing annually. Participants valued the program's reminders to reduce energy usage and the ability to use emergency generators during events. The dissatisfaction stemmed from the incentive being insufficient to outweigh the discomfort of staff working in a hot office during a peak event.

4.2.4.1.3 Net Promoter Score

Peak Performers received a net-promoter score[59] of 63%, with 73% of respondents being promoters, 17% were passive, and 10% were detractors.

[59] The net promoter score® is equal to the % of Promoters - % of Detractors. Promoters are respondents who rate the likelihood of recommending the service as 9 or higher on a 0-10 point scale. Detractors are those who rate it as 6 or lower on the same scale.

Promoters were satisfied with the Peak Performers program, citing great communication, easy participation, and suitable incentives. They valued its environmental and community benefits, reimbursement, and minimal team time needed. Many praised the smooth process, open communication, and strong partnership with PSO.

Passive respondents indicated a preference for earlier notification of peak events to enhance preparation and staff notification, although they acknowledged the rationale behind short notice. Several respondents noted that the program functions effectively within their organization.

Detractors expressed that the program's short-term energy savings may not outweigh the organization's broader needs. Some participants felt the incentives were insufficient and participated mainly to support the utility and community, while one respondent noted a lack of visible results and understanding of the program's efficiency.

4.2.5 Conclusions and Recommendations

The following summarizes the key findings of the evaluation of the Peak Performers Program:

- **The verified peak demand reduction for the 2024 program year is 107,841.23 kW, and the verified annual energy savings for the year are 1,134,454 kWh**. The percentage of load reduction ranged from 50.5% to 59.2% across three events. The program called three three-hour events, two less than last year but longer (the program in 2023 called five two-hour events).
- **The peak demand reduction is largely contributed by the top premises**. The top 20 premises with the highest kW peak reduction contributed 81% of the program's total. There were seven premises that were among the top-20 energy consumers had average peak demand reduction less than 33.3%.
- **The program realization rate is 93.8% when comparing the verified reduction to the reported values.** The is primarily due to differences in calculating the counterfactual baseline energy consumption. ADM used a weighted average of the best five models, each based on different combinations of the top 'm out of n' days in energy consumption. In contrast, the reported values relied on a single model that considered only the top three days.
- **The outlook for the program in PY2025 was positive, with no foreseen challenges in meeting goals.** The program's strengths include a customer-centric approach, offering autonomy, simplicity, and financial incentives. Participants appreciate the ease of participation, with flexibility and no penalties for non-participation. Monetary compensation is especially beneficial for public schools, providing additional funds through their curtailment efforts.

- **Survey participants had positive and effective communication experiences.** Overall satisfaction with the program was reported at 90%. Participants noted ease of participation, event notifications, and energy savings incentives as positive aspects. Communication about peak events was appreciated, though some wanted earlier notice to prepare staff. While most found the incentive adequate, a few felt it didn't justify the discomfort of participation. Despite this, the program's communication was effective and well-received.
- **Most participants were satisfied with the event frequency.** 60% of surveyed participants reported that the number of peak events in 2024 met their expectations. Most organizations preferred to participate in 5 to 7 events per year, with some expressing flexibility for additional events as needed, but the consensus was that the level of involvement was manageable.
- **A significant success this year was the increase in megawatt reduction, largely driven by data centers.** This, along with greater engagement from existing participants, showcases the program's effectiveness in targeting high-energy users and maintaining strong performance. However, challenges with the Vision system remain, necessitating improvements to better support the program's growth in the future.

The following recommendations are offered for continued improvement of the Peak Performers program.

- **Review the payment structure to encourage broader participation.** A few businesses have the potential to use most of the funds available for incentives. While the savings potential is great for the program, it may limit smaller businesses from participating. ADM recommends a review of the payment structure to ensure the program is available to all who would like to participate.

5 Research & Development Pilot Programs

The 2022-2024 Demand Side Management (DSM) filing for Public Service Company of Oklahoma (PSO) provided a provision to conduct research and development projects to discover new or improved energy efficiency and demand response processes, products, and services. The studies include behind-the-meter battery and connected water heater energy storage systems, non-wires solutions, new construction manufactured homes, efficient homes and communities, heat pump water heaters, and a virtual diagnostics tool (VDT) to support demand-side management. The follow sections provide a summary of research activities and results.

- Virtual Diagnostics Tool (VDT) - use AMI meter data to identify new energy efficiency and demand response opportunities for residential and commercial customers.
- Efficiency Homes and Communities - reviewed and field test residential technologies.
    - Housing Authority Cherokee Nation
    - Weldon House Project Achievements
    - Energy Star New Construction Manufactured Homes and Cool Roofs
    - Heat Pump Water Heater
- Demand Management Integrated Resources - researched innovative and emerging technologies to enhance demand response program offerings.
    - Behind the Meter Battery Energy Storage System (BTM BESS)
    - Connected water heater controls
- Non-Wires Alternative Pilot Study - researched a constrained circuit(s) in the service territory to reduce demand through energy efficiency and other measures.

5.1 Virtual Diagnostics Tool (VDT)

PSO implemented a Virtual Diagnostics Tool (VDT) to help PSO identify residential customers with above average energy intensity and to diagnose the cause (heating, cooling, lighting, etc.). The tool is accessed through a unique dashboard created for PSO that is integrated with AMI data. The dashboard and database can be updated to support objectives such as segmentation analysis, program design, and evaluation of savings for technologies.

The tool provides PSO with the following benefits:

- Engage with customers in a more meaningful manner once PSO understands their energy consumption patterns and persona.
- Target specific measures (energy efficiency, demand response, DER) to the right customer (or groups of customers) at the right time and location on the grid.
- Identify the customers with the greatest potential to save kWh and kW.
- To evaluate realized meter-based outcomes and to quantify delivered GHG emission reductions.
- To develop forecasted load on a substation basis.

Project deliverables include:

- Establish AMI and CIS data pipelines for ongoing data feeds. This step included building out QA and data processing automation to reduce time requirements going forward.
- Analyze program participation data to identify trends by different categorical variables to determine who is participating in different programs and find gaps in participation.
- Perform AMI based EM&V on all programs to identify program performance expectations at the individual household level and aggregated up through any relevant categorical variable to measure how different programs are performing for different groups of customers.
- Provide recommended measure lists for different customer groupings.
- Create a digital twin of every residential premise to simulate savings from different measures at the individual household level.
- Recommendation list for every premise of the measures that will have a positive impact for the customer, with ability to sort by available KPI's.
- Interactive Dashboard will allow PSO to select their top areas of impact which identifies customers in most-need of a customer program, and then show the simulated impact for various measures for that customer.
- Data Visualizations in multiple formats including aggregated and available in charts, mapped in a geospatial view, and in tabular formats at the individual customer level. All data can be exported for easy use.
- Prepare for full historical AMI transfer.

The tool is expected to be fully operational in the first quarter of 2025.

5.2 Efficiency Homes and Communities

Several activities were conducted from 2022-2024 related to further development of efficient homes and communities. This section presents the activities of a community demonstration project with the Cherokee Nation, a high-efficiency home project (Weldon House), an analysis of high efficiency new construction manufactured homes and associated cool roofs, and the installation of heat pump water heaters.

5.2.1 Community Demonstration Project

The goal of the community demonstration project is to develop a residential new construction plan and use of technologies that:

- Goes beyond normal baseline code standards for energy efficiency and resilience.
- Will have very low utility bills now and in the future, plus have a low cost to maintain.
- Is built to a higher standard than conventional homes.
- Is more durable, comfortable (year-round), and has better indoor air quality.
- Reduces outside noise.
- Overall, it is better for the environment and sets a new high standard for future homes.

5.2.1.1 Methodology

Both Ekotrope and Cove.Tool software were used to determine estimated energy savings and incremental cost information. Both software programs are approved by the Residential Energy Services Network (RESNET) and EPA for rating and verifying ENERGY STAR® homes. Each allows detailed modeling and configuration of inputs in the following categories:

- Construction materials
- Internal loads
- Shading and overshadowing
- HVAC + water heating equipment
- Duct location + infiltration.

Results of more than 50 modeling computations were compared in both software tools to gauge realistic kWh savings estimates as compared to the baseline home. The Tulsa weather station was selected to represent the climate zone for this analysis.

An estimate of incremental cost difference between the ECM upgrades and baseline cost compared to the kWh savings was considered. These estimates should be used to guide decision makers toward upgrades that have the greatest potential impact on energy use. Availability of product, labor to install, and occupant preferences are other key factors to cost differences and return on investment that fall outside the scope of this report. The energy rate assumed for the energy savings are based on the normalized residential energy tariffs for PSO at $0.11 per kWh (kilowatt per hour).

A baseline energy model was developed using a 1,700 square foot home with a two-ton HVAC system. The baseline home uses typical design practices found in PSO territory using current Oklahoma residential building code standards.

5.2.1.2 Model Results

The three selected designs result in energy savings of 22%, 40%, and 47% (in terms of meeting the requirements of a DOE Zero Energy Ready Home[60]). Home designs were rated as bronze through gold.

The bronze level home is like PSO certified homes constructed in the Tulsa market during the 2023 rebate year. These homes include R-15 blown insulation in the exterior walls, an entry level HVAC system with ducts in a traditional vented attic. Most of the savings are achieved through improvement in windows, a tight building envelope through additional air sealing strategies, and reduced air leakage in the duct system.

The silver level home provides efficiency gains with wall insulation and duct location. By adding a 1-inch extruded polystyrene (XPS foam) foam board to the exterior of the wall sheathing, you gain both insulation R-value and envelope sealing with very little costs (approximately $500 per home). Similarly, moving the ducts into conditioned space increases energy savings by approximately 15% and can be achieved through minimal increased costs depending on the design strategy. Due to the reduction in air changes inside the home, an air cycler system is required to deliver and mix outdoor air into the HVAC system supply.

Upgraded components of the gold home include all the same as Silver plus a geothermal system with desuperheat water. As noted in the graph, there is an estimated 7% reduction in energy use for these components. Although this reduction seems small, the overall consumption of the home is under 10,000 kWh per year which makes each incremental savings advancement harder to achieve. In a standard code-built home with little to no energy upgrades, a geothermal system with desuperheat water would result in 34% reduction in energy use. A summary of results for the four designs is shown in Table 5-1.

[60] https://www.energy.gov/eere/buildings/zero-energy-ready-home-program

Table 5-1: Community Demonstration Home Design Summary

Building Components	Baseline	Bronze	Silver	Gold
Certification	None	PSO Rebates	EnergyStar v3.1	DOE NZE Home EnergyStar v3.2
Annual Usage (kWh)	17,030	13,251	10,137	9,031
Annual Energy Savings	0%	22%	40%	47%
Potential Bill Savings	None	$415	$758	$880
HERS Score	**85**	**60**	**60**	**48**

The gold level design presents the DOE's net zero ready design. A Zero Energy Ready Home is a high performing energy efficient home that requires first and foremost construction practices that are the most energy efficient to minimize the overall electric load.

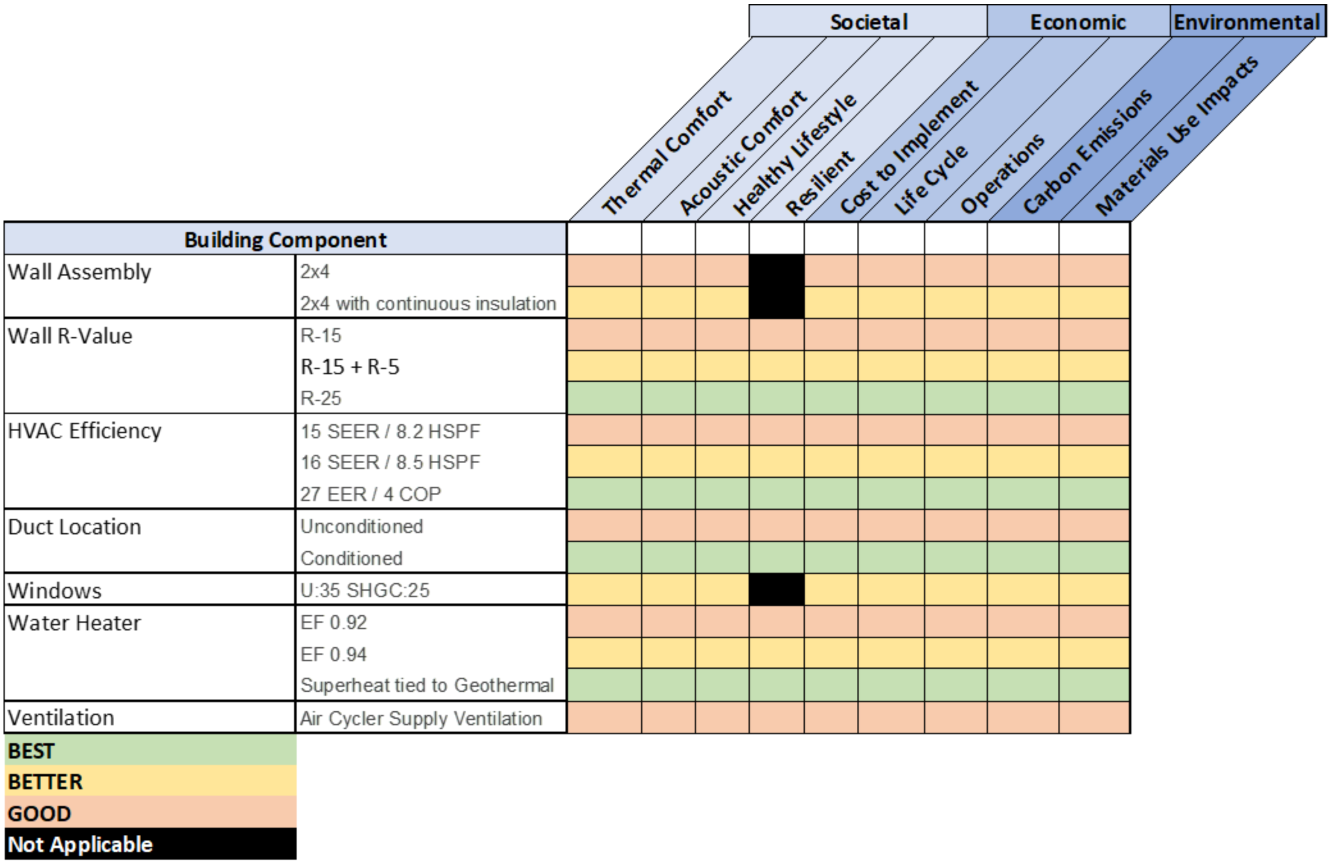
5.2.1.2.1 Non-Energy Benefits

The following diagram provides a high-level review of the societal, economic, and environmental non-energy benefits for the recommend energy conservation measures for the energy models presented in Table 5-1. The information is provided to show the impacts of measures beyond energy savings to allow for consideration of these factors in the decision-making process.

The extra investment in the Bronze through Gold home types provides the homeowner with benefits beyond energy savings. PSO customers have also reported on non- energy benefits. PSO homebuyer surveys show additional benefits when purchasing an energy efficient new home. These responses include:

- Lower long-term ownership costs
- Reduction in health issues such as asthma and COPD triggers
- Higher market value
- Increased comfort and sense of safety
- Reduced carbon emissions
- Safeguard against future energy price fluctuations.

Figure 5-1: Non-Energy Benefits of Each Building Component



5.2.1.2.2 Workforce Development

Builders will reach significant milestones in the pursuit of building toward net zero including achieving ENERGY STAR v3.1 and Indoor Air Plus certification. As part of this process, construction trades will need additional training to successfully execute technical strategies embedded in these certifications. This training will help sustain and retain a viable workforce that can support the needs of current and future building projects. One example of this training is the installation of rigid insulation around the exterior walls.

5.2.1.2.3 Net Zero Energy Ready

Net zero energy is defined as a system that produces at least as much energy as it consumes on an annual basis. A Zero Energy Ready Home is a high performing energy efficient home that can achieve net zero with the addition of a renewable energy system like roof top solar. To build a new construction Zero Energy Ready Home requires first and foremost construction practices that are the most energy efficient to minimize the overall electric load. In addition, a true net zero home must be all electric. The initial investment to reach a net zero status is often too much for a homebuilder to provide, therefore PSO is encouraging the adoption of design strategies that prepare the home for future net zero status. Silver and Gold tiers are the recommended building strategies for a Zero Ready Home. In addition to the building components found in Table 1, the home must meet the following conditions for future zero energy ready use as recommended by the Department of Energy*:

- Available free roof area within +/- 45° of true south.
- Roof allowable dead load rating can support an additional 6 lbs/sq.ft. for future solar system.
- Install a 1" metal conduit for the DC wire run from the designated array location to the designated inverter location, and from the inverter location to the electrical service panel (cap and label both ends).
- Install and label a 4x4 plywood panel area for mounting an inverter and balance of system components.
- Provide a labeled slot for a double-pole breaker in the electrical service.

Table 5-2: Estimated Performance

Building Component	Annual kWh Usage	kW Capacity DC	Estimated Qty of Panels	Estimated Solar Output (kWh/year)	Estimated System Cost	Estimated ROI of Solar Panes
Baseline Home	17,030	10	5	2,878	$ 5,215	5.92 years
Bronze Home	13,251	10	5	2,878	$ 5,215	4.60 years
Silver - Energy Star	10,137	10	5	2,878	$ 5,215	3.52 years
Gold - Net Zero Ready	9,031	10	5	2,878	$ 5,215	3.14 years

While achieving net zero is a long-term goal, there are obstacles to overcome in the short term. Current home designs for an average 1,700 square foot home allow for only 705 square feet of roof area for solar panel placement. Additionally, home orientation is a huge requirement when considering solar panel output.

5.2.1.3 Conclusion of Modeling

Evolving technology in energy efficiency provides home builders with thousands of possibilities for reducing the energy burden for new construction projects. The three options provided in this report represent the most attainable building practices based on the Oklahoma market today.

The three tiers (Bronze – Gold) are the best options based on the availability of materials, incremental cost increases, and potential energy savings. Of these three tiers PSO believes the top two for implementation are the silver or gold levels. This will allow the home builder to achieve ENERGY STAR v3.1 certification and zero ready.

5.2.1.4 Housing Authority Cherokee Nation

The Housing Authority of the Cherokee Nation is building twenty (20) Energy Star SFNH v3.1 Rev. 12 homes in Jay, OK using the PSO silver model guideline. The homes will meet the building component guidelines in Table 5-3.

Table 5-3: PSO Silver Model Components

Building Components	Baseline	Silver
Wall Assembly	2x4	2x4 with continuous insulation
Wall R-Value	R-13	R-15 + R-5
HVAC Type	Heat Pump	Heat Pump
HVAC Efficiency	14 SEER / 8.2 HSPF	16 SEER / 8.5 HSPF
Duct Location	Unconditioned	Conditioned
Windows	U:0.50 SHGC:0.30	U:0.30 SHGC:0.25
Water Heater	EF 0.92	EF 0.94
Ventilation	None	Air Cycler Supply Ventilation
Envelope Leakage (air changes/hour)	6	2
Certifications	None	ENERGY STAR v3.1
Estimated Upgrade Costs (from Baseline)	$0	$8,800
PSO Rebate Amount	None	$1,000
Pilot Bonus Rebate Amount	None	$3,450
Baseline Home Annual Usage kWh	17,030	17,030
Upgrade Home Annual Usage kWh		10,137
kWh Savings as compared to baseline	None	40%
Potential Yearly Utility Bill Savings ($0.11/kWh)		$758
Potential Return on Investment		8 years
HERS Score	**85**	**60**

5.2.2 High Efficiency Home: Weldon House Project Achievements

A local resident was highlighted by PSO for their energy efficiency achievements in their new construction home called the Weldon House. Energy simulations of the home were developed using Ekotrope to meet ENERGY STAR Certified and Net Zero Ready for new home construction standards. This initiative represents an innovative opportunity to not only drive deeper energy savings but also serves as a real-world educational tool for PSO to better educate new homeowners and builders to promote energy efficiency construction practices. Demonstrating these measures in action encourages market transformation in the PSO market and algins with supporting future PSO residential program objectives. The homeowners were instrumental in working with PSO during the story telling process of building the home and allow PSO to document the process from beginning to end to create the marketing collateral needed to promote the residential energy efficiency program for 2025 and beyond.

The Weldon home consumes 77% less annual electricity, a 90% reduction in winter peak demand and a 64% reduction in summer peak demand based on Oklahoma building codes. See Table 5-4.

Table 5-4: Weldon Home Energy Consumption

Home Design	Annual Energy (kWh)
Baseline Home	69,422
Net-Zero Energy Home (NZER)	15,598
Savings	**53,824**

The following energy efficiency measures were incorporated into the house design.

- Insulating Concrete Form Wall
  - Continuous R-25 insulation of the building envelope
    - STC sound transmission class 55 rating (reduces noise pollution)
    - Tornado resistant
    - Mold resistant
    - Insect resistant
- Insulated Stem Wall
- Vented Roof
- Encapsulated Attic
- Low Voltage PoE Lighting
  - Power over Ethernet LEDs
- Geothermal Water-to-Water Heat Pump
  - Geothermal system provides domestic hot water and space heating and cooling by using heat transfer through a heat exchanger.
- Radiant Ceiling Panels
  - Efficient and comfortable heating by radiating heat directly to occupants and surfaces
- Energy Recovery Ventilator (ERV)
  - Exchanges indoor air with fresh outdoor air while recovering heat and moisture
- High Efficiency Duct Work
  - All ducts are located within conditioned space and sized to reduce friction losses and increase air mixing
- Above Code Air Sealing
  - Blower door test results of 630 CFM at 50 pascals
- Exterior Roof Insulation

    - Additional layer of insulation
- Induction Cooktop
- Condensing Clothes Dryer

5.2.3 ENERGY STAR New Construction Manufactured Homes and Cool Roofs

PSO requested ADM Associates, Inc. (ADM) determine the energy impacts of both ENERGY STAR guidelines of manufactured homes, and the impacts of cool roofs installed on manufactured homes in PSO territory. Energy impacts will be determined by comparing expected pathways to ENERGY STAR Certification for single and double section homes against Housing and Urban Development (HUD) minimally code compliant manufactured homes through energy simulation. Results will include impacts when considering mechanical systems with heat pumps and central AC with electric heating.

Energy impacts for Cool Roofs will be determined by comparing single and multi-section manufactured homes, both new and pre-existing, to an assumed pre-existing manufactured home without a Cool Roof through energy simulation. Cool Roof characteristics will be based on Department of Energy specifications. Results will include impacts when considering mechanical systems with heat pumps and central AC.

The Department of Energy made available prototypical energy simulation models in EnergyPlus to represent various scenarios of ENERGY STAR Manufactured homes as well as HUD-compliant manufactured homes. These energy simulations will be the basis for the energy savings analysis.

ENERGY STAR certifications include improved building envelope, improved HVAC systems – either high efficiency gas furnaces or heat pumps, or a combination of factors to meet specific energy use reductions over a baseline of a Housing and Urban Development (HUD) minimally code compliant manufactured house, either single or multi-section. In general, Tier 1 single-section manufactured housing has less strict standards compared to Tier 2 multi-section standards: Tier 1 single section requires 16% energy costs savings over prior code, and Tier 2 for multi-section manufactured homes requires 34% energy costs savings over prior code. For this study, building shell insulation values, glazing system solar heat gain coefficients (SHGC), and mechanical system efficiencies will be primarily considered, though other variables may be adjusted as required. Insulation values are shown in Table 5-5 below.

Table 5-5: Energy Star requirements for a Tier 1 Single Section and Tier 2 Multi Section manufactured home.[61]

Variable	Tier 1 Single Section[62]	Tier 2 Multi Section (Envelope Only)[63]
Wall R Value	13	21
Ceiling R Value	22	33
Floor R Value	19	22
Glazing U-factor	0.5	0.30
Glazing SHGC	0.6	0.25
Door U-factor	0.40	0.40
High Efficiency Furnace AFUE	N/A	≥95
Electric Heat Pump	N/A	≥7.5HSPF2/14.3SEER2

Note that the values shown are only one method of fulfilling ENERGY STAR requirements through a combination of envelope improvements and mechanical system upgrades. These values are based on Version 2.1 ENERGY STAR requirements, adopted in 2022, and are reflected in DOE prototypical manufactured home models. Energy savings can also be calculated using U0 calculated by the Battelle Method, though these will not be considered in this study. There are additional requirements for ENERGY STAR certification, such as sealing and domestic hot water efficiencies, but will not be varied as part of this study.

Similar measures for cool roofs in commercial facilities are available in the Louisiana Technical Reference Manual (TRM). The US Department of Energy (DOE) defines cool roofs as having the specifications in Table 5-6.

Table 5-6: US DOE cool roof specifications

Roof	Slope Angle	Solar Reflectance[64]	Thermal Emittance	Solar Reflective Index (SRI)[65]
Low Sloped	9.5	0.55	0.75	≥64

[61] All values shown are for HUD thermal zone 2.
[62] Energy Conservation Program: Energy Conservation Standards for Manufactured Housing, prepared by the US DOE Office of Energy Efficiency and Renewable Energy, Federal Register Vol 87, No. 104, published May 31, 2022
[63] Solar reflectance and SRI must maintain those values for a minimum of 3 years after installation. Roofs must meet either both these solar reflectance and thermal emittance requirements, or a combination that meets or exceeds minimum SRI requirements.
[64] Urban, Bryan; Roth, Kurt; "Guidelines for Selecting Cool Roofs," prepared by The Fraunhofer Center for Sustainable Energy Systems for US Department of Energy. July 2010.
[65] US Green Building Council's Leadership in Energy and Environmental Design Cool Roof Definition, https://coolroofs.org/resources/leed, Residential definition, accessed 4/23/2024

SRI is a calculated value that weighs solar reflectance and thermal emittance. SRI and solar reflectance listed values are both for aged values, the expected values after 3 years.

5.2.3.1 Energy Savings Methodology

ADM's approach utilized EnergyPlus to customize Department of Energy (DOE) prototypical manufactured homes for data analysis. The approach is described as follows:

ADM utilized DOE prototypical manufactured home models, with the HUD minimally code compliant as a baseline, and ENERGY STAR Tier 1 and 2 models as the efficient case. Climate zone 3A models for Memphis, in HUD thermal zone 2, will be used. These are in the same DOE and HUD zones as PSO territory.

The following baseline scenarios were developed:

- HUDS Elec: HUD Single all Electric non-Heat Pump
- HUDS HP: HUD Single all Electric Heat Pump
- HUDS NG Furnace: HUD Single Natural Gas Furnace and Central AC
- HUDM Elec: HUD Multi all Electric non-Heat Pump
- HUDM HP: HUD Multi all Electric Heat Pump
- HUDM NG Furnace: HUD Multi Natural Gas Furnace and Central AC

The following Energy Star scenarios were developed:

- EST1 Elec: Energy Star Tier 1 (Single) all Electric non-Heat Pump
- EST1 HP: Energy Star Tier 1 (Single) all Electric Heat Pump
- EST2 Elec: Energy Star Tier 2 (Multi) all Electric non-Heat Pump
- EST2 HP: Energy Star Tier 2 (Multi) all Electric Heat Pump

Additional models were created to demonstrate the impacts of the following end-uses.

- Energy Star Appliances and high efficiency water heating
- Energy Star cooling equipment
- Energy Star levels for insulation and air infiltration
- ADM modified DOE single and multi-section manufactured residential home reference models in EnergyPlus in ways corresponding to values in Table 5-6 and Table 5-5 to demonstrate differences between minimally code compliant homes and Energy Star Version 2.1 compliant homes. Typical Meteorological Year (TMY) data was from Climate.One.Building.org. TMYx dataset for Tulsa, OK was used.
- To limit the number of simulations required to determine energy savings estimates, many variables were left as the values used by the DOE in the prototypical models. Table 5-7 shows the inputs deemed important to change and/or modify to represent configurable new construction manufactured homes meeting HUD compliance and Energy Star compliance.

Table 5-7: Energy Simulation Important Parameters

Classification	Metric	HUDS/M Elec	HUDS/M NG Furnace	HUDS/M HP	EST1 HP	ES T2 HP	ES T1 Elec	ES T2 Elec
Climate Zone	HUD Zone	2 (3A for DOE climate zone)	2 (3A for DOE climate zone)	2 (3A for DOE climate zone)	2 (3A for DOE climate zone)	2 (3A for DOE climate zone)	2 (3A for DOE climate zone)	2 (3A for DOE climate zone)
Thermal Envelope	Wall Insulation (calc. R-Value)	9.4	9.4	9.4	10.13	10.13	10.13	10.13
	Ceiling Insulation (calc. R-Value)	16.57	16.57	16.57	16.52	23.2	16.52	23.2
	Floor Insulation (calculated R-Value)	19.35	19.35	19.35	19.35	19.35	19.35	19.35
	Infiltration (ACH50)	554.97 cm2 (HUD multi), 327.04 cm2 (HUD single)	554.97 cm2 (HUD multi), 327.04 cm2 (HUD single)	554.97 cm2 (HUD multi), 327.04 cm2 (HUD single)	204.40 cm2	346.86 cm2	204.40cm2	346.86 cm2
	Window U-factor (glazing system)	2.84	2.84	2.84	2.84	1.7	2.84	1.7
	Window SHGC	0.3	0.3	0.3	0.3	0.3	0.3	0.3
HVAC	Gas Furnace Heating	NA	80% efficiency	NA	NA	NA	NA	NA
	Elec. Res. Heating	1 Efficiency	NA	NA	NA	NA	1 Efficiency	1 Efficiency
	AC Space Cooling	4.22 COP	4.22 COP	NA	NA	NA	4.22 COP	4.22 COP
	HP Space Heating	NA	NA	3.693	3.693	3.693	N/A	N/A
	HP Space Cooling	NA	NA	4.0685	4.0685	4.0685	N/A	N/A
	Thermostat	manual (72 heating, 75 cooling)	manual (72 heating, 75 cooling)	manual (72 heating, 75 cooling)	programmable (70/72 heating, 75/77 cooling)	programmable (70/72 heating, 75/77 cooling)	Programmable (70/72 heating, 75/77 cooling)	Programmable (70/72 heating, 75/77 cooling)
Water Heating	Gas Water Heater (EF / Gal.)	NA	.8 efficiency	NA	NA	NA	NA	NA
	Elec Water Heater (EF / Gal.)	1	NA	1	1	1	1	1
	Bathroom Faucets	prototype assumption	prototype assumption	prototype assumption	10% improvement	10% improvement	10% improvement	10% improvement
	Showerheads	prototype assumption	prototype assumption	prototype assumption	10% improvement	10% improvement	10% improvement	10% improvement
Appliances	Refrigerator	prototype assumption	prototype assumption	prototype assumption	10% improvement	10% improvement	10% improvement	
	Dishwasher	prototype assumption	prototype assumption	prototype assumption	10% improvement	10% improvement	10% improvement	10% improvement
	Clothes Washer and Dryer	prototype assumption	prototype assumption	prototype assumption	10% improvement	10% improvement	10% improvement	10% improvement
	Lighting	LED	LED	LED	LED	LED	LED	LED

Annual energy consumption from the energy simulations was compared to a sample of known manufactured homes that participated in the multifamily energy efficiency program. In general, the billing data showed relatively good agreement with the simulations, and no actions were taken to calibrate the models.

Average billing data consumption was 18,364 kWh, with a standard deviation of 10,212 kWh.[66] Note that specific information about the homes was not available, such as single/double wide or exact HVAC systems, only that energy efficiency measures had been installed, and that the homes were all electric. These are expected to be more efficient than an average home. In comparison, the average energy consumptions are shown in Table 5-8.

Table 5-8: Average of Energy Consumption for Model Calibration

Configuration	ES Homes	HUD Minimally Compliant	Multifamily Sample Participant Average
All	14,424	17,885	18,364
Multi-Section	15,811	20,464	28,576[1]
Single Section	13,037	15,306	8,152[1]

1. Represents one standard deviation above the average since home characteristics were not available.

In general, this was determined to be in relatively good agreement, with all ES manufactured homes average only being 3% off, and all simulations within 1 standard deviation. The standard deviation calculated did not include 0 values, with a maximum value of 37,176 kWh.

Energy consumption between the ENERGY STAR scenarios for single and multi-section manufactured homes were compared on a monthly consumption basis to applicable HUD-compliant single and multi-section manufactured homes. Energy consumption was compared for the whole facility, lighting, interior loads, water heating, and space conditioning.

Based on current definitions of a cool roof for a low-angle manufactured home, the impacts of cool roofs will be examined through modeling for both minimally code-compliant and ENERGY STAR manufactured homes. The cool roofs definitions used are based on solar reflectance and thermal emittance from the DOE and are defined in Table 5-9.

[66] The large standard deviation means that we expect approximately 68% of manufactured homes to use between 8,152 kWh per year and 28,576 kWh. This is a large range which is not ideal for calibration purposes.

Table 5-9: Cool Roof Reflectivity Properties in EnergyPlus

Asphalt Shingle Values	Thermal Absorptance	Visible Absorptance	Solar Absorptance
Baseline	0.9	0.7	1
New	0.75	0.35	0
3 Year	0.75	0.45	0
Old	0.75	0.5	1

These represent DOE definitions of a cool roof in EnergyPlus. Note that in EnergyPlus, only absorptance can be altered. For solar and visible absorptance, reflectance was defined as:

$$Reflectance_{solar,visible} = 1 - Absorptance_{solar,visible}$$

Thermal absorptance at equilibrium is equal to thermal emittance. Note that these are not the only values that impact savings, and not the only configurations possible that would meet the requirements of a cool roof. SRI can be met with a variety of reflectance and emittance values, and roof construction can also impact values. These alterations were applied to the outer construction layer of exterior roof of each DOE prototype described.

From these simulations, energy consumption was compared for the impacts of cool roofs. The energy efficiency measure, Cool Roofs, is the addition of a reflective surface painted onto the roof of the structure. The reflective surface will reduce cooling demand during periods of high solar gain. Cool roof impacts will be considered against both minimally code-compliant and Energy Star certified manufactured homes. Energy savings are calculated as the difference in cooling energy consumption between the DOE required rooftop reflective surface properties and standard rooftop reflective properties presented in the DOE prototypical energy simulation models.

5.2.3.2 Energy Impact Results

A comparison of annual electric energy consumption and annual electric energy savings (kWh) for the whole residence is shown in Table 5-10.

Table 5-10: ENERGY STAR Manufactured Homes Energy Savings

Energy Star Scenario	Baseline Scenario	Annual Electric Consumption (kWh)	HUD Baseline Electric Consumption (kWh)	Annual Electric Energy Savings (kWh)
EST1 HP	HUDS HP	12,052	12,778	726
EST2 HP	HUDM HP	14,940	17,063	2,123
EST1 HP	HUDS Elec	12,052	16,570	4,518
EST2 HP	HUDM Elec	14,940	22,164	7,225
EST1 Elec.	HUDS Elec	15,006	16,570	1,563
EST2 Elec.	HUDM Elec	17,554	22,164	4,611

The impacts of individual energy efficiency measures were explored based on available energy simulation results for ENERGY STAR Appliances and Water Heating, Insulation and Air Infiltration, and HVAC efficiency. Impacts will be discussed based on multi-section manufactured homes.

The installation of additional insulation and air sealing to reduce air infiltration was more beneficial than ENERGY STAR Appliances, higher efficiency water heaters, and higher efficiency HVAC equipment. A breakdown of energy savings impact by energy efficiency measure category is shown in Table 5-11.

Table 5-11: Measure Category Impact on Energy Savings

Energy Star Scenario	Baseline Scenario	Appliances and Water Heating Savings (kWh)	Insulation and Air Infiltration Savings (kWh)	HVAC Efficiency Savings (kWh)
EST1 HP	HUDS HP	228	692	233
EST2 HP	HUDM HP	291	3,390	274
EST1 Elec.	HUDS Elec	228	1,042	427
EST2 Elec.	HUDM Elec	291	3,933	508

Summer peak demand reduction is defined as the average hourly reduction from June through September on non-holiday weekdays from 2-6 PM. To represent this value, the cooling season energy simulation design day load was divided by 24 hours. Results are shown in Table 5-12.

Table 5-12: ENERGY STAR Manufactured Homes Summer Peak Demand Reduction Savings

Energy Star Scenario	Baseline Scenario	Summer Peak Demand Reduction (kW)
EST1 HP	HUDS HP	0.08
EST2 HP	HUDM HP	0.22
EST1 HP	HUDS Elec	0.25
EST2 HP	HUDM Elec	0.46
EST1 Elec.	HUDS Elec	0.22
EST2 Elec.	HUDM Elec	0.42

A 20-year measure life is assumed for new construction manufactured homes. This is consistent with lifetime savings assumptions made for the single-family new homes program. Results are shown in Table 5-13

Table 5-13: ENERGY STAR Manufactured Homes Lifetime Energy Savings

Energy Star Scenario	Baseline Scenario	Lifetime Energy Savings (kWh)
EST1 HP	HUDS HP	0.08
EST2 HP	HUDM HP	0.22
EST1 HP	HUDS Elec	0.25
EST2 HP	HUDM Elec	0.46
EST1 Elec.	HUDS Elec	0.22
EST2 Elec.	HUDM Elec	0.42

Estimated annual energy savings for Cool Roofs were determined by varying the solar reflectance and thermal emissivity of the roof for the developed manufactured home simulation models. Results are shown in Table 5-14. As the Cool Roof material is exposed to the elements, material property degradation after 3 years was considered based on information from the U.S. Department of Energy[67]. The calculated electric energy savings account for heating penalties.

[67] U.S. DOE Guidelines for Selecting Cool Roofs. V1.2. July 2010.

Table 5-14: Cool Roof Manufactured Homes Energy Savings

Manufactured Home Scenario	Efficient Solar Reflectance/Thermal Emissivity (3 Year Aged)	Baseline Solar Reflectance/Thermal Emissivity	Efficient Annual Electric Consumption (kWh)	Baseline Electric Consumption (kWh)3	Annual Electric Energy Savings (kWh)
EST1 HP	0.55/0.75	0.9/0.75	11,960	12,052	92
EST2 HP	0.55/0.75	0.9/0.75	14,816	14,940	124
EST1 Elec.	0.55/0.75	0.9/0.75	14,942	15,006	65
EST2 Elec.	0.55/0.75	0.9/0.75	17,471	17,554	83
HUDS HP	0.55/0.75	0.9/0.75	12,693	12,778	85
HUDM HP	0.55/0.75	0.9/0.75	16,927	17,063	136
HUDS Elec	0.55/0.75	0.9/0.75	16,497	16,570	73
HUDM Elec	0.55/0.75	0.9/0.75	22,044	22,164	120
HUDS Gas	0.55/0.75	0.9/0.75	7,844	7,917	73
HUDM Gas	0.55/0.75	0.9/0.75	10,662	10,782	120

The expected lifetime for Cool Roof is 15 years . With that said, degradation is a potential issue and may require additional effort. However, the estimates provided in Table 5-15 are reasonable.

Table 5-15: Cool Roof Manufactured Homes Lifetime Energy Savings

Manufactured Home Scenario	Lifetime Electric Energy Savings (kWh)
EST1 HP	1,384
EST2 HP	1,853
EST1 Elec.	970
EST2 Elec.	1,240
HUDS HP	1,274
HUDM HP	2,043
HUDS Elec	1,092
HUDM Elec	1,802
HUDS Gas	1,092
HUDM Gas	1,802

Cool Roof summer peak demand reduction was considered, as the intent of the measure is to reduce cooling load. Summer peak demand reduction is defined as the average hourly reduction from June through September on non-holiday weekdays from 2-6 PM. Results are shown in Table 5-16.

Table 5-16: Cost-Effectiveness Results (TRC)

Manufactured Home Scenario	Efficient Solar Reflectance/Thermal Emissivity	Baseline Solar Reflectance/Thermal Emissivity	Summer Peak Demand Reduction (kW)
EST1 HP	0.55/0.75	0.9/0.75	0.04
EST2 HP	0.55/0.75	0.9/0.75	0.05
EST1 Elec.	0.55/0.75	0.9/0.75	0.03
EST2 Elec.	0.55/0.75	0.9/0.75	0.03
HUDS HP	0.55/0.75	0.9/0.75	0.03
HUDM HP	0.55/0.75	0.9/0.75	0.05
HUDS Elec	0.55/0.75	0.9/0.75	0.03
HUDM Elec	0.55/0.75	0.9/0.75	0.05
HUDS Gas	0.55/0.75	0.9/0.75	0.03
HUDM Gas	0.55/0.75	0.9/0.75	0.05

5.2.3.3 Cost Effectiveness Results

Cost-effectiveness scores were calculated with assumptions made for the incremental cost of the more efficient manufactured home, the incentive, and no administrative costs associated with the program. Additionally, the net-to-gross ratio (NTGR) is of concern for the measure so results will be shown with a 100% NTGR and a 76% NTGR (based on 2023 findings for single-family new construction homes). Additionally, a 20-year measure life is assumed. Results for the Total Resource Test (TRC) scores are shown in Table 5-17.

Table 5-17: Cost-Effectiveness Results (TRC)

Manufactured Home Scenario	Efficient Solar Reflectance/Thermal Emissivity	Baseline Solar Reflectance/Thermal Emissivity	Summer Peak Demand Reduction (kW)
EST1 HP	HUDS HP	0.75	0.57
EST2 HP	HUDM HP	1.39	1.05
EST1 HP	HUDS Elec	0.64	0.92
EST2 HP	HUDM Elec	1.25	0.95
EST1 Elec.	HUDS Elec	0.80	0.61
EST2 Elec.	HUDM Elec	1.34	1.02

5.2.3.4 Conclusions and Recommendations

- Energy savings are realized with ENERGY STAR manufactured homes. Promoting more efficient manufactured homes will support grid resiliency and assist PSO with managing new residential load.

- Work with manufactured home companies to promote the availability of high-efficiency homes with eligibility requirements specific to reducing PSO peak loads. Custom elements for program-eligible homes will mitigate free ridership.

5.2.4 Central Oklahoma Habitat For Humanity Heat Pump Water Heater

PSO provided the Central Oklahoma Habitat for Humanity a 50-gallon heat pump water heater for a new construction residence in 2023. Energy savings were determined using Ekotrope energy modeling calibrated to billing data. Parameters for the new construction home were modified based on actual consumption data to calibrate the energy simulation in efficient condition.

The baseline condition was a code compliant new home, using the predetermined parameters within Ekotrope used for the New Homes program. Comparing yearly modeled consumption data in Ekotrope to the yearly billing data was used to validate modeling is within 10% variance. The baseline water heater used is a 92 efficient electric resistance water heater. ADM compared simulation-based savings to AR TRM V8.1 savings. A second simulation run was conducted using a natural gas water heater in the assumed baseline condition to determine natural gas annual energy savings.

5.2.4.1 Results

AMI consumption data was used to calibrate the energy simulation such that simulated annual energy consumption was within 1% of actual consumption. Energy simulation end-use consumption is shown in Table 5-18. Electric energy savings are based on the reduction in consumption of the installed heat pump water heater compared to an expected electric resistance water heater.

Table 5-18: HPWH Simulation Consumption Results and Savings

Annual End Use Consumption (Electric, kWh)	HPWH Consumption (kWh)	ERWH Consumption (kWh)	Annual Energy Savings (kWh)
Heating	4,208.4	4,208.4	0
Cooling	1,307.7	1,307.7	0
Hot Water	616.5	2,286.2	1,669.7
Lights & Appliances	4,265.5	4,265.5	0
Total	**10,398.1**	**12,067.8**	**1,669.7**

A comparison of annual energy savings between the energy simulation approach and a prescriptive approach for the heat pump water heater is shown in Table 5-19. Actual specifications for the installed heat pump water heater were used in both analyses. The prescriptive approach used the algorithm and assumptions from the Arkansas TRM (AR

TRM V8.1). The simulation vs TRM kWh realization rate is 70%. The simulation vs TRM kW realization rate is 90%.

Table 5-19: HPWH Simulation Results vs. Arkansas TRM

Electric Energy Impact	AR TRM Savings (kWh)	Simulation Savings (kWh)	Realization Rate (Simulation/AR TRM)
Energy Savings (kWh)	2,397	1,670	70%
Demand Reduction (kW)	0.21	0.19	90%

Energy simulation-based natural gas energy savings when comparing a heat pump water heater to a code-compliant natural gas water heater are shown in Table 5-20.

Table 5-20: HPWH Natural Gas Savings

Water Heater Type	Annual MMBTU
Heat Pump Water Heater Consumption	2.3
Gas Water Heater Consumption	16.0
Natural Gas Savings	**13.7**

5.3 Demand Management Integrated Resources - Behind the Meter Battery Energy Storage System (BTM BESS)

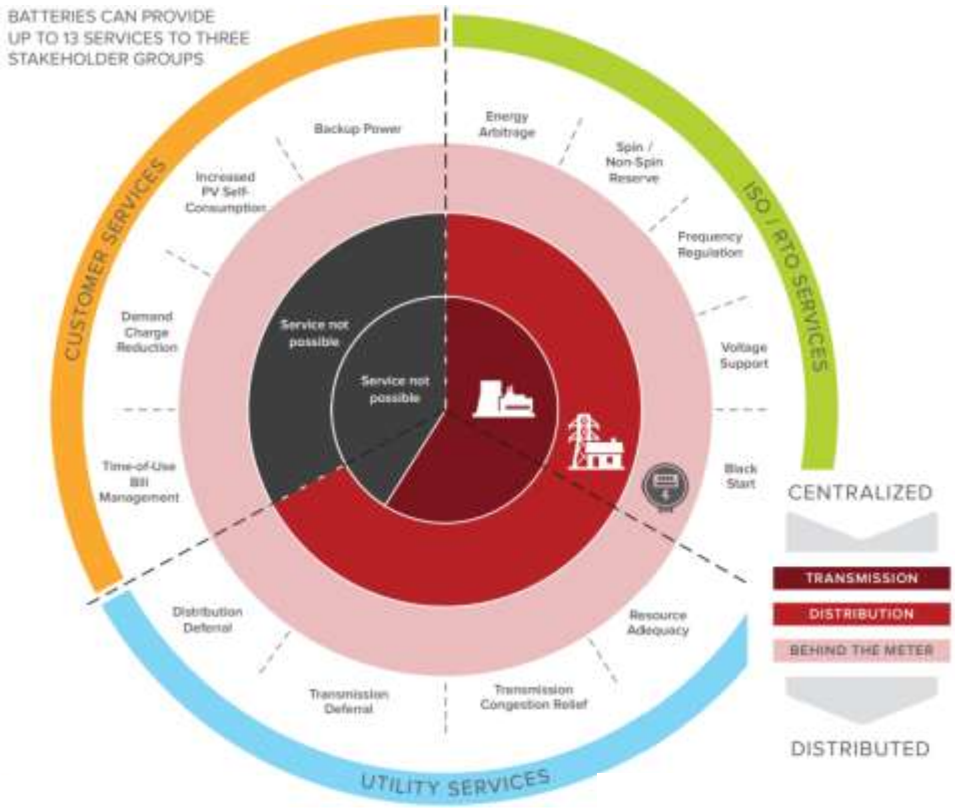
The objective of the pilot program was to study and test the properties of behind-the-meter (BTM) Battery Energy Storage Systems (BESS) to explore the potential for peak demand reduction, load shifting, solar integration, and backup power resources. ADM was contracted to assess the energy impact and provide feedback on the program's effectiveness from participants and stakeholders. This consists of participant surveys (to assess the installation process, system performance, and the participation process overall) and stakeholder interviews. In more detail, the objectives of the program are to:

- Better understand customer acceptance of the technology and observe the customer experience.
- Test the technology performance for both battery operation and dispatch control.
- Better understand the operational value and cost-effectiveness of various use cases.
- Enhance PSO's existing Demand Response Programs and capabilities.
- Assess customers' willingness to participate and engage with new technology as well as determine customer benefits.
- Understand how flexible load management (FLM) can be used to provide customer benefits and grid services as part of utility-hosted aggregation of DERs/Virtual Power Plants (VPP).

The proper placement of batteries in the electric grid is a topic for debate. There are indications that the most benefits can come from batteries installed behind the meter as the customers can then also take advantage of the resource. If trusted, BTM BESS can be relied upon for the same utility and market benefits as batteries installed between generation and the meter. The Rocky Mountain Institute (RMI) developed the graphic show in Figure 5-2 to demonstrate the potential benefits of batteries, particularly those installed behind-the-meter.[68]

[68] The Economics of Battery Energy Storage. Fitzgerald, G., Mandel, J., Morris, J., Touati, H. Rocky Mountain Institute. 2015

Figure 5-2:BTM BESS Advantages[69]



The pilot will be a success if it improves PSO's understanding of the technical and economic feasibility for residential BESS to scale the pilot into a program. This report provides information on program strategy and system configurations and then is broken out into electric grid impacts, customer experience, and cost-effectiveness.

Water heater controllers were installed at some participants residences and connected for demand response events in the fall of 2024. The Aquanta water heater controllers are designed to restrict operation of electric storage water heaters during demand response events. Benefits from the controllers will be analyzed in 2025.

5.3.1 Program Implementation – Behind the Meter Asset Aggregation and Control

PSO contracted with ICF to implement and manage the installation of battery systems on a small number of residences as a pilot program. ICF contracted with Sunverge to use their DERMS platform to control charging and discharging of the battery systems. Harvest Solar was hired as the installation contractor to incorporate LG RESU battery systems into residences with and without solar photovoltaics. Participants utilize various rate structures and have varying existing solar PV configurations. A summary of participants, their system types, and rates is shown in Table 5-21.

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[69] ibid

5.3.1.1 Program Implementation Strategy

Customers were recruited for the pilot study based on interest and existing solar PV system. ADM administered a recruitment survey for customers with existing solar to gather information on the type of system they have and their interest in the addition of batteries. In total, 30 customers participated in the pilot program (although batteries were never operational for one participant). Water heater controllers were placed on six of these participants electric storage water heaters.

Customers interested in participating received an energy audit from ICF to verify their solar PV systems, and meter configuration were feasible to participate in the program. If so, they were able to participate in the pilot study and receive the LG BESS for an installation fee.

5.3.1.1.1 Battery Energy Storage Systems

Existing solar PV systems varied by participant but can be simplified into two categories, those with forward connected, or AC systems, and backward connected, or DC systems. An AC solar PV system (forward connected) is one where the previous system includes a string or microinverter from DC to AC which was left alone. The PV system continues to go directly to the main load panel. The batteries and LG Inverter are wired separately. In a DC (backward connected) solar PV system, the solar PV output is wired into the LG inverter along with the batteries. Thus, the system’s single production meter represents energy from either the solar PV or the batteries.

5.3.1.2 System Configuration

Battery system configurations were dependent on existing solar PV configurations.

5.3.1.2.1 Battery Energy Storage System (BESS)

Of the twenty-nine participants with operational battery systems, twenty-one participants are on a time-of-day (TOD) rate structure, all of which have solar PV systems. Thirteen of these participants have a forward-connected, or AC-connected PV system, and eight have a backward-connected, or DC-connected PV system. Nine participants do not have solar PV systems. These participants are on a standard rate residential service (RS) or an electric vehicle residential service (RSEV). The number of participants under the various rate structures and system configurations are shown in Table 5-21.

Table 5-21 BESS Participant Configurations

System Type	Tariff	Count
Battery Only (BO)	RS	8
	RSEV	1
Battery with AC Solar PV	TOD	12
Battery with DC Solar PV	TOD	8
Total		**29***

*There were 30 participants overall, but one customer’s battery system never came online.

The Sunverge DERMS platform optimizes the flow of electricity for four scenarios, Blue Sky Days, Load Shifting, Storm Mode, and Power Outages.

Blue Sky Days

Under “normal” conditions, the Sunverge DERMS platform uses a pricing favorability algorithm to optimize the flow of electricity from the solar PV, batteries, and electric grid to supply the residential load in a cost-effective manner. This algorithm takes advantage of TOD and RSEV rate structures to minimize the resident's electric bill during the summer months (on-peak). A flat rate tariff configuration is used during the winter months (off peak) regardless of rate structure. Power flow is optimized using a proprietary forecast model.

Load Shifting

In times of excessive electric load, the Sunverge DERMS platform uses a demand response curtailment control strategy to reduce the residences load on the electric grid. The algorithm is designed to maximize load reduction for the electric grid to support grid resilience.

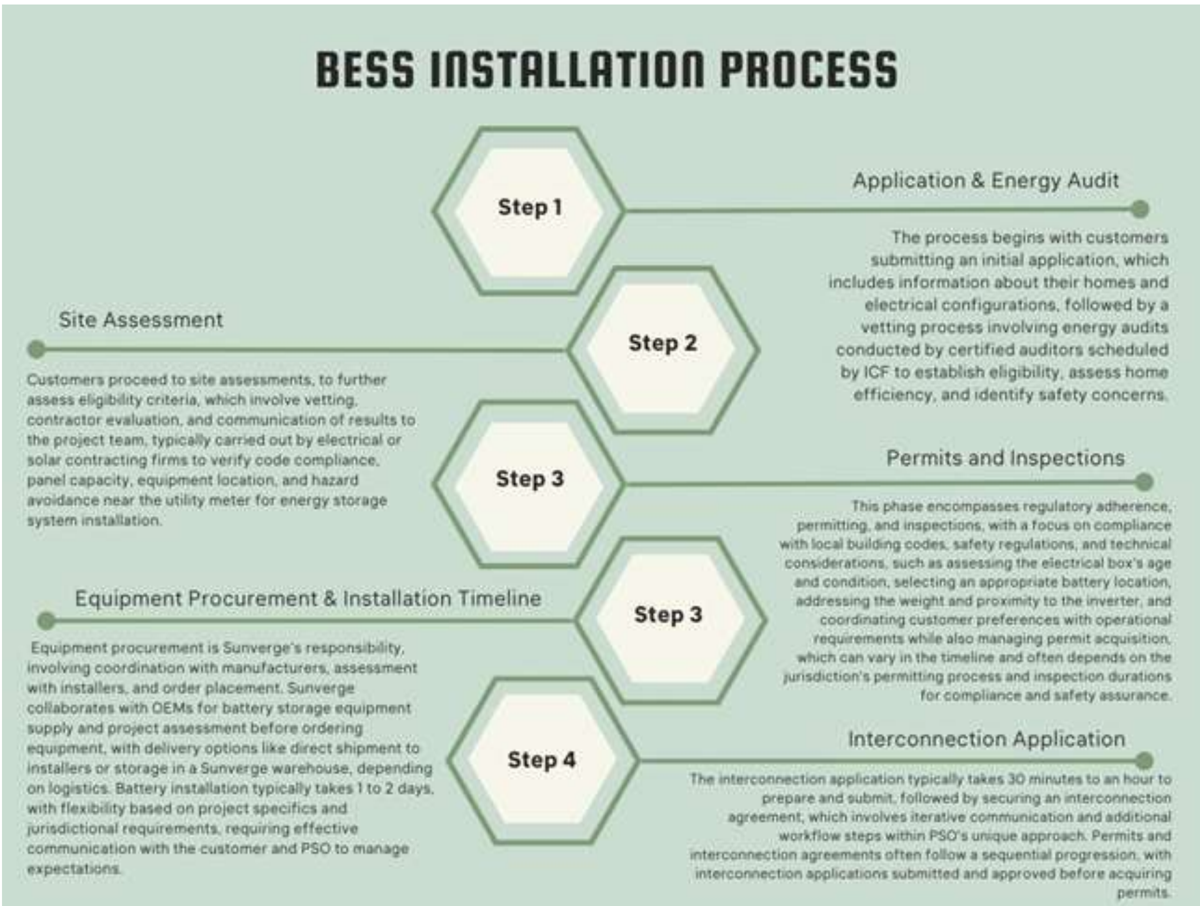
Power Outages

During power outage situations, the Sunverge DERMS platform optimizes the solar PV and battery power to supply the residences load for critical end-uses.

5.3.1.3 Overview of the Installation Process

The battery installation process includes several essential steps: application, energy audits, site assessments, permits and inspections, equipment procurement, and interconnection application. Initially, customers submit applications with required information. Energy audits follow, evaluating energy consumption patterns and providing sizing recommendations. Site assessments determine suitability and modification needs. Upon approval, the installer acquires permits, a process varying by location. Equipment procurement ensures components readiness. The installation team then installs the system per design specs. Post-installation, inspections verify compliance with local codes. Finally, the interconnection application facilitates grid connection. This process ensures a safe, compliant, and operational BESS, enhancing energy resilience and efficiency. Refer to Figure 5-3 for a graphical overview.

Figure 5-3: Graphical Overview of BESS Installation Process



5.3.1.4 Installation Timeline

Creating a comprehensive installation plan for each project or customer is a process involving various sequential components. The initiation typically revolves around the interconnection application, whose duration varies based on jurisdictional specifics. For instance, for a battery-only system, the approval of this application by PSO may span approximately two weeks.

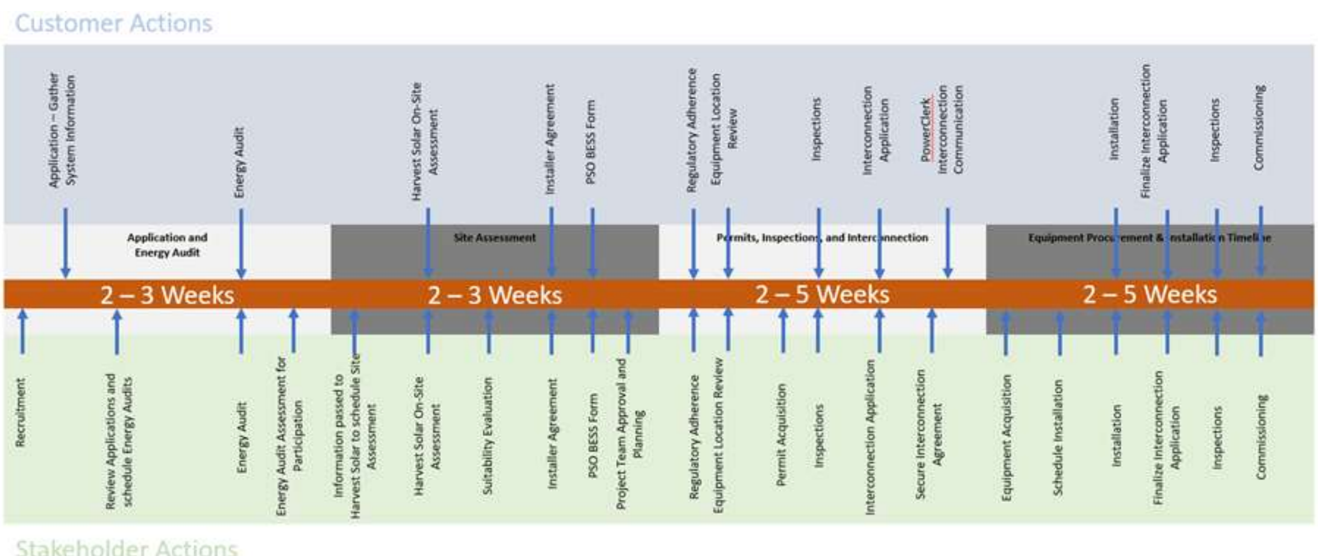
The coordination of site audit scheduling and the completion of essential paperwork commence post-approval. This phase necessitates homeowner availability, typically spanning two consecutive days for installation. Following this, the permitting process unfolds, taking a week after the finalization of the site audit and paperwork.

The subsequent phase involves the finalization of the interconnection application, which demands the submission of requisite documentation, including permit details and photographs. The duration of this step can be variable, often encompassing a few weeks. The requirement for a revenue meter on the battery may extend the timeline by a couple of weeks, encompassing utility personnel installing the meter. Inspections, executed prior to meter installation, introduce further variability in terms of timing.

Crucially, it's noteworthy that several of these steps can occur concurrently. While the interconnection application undergoes finalization, other parallel activities such as permitting, scheduling, and inspections might also be underway.

The anticipated timeline for the installation falls within the range of 1 to 2 months, starting from interconnection application submission and concluding with the final inspection and approval. Nevertheless, this timeframe's flexibility is dependent on specific project attributes, jurisdictional requirements, and other variables. Effective communication with the customer and PSO concerning the estimated timeline is important for managing expectations and facilitating timely project completion. See Figure 5-4 for a graphical illustration of the installation timeline.

Figure 5-4: BESS Installation Timeline



5.3.2 BESS Electric Grid Impacts

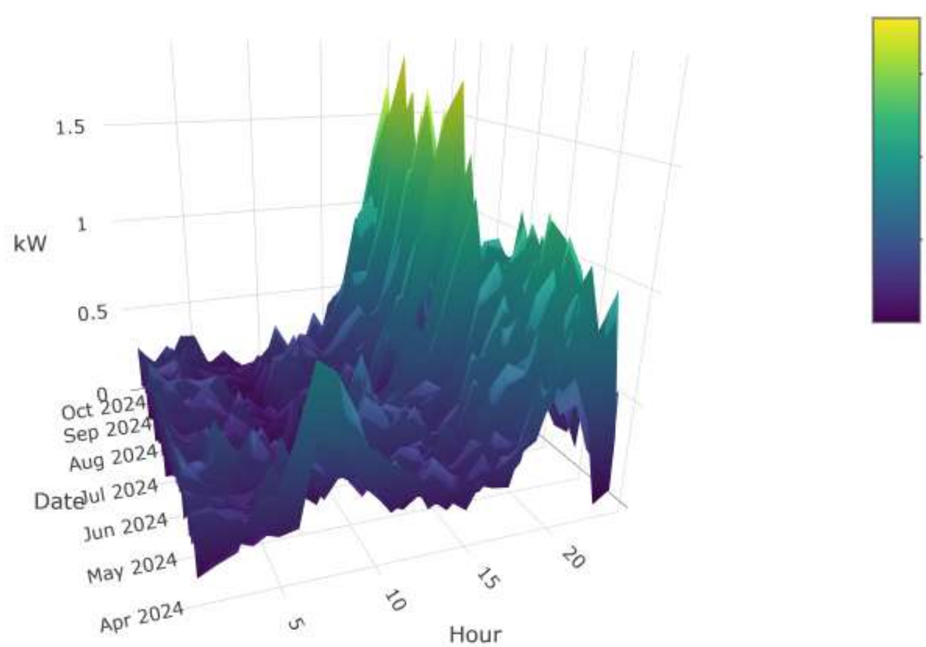
Substantial data is available on the operation of each participants' solar PV and battery system (referred to as telemetry data). Analysis of this data, along with utility meter data, has been focused on studying grid resilience, peak load reduction, and system performance from both the participants perspective and the grid perspective. As various system configurations were implemented using various rate structures, the results vary for each participant. To summarize the effectiveness of the pilot study, and determine future implications for a larger program, a few algorithms were determined and are described in this section. The algorithms are separated into the categories of Blue Sky Day grid resilience and automated demand response peak load reduction.

5.3.2.1 Battery Discharge

Battery energy storage allows for the discharge of stored electricity during opportune times. The Sunverge DERMS platform is designed to optimize the customer perspective through an algorithm focused on time-of-day rate structure. However, the total power discharged by the battery could be viewed as an opportunity for grid resilience.

Stored energy from the battery is discharged during off peak times when the energy management system predicts solar PV will be able to add to the batteries before the peak hours during the summer on-peak season. Figure 5-5 shows the average hourly battery discharge across all participants throughout the study. The figure demonstrates the prioritized discharge during the peak hours for price favorability. Discharging during off peak hours is the result of the energy management software balancing the charging ability of residences solar PV generation.

Figure 5-5:Average Battery Discharge on Blue Sky Days



Participants without solar PV (battery only) discharge in a different manner from those with solar PV. Battery only participants saw discharge mostly during the peak hours except for those who charge electric vehicles, and those who are on the residential flat bill rate. Average hourly battery discharge across battery only participants is shown in Figure 5-6.

Figure 5-6: Average Battery Discharge on Blue Sky Days for Battery Only Participants

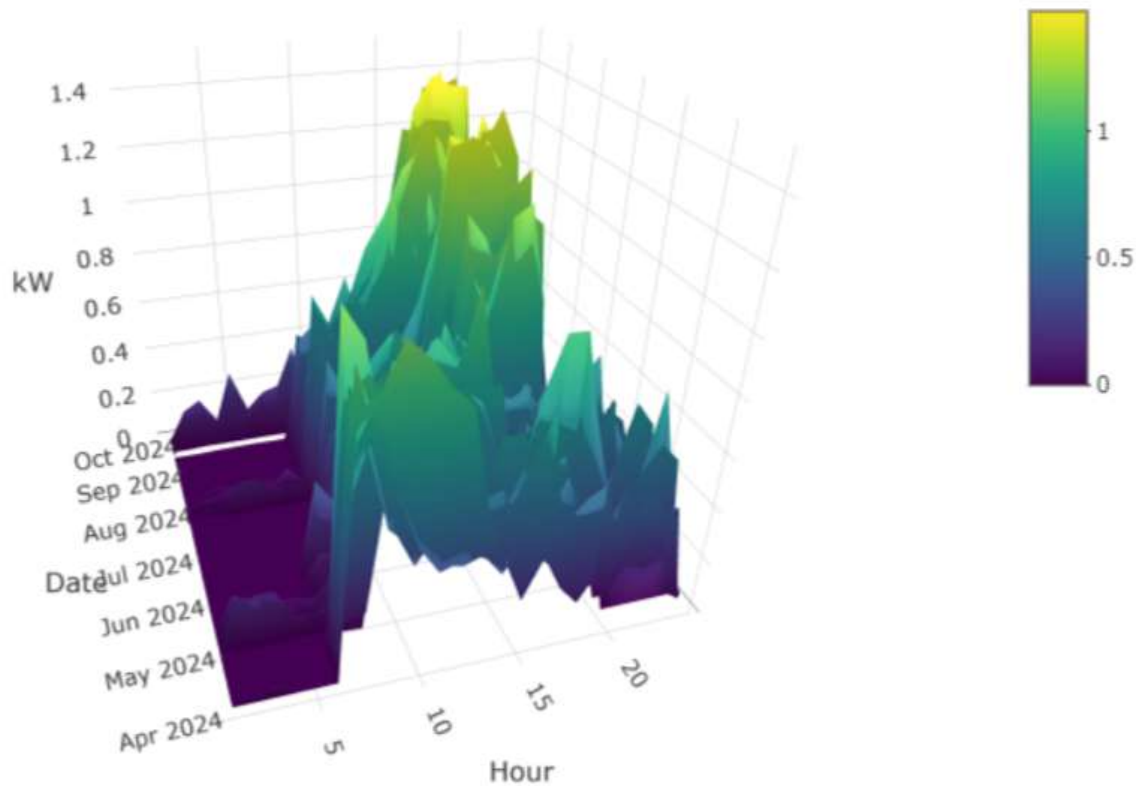
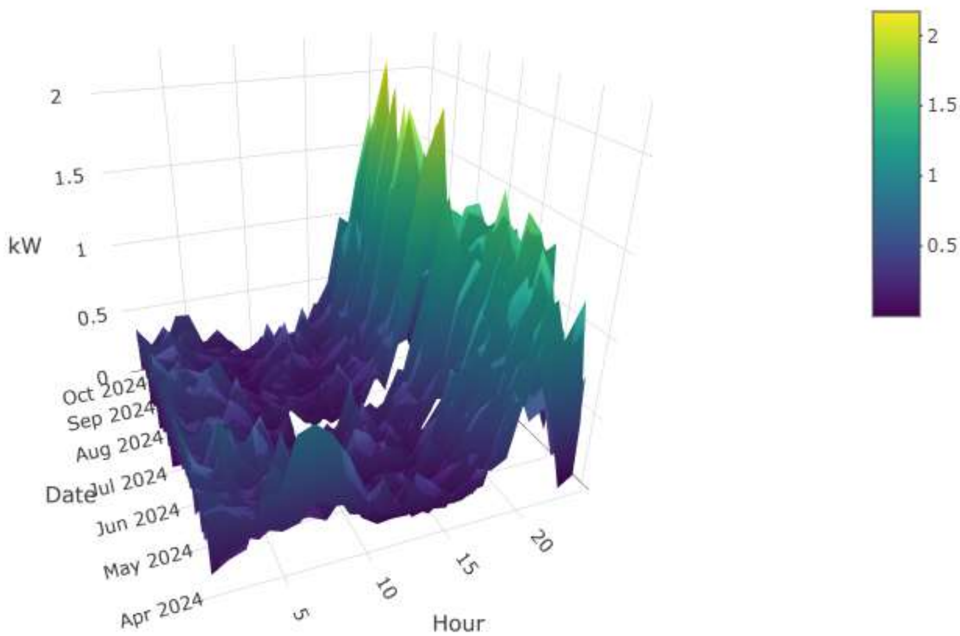


Figure 5-7 shows the average battery discharge for participants with solar PV, demonstrating the difference in discharge algorithm.

Figure 5-7: Average Battery Discharge on Blue Sky Days for Solar PV Participants



Installed battery systems have a capacity of 16 kWh and can be discharged at a rate up to 7.5 kW (inverter maximum capability). Charge rates and battery state of charge are monitored and controlled to enhance battery life. The energy management system is designed to keep the battery state of charge between 100% and 20%.

The average daily battery discharge between April and September of 2024 per participant is shown in Table 5-22. Additionally, the table represents the average participants' potential annual contribution to the electric grid through the discharge of the batteries. While not all battery discharge occurs during desired times of grid resilience, the majority is assumed to be due to the energy management algorithm. The average discharge rate indicates the batteries go through more than one discharge cycle per day.[70]

[70] Based on the assumption that 80% of the battery capacity is utilized (12.8 kWh) over 365 days resulting in 4,672 kWh per year if discharged once per day.

Table 5-22 Average Daily Battery Discharge Per Residence

Month	All Days (kWh)	Blue Sky Days (kWh)	Event Days (kWh)
April	8.55	8.55	NA
May	9.13	9.13	NA
June	8.98	8.61	11.07
July	10.61	10.05	13.55
August	10.80	10.14	13.04
September	8.37	8.58	10.58
Daily Average	9.41	9.18	12.06
Annual kWh Per Participant	**3,433.52**	**3,349.45**	**NA**

Table 5-22 shows the differences in daily battery discharge between blue sky days and demand response event days. Event days show a 29% increase in battery discharge, since the battery power output is not limited by net load on demand response event day. In other words, the amount of battery power used on blue sky days is dependent on load and solar production, which is not the case on demand response event days.

5.3.2.2 Blue Sky Day Grid Resilience

A goal of the pilot study is to understand how BTM BESS can support grid resilience; the ability of the grid to withstand, respond to, and recover quickly from disruptions.[71] Disruptions are most likely to take place during times of high demand. Two algorithms were developed to review battery system performance during Blue Sky Days to quantify the impact of a large-scale BTM BESS program, a battery advantage calculation, and a solar weather resilience calculation.

5.3.2.2.1 Battery Advantage

Power flow optimization during Blue Sky Days is dependent on whether it is on-peak season or off-peak season. The rate structure during the off-peak season is dependent on usage except for the RSEV rate structure, with a lower rate at night. During the on-peak season, the TOD rate structure has a higher price on weekdays between 2 PM and 7 PM.

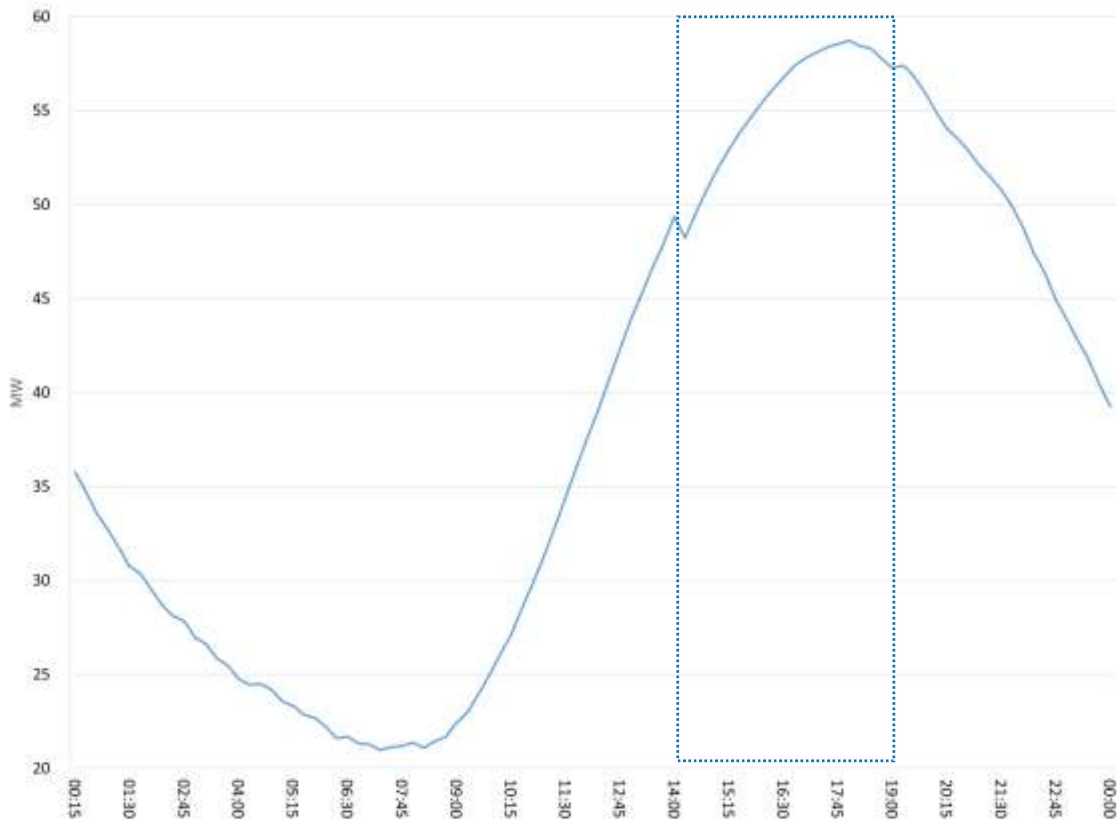
On-Peak Season Battery Advantage

During the summer months, the PSO load peaks in the late afternoon. An analysis of a typical summer weekday shows that the top of the load curve across all sectors is from roughly 2 PM to 10 PM (as shown in

[71] Power System Resilience | NREL

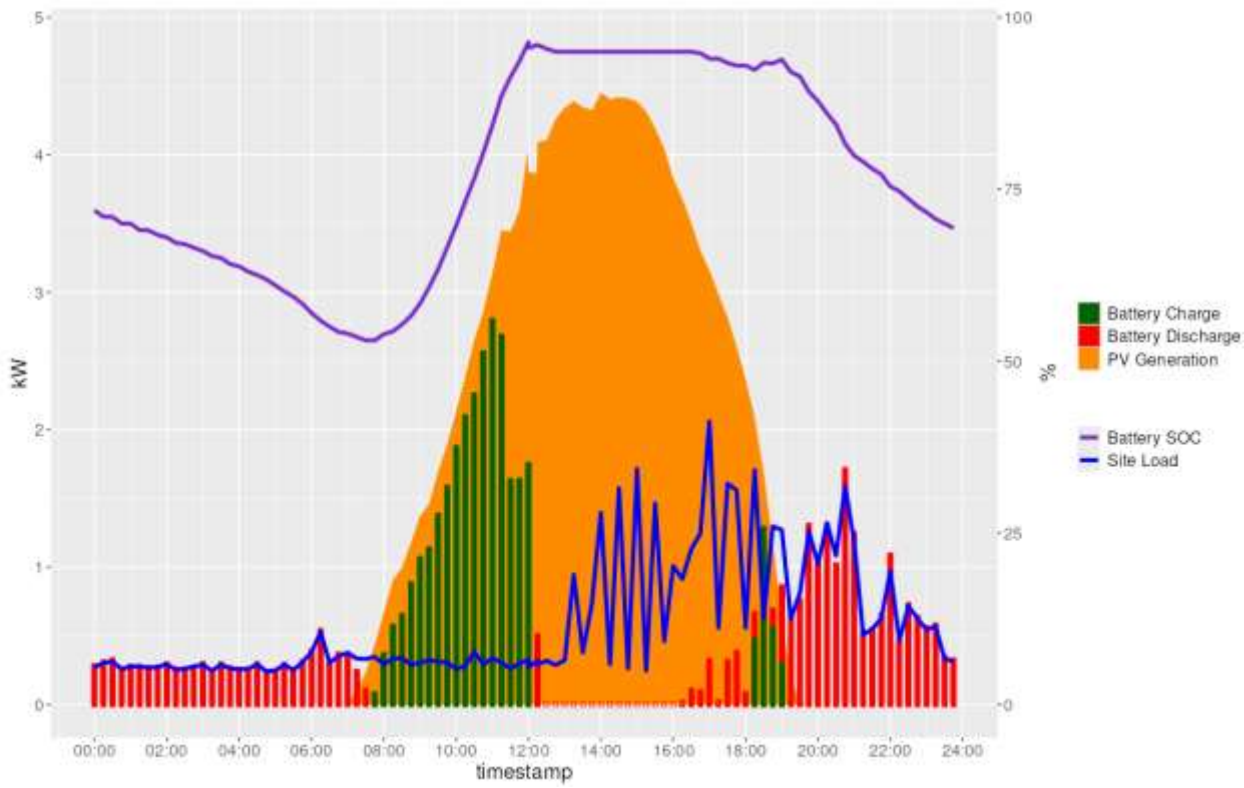
Figure 5-8 where load is above 50 MW).

Figure 5-8:Typical Summer Weekday Grid Load



For residences with existing solar, PV generation supports the early hours of the summer peak period. However, PV generation typically falls off around 5 PM (in summer), when the overall grid load remains high. For the remainder of the highest load period, 5 PM to 10 PM, when residential loads are high, the battery system can provide power to the home as an additional generation resource. Figure 5-9 shows a participant's power flow on a summer weekday. System performance, solar photovoltaic capacity, and load profile varied by site. The blue line represents the residential load, which is typical, with the load dropping off around 10 PM. PV Generation, shown shaded with yellow, starts to drop off around 5 PM with battery discharge compensating (red bars). The period where PV generation drops off and is supplemented by battery discharge is being called the battery advantage, until 10 PM.

Figure 5-9:Example BTM BESS Summer Day Power Flow



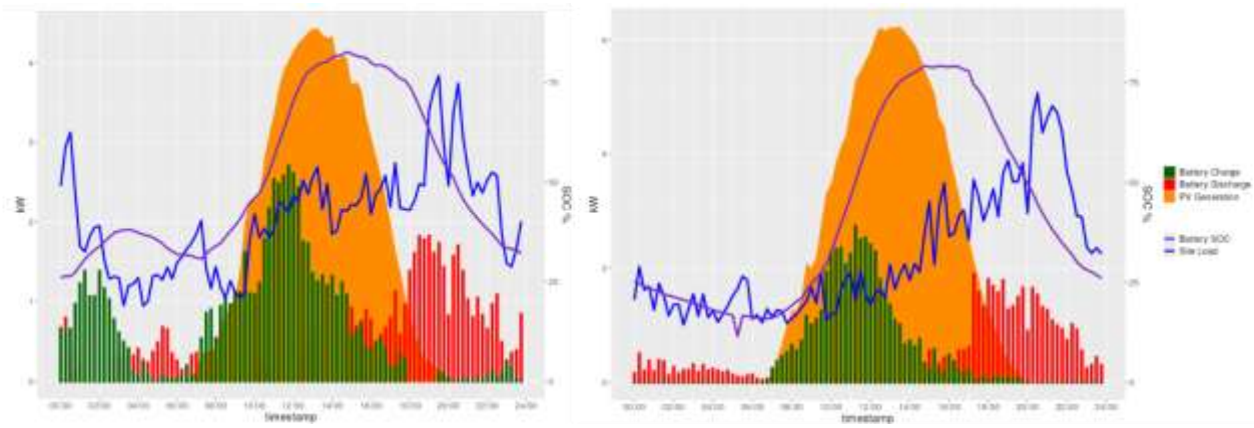
Battery advantage is calculated on a daily average basis as:

$$Battery\ Advantage\ (kWh) = \sum_{t=17}^{22} (battery\ discharge - PV\ generation)$$

Over half of the participants battery systems provided power for every hour between 5 PM and 10 PM. The battery system for the site shown in Figure 5-9 reduced the electric grid load by 2.5 kWh on this day from 5 PM to 10 PM. Sites reduced grid consumption by up to 15 kWh from 5 PM to 10 PM on non-event days.

Figure 5-10 shows the average PV generation and battery charging of sites configured with DC solar systems (left) and AC solar systems (right) on an optimal non-event day. DC solar systems averaged 5.44 kWh reduction of grid load from 5 PM to 10 PM and AC solar systems averaged 5.87 kWh reduction of grid load.

Figure 5-10:Average PV DC (Left) and PV AC Right) Performance on a Given Day



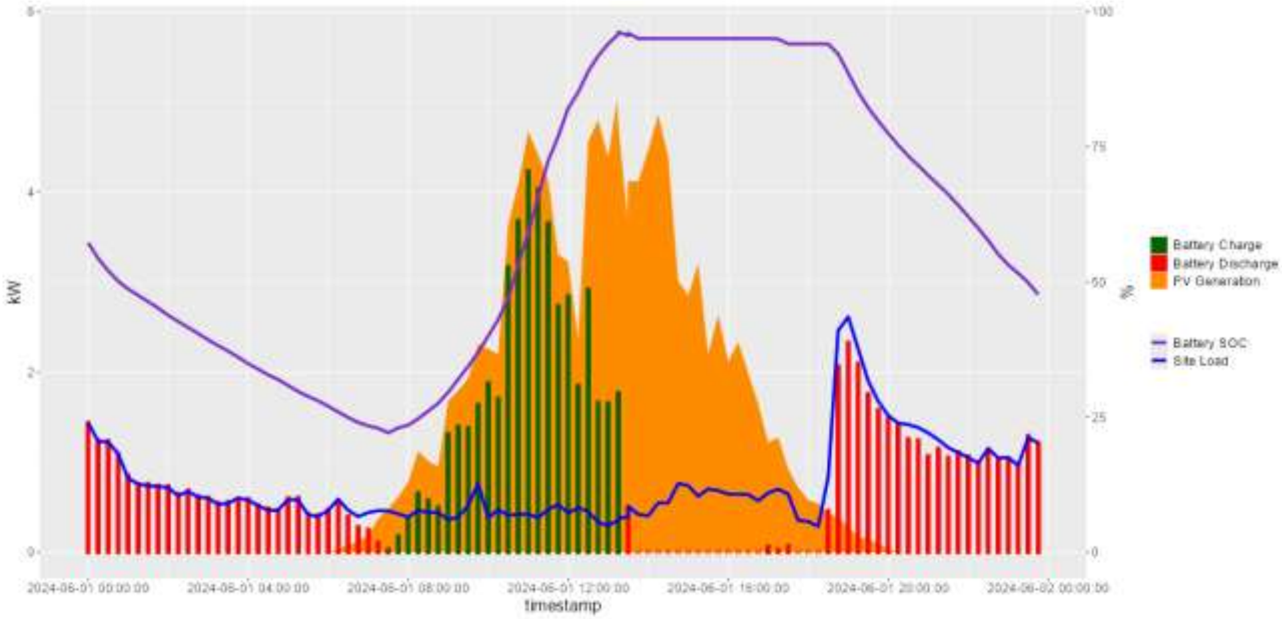
The average daily electricity provided by all battery systems during this period per residence is shown in Table 5-23.

Table 5-23 Average On-Peak Battery Advantage Per Residence

Average Daily Battery Advantage Per Residence (kWh)	Standard Deviation (kWh)	Highest Blue Sky Day Battery Advantage (kWh)	Lowest Blue Sky Day Battery Advantage (kWh)
3.74	2.12	9.50	0.19

Not all sites perform equally, and the algorithm is optimized to utilize the rate structure. Figure 5-11 for example shows a residence with a load profile where the load spikes in the evening. While it may have been beneficial for grid resiliency to discharge the batteries in the late afternoon, the battery power remained to meet the residences load in the evening and through the night. This participant utilizes a TOD rate structure, consuming little during daytime hours.

Figure 5-11:Example Algorithm Optimization – On-Peak



Furthermore, battery only sites tend to discharge the batteries earlier in the day. If they are on the RS rate structure, then they discharge throughout the day. Battery only sites could not export to the grid, so the systems are only capable of meeting the site load. Sites on the RSEV rate schedule and TOD schedule focus on discharging during the PSO on-peak hours of 2 PM to 7 PM. When comparing participants by group (system type and rate structure), those with backward connected systems and a TOD rate structure provide the highest benefit toward flattening out the afternoon/evening peak of the grid load.

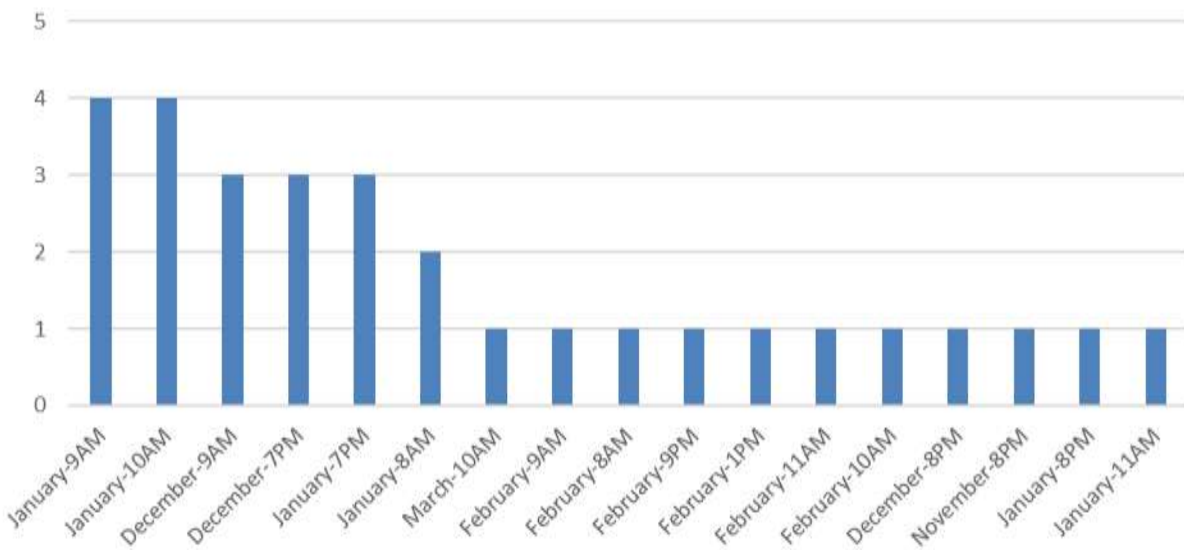
Table 5-24 Battery Advantage Comparison by Group – On-Peak

Season	Category	Average Daily Battery Advantage Per Residence (kWh)
On-Peak	BO	1.97
On-Peak	PVF	4.59
On-Peak	PVB	3.80
On-Peak	Rate RS	1.64
On-Peak	Rate TOD	4.26
On-Peak	Rate RSEV	2.31
On-Peak	**All**	**3.74**

Off-Peak Season Battery Advantage

The highest PSO grid loads in the off-peak season are often during the morning hours. Historical occurrences of peak loads in the off-peak season are presented in Figure 5-12, with the most common time being January weekdays at either 9 AM or 10 AM. The peak variability indicates that optimization of battery systems during the off-peak season may be difficult but could be based on weather forecasts as the peak periods often coincide with low temperatures. However, it is expected that the Sunverge DERMS platform does not differentiate by season but rather uses predictive analytics to develop a day-ahead forecast for customer price favorability. For this analysis, the same period (5 PM to 10 PM) is considered for the calculation of the battery advantage (that is, the period where load is expected to be high but solar PV generation is diminished).

Figure 5-12: Winter Peak Hour Occurrences over last 30 Years



In general, the battery advantage was lower during the off-peak, due to battery discharge not optimized for a peak period (on-peak period is prioritized for 2 PM to 7 PM). An example of battery discharge timing is shown in Figure 5-13.

Figure 5-13:Example Algorithm Optimization – Off-Peak

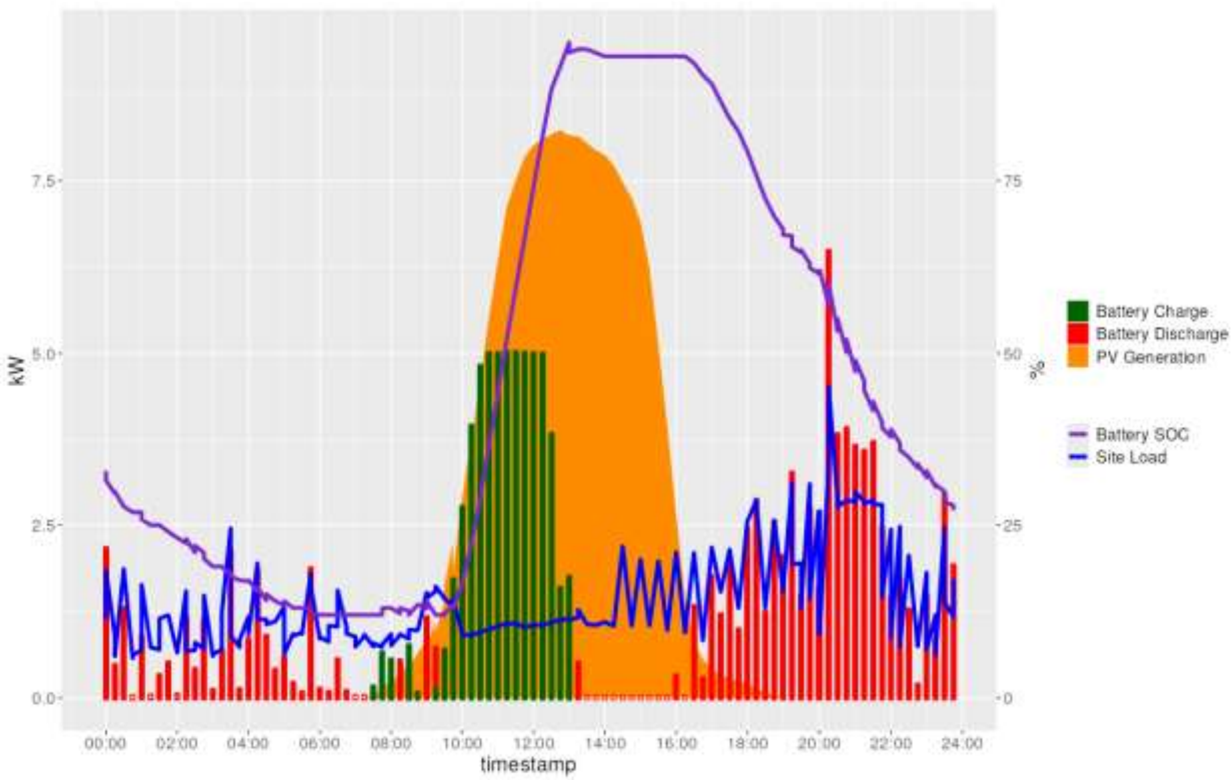


Figure 5-14 shows the charging pattern across all sites (average values) for an off-peak weekday.

Figure 5-14:Average Values Across All Sites for Off-Peak Day

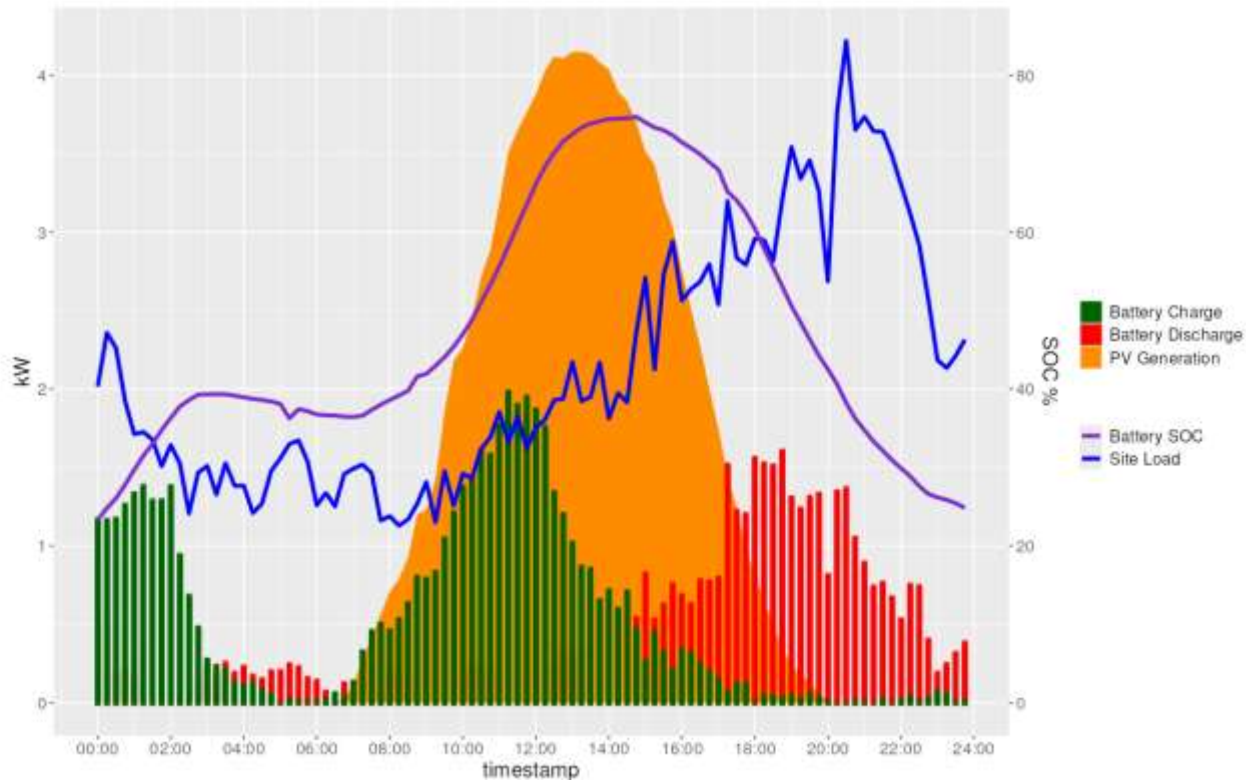
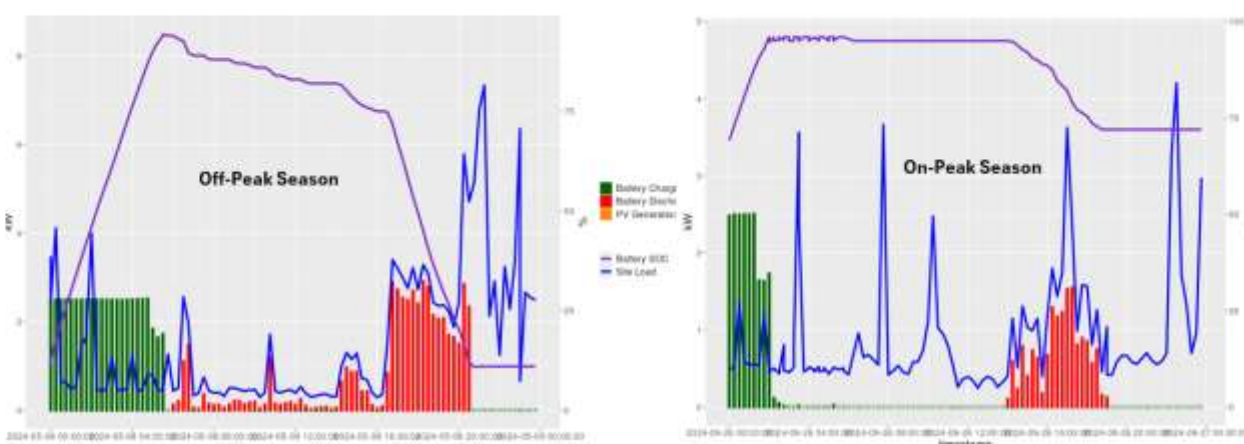


Figure 5-15 shows an example of the difference between battery discharge optimization in the off-peak season versus the on-peak season.

Figure 5-15:Example Battery Only Season Comparison



Battery advantage results by system type and rate schedule for the Off-Peak season are shown in Table 5-25.

Table 5-25 Battery Advantage Comparison by Group – Off-Peak

Season	Category	Average Daily Battery Advantage Per Residence (kWh)
Off-Peak	BO	1.62
Off-Peak	PVF	4.24
Off-Peak	PVB	2.82
Off-Peak	Rate RS	1.09
Off-Peak	Rate TOD	3.67
Off-Peak	Rate RSEV	2.33
Off-Peak	**All**	**3.14**

Overall program results are shown in Table 5-26.

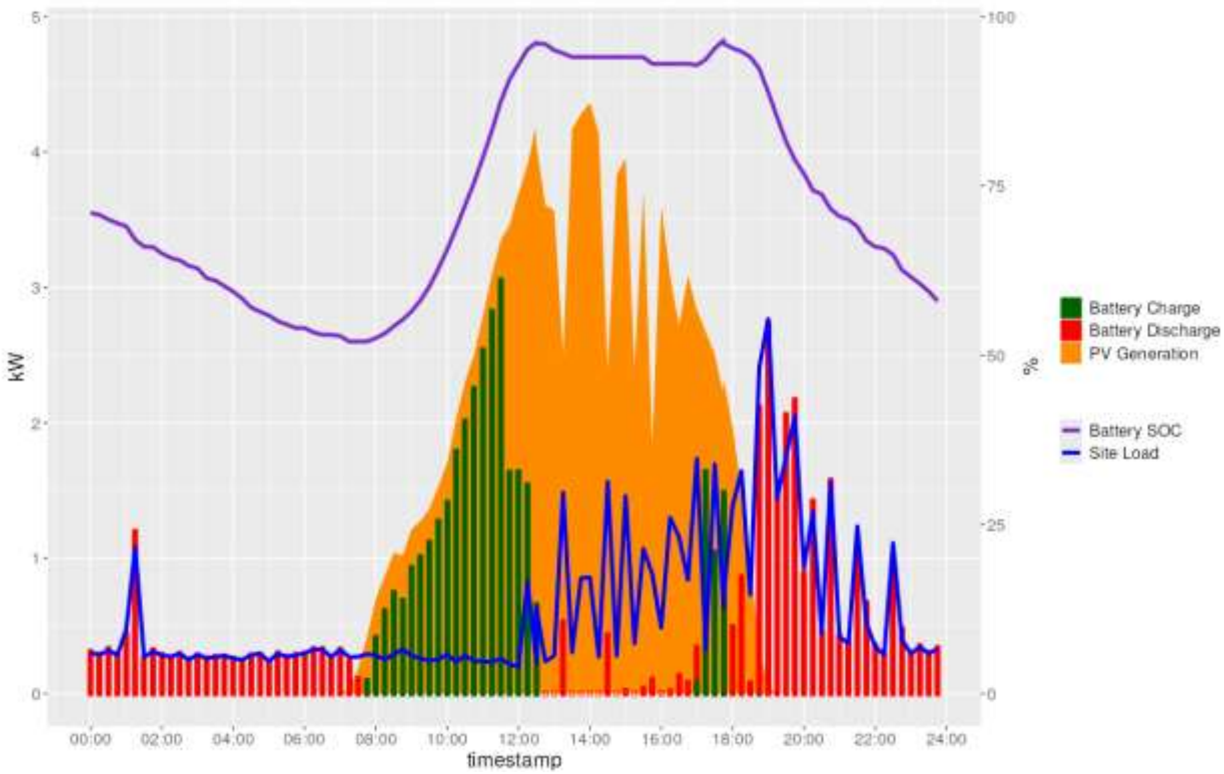
Table 5-26 Average Battery Advantage Per Residence – Off-Peak

Average Daily Battery Advantage Per Residence (kWh)	Standard Deviation (kWh)	Lowest Blue Sky Day Battery Advantage (kWh)	Highest Blue Sky Day Battery Advantage (kWh)
3.14	1.94	0.31	8.19

5.3.2.2.2 Solar Weather Resilience

Grid resilience can be enhanced by BTM BESS by compensating when solar PV generation drops due to weather conditions. While the Sunverge DERMS platform does not optimize solar weather resilience, it demonstrates the ability of BTM BESS to make residential solar PV generation a trusted distributed energy resource. An example is shown in Figure 5-16. In this example, price favorability is prioritized, however, there is compensation from the batteries for drops in solar PV generation.

Figure 5-16:Example of On-Peak Day Solar Weather Resilience



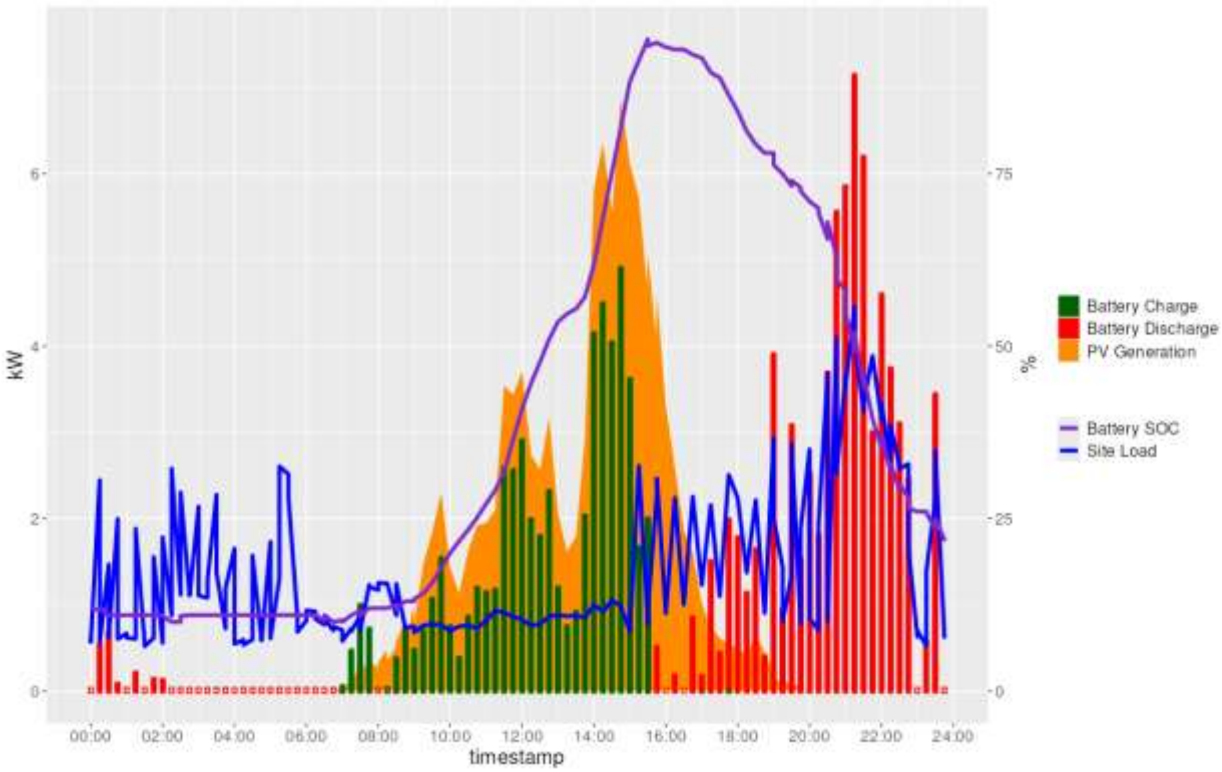
Solar weather resilience is calculated on an average daily basis, with the following equation:

$$Solar\ Weather\ Resilience\ (kWh) = \text{IF}[\text{ PVgeneration} > 0, \sum_{n=1}^{\infty} (\text{Battery Discharge})]$$

Over the summer period, the average residence utilized battery capacity to make up 23 kWh for weather events (such as clouds) during expected periods of solar generation from June through September (non-event weekdays).

A tradeoff is made between battery discharging during on-peak hours, when the load is high, and compensation for solar generation reduction. The day-ahead predictive analytics determines optimal charging and discharging for the participant. An example is shown in Figure 5-17 showing the battery system requiring a charge during periods of cloudy weather as it was used to meet the late afternoon and evening load. The energy management software would need a different algorithm to prioritize grid resilience for weather events.

Figure 5-17:Example of Discharge Priority



Charging Algorithm Optimization

To find the effectiveness of the charging algorithm in providing price favorability, an analysis determines if sites consumed less energy from the electric grid during the peak period after batteries were installed. This analysis was performed for participants on the TOD rate structure, reviewing consumption during peak hours on blue sky days using AMI data. Consumption was normalized for ambient temperature to remove any impact on consumption from the weather using a regression analysis approach. This analysis is referred to as Rate Structure Performance.

Of the 19 sites considered for analysis, two were considered outliers due to data issues. A binary regression factor accounted for consumption in the pre-installation or post-installation periods. Statistical significance was checked for each site to determine whether the installation parameter had a meaningful impact on a change in consumption. Eight participants showed a meaningful change. Results are shown in Table 5-27.

Table 5-27: Rate Structure Performance

Group	Count	Pre-Battery Avg. Peak Hourly Load (kW)	Post-Battery Avg. Peak Hourly Load (kW)	Percent Difference
All (Clean Data)	17	1.78	0.83	-21%
Statistically Significant	8	2.13	0.64	-42%

5.3.2.3 Active Demand Response Peak Load Reduction

Demand response events were called from the battery systems during peak hours of the on-peak season. The Sunverge DERMS platform was used to command the flow of electricity to and from the battery systems. Eighteen events were called, ranging from 2-4 hours duration on weekday afternoons. An analysis was performed to determine demand reduction during events. A summary of events is shown in Table 5-28.

Table 5-28: Demand Response Event Schedule

Date	Start Time (CT)	End Time (CT)
Friday, June 21	2pm	5pm
Tuesday, June 25	2pm	5pm
Wednesday, June 26	2pm	6pm
Friday, June 28	2pm	6pm
Tuesday, July 2	3pm	5pm
Tuesday, July 2	2pm	5pm
Wednesday, July 3	2pm	6pm
Monday, July 15	3pm	5pm
Monday, July 15	2pm	5pm
Tuesday, July 16	2pm	5pm
Wednesday, July 31	2pm	5pm
Thursday, August 1	2pm	5pm
Tuesday, August 6	2pm	6pm
Wednesday, August 7	2pm	6pm
Wednesday, August 14	2pm	6pm
Thursday, August 15	2pm	6pm
Monday, August 26	3pm	5pm
Tuesday, August 27	3pm	5pm
Thursday, September 19	3pm	5pm
Friday, September 20	3pm	5pm

Demand reduction during events was determined by calculating the difference between actual consumption (at the meter) and expected consumption. Expected consumption, known as the counterfactual baseline, was calculated based on consumption data before the battery system installation. This ensures that the results consider residents who previously had solar PV generation.

To determine the counterfactual baseline (estimated hourly consumption in the absence of a demand response event), consumption data was reviewed back to the beginning of 2022. For each day, the average hourly consumption (kW) was determined between 2 PM and 6 PM. The seven days with the highest average hourly consumption during this period were averaged for each hour for each site to determine the counterfactual baseline consumption for the event hour.

The calculated demand reduction was based on the energy management system controlling the battery power flow. The algorithms intention is to fully charge the batteries prior to the event and discharge the batteries for the duration of the event.

Some observations were apparent during events:

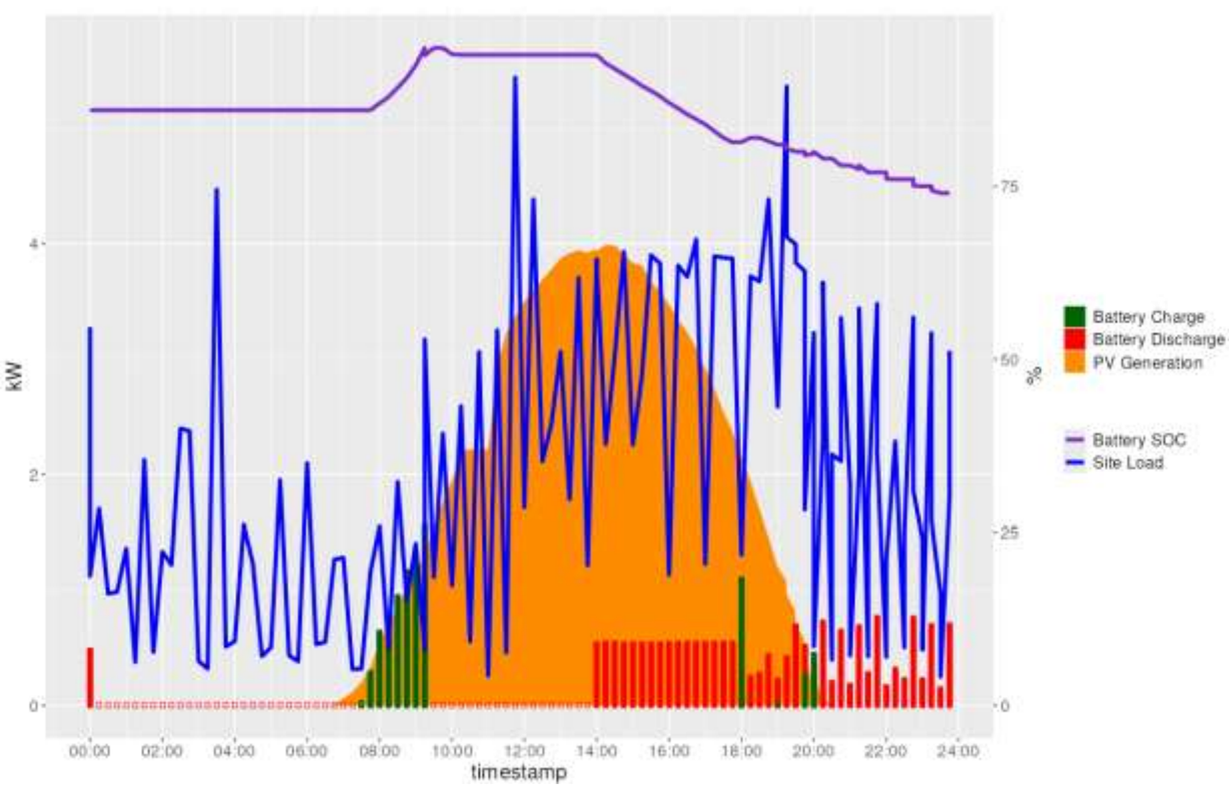
- Some battery systems were unable to continue to carry the residence's load for the duration of the event.
- Some battery systems discharged before an event, although this may not have impacted the duration in which the batteries could meet the load.
- Some battery systems did not fully discharge the batteries.

Several battery systems restrictions impacted these observations:

- Battery only sites could not export power to the electric grid
- DC coupled systems could only supplement the PV generation up to 7 kW, so battery discharge is more restricted compared to AC coupled systems.

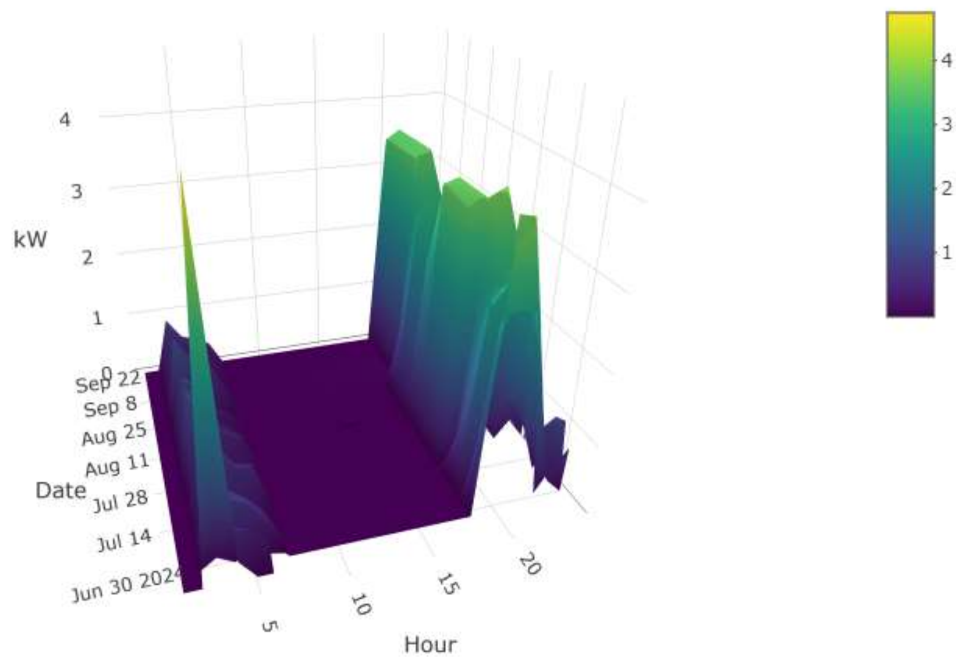
Data collected from a different site showed reduced discharge during the event period of 2 PM to 6 PM. See Figure 5-18. During this event, the batteries discharged at approximately 0.75 kW during the event.

Figure 5-18: Example of Event Day Slow Discharge



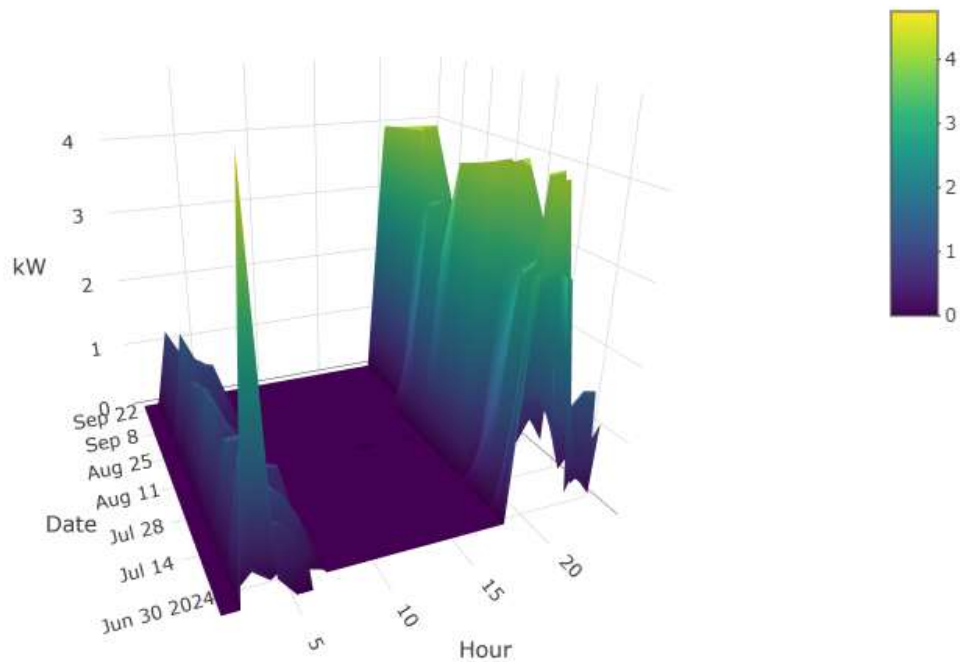
Each battery system installed has a capacity of 16 kWh and an inverter capable of delivering 7.5 kW. As previously discussed, discharge rates and amounts varied by site for each event. In theory, at 7.5 kW output from the batteries, the battery pack would average discharging approximately 5 kW per event hour. However, batteries should never be fully depleted, so one might expect to see approximately 4 kW discharge per event hour. Site-specific discrepancies are minimized when considering all residences combined. Figure 5-19 shows the hourly average battery discharge on event days across all participants. Battery systems were mostly discharged at around 3-4 kW, on average, during event hours.

Figure 5-19: Average Event Day Battery Discharge Across Participants



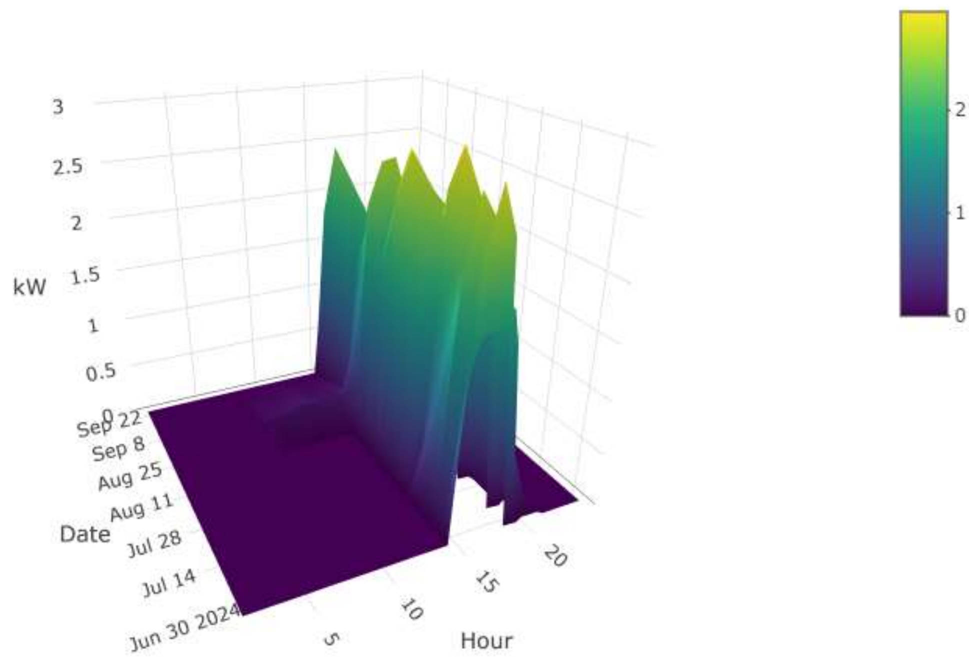
Battery discharge in the early hours of the day is a result of the energy management system planning for solar PV generation charging the batteries in the late morning and early afternoon before the peak period. Figure 5-20 shows the average hourly battery discharge from participants who have solar PV.

Figure 5-20: Average Event Day Battery Discharge from PV Participants



Battery only participants saw battery discharge occur during event periods, as expected. (See Figure 5-21)

Figure 5-21: Average Event Day Battery Discharge from Battery Only Participants

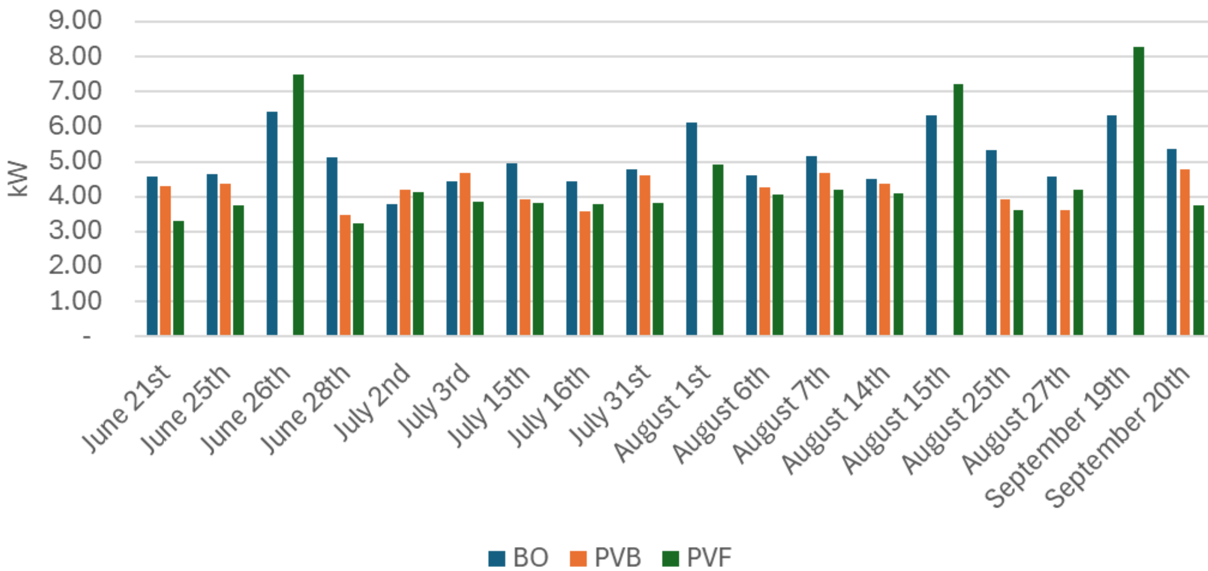


5.3.2.3.1 Demand Response Savings

The average hourly reduction during events across participants was 4.24 kW.[72] The average of the maximum hour reduction per event was 5.04 kW. The average hourly event reduction by system type is shown in Figure 5-22.

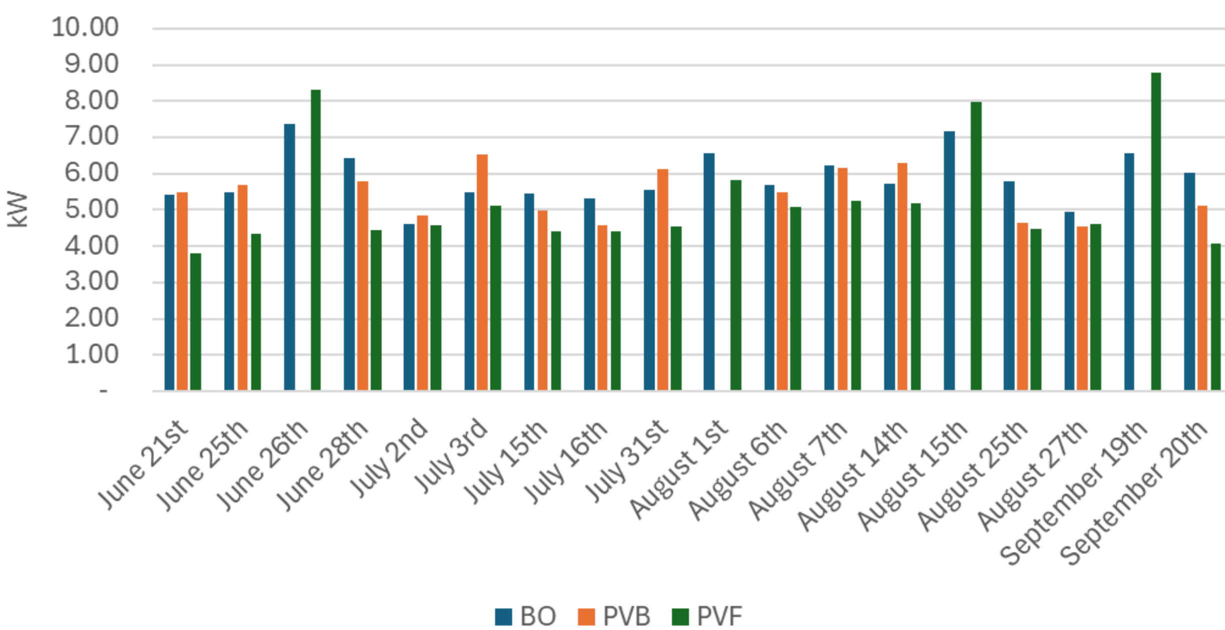
[72] Four sites were excluded as they were considered outliers with issues associated with the battery system or the data collected.

Figure 5-22: Average Event Hourly Reduction by System Type



The average of each event's largest hour reduction by system type is shown in Figure 5-23.

Figure 5-23: Maximum Event Hourly Reduction by System Type



The difference between the maximum hour and the average hour is mostly due to battery systems being depleted before completion of the event. Variances between event days is mostly caused by weather impacting solar PV generation and variances in the residence's load.

5.3.2.3.2 PSO Peak Load Alignment

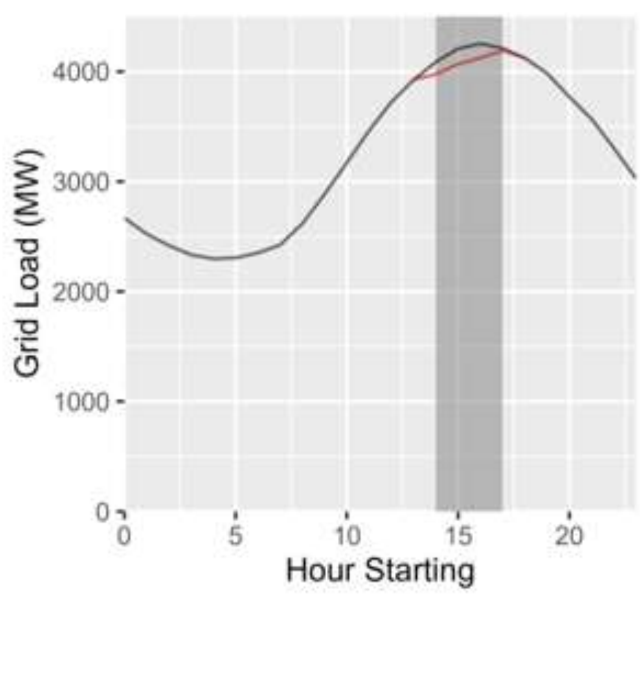
In 2024, PSO's peak load (accounting for demand response curtailment) would have occurred on August 1st from 4-5 PM CT and August 6th from 4-5 PM CT. During both peak hours, PSO called demand response curtailment events for Power Hours and Peak Performers. A battery event was called on August 1st, from 2 PM to 5 PM and August 6th from 2 PM to 6 PM. This section will compare curtailment on August 6th as the hours from 2 PM – 4 PM had a higher load compared to August 1st. A comparison of the battery pilot performance to Power Hours and Peak Performers is shown in Table 5-29.

Table 5-29 Event Impact on PSO Peak Hour

Event Type	Event Average Reduction (MW)	Event Peak Hour Reduction (MW)	PSO Load Reduction (%)
Power Hours	24.52	18.09	0.4%
Peak Performers	109.50	110.28	2.6%
Battery Event	0.11	0.12	0.003%
Total	**134.12**	**128.49**	**3.03%**

Figure 5-24 shows PSO's load profile on August 6th, 2024. The load (black line) is estimated during the demand response events, with the reduction due to curtailment shown by the red line.

Figure 5-24: PSO Load Profile for August 6, 2024



For comparison, Table 5-30 shows the average demand reduction during the event on August 6th for each residence or commercial site. The table shows the number of homes or commercial sites required to reach a PSO load reduction of 1% during the peak hour.

Table 5-30 Event Impact by Site on PSO Peak Hour

Event Type	Event Average Reduction (MW)	Event Peak Hour Reduction (MW)	Participation to Reduce PSO Load by 1%
Power Hours	0.0017	0.0012	34,542
Peak Performers	0.0911	0.0917	463
Battery Event	0.0047	0.0054	7,877

5.3.2.3.3 SPP Peak Load Alignment

The SPP peak load in 2024 occurred on August 14th from 4-5 PM CT. No demand response events were called on this day, and it did not align with PSO's peak day. Table 5-31 shows the impact on the SPP load had an event been called during this hour.

Table 5-31 Event Impact on SPP Peak Hour

Event Type	Event Average Reduction (MW)	Event Peak Hour Reduction (MW)	SPP Load Reduction (%)
Power Hours	24.52	18.09	0.21%
Peak Performers	109.50	110.28	1.26%
Battery Event	0.11	0.12	0.001%
Total	**134.12**	**128.49**	**1.47%**

For comparison, Table 5-32 shows the average demand reduction for each residence or commercial site. The table shows the number of homes or commercial sites required to reach an SPP load reduction of 1% during the peak hour.

Table 5-32: Event Impact by Site on SPP Peak Hour

Event Type	Event Average Reduction (MW)	Event Peak Hour Reduction (MW)	Participation to Reduce SPP Load by 1%
Power Hours	0.0017	0.0012	71,129
Peak Performers	0.0911	0.0917	954
Battery Event	0.0047	0.0054	16,221

5.3.3 BESS Customer Experience

This section presents findings from the pilot study from the participant perspective. Several surveys were administered to participants regarding recruitment, installation process, system operation, and demand response event operation. Additionally, a financial analysis was conducted on participant's monthly bill statements.

5.3.3.1 Customer Bill Analysis

Participants' monthly bills were analyzed for any statistical differences in total cost from the installation of the battery systems. Participants' monthly bills are complicated by various payment structures and rate structures. Across participants, 44 unique billing line items were present. To simplify the analysis, participants' aggregated line-item cost was used.

Two factors were considered for statistical significance:

- The month in which the battery installation took place (accounted for with a binary variable to indicate the period before the battery installation and period after the battery installation).
- Monthly average ambient temperature

A linear regression analysis with these two parameters was conducted for each participant. Findings from the review of statistical significance of the change in monthly bill based on battery system installation are as follows:

- Eleven residences showed a statistically significant difference in their monthly bill from before the battery system was installed.
    - Seven of these residents showed an average reduction of 44%. The remaining four residences showed an increase, averaging approximately 13%.
    - Two battery installations without solar power showed a statistically significant increase in their monthly bill. The remaining eight were inconclusive.
    - Seven of the battery installations with solar power showed a statistically significant decrease in their monthly bill. Two showed a statistically significant increase.
- Twenty-two participants monthly electric bills correlated with weather, as we would expect.

Due to the high uncertainty found in the statistical analysis, monthly bills were also reviewed without any statistical calculation. The average monthly bill before the battery installation was compared to the average monthly bill after the battery installation. Eleven residences were found to show a decrease in average monthly bill. These eleven mostly aligned with the statistical analysis, with seven residences showing an average monthly bill reduction and a statistically significant bill reduction based on the battery installation date. The average monthly reduction for these seven participants was 44%. However, five of these seven also showed a statistically significant reduction in consumption after batteries were installed. The consumption in reduction was normalized for weather, but external factors are expected to have contributed to the reduction. Therefore, only 2 sites could be determined with confidence to have a reduction in the monthly bill due to the installation of batteries.

Of the remaining twenty-two participants, the average change in monthly bills was a 15% increase. A summary of findings is shown in Table 5-33

Table 5-33 Financial Bill Statement Review

Classification	Count
Participants with Statistically Significant Change in Monthly Bill	11
Participants with Statistically Significant Reduction in Monthly Bill	7
Participants with Average Monthly Bill Reduction	11
Participants with Both Avg. Monthly Bill Reduction and Statistically Significant Reduction	7
Participants with Monthly Bill Reduction, Statistically Significant Reduction, and Reduced Consumption	5
Participants with high confidence in monthly bill reduction only due to battery installation	2
Total Residences in Study	**29**

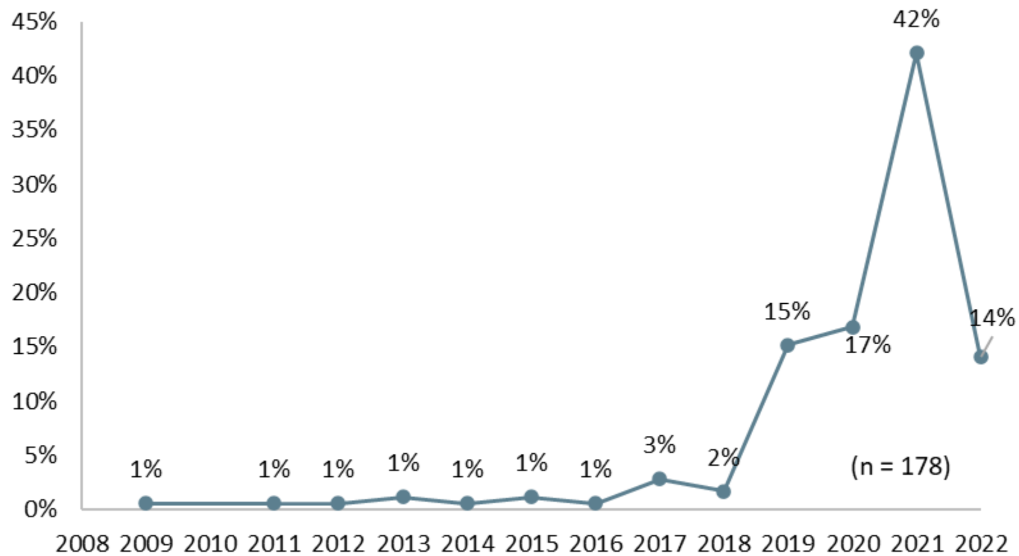
5.3.3.2 Participant Recruitment Survey

ADM administered an online survey to PSO residential customers who own solar systems. The purpose of the survey was to gauge interest in a potential pilot who would explore the use of residential battery systems to support PSO’s peak load management and environmental stewardship. The survey was sent to 969 customers and 178 surveys were completed online. The following section summarizes the key findings from the survey.

5.3.3.2.1 Solar Equipment

Most surveyed customers installed their solar equipment between 2019 and 2022, with 42% indicating they installed their equipment in 2021 (see Figure 5-25). Ten percent of survey respondents installed their equipment prior to 2016. This suggests that many solar customers have newer equipment (2020 or newer).

Figure 5-25: Year Solar Equipment was Installed



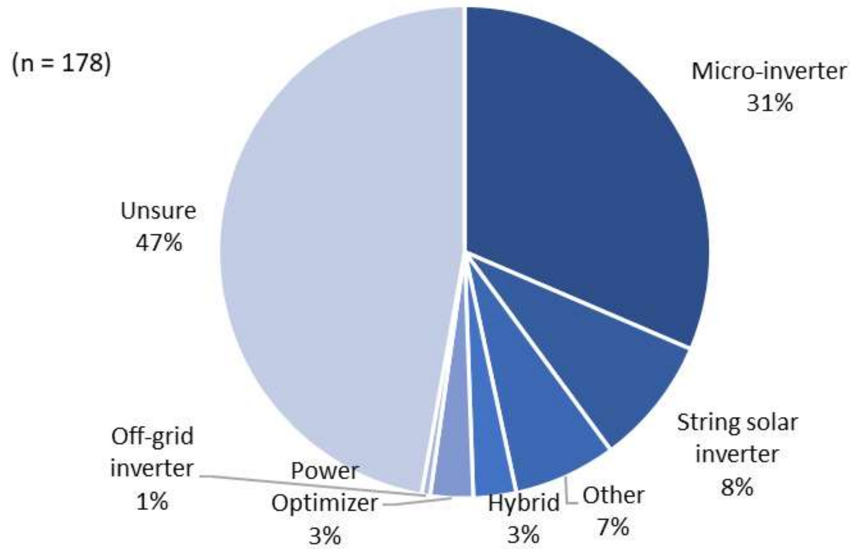
Thirty percent of respondents were unsure of the capacity of their solar system, followed by 25% who indicated their systems' capacity was 6 to 10 kW and 22% who indicated it was greater than 10 kW. (See Table 5-34)

Table 5-34: Approximate kW Capacity of Solar Systems

Response	Percentage of Responses (n = 178)
< 2 kW	3%
2 to 5 kW	20%
6 to 10 kW	25%
>10 kW	22%
Other ("30 panels")	1%
Unsure	30%

Almost half of survey respondents were unsure of the type of inverter they use for their solar equipment, followed by 31% who indicated their inverter was a micro-inverter and 8% who reported a string solar inverter (see Figure 5-26). Customers provided information about the make and model of their inverter. The Enphase IQ7, SolarEdge, Sunny Boy, and Solar Ark were the most common makers listed among respondents.

Figure 5-26: Type of Inverter Used by Solar Customers



5.3.3.2.2 Battery Equipment

Approximately 12% of survey respondents indicated they have battery equipment installed. Among those who did not have battery equipment, 77% considered purchasing it. Cost was the main reason they decided not to purchase battery equipment, followed by the solar installer or salesperson talking them out of the battery equipment (see Table 5-35).

Table 5-35: Reasons Customers Chose Not to Install Battery Equipment

Response	Percentage of Responses (n = 156)
Cost	59%
The solar installer or salesperson didn't offer or talked them out of it	26%
I didn’t see benefit	5%
Cost plus space or maintenance concerns	3%
Considering or installing soon	2%
Did not see benefit	2%
Waiting for new technology	1%
Not available	1%
Need different equipment to install	1%
Has a generator	1%

Among the 22 respondents who have battery equipment, 50% of respondents indicated they installed their battery equipment in 2021, followed by 18% who installed in 2020, 14% installed in 2022, 5% who installed in 2019, and 5% who installed in 2013 (9% were unsure). Thirty-two percent of customers who have battery equipment indicated the manufacturer was Enphase, followed by 23% who were unsure and 18% who reported Tesla (see Table 5-36).

Table 5-36: Battery Equipment Manufacturer

Response	Percentage of Responses (n = 22)
Enphase	32%
Tesla	18%
LG	5%
SolarEdge	5%
Sol Ark	5%
SOK LiFePO4	5%
AGM	5%
Other	5%
Unsure	23%

5.3.3.2.3 Participation Interest

Most survey respondents (91%) were interested in participating in a pilot study to explore the use of residential battery systems to support peak load management and environmental stewardship. Among respondents who have battery equipment, there were a total of 13 people who were interested in participating in the pilot and 4 who were unsure. (See Table 5-37)

Table 5-37: Equipment Type among Customers who have Battery Equipment and are Interested in Participating

Response	Count of Responses (n = 13)
Enphase	6*
LG	1
SolarEdge	1
Something else (AGM, SOK LiFeP04, Sol Ark)	4
Unsure	1**
*One additional respondent was unsure if they wanted to participate in the pilot. **Three additional respondents were unsure if they wanted to participate in the pilot.	

There were an additional 140 customers who do not have battery equipment and who were also interested in participating in the pilot. Many of the respondents had micro-inverters (see Table 5-38).

Table 5-38: Inverter Type among Customers without Battery Equipment who were Interested in Participating in the Pilot

Response	Count of Responses (n = 140)
String solar inverter	11
Hybrid	3
Off-grid inverter	0
Micro-inverter	50
Power Optimizer	5
Something else	9
Unsure	62

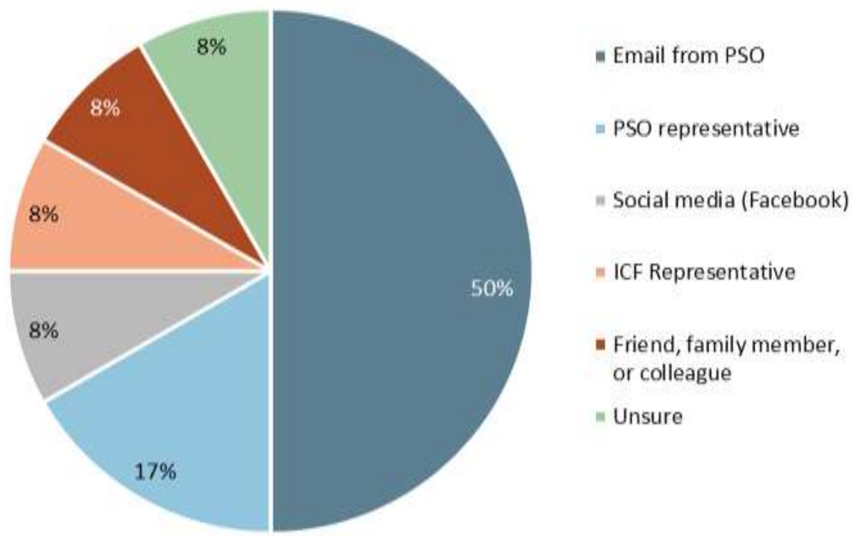
5.3.3.3 System Installation Survey

ADM administered an online survey to PSO residential customers who own solar systems and have installed battery energy storage systems. The purpose of the survey was to gather participants' insights into participant knowledge, awareness, and satisfaction with the program, as well as their motivations for participation. The survey was sent to 19 customers and 12 surveys were completed online. The following section summarizes the key findings from the survey.

5.3.3.3.1 Participant Experience with the Study

Participants' awareness of the BESS pilot study came from various sources. Most respondents (50%) reported learning about the program through emails from PSO. PSO representatives played a significant role, with 17% of respondents citing them as the channel through which they first became aware of the program. Other sources included friends, family members, or colleagues, social media, and an ICF representative. See Figure 5-27 for more information.

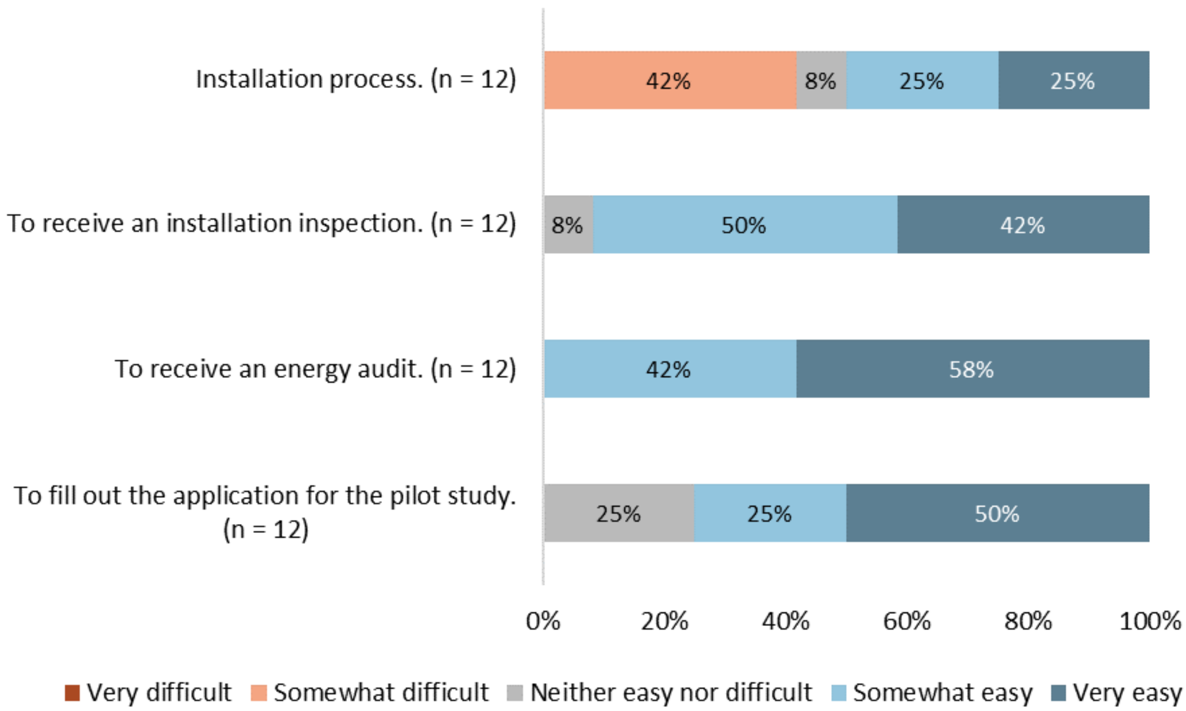
Figure 5-27 Source of Awareness (n = 12)



Survey participants found the application process for the pilot study to be straightforward, with 75% rating it as either very or somewhat easy. All found receiving an energy audit to be very or somewhat easy. Most (92%) found receiving an installation inspection to be either very or somewhat easy. Overall, the installation process received mixed feedback, with 42% finding it somewhat difficult, and 50% considering it somewhat or very easy. Refer to Figure 5-28 for additional information.

Participants provided feedback on what would have made the installation process easier. One respondent highlighted difficulty with wiring, resulting in frequent shutdowns and uncertainty about the system's proper functionality. Another participant mentioned significant changes made by the city inspector throughout the installation process. Equipment compatibility issues were raised, with customers suggesting the need for PSO to establish a testing laboratory for different equipment combinations, particularly crucial for widespread implementation. The lack of standardization in solar equipment interoperability was emphasized, with a call for PSO to advocate for more uniformity in this area. Additionally, concerns were raised about incomplete work, disconnection of monitoring equipment, and the installer's lack of experience in battery storage, contributing to a perceived longer-than-anticipated duration of the installation process.

Figure 5-28 Participants Rating of Various Aspects of the Battery Installation Process



5.3.3.3.2 Support and Information Provided

Most survey respondents indicated that the level of support they received during the installation process was somewhat or very supportive (see Table 5-39). Seven survey respondents indicated that they reached out to PSO to answer questions about the pilot study. Eighty-six percent stated that PSO thoroughly addressed their questions. One participant was unable to get an answer to their question regarding the decrease in production compared to the period before the battery installation.

Table 5-39 Level of Support Received During Installation

Response	Percentage of Survey Responses (n = 12)
1 (Not at all supportive)	0%
2	0%
3	33%
4	17%
5 (Very supportive)	50%

Seven respondents indicated they have experienced issues with their battery storage systems, such as malfunctions or breakdowns. These issues included recurring instances of the battery turning itself off, incorrect wiring affecting attached items, and the absence of access to production quantity information. Some experienced connection problems, requiring multiple visits for resolution, while others reported challenges such as the battery pack not maintaining a 'green' status and the inverter not utilizing solar array output effectively. Delays in PSO's approval process were noted, with frustration expressed over the prolonged interconnection approval timeline. Some participants faced difficulties in activating the battery portion and accessing monitoring software, while others dealt with malfunctions like a non-functional current monitor. Additionally, during a power outage, a backup shutdown occurred after the initial 10 minutes in one instance. Among those who experienced such problems, five customers indicated that the issue has yet to be resolved.

5.3.3.3.3 Participant Feedback and Suggestions

Participants in the BESS pilot study expressed various goals and expectations. These include seeking a more reliable source for solar-related information, ensuring their investment in solar systems proves worthwhile and contributes to the future. Some aim for backup power during outages and more efficient usage during high-demand hours. Others want to assess the impact of the battery on grid reliance, lower their electric bills, and have available power in the absence of PSO input. Additionally, participants express interest in studying how solar with a battery can address energy problems and contribute to cost reduction, grid stability, and environmental support. Some participants seek to lower their dependence on PSO and the grid, better utilize solar power, and explore the potential for savings and backup power. The study also provides an opportunity to learn about the interactions between solar generation, energy storage, and their effects on use, cost, and consumption.

Participants in the BESS pilot study provided feedback and suggestions for improvement. Recommendations included the need for more education for participants, ensuring a thorough installation process, and providing comprehensive information about the system and financial aspects of the program. Improvements in communication, better coordination in the installation and programming phases, and streamlined paper flow were emphasized. Participants expressed concerns about issues such as the battery not being registered, difficulties in monitoring and tracking performance, and the need for a more straightforward interconnection approval process. Some suggested reducing penalties and addressing legal considerations for solar panel installations in HOAs. Additionally, participants recommended the establishment of a development laboratory for testing equipment interactions and compatibility, as well as promoting the positive aspects of the distributed battery program to the public and within PSO.

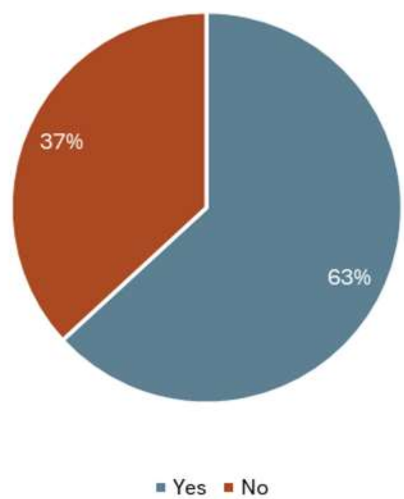
5.3.3.4 Participant Post Event Survey

ADM administered an online survey to PSO residential customers who own solar systems and have installed battery energy storage systems. The purpose of the survey was to gather participants' insights into participant knowledge, awareness, and satisfaction with the program battery events, as well as their motivations for participation. The survey was sent to 24 customers and 19 surveys were completed online. The following section summarizes the key findings from the survey.

5.3.3.4.1 Participant Experience with Battery Events

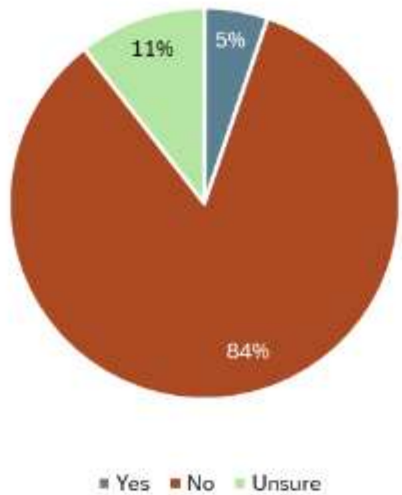
Most participants (63%) indicated they were aware of short-term demand response events managed by the utility, where their batteries were discharged to offset home loads and inject excess power into the grid. The remaining 37% were not aware of these events.

Figure 5-29 Participants' Awareness of Events (n = 19)



At the time of the survey, PSO conducted 12 events in which participants' batteries supplemented power to their homes, with the most recent event occurring on 8/14/2024. Most participants (84%) did not notice any difference in their electricity service during these periods, while 5% reported noticing a difference. An additional 11% indicated they were unsure. Among the one survey respondents who noticed a difference in their electric service during the events, they noted an increase in costs due to the need to recharge the battery following the event.

Figure 5-30 Did Customers Notice a Difference in their Electricity Service During Events (n = 19)

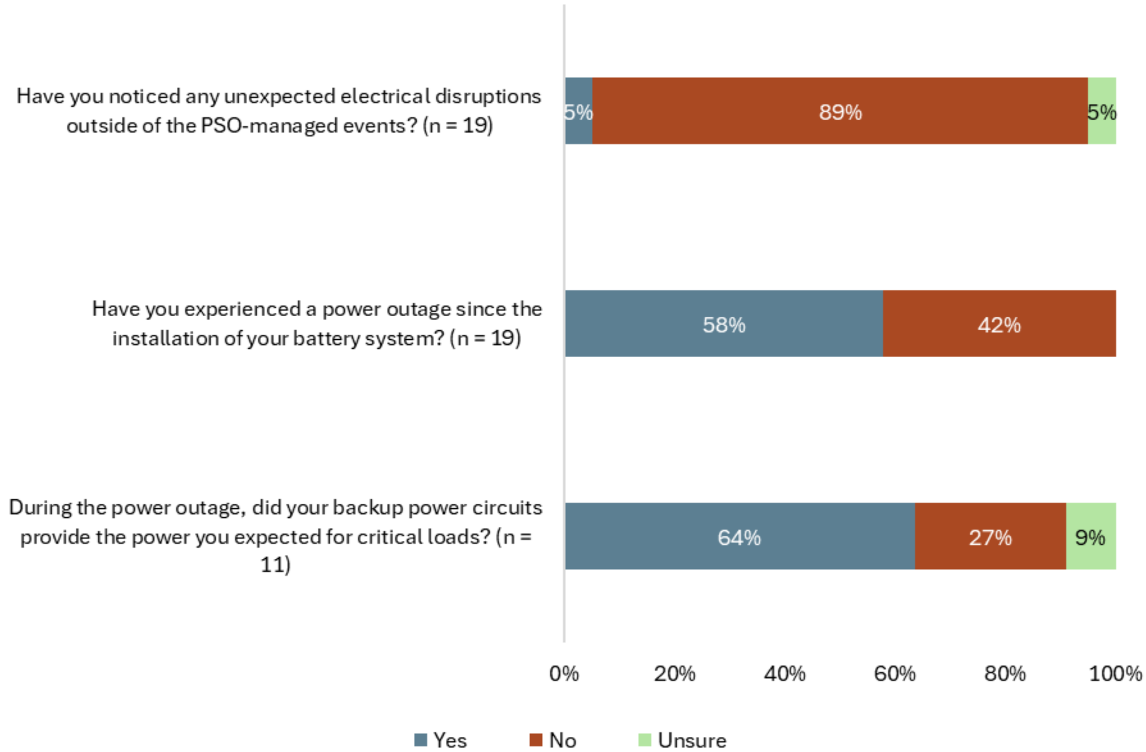


When asked if they had any information to share regarding events between June 21st and August 7th, participants provided a variety of responses. One participant suggested that PSO could send notifications when the battery is activated, allowing customers to actively monitor potential changes in service. Another noted that they were able to check their security system to confirm there was no power loss during the August 14th event and commented that the switch worked well. Several participants mentioned they were not aware of any issues or changes, with one respondent noting they only occasionally check the dashboard. Others reported that everything ran smoothly during the events, with no noticeable impact. However, one participant requested better updates during severe weather, mentioning they had only 12% battery life during a recent thunderstorm. Another highlighted a limitation with the Sunverge app, which does not allow access to past data beyond 24 hours. Finally, a participant expressed concerns about the financial value of using the battery during periods of high demand, suggesting that the current rate structure does not make it worthwhile.

5.3.3.4.2 Power Outage and Blue Sky Experiences

After installing battery systems, 58% of participants experienced power outages. Of those, 64% said backup power met expectations for critical loads, 27% disagreed, and 9% were unsure.

Figure 5-31 Experiences with Power Outages and other Unexpected Electrical Disruptions



Several participants described issues with their critical circuit loads during the outages. One participant experienced a failure of the system during the Father's Day 2023 storm in Tulsa, receiving only five minutes of backup power before it shut down entirely. They were unable to restart the system until power was restored a week later. Another participant noted that their master bedroom was not connected to the backup circuit as expected, and the system ran out of power within an hour, despite only powering the refrigerator and a few clocks. A third participant reported that the switchover to battery power took 5-6 minutes, which they found too long for a backup system, as it required the use of a UPS system to maintain Wi-Fi and internet access. Once switched over, all critical circuits were operational, but the delay in activation was the primary issue.

Regarding unexpected electrical disruptions outside of PSO-managed events, 5% of participants reported experiencing such disruptions, 89% did not, and 5% were unsure. One participant described a recent issue where the power flickered during a thunderstorm.

5.3.3.4.3 Non-Energy Benefits

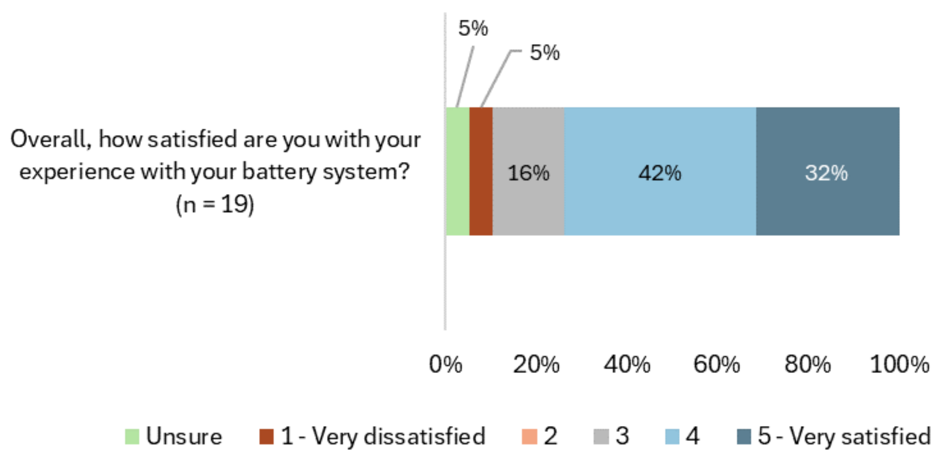
Regarding additional benefits from the battery system, responses varied among participants. One individual noted that having power during outages was beneficial, although they were unsure of other benefits. Another appreciated the modernization of their electrical system from a 1960s era 100 amp panel to a new 200 amp panel, which allowed for the addition of a car charging circuit. Some participants reported no additional benefits or expressed skepticism about energy savings due to inefficiencies in the battery system and perceived lack of savings. One respondent mentioned that the battery system caused a decrease in their overall energy production, making it difficult to see the benefits.

Concerning unexpected changes in the electric bill for June, several respondents did not recall any significant changes. Others noted increases in their bills due to higher usage, particularly during hot weather, or due to tariff changes. A few respondents found their bills confusing, citing difficulties in tracking solar production and battery usage. One individual reported that their bill was higher than the previous year, and another observed an increase in kWh import due to battery recharging from solar power.

5.3.3.4.4 Participant Feedback and Suggestions

Overall, 74% of participants were satisfied with their battery system experience, with 42% somewhat satisfied and 32% very satisfied. Sixteen percent were neutral, while one respondent (5%) were very dissatisfied. Additionally, 5% of participants were unsure about their level of satisfaction. See Figure 5-32.

Figure 5-32 Participants Rating of Various Aspects of the Battery Installation Process



Feedback on the BESS pilot program highlighted several areas of concern, including contractor training and compatibility issues during installation. Some respondents called for greater transparency regarding system switching periods and sought more information on the system's performance. One participant questioned the value of having a BESS without pairing it with solar power or a time of day tariff, noting that its primary benefit appears to be backup power. Commonly cited issues included connectivity problems and suggestions for enhancing the battery charge/discharge algorithm and optimizing energy efficiency through additional components like a smart panel. Dissatisfaction was expressed with the Sunverge user interface, and it was suggested that net metering rates should be revised. Installation challenges, such as disconnected panels and higher bills, were also noted.

Many participants commented positively on the program’s components and the communication from program representatives. There were calls for performance reporting to help users understand the system’s impact, as some were unsure if it was operating as intended. Recommendations included adding a smart panel to enhance energy efficiency and reassessing the battery charge/discharge algorithm to align better with the program's objectives.

The startup process was described by some as challenging and confusing, with concerns about ensuring the system supported all solar panels prior to installation to avoid additional costs and higher bills. Connectivity problems were frequently mentioned, along with a suggestion for PSO to implement a 1 to 1 net meter rate to improve the program's effectiveness. Despite these issues, participants generally viewed the program as a positive step toward grid modernization and appreciated the responsiveness of the program team.

5.3.4 Cost-Effectiveness

Behind-the-meter battery storage fits into several classifications of energy systems, one of them being a distributed energy resource. They are not a traditional energy efficiency measure in the sense that the purpose is not to reduce overall electric consumption but rather shift consumption to benefit the participant or the electric grid. The traditional energy efficiency cost-effective tests as well as the levelized cost of energy is used to determine whether the pilot study was cost-effective and whether battery systems could be cost-effective when scaled up.

Costs

This pilot study was a research and development program that studied emerging technology. The pilot's actual costs will be higher than one would expect to operate a program. Total program costs for 2024 are not available yet, so this calculation will assume that costs outside of the battery system and installation are only for the cost of the Sunverge DERMS platform.

Peak Demand Reduction

Peak demand reduction is the predominant benefit when using the traditional energy efficiency cost-effectiveness tests. Peak demand reduction was calculated similarly to the Peak Performers program or Power Hours Program. A residential air conditioning load shape was applied for these calculations, but it would be more accurate to develop a load shape based on battery charging cycles. However, due to various system designs, loads, and billing rate structures, a single load shape may never accurately represent the timing of charging cycles.

Grid Resilience – Avoided Generation

The traditional cost-effective tests are based on the premise that the installed equipment reduces consumption and thus avoids a certain amount of generation. Battery systems will not reduce overall generation, but they have the potential to reduce generation at strategic times when generation may be more expensive or detrimental in other ways. Additionally, most participants have solar PV, so the batteries have the potential to store the resident's solar PV generation during inopportune times of large-scale generation. To account for this, we will assume that the amount the battery discharges over a year provides a similar benefit as if generation were avoided entirely (as in treated as energy savings).

Emissions Impacts

Like avoided generation, emissions impacts are treated as energy efficiency. Time of day emissions vary based on the generation mix and could be included for a more accurate representation of actual benefits.

5.3.4.1 Cost-Effectiveness Results

Based on the assumptions listed in this section, the traditional energy efficiency cost-effectiveness scores are listed in Table 5-40.

Table 5-40: Cost-Effectiveness Score Results

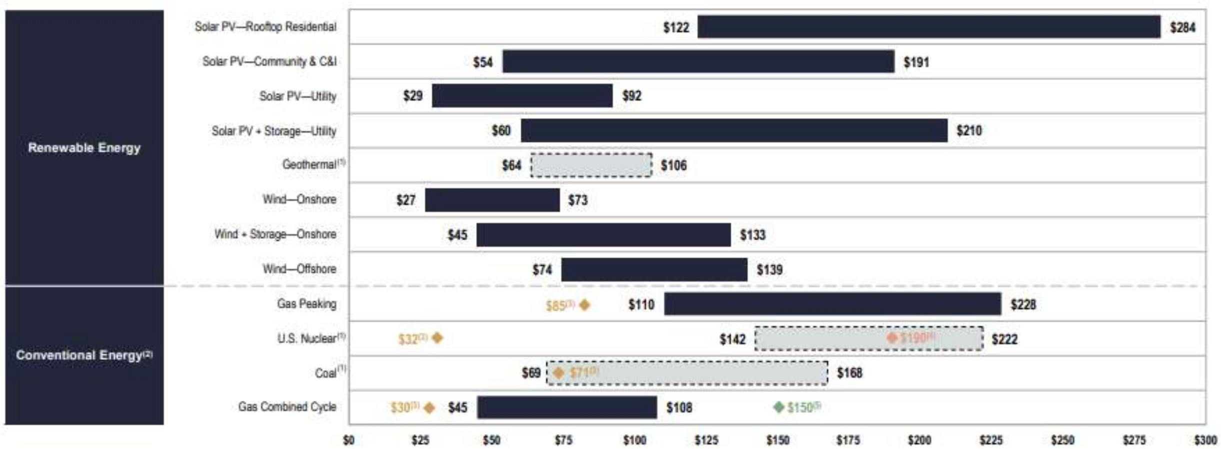
TRC	UCT	RIM	PCT	SCT
0.72	0.68	0.45	1.44	0.90

The system and installation costs were $18,900 per battery system. Reducing this cost would increase scores. Reducing system and installation costs to $13,500 would result in a positive TRC score.

5.3.4.2 Levelized Cost of Energy (LCOE)

The levelized cost of energy (LCOE) represents the average total cost of building and operating an energy-generating asset per unit of electricity generated over its lifetime. With this calculation, energy efficiency is often the lowest cost as the operating expenses over its lifetime are minimal compared to generation. For this calculation, battery system operation is the responsibility of resident at no cost. Operations and maintenance costs are held to the use of the Sunverge DERMS platform. The LG batteries come with software to control charge cycles, but do not have the benefit of optimizing charging and discharging to benefit the participant or electric grid. For this calculation we will assume a battery system life of 25 years and an associated annual energy management cost of $1500. A comparison of LCOE is shown in Figure 5-33. For the pilot study, the LCOE is approximately $200 per megawatt-hour, at the highest end of generation technologies. However, battery systems are comparable to gas peaking plants which range from $110 to $228. The estimated LCOE for a larger-scale program with Tesla Power Walls (using the assumptions mentioned in the previous section) is $120 per megawatt-hour. For comparison, estimated utility-scale battery LCOE is between $100 - $200 per megawatt-hour.[73]

Figure 5-33 LCOE Comparison[74]



[73] Utility-Scale Battery Storage | Electricity | 2024 | ATB | NREL
[74] Lazard Levelized Cost of Energy. June 2024. https://www.lazard.com/research-insights/levelized-cost-of-energyplus/

5.3.5 Conclusions and Recommendations

The following are conclusions developed from the analysis of telemetry data and site AMI data for the behind-the-meter battery energy system storage pilot study of 30 installations. The installations spanned residents with and without solar PV, with and without electric vehicles, and on TOD or flat billing rates.

- The energy management algorithm, focused on price favorability for the participant, was effective in reducing electric consumption from the grid during the peak period.
- A statistically significant reduction in monthly bills could not be determined.
- A different, or varying algorithm would be necessary to reduce the summer "duck curve" load profile.
    - Many participants load profiles do not follow the typical residential load.
    - The algorithm did not optimize solar PV generation replacement. The goal of the charging algorithm was not to provide supporting power to PV generation and therefore only periodically supplemented PV generation during weather changes.
    - The algorithm was not designed to optimize the second half of the peak period high load (after 7 PM).
- Off Peak benefits are uncertain as there is no TOD structure to optimize an energy management algorithm. This may be an opportunity for an algorithm to focus on grid resilience for winter weather events.
- Eighteen demand response events were called during the peak season, ranging from two to four hours.
- The useful battery system capacity was approximately 12.6 kW with the ability to discharge up to 7 kW. Due to event duration outlasting capacity, the average hourly battery contribution to demand reduction was 4.27 kW per battery system.
    - The energy management algorithm was mostly effective in entering events with 100% battery charge, however, in some instances, batteries were not fully discharged (to 20% state of charge).
- Forward configured (AC) solar systems are easier to work with than back configured (DC) solar systems. This is because the installed inverters for the batteries do not interfere with the solar PV inverter.
- Sites with electric vehicles demonstrate variable load profiles which may not align with energy management optimization.
- Customers with solar PV systems were interested in installing battery systems. 12% of survey respondents currently have batteries and 77% of respondents were interested and investigated battery systems. They had not installed battery systems due to the capital investment.
- Many survey respondents with solar PV and battery systems previously installed did not have significant technical knowledge of their system. Additionally, system

configurations vary. This is the product of variance between manufacturers and electrical connection decisions.

- Participants' motivation to install battery systems as part of the pilot was mostly financial and to ensure a backup power supply.
- Participants had concerns from the beginning about system configuration and operability, which were realized due to the complex nature of the systems, the variety of configurations, and the complexity of commissioning (permits, meter configurations, billing, etc.).
- The average satisfaction with the installation of the battery systems was approximately 75%.
- Most participants did not know there were events, and did not notice any impact on their electricity.
- 74% of respondents were satisfied with their battery system.
- PSO has a billing process in which customer costs are periodically reviewed and customers may be reclassified into different rate structures depending on their bill amount. This means that rate structures changed for some customers during the pilot program and was further exacerbated when customers pay an estimated average amount each month.
- The Sunverge DERMS Platform is dynamic and changes to optimize battery discharge took place throughout the summer of 2024. This resulted in inconsistent meter consumption.
- Third-party controlled demand response events demonstrated significant demand reduction over the first 1-2 hours of events.
- The optimization strategy should be variable or dynamic if the goal is to provide grid resilience for:
    - PV generation backup due to weather.
    - Address the whole peak period on a typical summer day.
    - Plan for non-peak season weather events.
- Behind-the-meter battery storage has the potential to support customer services, utility services, and ISO/RTO services, but from an energy management perspective these priorities do not all align.

The following recommendations are provided:

- As battery systems with solar PV can be complex and require resources for operation and maintenance, a bring-your-own-battery program design will benefit PSO.
    - Focus the program on active demand response to optimize battery discharge for grid resilience with demand response events ranging from 1-2 hours.
- Ensure battery systems are appropriately sized for the load, depending on the program goals. For example, an electric vehicle may have 3-4 times the capacity of a single residential battery bank.

- Ensure thermostat-based demand response events are linked to battery demand response events providing double the benefit.
  - Include additional devices if possible, such as water heaters and appliances such that the battery system can be a grid resource and provide for the site load.
- Consider the path taken by Southern California Edison (SCE), Pacific Gas & Electric (PG&E), San Diego Gas & Electric (SDGE), National Grid, Rhode Island Energy, Eversource, Cape Light Compact, and other utilities in working with Tesla Powerwall installation in the PSO territory to create a virtual power plant (VPP). These utilities provide incentives for events (by kWh across the event) in which the utilities claim the demand reduction. These are controlled devices but have automated overrides to protect the battery systems, and are managed by Tesla, making for a vertically integrated solution. Customers must already have obtained a Tesla Powerwall and then will select to opt into the VPP.
  - A barrier to success will be that participants identified the capital investment of a battery system being an obstacle.

5.4 Non-Wires Alternative Pilot Study

This pilot study implements site-specific energy efficiency and demand response measures to reduce the summer demand peak and winter demand peak on capacity strained electric circuits and substations. Reduction of summer demand was targeted for Oklahoma circuits XG-1 and XG-3 in Owasso from station 691 and additional review from previous NWS 2020 study for the reduction of winter demand on circuit 83831 in the Soper and Boswell area. Measures were implemented in 2020for circuit 83831 and 2023 for XG-1 and XG-3. Energy efficiency and demand response measures were implemented based on current program offerings for residential and commercial customers.

5.4.1 Summer Peak Demand Reduction Methodology

Summer demand reductions on circuits XG-1 and XG-3 consisted of demand response through residential thermostats (Power Hours Program), commercial and industrial curtailment through Peak Performers, and the installation of energy-efficient measures for both sectors. Demand response events were called during the summer months of 2023. The goal of this analysis is to determine demand reduction during PSO's peak hour. In 2023, the peak hour occurred from 4-5 PM CT on August 21st..[75]

5.4.1.1 Power Hours

The same methodology used for the Power Hours program was used to estimate the peak demand reduction for Owasso residents for the system peak hour. Baselines were calculated only using the subset of XG-1 and XG-3 residents. Load reduction differs from

[75] Summer peak hour is estimated based on the inclusion of curtailment due to demand response programs.

Power Hours results as for this study we are presenting the load reduction during the peak hour, not the average across the event. Power Hours participants were evaluated for PY 2023 and PY 2024.

5.4.1.2 Peak Performers

Demand response for commercial sites was measured by the Peak Performers program. Because baseline loads and reductions are calculated for each site, the reductions for Owasso businesses during the system peak hour were pulled from the Peak Performers analysis results. Participants were evaluated for 2023 and 2024.

5.4.1.3 Energy Efficiency Programs

The remaining sites were energy-efficiency program participants. Energy impacts could not be determined from a billing analysis for the system peak hour. Engineering algorithms, based on the provided project documentation, were used to determine the savings impact over the summer peak period. The methodology and results use findings from the analysis done in PY 2021.

5.4.2 Winter Peak Demand Reduction Methodology

Peak winter reductions were evaluated at 7-8 AM in December and January as the expected annual winter peak. Winter reductions are calculated for circuit 83831, providing electric to Soper and Boswell. The pilot will target the installation of energy efficiency measures within PSO's residential and commercial energy efficiency programs. These include weatherization, lighting, heat pumps, refrigeration, energy coaching, and HVAC tune-ups.

5.4.2.1 Residential Energy Efficiency Measures

A pre-post regression was used to estimate winter peak reduction for residential accounts. Additionally, control matching was implemented to compare energy usage from customers who received energy savings measures to a similar group of residential customers. AMI data was used for winter seasons from 2019 to 2024 (November 2018 – March 2024). The AMI meter data was combined with weather data from NOAA. Post periods were determined by the measure install date for each customer. Next, control matching was performed for the winter seasons in 2019 and 2020. Finally, a linear mixed effects regression model was used to determine the reduction for the estimated winter peak.

Equation 5-1 Difference-in-Difference Energy Savings Model

$$kWh_{i,t} = \beta_0 + \beta_1 HDD_t + \beta_2 CDD_t + \beta_3 Post_{i,t} + \beta_4 (Post_{i,t} * Treatment_i) + \alpha_i Customer_i + \varepsilon_{i,t}$$

Where,

t = monthly time interval

$kWh_{i,t}$ = average daily electricity use (in kWh) during time-period t

$Post_{i,t}$ = dummy variable identifying the post-treatment time-period

$Treatment_i$ = dummy variable identifying the treatment group customers

$Post_{i,t} * Treatment_i$ = an interaction term that identified customers in the treatment group

HDD_t = average daily *HDD* during time *t*

CDD_t = average daily *CDD* during time *t*

$Customer_i$ = mixed effects variable, meaning this value is unique to each premise

The coefficient of interest is the post * treatment variable. This indicates the kW savings after customers have installed energy efficiency measures.

5.4.2.2 Commercial Energy Efficiency Measures

Annual energy savings were determined based on engineering algorithms. Billing regression analyses proved inconclusive. End-use electric load shapes, based on the installed energy efficiency measures, were developed through energy simulations using eQUEST to determine the portion of annual energy savings attributed to the winter peak hours. Detailed M&V was not conducted on the commercial projects, so program-level realization rates were applied to desk review savings estimates.

5.4.3 Results

Peak demand savings by season are summarized by the tables in this section. Some programs compare results from different program years.

5.4.3.1 Summer Peak Demand Reduction

A Power Hours event was called on the peak days of August 21, 2023 and August 6, 2024. Peak hour reduction due to thermostat (Power Hours Program) events are shown in Table 5-41.The average peak hour reductions are considered the circuit-level peak demand reduction.

Table 5-41: Owasso Power Hours Results

Date	Responding Devices	NWS Demand Savings per Device (kW)	Peak Demand Savings (kW)
8/21/2023	42	1.35	56.72
8/6/2024	46	1.20	55.04
Average	**44**	**1.28**	**56.10**

Peak Performers events were called on the peak hour days in 2023 and 2024. Peak hour reduction due to participant voluntary curtailment (Peak Performers Program) are shown in Table 5-42. Although the participants varied, the average peak hour reductions are considered the circuit-level peak demand reduction.

Table 5-42: Owasso Peak Performers Results

Date	Sites	NWS Demand Savings per Device(kW)	Peak Demand Savings (kW)
8/21/2023	7	51.80	362.63
8/6/2024	6	27.54	165.25
Average	**7**	**39.67**	**277.69**

Peak demand reduction from commercial energy efficiency measures were calculated as the average peak demand reduction across typical summer peak hours based on engineering algorithms. Each site's measures are summarized in Table 5-43.

Table 5-43: Commercial Program Peak Reductions

Site Measures	Demand Savings (kW)
LED Lighting	0.56
LED Lighting	0.92
Refrigeration gasket, strip curtain	0.17
Refrigeration gasket	0.02
HVAC	7.07
LED Lighting	22.19
Total	**30.89**

Demand reductions during the typical PSO peak summer hour are summarized in Table 5-44.

Table 5-44: NWS Summer Peak Demand Reduction

Program	Demand Savings (kW)
Power Hours	56.10
Peak Performers	277.69
Commercial and Industrial	30.89
Total	**364.68**

5.4.3.2 Winter Peak Demand Reduction

A linear mixed effects regression model was run on 76 residential customers on the Soper Boswell circuit. The pre-period consisted of the Winter 2019 (December 2018 – Jan 2019) and Winter 2020 (December 2019 – January 2020) seasons. A model was run for each post-season after and for all seasons combined. See Table 5-45. Using the overall regression model, the winter peak demand saving is approximately 11.25 kW

Table 5-45: Residential Winter Peak Savings per Customer

Winter Season	Estimated Demand Savings (kW)	90% Confidence Lower Bound	90% Confidence Upper Bound
2021	0.169	0.104	0.234
2022	0.074	0.014	0.134
2023	0.093	0.016	0.169
2024	0.236	0.169	0.303
Overall	**0.148**	**0.097**	**0.199**

Commercial projects were completed within the Small Business Energy Solutions and Custom and Prescriptive Business Rebates Program. The 29 projects included LED lighting, refrigeration door heater controls, refrigeration evaporator/compressor controls, EC motors, and HVAC equipment. Load shapes were applied to evaluated annual energy savings (kWh) to determine winter peak savings (kW).

Table 5-46: Commercial Winter Peak Savings by Measure

Measure	Demand Savings (kW)
Lighting	51.72
Heat Pumps	4.37
Refrigeration Controls and Motors	9.12
Total	**65.21**

Total winter kW reductions are summarized in the table below.

Table 5-47: Total NWS Winter Peak Savings

Program	Demand Savings (kW)
Residential energy efficiency	11.25
Commercial energy efficiency	65.21
Total	**76.46**

5.4.4 Findings and Conclusions

The following summarizes the key findings of the NWS pilot.

- Residential and commercial end-use energy efficiency measures were implemented to mitigate capacity constraints on several PSO electric circuits.
  - One circuit was targeted to mitigate winter peak loads, with a goal of 500 kW peak load reduction. Evaluation found a realized peak load reduction of 76.46 kW.
    - Replacement of residential heating systems with heat pumps was the primary objective based on load analytics. While 93 heat pumps were installed, minimal winter peak savings were realized.
    - Commercial load reduction, mostly heat pumps and lighting, represented the majority of the pilot's peak load reduction.
  - Two circuits were targeted to mitigate summer peak demand reduction using PSO's demand response and energy efficiency programs. The peak summer load reduction goal was 460 kW. Evaluation found a realized peak load reduction of 364.68 kW.
    - The verified load reduction was mostly obtained through residential thermostat demand response and commercial and industrial demand response curtailment.

The following conclusions are provided:

- Continue supplementing substation investments with energy efficiency and demand response when addressing capacity issues.
  - Target energy efficiency and demand response based on the substations and circuits load profiles. AMI data can assist through tools such as the virtual diagnostics tool.

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 homogeneous measures. 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 "reported."

Verified: Refers to estimates of energy savings and peak demand reductions developed from program evaluation. Equivalent to "verified impacts" or also "verified."

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.

In-Service Rate (ISR): The percentage of measures incented that are installed and operating.

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 for 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 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 Peak Performers 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 program's 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 2022 - 2024 portfolio filing on June 23, 2021.[76] Reported impacts refer to energy savings and peak demand reduction estimates based on actual program participation in 2024, before program evaluation activities. Finally, verified impacts refer to energy savings and demand reduction estimates for 2024 developed through independent program evaluation, measurement, and verification (EM&V).

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

[76] Cause No. PUD 2021000041.

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. 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 annual energy savings (kWh), annual admin costs, total program costs, as well as a summary of the cost effectiveness analysis.

B.1.1 Cost Effectiveness Summary

This appendix covers all verified electricity and peak demand savings, and associated program costs incurred in the implementation of PSO's 2024 energy efficiency and demand response portfolio from January 1, 2024, through December 31, 2024.

The cost-effectiveness of PSO's 2024 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. Spending estimates were provided by PSO. The methods used to calculate cost-effectiveness are informed by the California Standard Practice Manual. [77]

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 2024 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. Measure life values came from the Oklahoma Deemed Savings Documents (OKDSD) or the Arkansas TRM.[78] Additionally, assumptions regarding incremental/full measure costs were necessary. These costs were taken directly from the portfolio plan, California's Database for Energy Efficiency Resources (DEER) 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.

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.

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[77] 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

78 http://www.apscservices.info/EEInfo/TRM6.pdf

Table B-2 lists each program included in this analysis, along with the final verified savings estimates, total expenditures, Utility Cost Test (UCT)[79] results, and Total Resource Cost Test (TRC) results. Impacts shown in Table B-2 presents values of 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).[80]
- 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 2024, PSO's overall portfolio is cost-effective based on both the UCT and TRC.

Table B-1: Projected by Program, 2024 (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	7,979	38,608,825	(160,327)	$11,959,747
Residential Energy Services	7,350	41,442,001	1,324,104	$9,470,841
Home Weatherization	983	2,670,356	155,169	$3,447,546
Conservation Voltage Reduction	9,223	34,793,768	-	$1,775,539
Total – EE Programs	**25,534**	**117,514,950**	**1,318,946**	**$26,653,673**
Power Hours	25,246	-	-	$2,163,843
Peak Performers	77,861	76,090	-	$4,294,431
Total – DR Programs	**103,107**	**76,090**	**-**	**$6,458,275**
Total – R&D Programs	**252**	**196,124**	**-**	**$841,902**
Total	**128,893**	**117,787,164**	**1,318,946**	**$33,953,850**

79 The UCT is also referred to as the Program Administrator Cost Test (PACT).
80 http://www.occeweb.com/rules/CH35finalrules111819.pdf.

Table B-2: Cost-Effectiveness by Program, 2024 (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	5,884	6,382	36,208,309	38,462,194	$11,476,201	1.46	1.81
Residential Energy Services	11,773	12,771	54,171,551	57,543,607	$10,834,737	2.06	1.81
Home Weatherization	2,723	2,954	5,008,807	5,320,594	$3,457,760	3.40	2.02
Conservation Voltage Reduction	4,400	4,773	22,569,621	23,974,528	$1,912,154	1.49	1.33
Total – EE Programs	**24,780**	**26,880**	**117,958,289**	**125,300,923**	**$27,680,853**	**1.78**	**1.64**
Power Hours	22,744	24,672	266,797	283,405	$1,588,095	3.48	2.15
Peak Performers	107,841	116,982	1,134,454	1,230,614	$5,410,697	10.50	2.96
Total – DR Programs	**130,586**	**141,654**	**1,401,251**	**1,514,019**	**$6,998,792**	**7.77**	**2.78**
Total – R&D Programs	**162**	**176**	**153,101**	**166,078**	**$669,070**	**0.79**	**4.27**
Total	**155,528**	**168,711**	**119,512,640**	**126,981,019**	**$35,348,715**	**2.07**	**1.81**

Benefits and costs associated with each cost-effectiveness test for the portfolio of energy efficiency and demand response programs is shown in Table B-3.

Table B-3: Portfolio Benefit/Cost Tests

Metric	Utility Cost Test	Total Resource Cost Test	Ratepayer Impact Measure	Societal Cost Test	Participant Cost Test
Benefit/Cost Ratio	**1.81**	**2.07**	**0.57**	**2.39**	**5.30**
Net Benefits ($000s)	38,697.38	52,975.56	(64,781.93)	68,833.42	105,549.67
Total Benefits ($000s)	86,468.71	102,539.03	86,468.71	118,396.90	130,090.69
Total Costs ($000s)	47,771.32	49,563.47	151,250.63	49,563.47	24,541.02

B.2 Energy-Efficiency Programs

PSO’s energy efficiency portfolio in 2024 consisted of four programs. Table B-4 provides a summary of program participation and verified net impacts for each of the energy-efficiency programs. Table B-5 provides reported costs per program.

Table B-4: Energy-Efficiency Programs – Verified Impacts (Net, at Generator)

Program	Number of Participants in 2024*	Verified Peak Demand Reduction (kW)	Verified Annual Energy Savings (kWh)	Verified Gas Savings (Therms)
Business Rebates	1,020	6,382	38,462,194	-94,462
Residential Energy Services	288,988	12,771	57,543,607	708,970
Home Weatherization	1,971	2,954	5,320,594	598,546
Conservation Voltage Reduction	55,644	4,773	23,974,528	0
Total – EE Programs	**347,623**	**26,880**	**125,300,923**	**1,213,054**

*Participants represent a residence or business who participated as opposed to the number of measures or projects. For Energy Saving Products, the actual number of customers is unknown and instead this count is of unique customers that received rebates for qualifying downstream measures. ESP in total rebated 268,122 products.

Table B-5: Energy-Efficiency Programs – Reported Costs

Program	Annual Non-EM&V Admin Costs ($)[81]	Annual EM&V Admin Costs ($)	Annual Cash Inducement Costs ($)[82]	Annual Non-Cash Inducement Costs ($)[83]
Business Rebates	$359,001	$332,862	$6,805,235	$3,979,103
Residential Energy Services	$280,394	$340,209	$6,882,067	$3,332,067
Home Weatherization	$95,166	$41,066	$3,176,759	$144,769
Conservation Voltage Reduction	$20,602	$58,164	$0	$1,833,388
Total – EE Programs	**$755,164**	**$772,301**	**$16,864,061**	**$9,289,327**

Table B-6 shows the measures with measure life and associated programs. The measure life for Business Rebates measures is calculated as a weighted average based on annual energy savings. The programs for Behavioral Modification and Peak Performers each have a Tier 1 EUL of one year. Conservation voltage reduction has an EUL of 25 years.

81 Non-EM&V Admin Costs include PSO staff labor costs and overhead costs.
82 Cash inducement costs refer to customer rebate costs.
83 Non-cash inducement costs include third party implementation costs.

Table B-6: Measure Life

Measure	Measure Life	Business Rebates	Multifamily	Home Weatherization	Energy Saving Products	Homes Rebates	Education	Power Hours	CVR	Behavioral	Business Demand Response
Air Sealing	11		X	X		X					
Duct Replacement	20					X					
Duct Sealing	18		X	X		X					
Central AC	19					X					
Air Source Heat Pump	16		X			X					
Ground Source Heat Pump	25					X					
Insulation - Attic	20		X	X		X					
Insulation - Kneewalls/Vertical Attic Wall	20					X					
Insulation - Exterior Wall	20					X					
HVAC Tune-Up	10		X			X					
WiFi Thermostat	11				X	X					
New Construction Homes	20					X					
Home Energy Check-Up	10					X					
Lighting	12	X	X	X	X		X				
Custom	14	X									

Measure	Measure Life	Business Rebates	Multifamily	Home Weatherization	Energy Saving Products	Homes Rebates	Education	Power Hours	CVR	Behavioral	Business Demand Response
HVAC	12	X									
Kitchen & Appliances	13	X									
Commercial New Construction Lighting	10	X									
Oil & Gas	14	X									
Refrigeration	9	X									
HVAC	17	X	X								
Advanced Power Strip	10				X		X				
Furnace Filter Alarm	14						X				
Water Heater Temp. Setback	2						X				
Refrigerator temp setback	1						X				
Furnace Filter	0				X						
Bathroom Ventilation Fans	12				X						
Door Seals and Sweeps	15				X						
Room Air Conditioners	11				X						
Room Air Purifiers	9				X						
Spray Foam	15				X						

Measure	Measure Life	Business Rebates	Multifamily	Home Weatherization	Energy Saving Products	Homes Rebates	Education	Power Hours	CVR	Behavioral	Business Demand Response
Clothes Dryers	13				X						
Clothes Washers	14				X						
EV Chargers	10				X						
Heat Pump Water Heaters	10				X						
Water Heater Jacket	7			X							
Water Heater Pipe Insulation	13			X							
Faucet Aerators	10		X	X							
Refrigerator	17		X								
Low Flow Shower Head	10		X								
Windows	20		X								
Home Energy Report	1									X	
Conservation Voltage Reduction	25								X		
DLC Events	1							X			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-7: 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	**1.81**	**1.46**	**0.47**	**1.69**	**3.36**
Net Benefits ($000s)	8,787.82	6,696.22	(22,373.60)	10,025.56	24,579.23
Total Benefits ($000s)	19,683.03	21,206.44	19,683.03	24,535.78	34,999.48
Total Costs ($000s)	10,895.21	14,510.22	42,056.63	14,510.22	10,420.25

B.2.2 Residential Energy Services Program

Table B-8: Residential Energy Services Benefit/Cost Tests

Metric	Utility Cost Test	Total Resource Cost Test	Ratepayer Impact Measure	Societal Cost Test	Participant Cost Test
Benefit/Cost Ratio	**1.81**	**2.06**	**0.43**	**2.39**	**5.07**
Net Benefits ($000s)	8,459.11	13,308.25	(24,568.69)	17,498.96	36,978.35
Total Benefits ($000s)	18,848.66	25,897.65	18,848.66	30,088.36	46,060.28
Total Costs ($000s)	10,389.55	12,589.40	43,417.35	12,589.40	9,081.92

B.2.3 Residential Energy Services: Multifamily SubProgram

Table B-9: Multifamily Benefit/Cost Tests

Metric	Utility Cost Test	Total Resource Cost Test	Ratepayer Impact Measure	Societal Cost Test	Participant Cost Test
Benefit/Cost Ratio	**2.15**	**3.27**	**0.52**	**3.84**	**5.29**
Net Benefits ($000s)	1,709.22	2,892.60	(2,954.97)	3,617.66	5,473.78
Total Benefits ($000s)	3,196.26	4,167.77	3,196.26	4,892.83	6,748.95
Total Costs ($000s)	1,487.04	1,275.17	6,151.23	1,275.17	1,275.17

B.2.4 Home Weatherization Program

Table B-10: 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	**2.02**	**3.40**	**0.66**	**4.06**	**5.10**
Net Benefits ($000s)	3,522.83	8,297.17	(3,558.62)	10,576.84	13,018.16
Total Benefits ($000s)	6,980.59	11,754.93	6,980.59	14,034.60	16,194.92
Total Costs ($000s)	3,457.76	3,457.76	10,539.21	3,457.76	3,176.76

B.2.5 Residential Energy Services: Energy Saving Products SubProgram

Table B-11: 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	**6.81**	**3.57**	**0.34**	**3.98**	**9.18**
Net Benefits ($000s)	3,804.67	3,838.31	(8,643.50)	4,456.26	11,417.96
Total Benefits ($000s)	4,459.60	5,333.64	4,459.60	5,951.59	12,814.01
Total Costs ($000s)	654.94	1,495.33	13,103.11	1,495.33	1,396.05

B.2.6 Residential Energy Services: Home Rebates SubProgram

Table B-12: Home Rebates Benefit/Cost Test

Metric	Utility Cost Test	Total Resource Cost Test	Ratepayer Impact Measure	Societal Cost test	Participant Cost Test
Benefit/Cost Ratio	**1.24**	**1.62**	**0.50**	**1.95**	**3.39**
Net Benefits ($000s)	1,525.45	4,992.72	(7,886.08)	7,634.09	13,545.85
Total Benefits ($000s)	8,016.71	13,055.31	8,016.71	15,696.69	19,212.01
Total Costs ($000s)	6,491.26	8,062.60	15,902.79	8,062.60	5,666.17

B.2.7 Residential Energy Services: Education SubProgram

Table B-13: Education Benefit/Cost Test

Metric	Utility Cost Test	Total Resource Cost Test	Ratepayer Impact Measure	Societal Cost test	Participant Cost Test
Benefit/Cost Ratio	**1.89**	**2.08**	**0.38**	**2.33**	**5.17**
Net Benefits ($000s)	738.48	903.32	(2,531.11)	1,109.65	3,105.11
Total Benefits ($000s)	1,571.87	1,736.72	1,571.87	1,943.05	3,849.64
Total Costs ($000s)	833.40	833.40	4,102.99	833.40	744.53

B.2.8 Residential Energy Services: Behavioral Modification SubProgram

Table B-14: Behavioral Benefit/Cost Test

Metric	Utility Cost Test	Total Resource Cost Test	Ratepayer Impact Measure	Societal Cost test	Participant Cost Test
Benefit/Cost Ratio	**1.74**	**1.74**	**0.39**	**1.74**	**-**
Net Benefits ($000s)	681.30	681.30	(2,553.03)	681.30	3,435.66
Total Benefits ($000s)	1,604.21	1,604.21	1,604.21	1,604.21	3,435.66
Total Costs ($000s)	922.91	922.91	4,157.24	922.91	-

B.2.9 Conservation Voltage Reduction

Table B-15: CVR Benefit/Cost Test

Metric	Utility Cost Test	Total Resource Cost Test	Ratepayer Impact Measure	Societal Cost test	Participant Cost Test
Benefit/Cost Ratio	**1.33**	**1.49**	**0.44**	**1.87**	**-**
Net Benefits ($000s)	5,181.90	7,887.14	(26,688.49)	13,838.72	26,640.85
Total Benefits ($000s)	21,124.90	23,830.14	21,124.90	29,781.72	26,640.85
Total Costs ($000s)	15,943.00	15,943.00	47,813.40	15,943.00	-

B.3 Demand Response Programs

PSO’s demand response portfolio in 2024 consisted of two demand response programs. Table B-16 provides a summary of program participation and verified net impacts for the 2024 demand response portfolio. Table B-17 provides a summary of 2024 program costs.

Table B-16: Demand Response Programs – Verified Impacts (Net, at Generator)

Program	Number of Participants in 2023	Verified Peak Demand Reduction (kW)	Verified Annual Energy Savings (kWh)	Gas Savings (Therms)
Power Hours	13,611	24,672	283,405	0
Peak Performers	228	116,982	1,230,614	0
Total – DR Programs	**13,839**	**141,654**	**1,514,019**	**0**

Table B-17: 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	$143,752	$51,965	$603,343	$774,947
Peak Performers	$101,316	$34,796	$5,180,361	$94,224
Total – DR Programs	**$245,067**	**$86,761**	**$5,783,704**	**$869,171**

B.3.1 Power Hours Program

Table B-18: 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	**2.15**	**3.48**	**2.11**	**3.48**	**-**
Net Benefits ($000s)	1,803.91	2,407.26	1,780.69	2,407.26	628.02
Total Benefits ($000s)	3,377.92	3,377.92	3,377.92	3,377.92	628.02
Total Costs ($000s)	1,574.01	970.66	1,597.23	970.66	-

B.3.2 Peak Performers Program

Table B-19: Peak Performers Benefit/Cost Test

Metric	Utility Cost Test	Total Resource Cost Test	Ratepayer Impact Measure	Societal Cost test	Participant Cost Test
Benefit/Cost Ratio	**2.96**	**10.50**	**2.91**	**10.50**	**4.08**
Net Benefits ($000s)	10,611.62	14,496.89	10,512.85	14,496.89	3,990.18
Total Benefits ($000s)	16,022.31	16,022.31	16,022.31	16,022.31	5,285.28
Total Costs ($000s)	5,410.70	1,525.43	5,509.46	1,525.43	1,295.09

B.4 Research and Development

PSO’s research and development portfolio resulted in annual energy savings and peak demand reduction not captured within the portfolio’s residential or commercial energy efficiency or demand response programs. The following tables provide a summary of activity and results.

Table B-20: Research and Development Programs - Verified Impacts (Net, at Generator)

Program	Number of Participants in 2024	Verified Peak Demand Reduction (kW)	Verified Annual Energy Savings (kWh)	Verified Gas Savings (Therms)
Research and Development	31	176	166,078	0
Total – RND Programs	**31**	**176**	**166,078**	**0**

Table B-21: Research and Development Programs - Reported Costs

Program	Annual Non-EM&V Admin Costs	Annual EM&V Admin Costs	Annual Cash Inducement Costs	Annual Non-Cash Inducement Costs
Research and Development	$138,790	$154,801	$101,103	$274,377
Total – R&D Programs	**$138,790**	**$154,801**	**$101,103**	**$274,377**

Table B-22: Research and Development Programs Benefit/Cost Test

Metric	Utility Cost Test	Total Resource Cost Test	Ratepayer Impact Measure	Societal Cost Test	Participant Cost Test
Benefit/Cost Ratio	**4.27**	**0.79**	**1.36**	**0.98**	**0.50**
Net Benefits ($000s)	330.19	(117.35)	114.00	(10.79)	(285.18)
Total Benefits ($000s)	431.30	449.65	431.30	556.21	281.82
Total Costs ($000s)	101.10	567.00	317.30	567.00	567.00

B.5 Avoided Costs

The avoided costs in Table B-23 were developed for energy, capacity, transmission, and distribution (T&D), and CO_2 during the portfolio design process (PUD 2021000041) 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).[84]

[84]https://psoklahoma.com/global/utilities/lib/docs/ratesandtariffs/Oklahoma/PSO%20Riders%20Jan%2020 19.pdf

Table B-23: Avoided Costs from PSO Portfolio Plan

Year	SPP - Energy	SPP Capacity		T&D Costs	CO2	Natural Gas
	$/MWh	$/MW-day	$/kW-yr	$/kW-yr	($/metric tonne)	($/Mcf)
2022	$42.85	$263.35	$96.12	$33.66	$0.00	$5.37
2023	$46.06	$268.14	$97.87	$34.27	$0.00	$5.40
2024	$49.52	$273.03	$99.66	$34.90	$0.00	$5.43
2025	$50.56	$278.00	$101.47	$35.53	$0.00	$5.46
2026	$53.28	$283.07	$103.32	$36.18	$0.00	$5.49
2027	$56.46	$288.22	$105.20	$36.84	$0.00	$5.52
2028	$77.56	$293.47	$107.12	$37.51	$13.61	$5.69
2029	$77.73	$298.82	$109.07	$38.19	$14.08	$5.86
2030	$78.89	$304.26	$111.06	$38.89	$14.58	$6.03
2031	$78.98	$309.80	$113.08	$39.60	$15.09	$6.20
2032	$79.91	$315.45	$115.14	$40.32	$15.62	$6.37
2033	$82.12	$321.19	$117.24	$41.05	$16.16	$6.54
2034	$83.72	$327.04	$119.37	$41.80	$16.73	$6.71
2035	$85.02	$333.00	$121.55	$42.56	$17.31	$6.88
2036	$86.71	$339.07	$123.76	$43.34	$17.92	$7.05
2037	$89.98	$345.24	$126.01	$44.13	$18.55	$7.22
2038	$92.75	$351.53	$128.31	$44.93	$19.20	$7.40
2039	$93.72	$357.93	$130.65	$45.75	$19.87	$7.57
2040	$97.16	$364.45	$133.03	$46.58	$20.56	$7.74
2041	$98.82	$371.09	$135.45	$47.43	$21.28	$7.91
2042	$100.30	$377.85	$137.92	$48.30	$22.03	$8.08
2043	$103.10	$384.74	$140.43	$49.18	$22.80	$8.25
2044	$105.94	$391.74	$142.99	$50.07	$23.60	$8.44
2045	$109.88	$398.88	$145.59	$50.98	$24.42	$8.62
2046	$113.78	$406.15	$148.24	$51.91	$25.28	$8.81
2047	$117.34	$413.54	$150.94	$52.86	$26.16	$9.00

Appendix C: Summary of the 2022 2024 Demand Portfolio Energy Efficiency & Demand Response Programs

C.1 Introduction

Public Service Company of Oklahoma (PSO) received approval of the 2022 - 2024 Demand Portfolio, by the Oklahoma Corporation Commission in 2021, in Cause No. PUD 2021000041. 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 PSO's 2022-2024 Demand Portfolio is calculated based on verified energy savings and peak demand reduction for each of the energy efficiency and demand response programs. The cash inducements paid were reconciled and verified with the tracking and reporting system. 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 are shown in this section. The peak demand reduction (kW) and annual 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.

C.1.2 kWh Energy Savings

The annual energy savings (kWh) presented in Table C-1 represent verified 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	2022	2023	2024	2022-2024	3-Year Goal	% to Goal
Energy Efficiency Programs						
Business Rebates	44,612,699	38,424,199	38,462,194	121,499,091	116,096,391	105%
Residential Energy Services	55,335,876	56,674,392	57,543,607	169,553,875	122,333,178	139%
Home Weatherization	4,213,453	4,817,559	5,320,594	14,351,606	8,011,067	179%
Conservation Voltage Reduction	16,927,422	37,293,520	23,974,528	78,195,471	88,835,153	88%
Energy Efficiency Totals	**121,089,450**	**137,209,670**	**125,300,923**	**383,600,042**	**335,275,789**	**114%**
Demand Response Programs						
Power Hours	130,989	227,776	283,405	642,169	0	NA
Peak Performers	822,519	1,184,050	1,230,614	3,237,182	206,076	1571%
Demand Response Totals	**953,508**	**1,411,825**	**1,514,019**	**3,879,352**	**206,076**	**1882%**
Research and Development Programs						
Research and Development	-	-	166,078	166,078	548,717	NA
R&D Totals	**-**		**166,078**	**166,078**	**548,717**	**30%**
Total	**122,042,957**	**138,621,495**	**126,981,019**	**387,645,472**	**336,030,581**	**115%**

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	2022	2023	2024	2022-2024	3-Year Goal	% to Goal
Energy Efficiency Programs						
Business Rebates	9,172	6,688	6,382	22,243	24,035	93%
Residential Energy Services	11,904	12,271	12,771	36,946	21,750	170%
Home Weatherization	2,417	2,605	2,954	7,976	2,948	271%
Conservation Voltage Reduction	3,882	11,741	4,773	20,396	23,547	87%
Energy Efficiency Totals	**27,375**	**33,305**	**26,880**	**87,561**	**72,280**	**121%**
Demand Response Programs						
Power Hours	16,390	23,895	24,672	64,957	64,008	101%
Peak Performers	59,870	63,728	116,982	240,580	210,873	114%
Demand Response Totals	**76,260**	**87,623**	**141,654**	**305,537**	**274,881**	**111%**
Research and Development Programs						
Research and Development	**-**	**-**	**176**	176	688	26%
Research and Development Totals	**-**	**-**	**176**	**176**	**688**	**26%**
Portfolio Total	**103,635**	**120,928**	**168,711**	**393,274**	**347,849**	**113%**

C.1.4 Program Costs

The program costs presented in Table C-3 represent total spending of the demand portfolio.

Table C-3: Total Program Cost by Program

Program	2022	2023	2024	2022-2024	3-Year Goal	% to Goal
Energy Efficiency Programs						
Business Rebates	$10,865,860	$10,596,028	$11,476,201	$32,938,089	$35,545,622	93%
Residential Energy Services	$11,398,035	$11,345,093	$10,834,737	$33,577,865	$30,549,377	110%
Home Weatherization	$3,361,071	$3,474,717	$3,457,760	$10,293,548	$10,294,676	100%
Conservation Voltage Reduction	$357,203	$2,008,740	$1,912,154	$4,278,097	$4,555,971	94%
Energy Efficiency Totals	**$25,982,169**	**$27,424,579**	**$27,680,853**	**$81,087,600**	**$80,945,645**	**100%**
Demand Response Programs						
Power Hours	$1,723,832	$1,588,064	$1,588,095	$4,899,991	$6,471,965	76%
Peak Performers	$3,234,711	$3,344,719	$5,410,697	$11,990,126	$12,037,752	100%
Demand Response Totals	**4,958,543**	**4,932,783**	**6,998,792**	**16,890,117**	**18,509,717**	**91%**
Research and Development Programs						
Research and Development	$371,944	$909,831	**$669,070**	$1,950,845	$2,587,706	75%
Research and Development Totals	**$371,944**	**$909,831**	**$669,070**	**$1,950,845**	**$2,587,706**	**75%**
Total	**$31,312,655**	**$33,267,193**	**$35,348,715**	**$99,928,562**	**$102,043,068**	**98%**

C.1.5 Cash Inducements

Cash inducements are presented in Table C-4. Cash inducements are direct payments to customers or trade allies on behalf of customers, namely rebates and incentives.

Table C-4: Total Cash Inducements by Program

Program	2022	2023	2024	2022-2024	3-Year Goal	% to Goal
Energy Efficiency Programs						
Business Rebates	$6,354,687	$6,205,277	$6,805,235	$19,365,198	$20,319,592	95%
Residential Energy Services	$7,084,378	$7,268,486	$6,882,067	$21,234,931	$18,089,672	117%
Home Weatherization	$3,077,531	$3,153,862	$3,176,759	$9,408,152	$7,999,755	118%
Conservation Voltage Reduction	$0	$0	$0	$0	$0	N/A
Energy Efficiency Totals	**$16,516,596**	**$16,627,625**	**$16,864,061**	**$50,008,282**	**$46,409,019**	**108%**
Demand Response Programs						
Power Hours	$523,111	$688,662	$603,343	$1,815,116	1,561,500	116%
Peak Performers	$2,933,222	$3,013,232	$5,180,361	$11,126,815	10,019,175	111%
Demand Response Totals	**$3,456,333**	**$3,701,894**	**5,783,704**	**$12,941,931**	**11,580,675**	**112%**
Research and Development Programs						
Research and Development Totals	**$-**	**$470,322**	**101,103**	**$571,426**	**712,152**	**80%**
Total	**$19,972,929**	**$20,799,842**	**22,748,868**	**$63,521,639**	**58,701,846**	**108%**

C.1.6 Cost Effectiveness

Figure C-1 shows the Demand Portfolio's Total Resource Cost Test (TRC) results and Utility Cost Test (UCT)[85] results for each year. The reported impacts are net-at- generator, reflecting NTG assumptions and line losses as described in each year's 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).

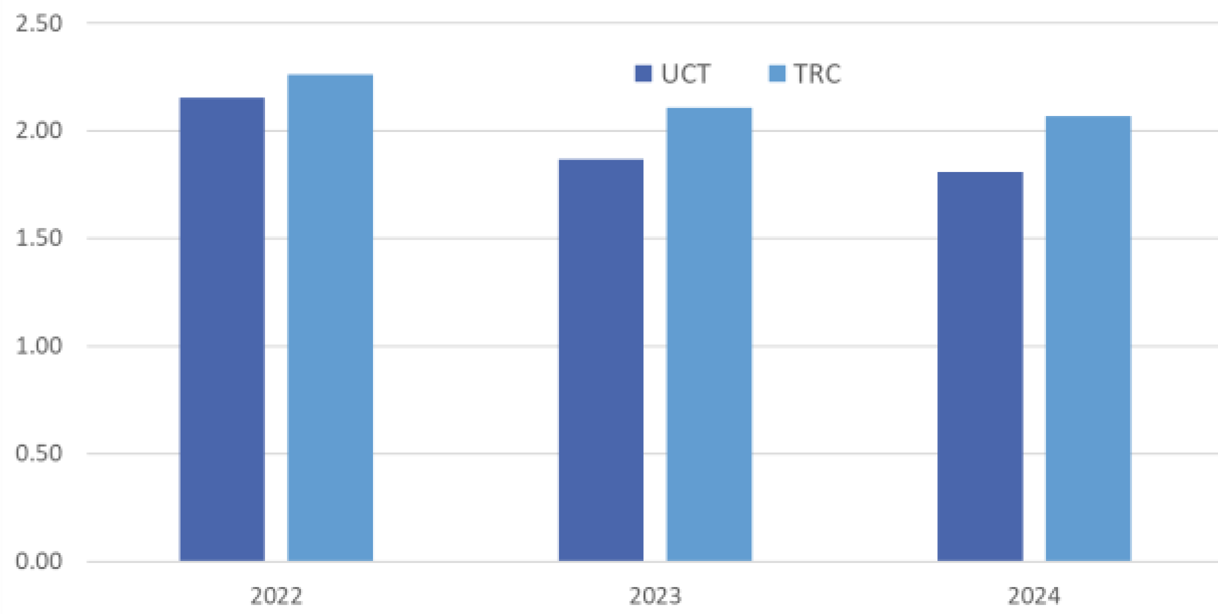
In addition to TRC and UCT results, results from the Ratepayer Impact Measure (RIM), Participant Cost Test (PCT) and Societal Cost Test (SCT) are included in each year's Annual Report. Based on reported program impacts and spending through December 31, 2024, PSO's overall portfolio is cost-effective based on both the TRC and UCT.

Figure C-1 shows the changes in cost effectiveness ratios over the portfolio period.

[85] The UCT is also referred to as the Program Administrator Cost Test (PACT)

The ratios greater than one emphasize the significant benefit provided customers over cost incurred.

Figure C-1: Demand Portfolio Cost Effectiveness by Year



C.2 Energy-Efficiency Programs

In 2024, PSO offered customers a suite of residential energy efficiency subprograms under Residential Energy Services, a suite of commercial and industrial energy efficiency subprograms under Business Rebates, and a Home Weatherization program for low-income customers. The Residential Energy Services program consists of the following subprograms: Multifamily and Manufactured Homes, Energy Saving Products, Home Rebates, Behavioral Modification, and Education. The Business Rebates program consists of the following subprograms: Custom and Prescriptive, Small Business Energy Solutions, and Commercial Midstream.

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, Agricultural, 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. The program included targeted subprograms in Small Business Energy Solutions, Midstream retail discounts, Retail Sales, and Custom and Prescriptive measures (including strategic energy management).

C.2.2 Residential Energy Services

PSO’s Energy Saving Products Program seeks to generate energy and demand savings for residential customers through the promotion of air filters, weatherization measures, electric vehicle chargers, smart thermostats, heat pump water heaters, and EnergyStar® appliances. The purpose of this program is to provide PSO residential customers inducements for purchasing products that meet high efficiency standards. The program included delivery mechanisms of upstream retail discounts for appliances, downstream rebates for appliances and EV Chargers, free-of-charge LEDs distributed through food banks, and a limited time-offering through the PSO website for appliances.

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.

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 with the take-home energy efficiency kit. Energy savings are achieved when these measures are installed in homes.

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.

PSO's Multifamily and Manufactured Homes Program seeks to generate energy savings for owners, operators, and service providers of Multifamily facilities and manufactured homes 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 (i.e., chillers) that do not fall into prescriptive measure categories are rebated on a per kWh and kW impact basis. Energy efficiency measures for manufactured homes included direct install measures (LED screw-in light bulbs replacing incandescent, low-flow showerheads, and faucet aerators) as well as duct sealing and air sealing. Eligible manufactured homes must use electric heating.

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 with the financial assistance they need to make their homes more energy efficient, increase comfort levels, and reduce their utility bills.

C.2.4 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: Peak Performers for Non-Residential customers and Power Hours for residential customers.

C.3.1 Peak Performers Program

The Peak Performers 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. 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. 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 2024 program.

Table D-1: Program Implementer Identification

Program(s)	Implementation Contractor	Contact	Contact Title	Contact Address	Contact Phone	Contact Email
Business Rebates	ICF International	Andrea Palmer	Portfolio Director	7136 S. Yale Ave. #330, Tulsa, OK	918-594-4582	Andrea.palmer@icf.com
Multifamily and Manufactured Homes	ICF International	Andrea Palmer	Portfolio Director	7136 S. Yale Ave. #330, Tulsa, OK	918-594-4582	Andrea.palmer@icf.com
Home Weatherization	Titan ES, LLC	Scott Carter	Vice-President	1327 N 105th E Ave, Tulsa OK 74116	405-632-1700	scarter@titanes.us
	Revitalize T-Town	Jennifer Barcus - Schafer	Chief Executive Officer	14 E 7th St, Tulsa, OK 74119	918-742-6241	jennifer@revitalizettown.org
Energy Saving Products, Home Rebates	ICF International	Andrea Palmer	Portfolio Director	7136 S. Yale Ave. #330, Tulsa, OK	918-594-4582	Andrea.palmer@icf.com
Education	AM Conservation Group	Josh Levig	Director of Program Management	976 United Circle, Sparks, NV 89431	775-813-7445	jlevig@amconservation.com
Power Hours	EnergyHub	Sanjay Pai	Associate Director	41 Flatbush Ave, Ste 400A Brooklyn, NY 11217	203-809-5214	pai@energyhub.net
Peak Performers	PSO	Mary Jackson	EE & Consumer Program Coordinator Sr	212 E. 6th St. Tulsa, OK 74119	918-700-2325	majackson@aep.com
CVR	PSO	Tyler Devereux	Director Reliability & Grid Modernization	212 E. 6th St. Tulsa, OK 74119	918-599-2218	hdevereux@aep.com
Behavioral	Oracle	Karis Huddleston	Customer Success Manager	2300 Oracle Way, Austin TX 78741	928-848-6395	Karis.huddleston@oracle.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 service provider recruitment and training events, customer outreach events, and other non-lighting promotion events throughout the program year.

Table E-1: Service Provider Recruitment & Training Events, Customer Outreach Events, and Other Non-Lighting Promotional Events

Date	Name	Type	City Name or Virtual	Number of Attendees
1/4/2024	Tulsa CSR January 2024 Meeting	Category 2 – CS&M & External Affairs meetings	Virtual	8
1/11/2024	Southeast CSR monthly updates-Jan	Category 2 – CS&M & External Affairs meetings	Virtual	4
1/18/2024	Blanchard Chamber of Commerce Meeting	Category 3 – Civic/Assoc/Community Meetings	Blanchard	20
2/1/2024	Jay Chamber of Commerce Meeting February 2024	Category 3 – Civic/Assoc/Community Meetings	Jay	32
2/1/2024	Tulsa CSR February 2024 Meeting	Category 2 – CS&M & External Affairs meetings	Virtual	4
2/1/2024	McAlester SP Kickoff Training	Category 1 – Service Provider meetings	McAlester	27
2/8/2024	Southeast CSR Monthly Meeting (Feb)	Category 2 – CS&M & External Affairs meetings	Virtual	4
3/1/2024	Tulsa CSR March 2024 Meeting	Category 2 – CS&M & External Affairs meetings	Virtual	5
3/7/2024	Jay Chamber of Commerce Lunch & Learn March 2024	Category 3 – Civic/Assoc/Community Meetings	Jay OK	28
3/9/2024	Check presentation - WeStreet Credit Union	Category 3 – Civic/Assoc/Community Meetings	Tulsa	7
3/14/2024	March-Southeast CSR Monthly Update Meeting	Category 2 – CS&M & External Affairs meetings	Virtual	6
3/14/2024	Broken Arrow Chamber Small Business Networking	Category 3 – Civic/Assoc/Community Meetings	Broken Arrow	
4/1/2024	Tulsa CSR April 2024 Meeting	Category 2 – CS&M & External Affairs meetings	Virtual	5

Date	Name	Type	City Name or Virtual	Number of Attendees
4/2/2024	Leedey Chamber of Commerce	Category 3 – Civic/Assoc/Community Meetings	Leedey	13
4/11/2024	Muskogee Creek Nation Green Team Presentation	Category 3 – Civic/Assoc/Community Meetings	Muskogee	25
4/11/2024	April-Southeast CSR Monthly Update Meeting	Category 2 – CS&M & External Affairs meetings	Virtual	N/A
4/25/2024	Broken Arrow Chamber Luncheon 4/25/24	Category 3 – Civic/Assoc/Community Meetings	Broken Arrow	N/A
4/25/2024	Business Owner Network Group Networking event	Category 3 – Civic/Assoc/Community Meetings	Tulsa OK	N/A
5/1/2024	Tulsa CSR May 2024 Meeting	Category 2 – CS&M & External Affairs meetings	Virtual	7
5/2/2024	Jay Chamber of Commerce Meeting May 2024	Category 3 – Civic/Assoc/Community Meetings	Jay	18
5/6/2024	Breakfast b4 Business	Category 3 – Civic/Assoc/Community Meetings	Lawton	N/A
5/9/2024	May-Southeast CSR Monthly Update Meeting	Category 2 – CS&M & External Affairs meetings	Virtual	5
5/9/2024	CSR Monthly Meeting	Category 2 – CS&M & External Affairs meetings	Lawton	2
5/20/2024	KIWANIS Club Meeting	Category 3 – Civic/Assoc/Community Meetings	Weatherford	25
6/3/2024	Tulsa CSR June 2024 Meeting	Category 2 – CS&M & External Affairs meetings	Virtual	6
6/6/2024	Inola Chamber of Commerce June 2024	Category 3 – Civic/Assoc/Community Meetings	Inola	16
6/6/2024	Chamber of Commerce Chickasha	Category 2 – CS&M & External Affairs meetings	Chickasha	N/A
6/12/2024	Procurement Event	Category 3 – Civic/Assoc/Community Meetings	Lawton	N/A
6/13/2024	June-Southeast CSR Monthly Update Meeting	Category 2 – CS&M & External Affairs meetings	Virtual	5
6/13/2024	Tulsa Area Manufacturing Assoc Networking After Hours - TIMCO Machine Tools	Category 3 – Civic/Assoc/Community Meetings	Broken Arrow	N/A

Date	Name	Type	City Name or Virtual	Number of Attendees
6/17/2024	Lunch and Learn -CC Chickasha	Category 3 – Civic/Assoc/Community Meetings	Chickasha	11
6/19/2024	Counter Day by Hunzicker Brothers-Clinton, OK	Category 1 – Service Provider meetings	Clinton, OK	10
6/20/2024	Meeting Chamber of Commerce Lawton	Category 3 – Civic/Assoc/Community Meetings	Lawton	N/A
6/26/2024	Northeast Oklahoma Regional Alliance (NORA) State of the Region Annual Meeting	Category 3 – Civic/Assoc/Community Meetings	Pryor	60
7/11/2024	July-Southeast CSR Monthly Update Meeting	Category 2 – CS&M & External Affairs meetings	Virtual	N/A
7/15/2024	Tulsa CSR July 2024 Meeting	Category 2 – CS&M & External Affairs meetings	Virtual	N/A
7/16/2024	PSO Key AM / ICF luncheon 2024	Category 2 – CS&M & External Affairs meetings	Tulsa	7
7/19/2024	Tulsa Area Manufacturing Assoc Networking After Hours - Tulsa Oilers Football	Category 3 – Civic/Assoc/Community Meetings	Tulsa	12
7/25/2024	AEEOK networking event - Tulsa 7/25/24	Category 3 – Civic/Assoc/Community Meetings	Tulsa	6
7/25/2024	Broken Arrow Chamber Luncheon 7/25/24	Category 3 – Civic/Assoc/Community Meetings	Broken Arrow	N/A
8/1/2024	Tulsa CSR August 2024 Meeting	Category 2 – CS&M & External Affairs meetings	Virtual	12
8/15/2024	August-Southeast CSR Monthly Update Meeting	Category 2 – CS&M & External Affairs meetings	Virtual	5
8/22/2024	Okmulgee Main Street	Category 3 – Civic/Assoc/Community Meetings	Okmulgee	N/A
8/26/2024	Check presentation - Tulsa Tube Bending	Category 3 – Civic/Assoc/Community Meetings	Tulsa	N/A
8/28/2024	ORA EXPO	Category 3 – Civic/Assoc/Community Meetings	Oklahoma City, OK	N/A
8/29/2024	Service Provider Training	Category 1 – Service Provider meetings	Lawton	15
8/30/2024	Business Owners Network Group Ladies Breakfast	Category 3 – Civic/Assoc/Community Meetings	Tulsa	35

Date	Name	Type	City Name or Virtual	Number of Attendees
9/5/2024	Broken Arrow Chamber Speed Networking Event 9/5	Category 3 – Civic/Assoc/Community Meetings	Broken Arrow	50
9/5/2024	Jay Chamber of Commerce Meeting September 2024	Category 3 – Civic/Assoc/Community Meetings	Jay	32
9/5/2024	Bartlesville Chamber Business EXPO / Business After Hours	Category 3 – Civic/Assoc/Community Meetings	Bartlesville	100
9/12/2024	Delaware County Resource Roundtable Networking Event	Category 3 – Civic/Assoc/Community Meetings	Kansas OK	N/A
9/12/2024	September-Southeast CSR Monthly Update Meeting	Category 2 – CS&M & External Affairs meetings	Virtual	0
10/1/2024	Tulsa CSR October 2024 Meeting	Category 2 – CS&M & External Affairs meetings	Virtual	15
10/1/2024	Inola Chamber of Commerce October 2024	Category 3 – Civic/Assoc/Community Meetings	Inola	14
10/2/2024	AEEOK First Wednesday Energy Nexus Breakfast 10/2/24	Category 3 – Civic/Assoc/Community Meetings	Tulsa	8
10/2/2024	Crawford Electric Supply Service Provider Training	Category 1 – Service Provider meetings	Virtual	3
10/10/2024	October- Southeast CSR Monthly Update Meeting	Category 2 – CS&M & External Affairs meetings	Virtual	3
10/15/2024	Northeast Oklahoma Regional Alliance (NORA) Regional Summit	Category 3 – Civic/Assoc/Community Meetings	Tahlequah	60
10/22/2024	Broken Arrow Chamber Manufacturing Luncheon 10/22/24	Category 3 – Civic/Assoc/Community Meetings	Broken Arrow	N/A
10/22/2024	Roger Ferrer Conference in Stillwater	Category 2 – CS&M & External Affairs meetings	Stillwater	100
10/23/2024	AEEOK Energy Conference-Roger Farrer	Category 3 – Civic/Assoc/Community Meetings	Stillwater	N/A
10/29/2024	Bartlesville Chamber Speed Networking 10/29	Category 3 – Civic/Assoc/Community Meetings	Bartlesville	12
10/29/2024	Broken Bow Chamber of Commerce	Category 3 – Civic/Assoc/Community Meetings	Broken Bow, OK	26

Date	Name	Type	City Name or Virtual	Number of Attendees
10/29/2024	Meeting Great Plains Tech C. employees	Category 3 – Civic/Assoc/Community Meetings	Lawton	N/A
10/30/2024	United Way Gumbo Luncheon PSO	Category 3 – Civic/Assoc/Community Meetings	Lawton	50
11/1/2024	Tulsa CSR November 2024 Meeting	Category 2 – CS&M & External Affairs meetings	Virtual	N/A
11/7/2024	Broken Arrow Chamber Speed Networking Event 11/7	Category 3 – Civic/Assoc/Community Meetings	Broken Arrow	50
11/14/2024	November-Southeast CSR Monthly Update Meeting	Category 2 – CS&M & External Affairs meetings	Virtual	0
12/2/2024	Tulsa CSR December 2024 Meeting	Category 2 – CS&M & External Affairs meetings	Virtual	N/A
12/12/2024	December-Southeast CSR Monthly Update Meeting	Category 2 – CS&M & External Affairs meetings	Virtual	4

Appendix F: Marketing Synopsis – Customer Engagement

The following pages of this appendix provide examples of materials used to promote, engage, and educate customers on PSO's Demand Portfolio in the 2024 program year.

PSO's customer engagement strategies for Power Forward with PSO continue to evolve in attracting, engaging, and educating customers on energy efficiency. Multichannel customer engagement strategies are utilized to increase opportunities for customer awareness, engagement and education.

F.1 2024 Program Customer Engagement Goals

This section presents the methods used to meet PSO's portfolio engagement goals.

F.1.1 Strategies and Tactics

- Identify unknown audiences, reach underserved demographics, segment creative and messaging, with a focus on improving program parity.
- Utilize dynamic content to improve paid media with social media channels.
- Utilize paid media to deliver targeted messages to customers.
- A/B Message Testing
- Develop content to support paid media and digital channels.
- Continue to identify opportunities for customer education.
- Collect feedback from customers, industry experts and partners to improve the clarity, effectiveness and follow-up efforts of PSO's energy-efficiency program marketing.

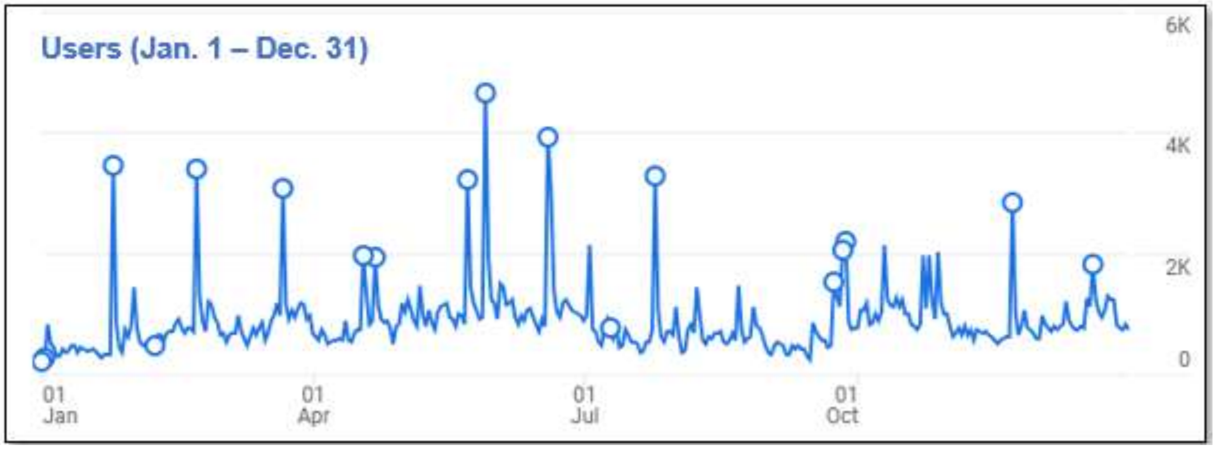
F.1.2 PSO Website

The PSO Power Forward website showcases all the consumer programs that focus on energy efficiency. Home and business rebate information is available on the website for those interested in purchasing or upgrading their home or business. Energy efficiency tips and tricks are also present on the website to help homeowners plus business owners.

F.2 Overall Website Performance

For 2024, there were 304,921 total users, 114,544 engaged sessions, and 575,170 pageviews on the Power Forward website. In comparison to 2023, total users increased by approximately 70,000 and nearly 80,000 pageviews in 2024.

Figure F-1: Overall User Visits

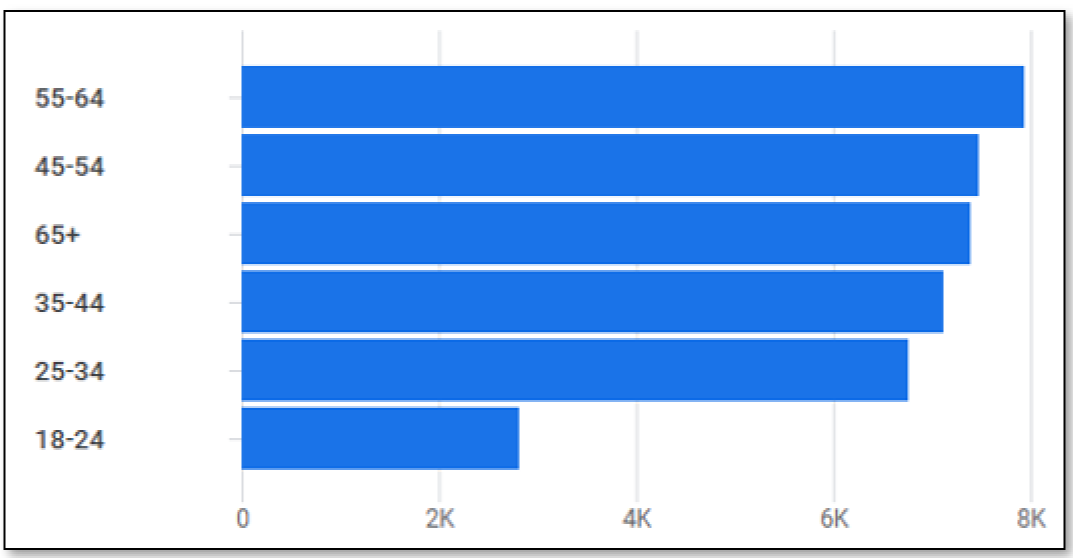


F.2.1 Site Visitors: By Age & Gender

Website visitors for 2024 fluctuated across all age groups, however the primary users fell within the 45-54 and 55-64 year old age ranges. Website demographic is both male and female with the amount of female users being 56% of users for 2024.

Figure F-2: Age Group Comparison

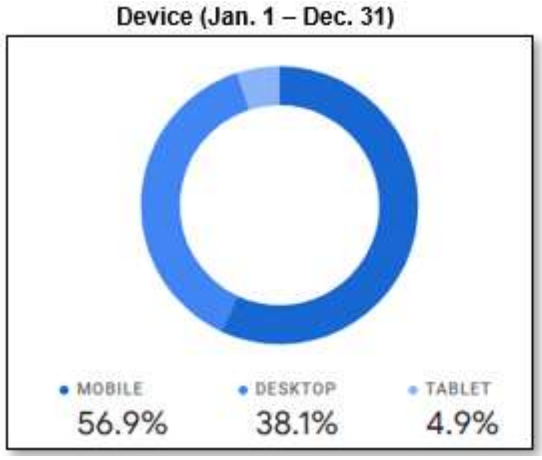
AGE (Jan. 1 – Dec. 31)



F.2.2 Site Visitors: By Device

Most website users in 2024 used mobile devices. Performance metrics continue to show that mobile is the primary device used. Desktop users made up the second largest device group while tablet users were significantly lower than mobile or desktop users.

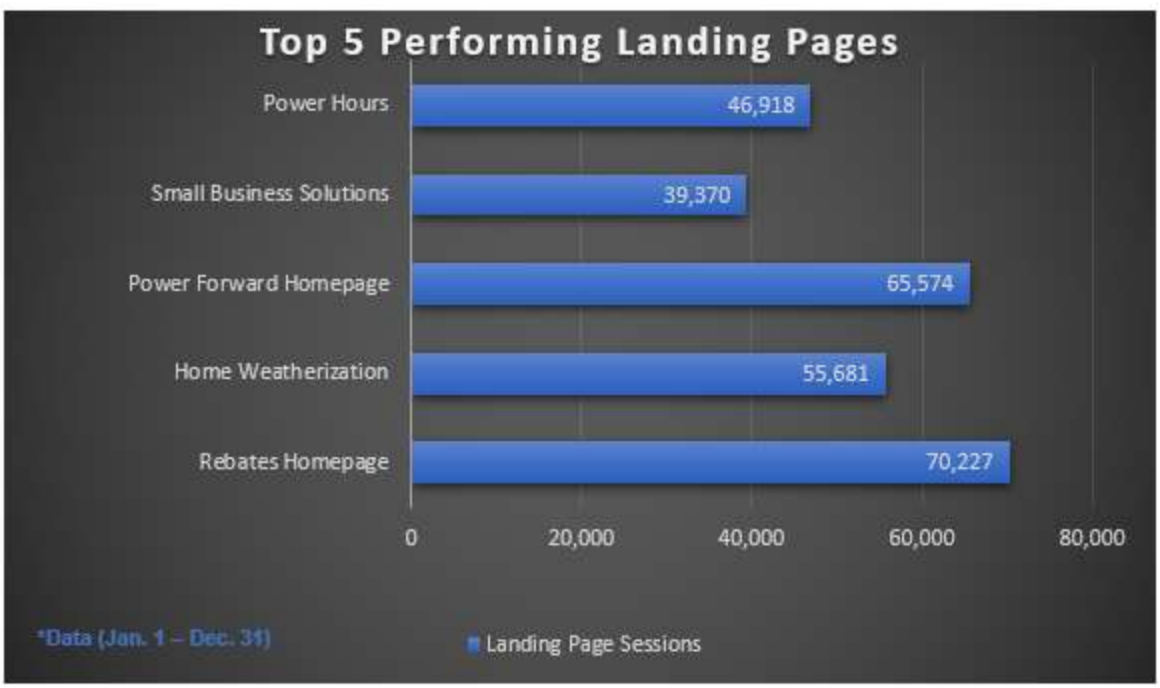
Figure F-3: Site Visitors by Device



F.2.3 Website Engagement

The following pages have the most engagement – determined by total page views by users. The general rebates landing page was the top performing landing page in 2024, which was followed by the Power Forward general landing page. The Small Business landing page became one of the top performing landing pages, which is new compared to 2023 results.

Figure F-4: Website Engagement



F.2.4 Paid Search Results

Paid search is utilized each year to capture customers at the start of their energy efficiency journey. In 2024, we consistently refined search keywords to increase media effectiveness to support engagement tactics while making sure to have easily accessible information for customers looking for PSO's Consumer Programs and/or rebate options.

Top Search Terms for 2024

Residential: " pso power hours", "pso rebates", "energy saving rebates", "energy saving program", "home energy savings"

Commercial: "commercial energy rebates", "business energy rebates", "commercial hvac rebate", "commercial rebates", "HVAC Commercial Rebates"

F.2.5 Web Traffic

F.2.5.1 Social Media

Social media continues to be a strong driver of traffic to the PSO Power Forward website. In 2024, we continued placements on Facebook/Instagram and LinkedIn for media in order to reach customers across a several platforms where content is highly consumed. Dynamic content was utilized like the previous year to better understand what customers preferences were when it came to specific images and/or verbiage.

F.2.5.2 Display

Programmatic display was another great driver to the PSO Power Forward website. The content was a mixture of energy efficiency and rebate information in both static and animated display banners. Data showed that both commercial and residential customers preferred animated display banners over static.

F.2.5.3 Videos

In 2024, the video engagement strategy leveraged multiple programmatic and connected television platforms (YouTube, Facebook/Instagram, LinkedIn, Hulu, etc.) in order to reach a wider customer base. Optimizations focused on fine tuning audience targeting on these platforms to maximize KPIs while reducing spend.

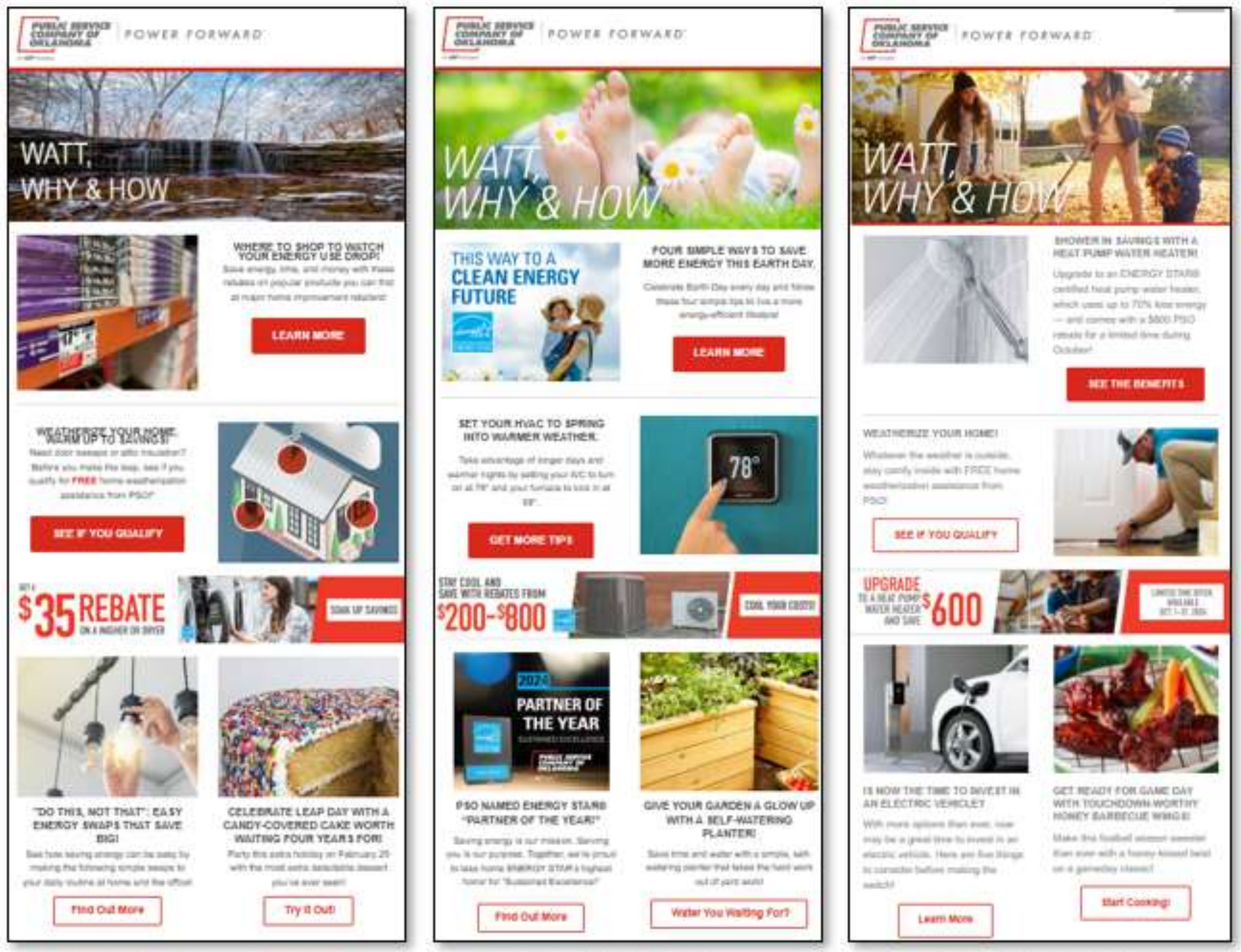
F.2.5.4 Email Engagement

Email communications for 2024 were sent to not only residential PSO customers but commercial as well. Email content focused on home and business rebates available to customers plus energy efficiency program information for those who may be searching for ways to increase energy savings in their home or business. Emails included clear call to action buttons to improve customer engagement and experience.

F.3 Creative Examples

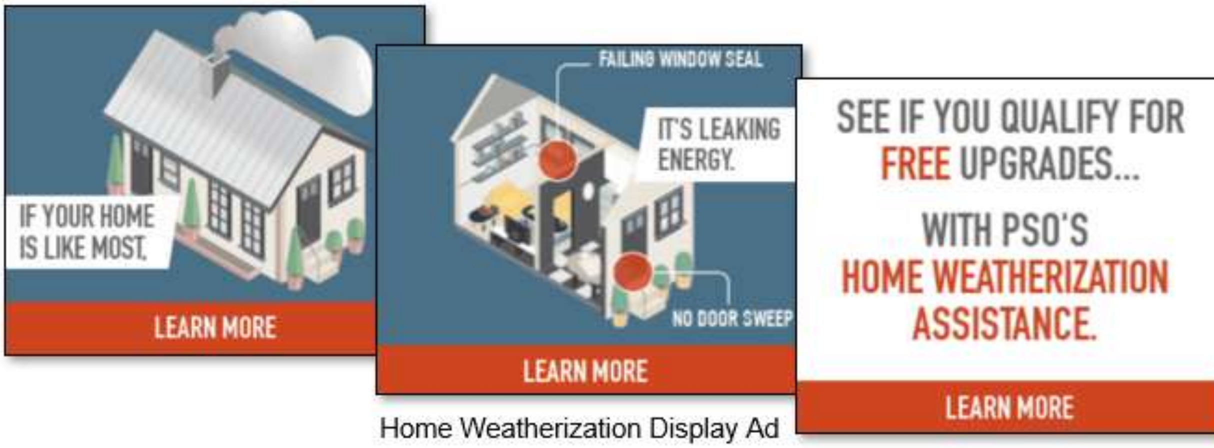
A residential newsletter was sent to approximately 380,000 customers the third Thursday of each month. The content highlighted energy-saving blog content, tips and available rebates and/or the Limited Time Offer (LTO) occurring that month. Customers were encouraged to visit the PSO Power Forward for more information about these energy-saving blogs.

Figure F-5: Residential Newsletter



February Newsletter April Newsletter September Newsletter

Figure F-6: Home Weatherization Creative Content



Home Weatherization Display Ad

Stay comfortable indoors while spring blooms outdoors! **PSO's Home Weatherization** program provides **FREE energy efficient upgrades**, including attic insulation, air and duct sealing, and more for qualifying customers.

How does it work?

If your home qualifies, our service provider, Titan ES, will perform an energy assessment and complete the necessary energy upgrades at no cost to you.

Home Weatherization assistance is available to PSO customers who own or rent a home in PSO's service territory with an annual household income of $55,000 or less. The residence must be a single-family home less than 2,200 square feet in size and built in or prior to 2010 to qualify.

REQUEST WEATHERIZATION UPGRADES!

Don't qualify? Don't worry! We have all types of rebates for your home.

If you need assistance with your current energy costs, learn more about how Low Income Home Energy Assistance Program (LIHEAP) may help.

Is your home leaking? Air leaks account for up to 40% of energy used for heating and cooling a typical home. So, make sure your home is as energy efficient as it can be! See if you qualify for PSO's Home Weatherization program that provides **FREE energy efficient upgrades**, including air and duct sealing, attic insulation and more!

How does it work?

If your home qualifies, our service provider, Titan ES, will perform an energy assessment and complete the necessary energy upgrades at no cost to you.

Home Weatherization assistance is available to PSO customers who own or rent a home in PSO's service territory with an annual household income of $55,000 or less. The residence must be a single-family home less than 2,200 square feet in size and built in or prior to 2010 to qualify.

REQUEST YOUR WEATHERIZATION UPGRADES!

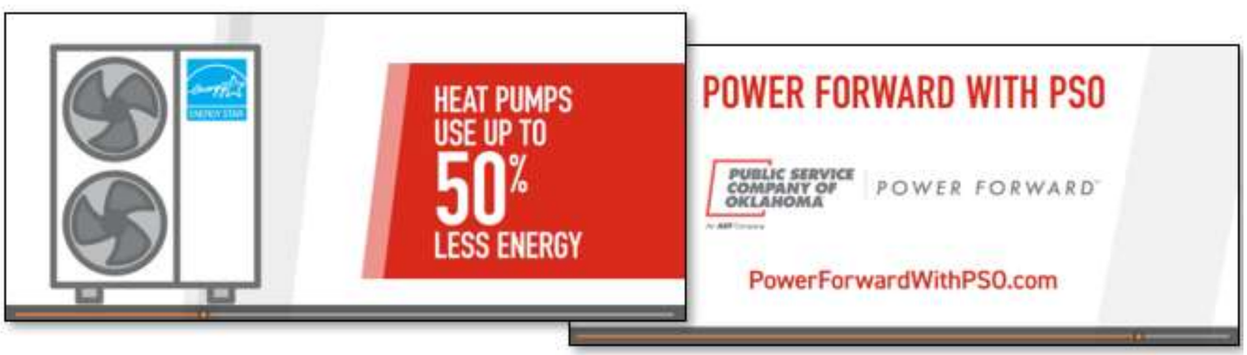
Don't qualify? Don't worry! We have all types of rebates for your home.

Home Weatherization Customer Emails

Home Rebates Creative Content

A/C Tune-Up Billboard

Home Rebates Bill Insert – St. Jude Dream Home



Home Rebates Display Video – Heat Pump

Figure F-7: Power Hours Creative Content

Power Hours End of Season Email

Power Hours Tri-Fold Brochure

Figure F-8: Small Business Creative Content

Small Business Print Ad – Tulsa People Magazine

Small Business LinkedIn Paid Social Media Carousel Ad

Figure F-9: Commercial Creative Content

Business Rebates Billboard - Custom

Business Rebates Video – Oil & Gas

Figure F-10: Peak Performers Creative Content

Peak Performers Print Ad
Tulsa People

GOLDEN YEARS, GOLDEN SAVINGS WITH PEAK PERFORMERS AT MONTEREAU RETIREMENT COMMUNITY

PROBLEM:

Montereau is a locally owned, not-for-profit, resort-style retirement community. Its energy consumption is primarily from three mechanical high-pressure coolers plus electrical motors for circulating water throughout the 850,000 sq. ft. facility. Montereau was looking for energy savings, but mostly wanting to incorporate energy efficiency. So, they enrolled in PSO's Peak Performers. While Montereau wasn't a previous Peak Performer participant, their Director of Plant Operations, Tadd Weese, had participated in the program before joining Montereau. "It was an easy sell," says Tadd. "It made us more responsible citizens, and there are fiscal benefits as well. It was a no-brainer."

SOLUTION:

While Montereau has seen a decrease in energy consumption and costs, they really appreciate Peak Performers because it has made them more familiar with their emergency generation power. "It has given us the opportunity to look at expanding what we can put on those circuits so that we can be more efficient in the event that we do have a power outage," says Tadd. "Also, we can be more fiscally responsible and a better citizen for taking more load off of the grid." Given peak event times may fall during residents' dinner hours, reducing lighting or thermostats is not always feasible for this facility's environment. However, Peak Performers is flexible based on customer's different needs. Montereau has reduced their load primarily by pushing a portion of their energy usage to their generators.

RESULTS:

Montereau has seen approximately a two-percent decrease in energy consumption. Participating in Peak Performers has also given Montereau a better view of their organization's overall energy usage. Because of this, Tadd says he "absolutely" would recommend Peak Performers to his peers. "I've mentioned the benefits to all of my counterparts who have emergency generation capabilities," says Tadd. Montereau has been so pleased with PSO, they have also taken advantage of PSO's other energy saving opportunities. "We've used PSO's retrofit lighting rebates that are available when completing upgrades as well," says Tadd. To that end, Montereau has switched to LED lighting throughout the facility as much as possible. Tadd credits PSO not only for the value of its programs, but also for the quality of its customer service. "This program has been very professionally run. It has been very well executed," says Tadd. "The communication has been tremendous."

Peak Performers Overview Booklet Case Study

F.4 Community Engagement

PSO participated in a variety of community events, including tradeshows, program presentations, seminars and more throughout 2024. Local community events are used to help educate customers and service providers to bring awareness to rebates plus energy efficiency program offerings throughout the state.

- 85+ service provider training events plus internal training for programs.
- 40+ local community events throughout the state (Lawton, McAlester, Tulsa, etc.)

BOK Center Indoor Event

Tulsa Home & Garden Show

Tulsa State Fair

Catoosa Liberty Fest

Appendix G: Overview of ADM Associates

ADM Associates is a professional services corporation providing research and consulting services in applied energy engineering and economics to utilities and other clients nationwide. The services ADM provides primarily relate to comprehensive energy research and energy-efficiency program implementation and evaluation. ADM's headquarters are in Sacramento, California with regional field offices in Nevada (Reno), Portland (Oregon), and the California Bay Area (Fremont). ADM has remote staff located throughout the country, including Oklahoma. 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 over 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 always required. 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.